UNDP/UNEP "Economic Valuation of Ecosystem Services" Technical Assistance Project

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Ecosystem Services and their Role in Poverty Alleviation in Armenia - A Case Study of Karaberd Gold Mine

Final Report

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List of abbreviations

EIE	Environmental Impact Expertise
EIA	Environmental Impact Assessment
ES	Ecosystem Service
ESA	Ecosystem services approach
GDP	Gross domestic product
PEI	Global Poverty and Environment Initiative
SPM	Suspended Particulate Matter
TEEB	The Economics of Ecosystems and Biodiversity
UNDP	United Nations Development Program
UNEP	United Nations Environment Program

Executive Summary

Background

The United Nations Environment Program (UNEP) and the United Nations Development Programme (UNDP) joint Poverty Environment Initiative (PEI) in the Republic of Armenia aims to contribute to poverty reduction and improve the well-being of poor and vulnerable groups through mainstreaming the environment into national development processes.

During a PEI scoping mission in August 2010 an understanding of the **economic value of ecosystem services (ES)** and their influence on human-well being was identified as being of great importance to environmentally sustainable decision making and poverty reduction in Armenia. A PEI Technical Assistance project (TA) was consequently prepared with the UNDP Country Office in Armenia. The project's objectives were to:

- Strengthen the knowledge base and capacity at the national, provincial and local levels in ecosystem valuation; and,
- Develop an independent expertise in ecosystem valuation in order to provide scientific based evidence to stakeholders and decision makers.

A national group of independent experts was formed under the TA project. This group of experts undertook a study of the Karaberd Gold Mine. ***It should be borne in mind that the pilot study focused on capacity building through a 'learning by doing' approach, rather than on carrying out a definitive assessment.***

The pilot study – Karaberd Gold Mine

The proposed Karaberd Gold Mine is in Lori Marz, in the north of Armenia. The mine is within the administrative borders of Karaberd village and is 30km from Yerevan and 10km from Vanadzor City (the capital of Lori Marz). Other nearby settlements are Pambak village, Gugark village and Vanadzor city. Of note is that there is a settlement of 10-12 households located 0.8km from the mine, which is part of Karaberd village (referred to as 'Karaberd Settlement' throughout this report). The immediate area of the mine is devoid of forest cover and used as grasslands. However, near the mine along the earthen road to Karaberd settlement, which is intended to be used for ore transportation, there is a 3.9 hectares forest area where mostly oaks and related tree varieties are presented.

In terms of its reserves and anticipated productivity Karaberd mine can be classified as a low impact mine (small mine). An output of 2,500 tons of exploitable ore is expected in the first 3 years from the open pit mine and 30,000 tons for the subsequent 7-8 years from the undergound mine. The current explored area of the mine is 6.4 ha at a height of 1,700-1,775 m above sea level and with an average slope of 10-15 degrees. The surrounding area ranges from 1,300 to 1,850 m with mostly steep slopes. The plot of the open pit mine is 1.1 ha and the waste landfill covers 1.5 ha of forest free land. The ore is to be transported via railway to the Ararat gold extractive factory. The expected extracted gold and silver is 213.4 kg and 367.8 kg respectively.

Mining is a key economic activity in Armenia, contributing 5.4% to GDP (2012), but there are concerns about the impact of mining operations on the environment. The study of the impact of the Karaberd gold mine on ecosystem services and the well-being of the community aims to inform decision making at the site, while also presenting a methodology that can be adopted at other locations to ensure mining is practiced in a responsible and sustainable manner. Lori region has one of the highest poverty and unemployment rates in the country. Karaberd and Pambak villages, located near the proposed mine site, are considered to be low-income communities.

At the national level, the pilot study is aligned to a number of key Government policies and laws.

A **law on innovative economic instruments in the environment sector** was approved by the Government in 2013. It is proposed to submit an action / implementation plan to the Government related to this law. A new law on ecosystem services will be one of the implementation points. It is anticipated that this will establish a methodology on natural capital valuation and cover indicators on green growth and green funding.

A new environmental law is also being developed with support from the Government of Germany. This umbrella law is expected to acknowledge the importance of the ecosystems services approach and the valuation of natural assets.

The current study is therefore very timely as a means of demonstrating an approach for integrating the value of ecosystem services into decision making.

Approach

The pilot project has adopted an **ecosystem services approach (ESA)**. The ecosystem service approach is based on the Millennium Ecosystem Assessment (2005) classification of ecosystem services into the following four categories:

- ***Provisioning services*** relate to the tangible products, such as fish and timber provided by ecosystems;

- ***Regulating services*** refer to the natural processes of ecosystems such as waste assimilation and carbon sequestration that contribute to social wellbeing;

- ***Cultural services*** may be associated with both use and non-use values and relate to the non-material benefits obtained from ecosystems, for example, through tourism and educational use of the environment; and,

- ***Supporting services*** which are necessary for the production of all other ecosystem services (e.g. soil formation or nutrient cycling). Supporting services differ from the other services in that their impacts on people are either indirect (via provisioning, regulating or cultural services) or occur over a very long time.

Mining, while dependent of ecosystem services such as water supply for mineral processing, can impact biodiversity and ES in a variety of ways. These impacts include (UNEP, 2010):

- **Habitat loss and fragmentation** through surface mining, creation of waste rock dumps and secondary developments from roads and influx of employees;
- **Water Pollution** of habitats and water supplies from chemical contamination and solid waste (storage of waste / tailings);
- **Air pollution** from quarrying which can disturb plant and animal (and human) communities through dust;
- **Excessive water withdrawal** that can impact on local water systems altering creeks, rivers, and watershed regimes;
- **Noise** which can disturb communities and animals and plants; and,
- Use and disposal of some heavy metals can have significant negative impacts on soils, water resources, animal and human health.

A seven step methodology was followed at the study site, as summarised in the Figure below. This methodology can be generally applied (across different sectors and ecosystem services) to analyse the economic value of ecosystem services, tradeoffs associated with their use and degradation and their contribution to social welfare under different management practices.

The main analytical activities undertaken by the pilot study were: an in-depth socio-economic assessment of the area (including a face to face household survey); a biodiversity survey; a review of the mining Company’s Environmental Impact Assessment (EIA); a qualitative assessment of the ecosystem services at the site; a monetary assessment of key provisioning services; a scenario analysis covering Business as Usual (BAU) mining, mining based on best international practices and a no-mining development alternative for the site; an assessment of the distributional impacts of the mine; and, a legal review.

Given that capacity building was a core objective of this project and the fact that the project scope was to undertake an initial pilot study in ecosystem valuation, a comprehensive assessment was not possible.

It is important to note that it was not possible to undertake a life cycle analysis, which would identify the impacts of the mining operation across its four key phases (ore exploration, construction of the mine, production and rehabilitation of the site). The pilot study is focused on the **excavation stage of production** only

It has not been possible to undertake a cost benefit analysis of the three scenarios, as net revenue is not estimated for the 'no mining' scenario. Furthermore, only a limited number of ES have been monetized. Impacts on water flow regimes and health may be significant but data are missing to link the impact of the mine to changes in water flow or to changes in ambient air quality. These 'costs' should be deducted from the benefits of mining.

NPVs are not calculated as it would be misleading to calculate NPVs given gross estimates are not available for all the scenarios. It should be noted however, that the benefits of mining will occur over 11 years, while ES, if sustainably managed, will continue for a much longer period.

Figure: Key steps in the economic assessment

Step 1: Site selection and stakeholder consultation	• Consult on project and potential study sites • Select pilot site • Specify & agree the policy issue with stakeholders
Step 2: Characterize the study and determine the context for the assessment	2a. Develop a conceptual understanding of the physical characteristics of the area to be studied e.g. its size, soil type, typography and hydrology 2b. Undertaken a socio-economic analysis 2c. Define the issues. What are the main threats to ecosystem services, who is being affected and how? 2d. Define scenarios to be analyzed
Step 3: Define the scope of the economic assessment	• Undertake qualitative assessment of ecosystem services • Determine data availability (scientific / quantitative) • Select ecosystem services to be valued. • Select key economic indicators
Step 4: Quantification of impacts	• Quantify (in bio physical terms) the impacts of each scenario, taking into consideration both on-site and off-site impacts
Step 5: Undertake valuation of ecosystem	• Derive monetary estimates of the ecosystem services under the selected scenarios using appropriate valuation approach
Step 6: Analysis of economic evidence	• CBA (economic & financial perspective). Aggregation, discounting, sensitivity analysis • Impacts of different scenarios on key indicators – e.g. employment, incomes, tax revenues • Distributional analysis and implications for poverty alleviation • Identification of sustainable financing / development mechanisms
Step 7: Understanding the institutional requirements	Specify the institutional barriers to achieving sustainable and equitable economic development

Pilot study findings

Socio-economic assessment

The socio-economic assessment is based on a review of available official reports and statistics and a household survey, which covered 20 households in Karaberd village, 8 households in Karaberd settlement, 20 households in Pambak, 50 households in Gugark and 50 households in Vanadzor city. Key findings from the socio-economic assessment are:

- The local communities likely to be impacted by the mine are poor. There is 53% unemployment in Karaberd village, 32% in Pambak, and 51% in Gugark and economic migration rates are high. Agriculture is largely limited to the cultivation of homestead plots, where crops are grown for domestic purposes and therefore make a significant contribution to food security. Animal husbandry is the main activity the productivity of which depends on the sustainable use of pasture land. Most households are dependent on underground water and there is limited water available for irrigation purposes. Therefore any impact to the spring supplying water, located near the mine, is a serious concern. Karaberd village and Settlement have no health facilities, poor roads and no school.
- Awareness of the mine varies across the areas expected to be impacted by the mining operation. In Karaberd village and settlement all households were aware of the possible operation of Karaberd gold mine. However, only households in Karaberd village were informed of the public hearings on the mine. For Pambak, Gugark and Vanadzor city, 40%, 0% and 16% respectively were aware of the possible operation of the mine. None of these areas were invited to participate in the public hearings on the mine.
- About 85-90% of the respondents in Karabard Village (compared to Karabard Settlement 37-87%, Pambak 25-50%, Gugark 4-8%, and Vanadzor City 26-48%) felt that the mining operation would have a positive impact on the economic development of the community and create additional sources of income.
- In Karaberd Village 35-65% of the respondents and the Village Major believe that the mine will have no environmental and health impacts since it is far from the village. This is in contrast to Karaberd settlement where *all* the respondents believe that the mining operation will have a negative impact on the environment and health. In the other survey villages the percentages were: Pambak 30-70%; Gugark 60-72%; and. Vanadzor 82-86%.

Biodiversity survey

A rapid survey of fauna and flora was undertaken at the study site in August 2013. No species listed in the Red Book of the Armenian Flora were observed in the study area. A possible exception is a species of Iris found, however to precisely identify this species it is necessary to visit the area when the plant is at an earlier stage of vegetation.

Review of the EIA process

The Company EIA report is mostly in accordance with the procedures adopted by the Republic of Armenia. The main limitations of EIA undertaken by the Company include:

- The analysis is based on literature and previously conducted research, no site specific assesments are made;
- Groundwater is not assessed although the risk of groundwater becoming contaminated or drying up is a key concern of local communities. It is also likely that explosions at the mine will impact water flow and quality;
- The impacts of fine particles, which are likely to reach Vanazdor, are not assessed. There are no standards for Suspended Particulate Matter (SPM) in Armenia and data on SPM is not collected. As a result it is not possible to find a correlation between SPM and respiratory illness, although this link has been proven in other countries;
- There is only a general assessment of indigenous biodiversity and it is not clear from the Company's EIA if there are any endangered species. The description of the flora and fauna and land resources relates to the whole region, and a specific analysis of the immediate mining area is missing;

- The EIA does not refer to the structure of tailings;
- Closure and decommissioning procedures are absent; and,
- The scope of the EIA is insufficient because it only covers Karaberd Village.

Valuing of ecosystem services

A high level valuation of key provisioning services (food production and collection, pasture provision and honey production) was undertaken at the site, **focused on Karaberd Village and settlement only**. It was not possible within the study to value regulating services. This would require more detailed bio-physical studies in the first instance in order to quantify these services and specify their links to economic activities. Challenges related to the valuation of ecosystem services include:

- The valuation of Ecosystem Services is limited by data avialbility. In most cases this is physical, rather than economic data. As a result it was not possible to estimate the value of any of the regulating services at the site.
- Bio physical data is needed, which can relate the environmental impact of the mine to a change in the provision of the ES that can then be linked to an economic activity. Important regulating services at the site to consider are:
    - There is an underground water outflow in Karaberd settlement which serves as a source of drinking water. The springs in the mining area may be impacted (e.g. through blasting activities) resulting in a deterioration of water quality, and a reduction in flow / possible drying out of streams and rivers. The relationship between underground and surface water has not be studied in any detail at the site.
    - Diseases of the respiratory system and invasive communicable diseases are among the largest contributors to morbidity across all age groups in the area. However, there is no monitoring of SPM or dose response studies available rendering it impossible to analyze the relationship between air emissions from the mine and the risk of an increase in respiratory illness.

Scenario Analysis

The pilot study compares three alternative scenarios for the site - mining under a Business as Usual Scenario (BAU), mining following best international practices, and an alternative development option where activities such as animal husbandry and bee keeping are optimized over time.

- BAU Mining. Throughout the eleven year operational period of Karaberd gold mine the cumulative profit (without accounting for capital costs) will amount to US$32,741,700 (US$28,411,200 from the underground mine and US$4,330,500 from the open-pit mine). The overall capital investment in the open-pit is US$1,253,250. This investment can be recouped in 0.9 years. The capital investment required for the underground mine is US$1,039,000, which can be recouped in 0.3 years.
- Sensitivity analysis on a range of key variables indicates the ***financial*** robustness of the proposed mining operation. That is from the Company's perspective, without having to consider the social costs of the mine, the mine is a highly viable investment. The impact of changes in operating costs, the anticipated gold content of the ore extracted and the price of gold on the payback period suggest that even given an increase in cost by 40% or a fall in the gold price or gold content by 40% the payback period on capital invested will not exceed 2.6 years
- A **social (economic) assessment** includes the broader impacts on society. This factors in the damage and / or loss of ecosystem services at the site. In the case of the Karaberd Gold mine, the impact on provisioning services were not found to be significant. However, it was not possible to quantify impacts on key regulating services.
    - Overall the impact of the mine on provisioning services is not likely to be large. Only 3,000 m^2 of orchards belonging to the local community near the mine, with an output of 2-4 tons, are expected to be impacted. Further, the mine is estimated

  to reduce wild fruit and berry collection by only 200-300kg a year. Honey production in Karaberd Settlement is not expected to be impacted.
  - While air quality according to the Company's EIA is expected to remain within acceptable norms during mining operations, PM10 has not been measured and may have an impact on health. It is also not possible without further study to understand the implications of the mining operation on water flow regulation, and whether local springs will be affected and /or local streams will be at risk of drying up.
  - The assessment only considers Karaberd village. Pambak village is expected to lose use of 12ha of pasture land due to the mine but the implications of this in terms of lost productivity have not been calculated.
- A qualitative description of mining based on **international practices** indicates that there are a number of measures that can be adopted to mitigate the impact of the mine. These measures have not been costed, but would enable mining companies to better externalize their impacts on society. Some international companies are exploring concepts such as 'No Net Loss' and 'Net Positive Impact', in which unavoidable, residual biodiversity impacts are offset by conservation activities (usually very close to the impact site), with the aim of being at least equal in value to damages that cannot be avoided.
- The **alternative development scenario** considers how the land could be used if the mining operation did not go ahead. It is generally agreed that animal husbandry and apiculture have good potential in the area, and agricultural crops may also be developed. The potential for developing tourism is limited. In order to develop agricultural it will be necessary to install irrigation systems while the comprehensive use of pastures will require pasture management and planning, water sources for animals, repair of roads and the construction of animal barns and infrastructure. It was not possible to estimate the cost of these measures within this study. The gross annual benefit of a sustainable agriculture option is estimated at US$1,579,111 - 1,911,407, compared to US$162,247 – 216,172 under the baseline.
- It was not possible to compare the options within a Cost Benefit Analysis as the costs of the sustainable agricultural scenario were not estimated. However it is worth noting:
  - The mining option and sustainable agricultural production option are not totally mutually exclusive. Only a small area of land is expected to be impacted by the mine. It is therefore feasible to develop agriculture alongside the mining operation, and achieve significant gains for the local community relative to the baseline.
  - Only a limited number of ES have been monetized. Impacts on water flow regimes and health may be significant but data are missing to link the impact of the mine to changes in water flow or to changes in ambient air quality. These 'costs' should be deducted from the benefits of mining.
  - While it would be misleading to calculate NPVs given gross estimates are not available for all the scenarios, it is important to note that the benefits of mining will occur over 11 years, while ES, if sustainably managed, will continue for a much longer period.

The Table below summarizes the results of the scenario analysis.

Table: Overview of Scenarios (US$)

	Baseline	BAU Mining / year	Best Practice Mining	Optimal (Sustainable) Agricultural production / year
Gross revenue	US$162,247 – US$216, 172	Open pit mine: US$ 3,170,500 (a year for 3 years) Underground mine: 5,665,200 (for 7 years)	Assumed to be the same as the BAU scenario	US$ 1,579,111 – US$ 1,911,407 (on-going)
Net revenue	*Costs not estimated*	Open pit Mine – US$1,443,500 per year (3 years) Underground mine US$3,551,400 per year (for 8 years) (excludes capital costs)	*Additional costs / benefits of mining operation based on best international practice not calculated*	*Costs not estimated but will include investment in irrigation systems*
Net revenue *minus* environmental externalities	*Environmental externalities not estimated but overgrazing evident in some areas*	Open pit Mine – US$ 1,439,797 per year (3 years) Underground mine US$3,547,697 per year (for 8 years) [1]	*Additional costs / benefits of mining operation based on best international practice have not been calculated*	*Environmental externalities not estimated but the sustainable agriculture option should address the negative impacts under the baseline.*

Notes: 1/ This includes the lost income from agriculture and the collection of wild berries and fruits, taking the upper end of the scale of US$3,703 per year.

Distributional analysis

It is important to understand who will 'win' and who will 'lose' as a result of a development or management decision, and how those that lose may be adequately compensated to promote an equitable development path that acts in favor of poverty alleviation.

The mining company has stated that 2 million AMD (US$4,938) will be allocated to the Karaberd community per year, roads will be reconstructed and necessary infrastructure established. However, no formal agreements are in place. While the proposed contribution would improve the village's finances (the community budget is reportedly currently only US$12,121), it is a small amount given the profit that the company will be making.

While the national Government will receive US$1.3 million a year from the Mining Company, it is not clear how this money will be invested to develop the country and alleviate poverty. For mining to play a role in poverty alleviation payments from money to the State and Regional Government need to be specifically used to create new capital such as more developed human resources and infrastructure, particularly in the affected rural areas. **This recommendation is pertinent for the pilot study site, where the analysis indicates that investment in agriculture could greatly enhance productivity and income relative to the baseline**. Furthermore mining companies must be required to reclaim land / support local communities both during and after the mining operation.

Institutional and legal

- Key gaps in Armenia's environmental protection legislation include:
  - Armenia currently does not have a law that sets criteria and standards for environmental impact assessment (EIA), although such a law is currently being drafted. There is however the Law on Environmental Impact Expertise (EIE) which regulates the process of expertise, public hearings, and activities that are subject to environmental impact expertise.
  - EIA in Armenia typically lacks important information (e.g. a comprehensive consideration of all environmental impacts, calculation of economic damage) as there is no law specifying EIA criteria and standards.
  - In the process of an expert evaluation, it is not required that the accuracy of the EIA be verified. Furthermore it is not uncommon for the EIA to be prepared by the entity that will undertake the economic activity.
  - While the Law on EIE regulates public hearings, it violates the Aarhus Convention in that it does not require that the expert takes into account the opinions of the affected community. Full compliance with the Aarhus Convention will require amending a number of laws and regulations.
  - The use of the term 'ecosystem' occurs only a few times in RA national legislation, while the terms 'ecosystem services' and 'ecosystem services valuation' do not occur at all. However, a Government Decision (No.16-8 of April 25 2013) commissions the Minister of Nature Protection to develop, within a 6-month period, a strategy for innovative financial mechanisms in the environmental sector.
- Mining specific issues include:
  - Up until the end of 2011, an estimated 99.6% of industrial waste in Armenia was mining waste. However, since 2012 mining 'waste' (including tailings) has been defined by law as 'residue' ('lsakuyt'). As such, they are not subject to environmental-protection fees levied against waste deposits.
  - Article 14 of the new RA Mining Code states that when mining rights expire, sole ownership of the industrial piles (technology-made mines) passes to the Republic of Armenia. The law is silent on the public health and environmental liability of these "industrial piles" to surrounding communities and who bears the liability

Conclusions and Recommendations

This study of the impact of the Karaberd gold mine on ecosystem services and the well-being of the community aims to inform decision making at the site, while also presenting a methodology that can be adopted at other locations to ensure mining is practiced in a responsible and sustainable manner. The pilot study presents a framework for a comprehensive assessment of the impacts of mining and for comparing mining with alternative land uses and development options. More broadly the analytical framework presented in this report provides an approach that can be applied across Sectors and ecosystems for demonstrating the implications of environmental damage to Armenia's economic and poverty alleviation objectives.

Karaberd gold mine can be classified as a small mine. While larger mines are likely to have more significant impacts, there are many actual and proposed small mines in Armenia, whose overall *cumulative* impact can be significant. The study is therefore useful in terms of presenting an analysis of a 'representative' small mining operation, as well as a flexible analytical methodology which can equally be applied to mines of any size.

A key objective of the study was to train a team of experts in ecosystem service valuation in Armenia and to more broadly raise awareness of the importance of considering the value of ecosystem services in decision making. To meet these objectives a national team of experts completed the pilot study of Karaberd Gold Mine and three national workshops were held to present and discuss the findings.

The valuation of ecosystem services is in its infancy in Armenia. One recent study of Lake Sevan was also similarly focused on the valuation of provisioning services, indicating the challenges associated with the estimation of regulating services. However work in this area is extremely timely given the Government's recent commitment to a law on innovative economic instruments in the environment sector and the proposed new environmental law.

Mining makes a significant contribution to the economy in Armenia, representing 5.4% GDP (2012), and has the potential to continue to contribute to development. However for this development to be sustainable and equitable a number of conditions need to be met: (i) environmental, social and economic costs need to be accounted for in the evaluation of mining projects; (ii) the country / communities must get a fair share of the value of the extracted resources; (iii) the institutional capabilities of the government to evaluate social costs and benefits and regulate mining activities need to be strengthened; (iv) money from mining needs to be specifically used to create new capital such as more developed human resources and infrastructure, particularly in the rural areas; and, (v) Mining companies must be required to reclaim land / support local communities both during and after the mining operation.

Mining projects in Armenia should only proceed when they provide an adequate return on the capital investment *and* cover the environmental and social costs of their operations. The latter includes pollution abatement and the restoration of the mined area when the mine closes.

Recommendations for developing the ecosystem services approach in Armenia are discussed below.

Awareness & capacity building

- The concept of ecosystem services is a novel approach to environmental accounting and protection in Armenia. Environmental education and awareness building on ES across all stakeholders is important to ensure a broad understanding of their importance.
- It is important that senior Government Ministries (e.g. Ministry of Finance), with budget responsibilities across sectors, are aware of the importance of incorporating an ESA into decision making.
- If 'mainstreaming' of ES into laws and government policies and actions plans is to be successful it is necessary to interact with Government from the very beginning to ensure that the technical work is demand driven and policy makers are on board.
- While senior decision makers need to have an understanding of the approaches and results, to have confidence in the project outputs, such high level officials are liable to change following elections. Therefore in order to ensure continuity in the project's outputs technical staff should be trained in the use of the tools.
- It was intended that the expert group formed under this project would be sustainable beyond the duration of the PEI TA project. However it is evident that more in-depth training is required to build up an expertise in ES valuation and economic assessment. Possible considerations are - funding Armenia students on overseas Master courses so that a real understanding and knowledge of the subject is built up and sending participants on short (regional) courses. Participants should be carefully selected and preferably have a background in economics and in environmental management.
- Training is also needed in approaches to estimate environmental impacts and how to link changes in the environment to changes in ecosystem service provision and health, which can then be valued.
- It is necessary to develop the Government's expertise in EIA so that they are able to properly evaluate EIAs that companies submit.

Building up biophysical data

- The valuation of regulating services in particular is underpinned by bio-physical data, which is generally lacking in Armenia. For example to estimate the extent to which downstream hydropower and irrigation schemes depend on upper catchment protection services it would be necessary to relate catchment deforestation to a particular rate of soil erosion, consequent siltation of a hydropower dam and reduced power outputs. To be able to specify these kinds of relationships typically involves consultation with experts, and situation-specific laboratory or field research, controlled experiments, detailed modeling and statistical regression.

- ES valuation in Armenia would benefit from better spatial mapping / GIS data, water balance models (that convey the relationship between underground and surface water and current uses of water), seasonal testing of water and quality, and studies that link levels of air and water pollution to impacts on ecosystems services and health. This information is currently extremely limited in Armenia.
- The EIA process has a role in building up the required physical data. However, more stringent standards and a review process need to be attached to the EIA process to facilitate this.

Further ecosystem valuation studies

Mining

There are a number of ways further study of Armenia's mining sector could support decision making. These include:

- Given the significance of land degradation in Armenia, it is important to understand the cumulative impacts of mining. The impact of a (small) mine looked at in isolation can be misleading if it does not take into consideration others mines (or activities) contributing to environmental impacts in a given watershed or area.
- To fully understand the impact of a given mine a life cycle approach should be adopted (from exploration through to reclamation of the site). The pilot study only considered the excavation stage of mining.
- Large mines will inevitably have a larger environmental footprint and significant tradeoffs. A study of a large mine would be useful as a benchmark of these impacts and tradeoffs, and the economic and social implications.
- In step with the World Bank's Wealth Accounting and the Valuation of Ecosystem Services (WAVES) Global Partnership Programme a comprehensive inventory and valuation of Armenia's minerals would be useful to demonstrate the country's existing mineral wealth and facilitate the design of competitive / optimal extraction rates. Such information would also inform the key policy question of how income from minerals could be invested to promote social and sustainable development. To date, the main weakness of mineral-driven development has been the inability of host governments to effectively utilize mine revenue. A more sophisticated **mineral account** could include the impacts / costs of mining on the environment and support policies on land reclamation. Wealth accounting in Armenia would need to be supported by training and capacity building.

Other sectors

- A consultation on potential study sites undertaken for this project indicates the range of issues that could benefit from the valuation of ecosystem services in Armenia. In addition to further studies on mining these include studies of wetlands, agriculture, water pricing, forestry and tourism.

Legal

- The new EIA law should include a CBA requirement (scenario analysis), which promotes the use of internationally recognized valuation approaches such as market based approaches, productivity approaches, travel cost approach and contingent valuation.
- Given the general international trend towards more public disclosure, public hearing reports should be made available.
- More generally, it is recommended to consider that the legal basis of ecosystem

management and conservation may be strengthened through the integration in appropriate laws and/ or regulations of: legal definitions of ecosystems and ecosystem services; the recognition of the principle of ecosystem management; the recognition of the importance of ecosystems in environmental planning; the requirement to collect and assess ecosystem data in environmental monitoring and information systems; the recognition of ecosystems and their services in EIA and SEA; and a framework for financial instruments including charges and fees for uses of ecosystem services and payments for ecosystem services where necessary and appropriate to landowners and others as remuneration of their efforts to conserve ecosystem and their services. A first step may be the consideration of these issues in the process of preparation of a general environmental protection legislation for Armenia.

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Introduction

1.1 Background to study

The United Nations Environment Program (UNEP) and the United Nations Development Programme (UNDP) joint Poverty Environment Initiative (PEI) in the Republic of Armenia aims to contribute to poverty reduction and improve the well-being of poor and vulnerable groups through mainstreaming the environment into national development processes.

During a PEI scoping mission in August 2010 an understanding of the economic value of ecosystem services (ES) and their influence on human-well being was identified as being of great importance to environmentally sustainable decision making and poverty reduction in Armenia. A PEI Technical Assistance project (TA) was consequently prepared with the UNDP Country Office in Armenia to strengthen the knowledge base and capacity at the national, provincial and local levels on the links between ecosystem services and development and to build expertise in ecosystem services valuation.

A National Group of Independent Experts was formed under the TA project to provide scientifically based evidence and information to various stakeholders, facilitate discussions, and build consensus on policies and programmes on economic growth, environment and poverty reduction. The group was inter-disciplinary and consisted of economists, a statistician, ecologists and a mining expert. The intention is that this group will be sustainable beyond the duration of the PEI TA project. The group worked closely with an International Consultant developing their capacity in ecosystem valuation through undertaking a pilot study (i.e. learning by doing approach). The results of the pilot study are presented in this report.

The project **objectives** were to:

- Strengthen the knowledge base and capacity at the national, provincial and local levels in ecosystem valuation
- Develop an independent expertise in ecosystem valuation in order to provide scientific based evidence to stakeholders and decision makers

The main analytical activities undertaken by the pilot study were: an in-depth socio-economic assessment of the area (including a face to face household survey); a biodiversity survey; a review of the mining Company's Environmental Impact Assessment (EIA); a qualitative assessment of the ecosystem services at the site; a monetary assessment of key provisioning services; a scenario analysis covering Business as Usual (BAU) mining, mining based on best international practices and a no-mining development alternative for the site; an assessment of the distributional impacts of the mine; and, a legal review. Given that capacity building was a core objective of this project and that the project scope was to undertake an *initial* pilot study in ecosystem valuation, a comprehensive assessment was not possible.

The pilot valuation study sought to address the following key questions:

- How do ecosystem services in Armenia support economic growth, employment and prosperity?
- What risks / costs are associated with their damage / loss?
- What are the links between ecosystem services and poverty alleviation?
- What are the cost and benefits of following best international practice in the mining sector in Armenia?

1.2 Layout of report

The rest of this report is organized as follows:

- Section 2 presents an overview of the methodology and analytical framework adopted for this study. This is discussed in more detail in Annex 1;
- Section 3 details how the pilot study was selected and the scope of the pilot study;
- Section 4 presents a brief overview of the mining sector in Armenia as high level context for the pilot study;
- Section 5 provides a detailed overview of the socio-economic assessment, including the findings of the household survey;
- Section 6 presents a qualitative assessment of the ecosystem services found at the pilot site;
- Section 7 provides an overview of the impact of the mine on the area's ecosystem services. It includes a critique of the Mining Company's EIA process.
- Section 8 values the provisioning services within the study site under the baseline.
- Section 9 compares three land use scenarios for the study site – business as usual mining, mining under best international practices, and an alternative development scenario (no-mining option) based on agricultural development of the area;
- Section 10 presents a distributional analysis of the three scenarios;
- Section 11 presents legal review; and,
- Section 11 concludes and makes recommendations for the further application of the ecosystem services approach in Armenia.

2 Methodology / analytical framework

2.1 Ecosystem Services Approach

The pilot project has adopted an ecosystem services approach (ESA). The ecosystem service approach is based on the Millennium Ecosystem Assessment (2005) classification of ecosystem services into the following four categories:

- ***Provisioning services*** relate to the tangible products, such as fish and timber provided by ecosystems;

- ***Regulating services*** refer to the natural processes of ecosystems such as waste assimilation and carbon sequestration that contribute to social wellbeing;

- ***Cultural services*** may be associated with both use and non-use values and relate to the non-material benefits obtained from ecosystems, for example, through tourism and educational use of the environment; and,

- ***Supporting services*** which are necessary for the production of all other ecosystem services (e.g. soil formation or nutrient cycling). Supporting services differ from the other services in that their impacts on people are either indirect (via provisioning, regulating or cultural services) or occur over a very long time.

The ESA explicitly recognizes that ecosystems and the biological diversity contained within them contribute to individual and social wellbeing. Importantly it recognizes that this contribution extends beyond the provision of goods such as mineral products, timber or fish to the natural regulating functions of ecosystems such as carbon sequestration. The ESA therefore provides a framework for considering whole ecosystems in decision making and for valuing the services they provide.

It is important to note that economic valuation is focussed on the 'final benefits' or 'outcomes' realised by society from the services ecosystems provide, not the services and functions that contribute to those outcomes. This is to avoid double counting. The benefits generated by supporting services, while fundamental to the provision of final benefits, are not valued independently as they are intermediate benefits which contribute to the provision of a range of final benefits. Their value is captured in the valuation of the final outcomes associated with the services they support. Supporting services include soil formation and retention, primary production and habitat provision.

Health is also not explicitly listed as an ecosystem service as health benefits are considered to be provided by a range of services such as food, flood protection benefits and a clean environment for recreation. The health cost associated with deterioration in these services may be used to measure the benefits provided by an ecosystem. **Biodiversity** is also considered to be cross cutting, the final benefits of which could be associated with a range of services. An exception is biodiversity non-use which is listed as a separate service. Table 1 provides an overview of potential ecosystem services. The range of services will vary between ecosystems and between sites. A range of established economic valuation methods exist to estimate the monetary value of these ecosystem services.

Table 1: Overview of potential Ecosystem Services

ES Type	Service	Benefit / outcome
Provisioning Services	Food	Wild meats, fruits, crops, freshwater fish harvested for commercial and subsistence purposes.
	Wood	Timber, fuel wood and fibre
	Water	Public water supply, water for industrial and agricultural usage
	Natural medicines and biochemicals	Natural medicines
	Source of energy (fuel etc)	Energy provision e.g., hydropower
Regulating Services	Regulation of GHGs	Carbon sequestration
	Micro-climate stabilization	Air quality
	Water regulation (storage and retention)	Flood and storm protection
	Waste processing	Detoxification of water and sediment / waste
	Nutrient retention	Improved water quality
Cultural Services	Spiritual, religious, cultural heritage	Use of environment in books, film, painting, folklore, national symbols, architecture, advertising
	Educational	A 'natural field laboratory' for understanding biological processes
	Recreation and ecotourism	Bird watching, hiking, canoeing
	Landscape and amenity	Property price premiums due to views
	Biodiversity non-use	Enhanced wellbeing associated for example with bequest or altruistic motivations

2.2 Key steps in the analysis

A summary of the methodology adopted for this study is provided here, with more detail provided in Annex 1. This methodology can be generally applied to analyse the economic value of ecosystem services, tradeoffs associated with this use and degradation and their contribution to social welfare under different management practices. The methodology is based on seven key steps as presented in Figure 1.

Step 1, site selection and stakeholder consultation, selects the study site, introduces the project to stakeholders to ensure their buy-in, and agrees main policy issues with stakeholders. This is discussed in Section 3.

Step 2 characterizes the study site and determines the context for the assessment. This step involves building up a detailed understanding of the area under study (socio-economic factors, physical characteristics and the type of pressures facing the site under current and proposed management regimes) and an identification of alternative sustainable management options. This is covered in sections 5-8.

Step 3 defines the scope of the economic assessment. Under Step 3 the key ecosystem services at the site such as – crops grown, water regulation and flow benefits and tourism are identified through a qualitative assessment. It is generally not possible to quantify all ecosystem services; therefore prioritization is required based on the significance of the service, and the data and resources available for the assessment. This is covered in section 6.

Step 4 quantifies in bio-physical terms the impact of the selected scenarios on the ecosystem services provided. This is an important step underpinning the valuation of the impacts. This is covered in sections 7 and 9.

Step 5 values those ecosystem services identified in Step 3 and 4 as being significant and possible to value given available data and resources, using the most suitable valuation approaches. This is covered in sections 8 and 9.

Step 6 analyses the valuation undertaken in Step 5. For example: unit values need to be aggregated based on the appropriate population, or by the number of hectares, benefiting from the land use to derive total values; sensitivity analysis is required to highlight to decisions makers the confidence that may be attached to the values; and, discounting of annual values and one off costs over an appropriate timeframe is undertaken to derive net present values (NPV). A distributional analysis is an essential part of the analysis. This is used to draw out who wins from current and potential scenarios and who loses (taking into account both on-site and off-site costs and benefits). This information can be used to illustrate the links between ecosystem services and poverty alleviation and to develop mechanisms to compensate those who lose under a particular scenario. This is covered in sections 9 and 10.

Step 7 involves a discussion of the institutional barriers to achieving optimal economic development. This is covered in section 11.

It should be noted that the 7 steps often have feedback loops and do not need to be always followed in sequence. Earlier steps may be refined as new information becomes available as the study progresses.

Figure 1: Key steps in the economic assessment

Step 1: Site selection and stakeholder consultation	• Consult on project and potential study sites • Select pilot site • Specify & agree the policy issue with stakeholders
Step 2: Characterize the study and determine the context for the assessment	2a. Develop a conceptual understanding of the physical characteristics of the area to be studied e.g. its size, soil type, typography, hydrology 2b. Undertaken a socio-economic analysis 2c. Define the issues. What are the main threats to ecosystem services, who is being affected and how? 2d. Define scenarios to be analyzed
Step 3: Define the scope of the economic assessment	• Undertake qualitative assessment of ecosystem services • Determine data availability (scientific / quantitative) • Select ecosystem services to be valued. • Select key economic indicators
Step 4: Quantification of impacts	• Quantify (in bio physical terms) the impacts of each scenario, taking into consideration both on-site and off-site impacts
Step 5: Undertake valuation of ecosystem	• Derive monetary estimates of the ecosystem services under the selected scenarios using appropriate valuation approach
Step 6: Analysis of economic evidence	• CBA (economic & financial perspective). Aggregation, discounting, sensitivity analysis • Impacts of different scenarios on key indicators – e.g. employment, incomes, tax revenues • Distributional analysis and implications for poverty alleviation • Identification of sustainable financing / development mechanisms
Step 7: Understanding the institutional requirements	Specify the institutional barriers to achieving sustainable and equitable economic development

3 Stakeholder consultation and site selection

An extensive stakeholder consultation was undertaken to select the pilot study. Details for this are provided in Annex 5. This included a National workshop held in May 2012 to introduce the project and solicit views on a study site, followed by an expert workshop to define a short list of potential sites. The National workshop was attended by 44 participants from a range of institutions[1]. Key Government Departments were consulted on the short list of potential study sites agreed on at the expert workshop and based on these discussions a field visit was undertaken in July 2012 to Suynik province as the identified study area. The project initially embarked on a study of the proposed Mazra gold mine in Suynik province, but discontinued with this when plans to exploit the mine were dropped. Following further consultations the Karaberd Gold mine was selected as the pilot site in February 2013.

The Karaberd gold mine was selected as the pilot study area for the following reasons:

- **Contribution of the pilot study to management of a national priority**. Mining is a key economic activity in Armenia, contributing 5.4% to GDP (2012), but there are concerns about the impact of mining operations on the environment. The study of the impact of the Karaberd gold mine on ecosystem services and the well-being of the community aims to inform decision making at the site, while also presenting a methodology that can be adopted at other locations to ensure mining is practiced in a responsible and sustainable manner.
- **Data availability to undertake the study**. Some baseline data to inform the study was available, namely: the Working Design and Environmental Impact Assessment documents developed and submitted by ASSAT, the company intending to exploit the mine; the Technical-Economic Feasibility Study; some ecological baseline data, particularly on water pollution (e.g. a report on 'Results of the ecological monitoring of Republic of Armenia (RA)' and the 'Environmental Effect Monitoring Center' State Non-Commercial Organization (SNCO) RA Ministry of Nature Protection; and, the Lori marz Socio-Economic Development Program for 2010-2013 developed by Lori Marzpetaran.
- **Opportunity to contribute to the understanding of the area.** There are a limited number of projects in the region such as the Community Small Scale Afforestation/Reforestation Project in RA Lori Marz, and Fichtner GmbH & Co. KG who are co-operating with the Armenian Office of the European Commission (EC) on 'Technical Assistance to Armenia, Azerbaijan, Georgia and Moldova with respect to their Global Climate Change Commitments Regional Project (2006)'. However, the area has *not* been widely studied presenting an opportunity for the pilot study to contribute to the generation of primary data for ecosystem services valuation.
- **Links to poverty**. Lori region has one of the highest poverty and unemployment rates in the country. Karaberd and Pambak villages, located near the proposed mine site, are considered to be low-income communities. According to the EIA document ASSAT is intending to employ 20 people at the mine and to provide Karaberd community with 2,200,000 AMD (around US$5,000) annually. The pilot study therefore presents an opportunity to analyze the distribution of mining profits at the community, regional and national level.
- **Wide range of potentially impacted ecosystems**. The site is multi-dimensional in terms of coverage of ecosystems and their services and concerned sectors. Potential issues surrounding the mining operation, identified at the site selection stage, include:
    - Water quality and quantity issues. The site is characterized by the presence of underground water courses and the geological structure of site is favorable for

[1] The workshop was attended by representatives from - the Ministry of Nature Protection, State Environmental Inspectorate, 'Nature Protection Expertise' SNCO, Ministry of Economy, National Statistical Service, 'Armenian Forest' SNCO, Ministry of Territorial Administration, Ministry of Health, World Bank Armenia, USAID/Armenia, Trans-boundary Joint Secretariat (KfW funded project), REC Caucasus, WWF Armenia and CSOs.

surface water penetration. Mining operations are likely to impact water resources and water ecosystem services;
- o The seismic risk is high (8-9 grades); and,
- o Agriculture and cattle breeding are the main economic activities of the impacted communities. The importance of the pasture land to communities warrants an analysis of possible viable alternatives to mining.

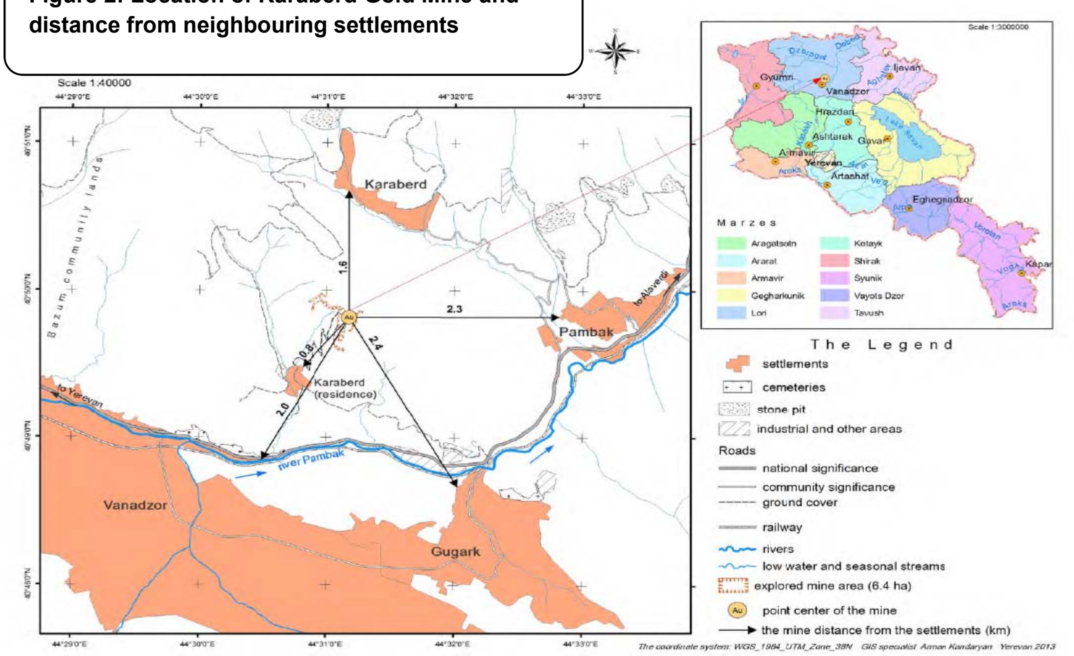
In May 2013 an initial site visit was undertaken to Lori marz during which community leaders and/or local authority representatives of Karaberd, Pambak and Gugark villages were visited in order to introduce the project and the proposed household survey and to discuss issues related to the proposed mine at the community level. All community leaders were supportive of their communities participating in a household survey.

An **interim consultation workshop** was held in Yerevan in July 2013 to present the results of the socio-economic assessment, financial analysis of the proposed mining operation and the interim site assessment results. This workshop was attended by around 30 participants from a range of Government institutions, International Organizations and Civil Society Organizations (CSOs). A final workshop was held in March 2014 to present the findings of the study, and to discuss their policy implications and the further development of ecosystem services valuation in Armenia.

3.1 Overview of pilot study – Karaberd Gold Mine

The proposed Karaberd gold mine has a license to operate. It is situated in the north of Armenia, in Lori marz, within the administrative borders of Karaberd village. It is 30km from Yerevan and 10km from Vanadzor City (the capital of Loti Marz). Karaberd village is located 1.6km north of the mine, Pambak village 2.3km to the east, Gugark village 2.4 km to the south-east and Vanadzor city 2km to the south-west. Of note is that there is a settlement of 10-12 households located 0.8km from the mine, which is part of Karaberd village. This settlement is referred to as 'Karaberd Settlement' throughout this report (Figure 2). The immediate area of the mine is devoid of forest cover, and the areas are used as grasslands. However, near the mine along the earthen road to the nearby Karaberd settlement, which is intended to be used for ore transportation, there is a 3.9 hectares forest area where mostly oaks and related tree varieties are presented.

Figure 2: Location of Karaberd Gold Mine and distance from neighbouring settlements



The mine lies on the southern slopes of the Bazum mountain chain, on the left bank of the Pambak River. The Bazum mountain chain represents the most north-western edge of the Small Caucasus rocky mountain system, which runs west to east from the Karchakh Mountain pass to Gayladzor gorge. It has an average height of 2,800 meters, peaking at Urasar Mountain at a height of 2,992 meters. The slopes of the mountain chain grow steep across the town of Vanadzor where the Karaberd gold mine is located.

The **climate i**n the region of Karaberd gold mine is moderate and relatively moist and humid year-round. In January the average temperature ranges from -2° to -4°, and during July-August 18°-20°. Annual precipitation is 600-700mm, with a maximum rainfall in the spring and at the beginning of summer. In winter, from the first half of December, a firm snow cover of 5-20cm is formed. The average wind speed is 3-4m/second, and in the mining area the winds mainly blow from north-east to south-west.

Following the discovery of manganese, gold and copper by Meghrut's prospecting team various geological studies have been conducted in the area of the proposed Karaberd mine and across the region[2]. In 2002 a feasibility report was compiled on the industrial significance of Karaberd mine, in which the mine was evaluated, as a gold mine creating quartz rocks - molten material, for the Alaverdy Copper Factory. This study was approved by the State Inspectorate of the RA Ministry of Nature Protection (MoNP) (Protocol No 129, 03.05.2002).

ASSAT LLC carried out geological studies at the site in 2007-2008. Following this, reserves of C_1+C_2 category (ore – 303,200 tons, gold – 1,631.8 kg, silver - 2.920 tons) were approved by the MoNP (decision No 321, 29 March 2012)[3].

The current explored area of the mine is 6.4 ha at a height of 1,700-1,775 m above sea level and with an average slope of 10-15 degrees. The surrounding area ranges from 1,300 to 1,850 m with mostly steep slopes. The plot of the open pit mine is 1.1 ha and the waste landfill covers 1.5 ha of forest free land.

In terms of its reserves and anticipated productivity Karaberd mine can be classified as a low impact mine (small mine). An output of 2,500 tons of exploitable ore is expected in the first 3 years from the open pit mine and 30,000 tons for the subsequent 7-8 years from the undergound mine. By means of comparison, the annual output of Deno Gold Mining CJSC is expected to be 600,000 tons, and that of Teghut mine of Armenian Copper Programme CJSC is 7 million tons/year.

Container-type mobile constructions will be located at the working area of opencast and underground mines. The extracted ore will be transported by truck to the railway station in Vanadzor city, 11-12 km away, where it will then be taken by rail to the Ararat Gold Recovery Company. The expected extracted gold and silver is 213.4 kg and 367.8 kg respectively

3.2 Policy context

At the national level, the pilot study is aligned to a number of key Government policies and laws. A **law on innovative economic instruments in the environment sector** was approved by the Government in 2013. It is proposed to submit an action / implementation plan to the Government

[2] Geological and exploratory works were conducted between 1972-2002 by Meghrut, Pambak expedition, 'Gugark Geo' State CJSC and by Manes and Valex CJSC.

[3] Reserves of category A - detail proven reserves. Ore bodies and mine delineated. Quality and quantity of ore development conditions reliably determined.

Reserves of category B - sufficient detail proven reserves. Field and the bulk of the ore bodies delineated. Quality and quantity of ore development conditions are defined in detail.

Reserves of category C1 - proven by a sparse network of reserves. Contours deposits and ore bodies are interpreted reliably.

Reserves of category C2 - Inferred reserves. Contours orebodies defined mainly by extrapolation within the known geological structures and deposits adjacent to categories A, B, C1 space.

related to this law. A new law on ecosystem services will be one of the implementation points. It is anticipated that this will establish a methodology on natural capital valuation and cover indicators on green growth and green funding.

A new environmental law is also being developed with support from the Government of Germany. This umbrella law is expected to acknowledge the importance of the ecosystem services approach and the valuation of natural assets.

The current study is therefore very timely as a means of demonstrating an approach for integrating the value of ecosystem services into decision making.

In terms of **mining** it is hoped that the pilot study presents a framework for a comprehensive assessment of the impacts of mining and for comparing mining with alternative land uses and development options. The pilot study can be classified as a small mine. While larger mines may have more significant impacts, there are many actual and proposed small mines in Armenia, whose overall *cumulative i*mpact could be significant. The study therefore is useful in terms of presenting an analysis of a 'representative' small mining operation, as well as a flexible analytical methodology which can equally be applied to mines of any size.

Mining inevitably has an impact on its environment. Prevention of negative impacts requires sound management beginning with the exploration and planning of a mine, through the life-cycle of its operation, to decommissioning and rehabilitation of the site. Environmental and mining legislation on environmental impacts has been enacted in order to prevent pollution of the environment and to reduce emissions, for example, the Mining Code of RA (article 3, point 34; article 50) provides the application of the Best Available Techniques (BAT) and the Best Environmental Practicies (BEP) but in practice they are not used. The analytical framework presented in this report provides an approach for demonstrating the implications of environmental damage to the Armenia economic and poverty alleviation objectives.

3.3 Scope

The main objective of the pilot study has been to introduce key concepts and a framework for analysis rather than to complete all analytical aspects of the study.

The pilot study compares three alternative scenarios for the site - mining under a Business as Usual Scenario (BAU), mining following best international practices, and an alternative development option where activities such as animal husbandry and bee keeping are optimized over time. Ecosystem services have been monetized where possible.

The geographical boundary of the study area represents the area within which the impacts of the mining operations on the environment are expected to be felt. It therefore covers the villages of Karaberd, Pambak, and Gugark and Vanadzor city.

It is important to note that it has not been possible to undertake a life cycle analysis, which would identify the impacts of the mining operation across its four key phases (ore exploration, construction of the mine, production and rehabilitation of the site). The pilot study is focused on the **excavation stage of production** only. The main phases of a mining operation, along with a description of their potential environmental impacts, are presented in Annex 3.

4 The mining sector in Armenia

This section provides background on the mining sector in Armenia – its history and current contribution to the economy.

Mining has a long tradition in Armenia, with historic evidence suggesting that the first mines began operating 3-4,000 years ago. The first copper smelter in northern Armenia (Akhtala, Alaverdi and Shamlugh) dates back to the late 18th century. Since then, over four hundred mines have been opened. During the Soviet Union period mining was a growth sector that produced essential raw materials for other sectors of the economy. At present, there are hundreds of mines operating in Armenia, of which 8-10 produce precious or base metals (e.g. gold, silver, copper, molybdenum, zinc, and lead). At the other mines industrial minerals are extracted (e.g. basalt, granite, marble, travertine, pumice-stone, limestone, salt, gypsum and diatomite). In addition a number of metal ore and industrial mineral mines are currently planned in all marzes (regions) of Armenia.

In 2013, 424 licenses for mineral extraction, including 25 licenses to operate metal deposits were issued. Furthermore, 125 licenses for geological exploration were also issued, 63 of them for the exploration of metallic minerals. In 2012, 97 mines (including 5 metal mines) notified the tax service of Armenia on the termination of activities. Annex 2 presents information about metal mine ores and metals deposits of Armenia and also information about mining licensees and annual production.

Table 2 shows production levels for base and precious metals over the period 2007-2012. The production levels can be seen to have increased for most minerals over this period, especially for copper, zinc, gold and silver, whose production levels have more than doubled.

Table 2: Basic metal mining production of RA

Manufacture of main base and precious metals	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Copper, tons	17,400	18,540	22,968	30,707	33,213	40,453
Zinc, tons	2,270	3,430	3,215	6,600	7,170	7,457
Molybdenum concentrate, tons	4,211	4,385	4,280	4,292	4,722	5,331
Ferro-molybdenum, tons	5,977	5,323	5,144	5,126	5,525	5,834
Smelter production of copper, tons	6,954	6,480	6,858	7,644	8,876	10,074
Gold, kg	1,300	1,359	944	1,946	2,147	2,890
Silver, tons	6.9	44.3	10.8	21.9	19.1	22.2

The Mining sector makes a significant and growing contribution to Gross Domestic Product (GDP). Tables 3 and 4 present key socio-economic indicators related to the mining sector of Armenia. Mining's contribution to GDP has increased year on year since 2007, reaching 5.4% in 2012. In 2012 Mining directly employed 1.43% of the population, rising to 3.56% for those 'indirectly' employed in the sector.

Table 3: Mining industry contribution to the economic development of Armenia

Indexes	2007	2008	2009	2010	2011	2012
Contribution to GDP (%)	3.6	2.6	2.8	4.2	5.1	5.4
Share in industry, %	15.9	12.6	13.2	17.7	17.0	17.3
Mining industry's gross revenue, US$ (million)	332.7	304.8	243.8	389.4	456.8	477.3
Mining and basic metals manufacturing gross revenue. US$ (million)	690.1	647.8	504.9	750.8	887.0	883.4
Export volume of Armenia, US$ (million)	1,152.3	1,057.2	710.2	1,041.1	1,334.3	1,380.2
Mining products export volume, US$ (million)	174	173	146	307	404	403.2
Share of mining products in export, %	15.1	16.4	20.5	29.5	30.3	29.2
Mining and basic metals manufacturing products export volume, US$ (million)	357.4	343.0	261.1	459.7	430.2	406.1
Share of mining and base metals manufacturing products in export, %	53.6	55.1	59.1	73.7	66.5	64.0
Import volume of Armenia, US$ (million)	3,267.7	4,426.1	3,321.1	3,748.9	4,145.3	4,261.2
Mining products import volume, US$ (million)	516	665	541	666	822	9,15.6
Share of mining products in import, %	15.8	15.0	16.3	17.7	19.8	21.5
Payments for nature use / Royalties (mining only), US$ (million)	10.1	10.6	7.5	10.7	12.6	41.7
Tax income of Armenia, US$ (million)	1,445.3	1,994.8	1,427.3	1,578.5	1,739.0	1,801.4
Share of nature use payments in tax incomes, %	0.7	0.53	0.53	0.7	0.72	2.32

Table 4: Employed population by types of economic activity

Average annual, 1000 persons	2007	2008	2009	2010	2011	2012	2012 by percent
Employed, total	1,101.5	1,183.1	1,152.8	1,185.2	1,175.1	1,172.8	100
Mining	8.6	8.3	7.3	7.6	15.5	16.8	1.43
Indirectly employed connected with mining	About 25,000						3.56

5 Socio-economic analysis

A socio-economic assessment was undertaken of the areas expected to be impacted by the proposed mine, namely - Karaberd village, Karaberd settlement, Pambak village, Gugark village and Vanadzov City. The socio-economic assessment is based on a review of available official reports and statistics and a household survey undertaken as part of this study. The household survey solicited information on household profiles, social conditions, employment, dependence on the environment and views on the proposed mine. The survey sample was randomly selected and covered 20 households in Karaberd village (38.4% of the population and 78% of households) and 8 households in Karaberd settlement (74.2% of the population and 80% of households), 20 households in Pambak (11.2% of the population and 23.3% of households), 50 households in Gugark (around 3% of households) and 50 households in Vanadzor city (around 0.2% of households)[4].

5.1 Karaberd village

Karaberd village was established in the 1820-1840s, abandoned in 1973 and resettled by the Government of the Republic of Armenia in 1990. It is located 1,550-1,655 meters above sea level and covers an administrative area of 14.5 km^2. Karaberd village is 130 km away from the capital city of Yerevan, 15 km from Vanadzor, and 5km from Pambak railway station. It borders the villages of Vahagni, Bazum, Pambak and Gugark.

According to the Ministry of Territorial Administration of the Republic of Armenia, as of 1 January 2011 there were 35 households, with a resident population of 91 compared to an official population of 141. As of 1 January 2013 this had increased to 41 households, with a resident population was 83 people and an official population was 156 people. The discrepancy between the ‘actual / official’ and resident population is due to the fact that part of the population resides in Vanadzor, but are registered in Karaberd. The majority of the population is of retirement age – 65 years and older (70 people, 28 of which are women).

Migration rates are high and on the increase. In 2013, 16 people from 6 households migrated for work to the Russian Federation compared to 2 people in 2011. Based on the household survey,12.5% of households have a family member working abroad providing remittances from 3,000 to 13,000 Russian Rubles (RUR) a year [5].

Based on the household survey 47% of the population over 15 years of age are employed. Most people are engaged in agriculture, particularly animal husbandry as crop cultivation is not profitable. However two people work in a public establishment (one with the village municipality), and one person is employed in a private company.

Agricultural land covers 1,299 ha, of which 64 ha is arable, 314 ha grassland, 302 ha pasture and 552 ha ‘other’ lands. Less than 1 ha of land is being cultivated due to the fact that it is unprofitable and the lack of irrigation system. The main crops are potato and cabbage[6]. Arable land often suffers from heavy rainfall, hail, and sometimes from drought. In wet years it is possible to harvest crops successfully, however in dry years the farmers lose around 50% of their yield. Irrigation is considered to be impossible due to geography.

The villagers mainly cultivate their homestead land plots, the size of which varies between 50m^2 and 1,000m^2. Beans and potato are the most common products cultivated and are consumed by

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[4] In Vanadzor the sample was based on a random selection in the districts located closest to the mine.

[5] Exchange rate: 1 US$=32.70 RUR

[6] In 2012 0.36 ha of wheat, grain and leguminous plants were cultivated. This led to the production of: 260 centners of potato; 21 centners of vegetables; 690 centners of fruits and berries (comprising 300 centners of apple, 70 centners of pear, 300 centners of plum, 4 centners of cherry, 12 centners of walnut and 4 centners of berries); 1,400 centners of sown and natural hay was accumulated. In addition villagers gathered 6 centners of mushrooms and 30 centners of wild fruits and berries.

the households. The average annual yield of beans varies between 10 and 100 kg, and the average annual yield of potato between 300 and 600 kg. All households have fruit trees and berries in their homestead orchards, consumed by the household. The majority of the households use drinking water to irrigate their homestead orchards, 30% also use rainwater. Based on survey responses 15% of households do not have enough irrigation water, and 20% have no irrigation water.

As of 1 January 2013, and based on official statistics, 80 households were engaged in animal husbandry and apiculture producing milk, meat, wool, eggs and honey. The number of cows and bulls has increased over the past two years, up from 209 in 2011 to 297 in 2013. Conversely, the number of sheep and goats has decreased from 203 in 2011 to 120 in 2013. According to the Village Mayor wolves kill a significant number of sheep. The number of other agricultural animals has been relatively stable and there are currently 13 horses, 300 hens and 108 beehives in the village. In dry years animal husbandry also faces great difficulties, due to the shortage of grass and concentrated feedstuff to cover the period during which the livestock are in the stalls.

According to the household survey, 75% of households engage in animal husbandry. Two households had 25 and 39 cattle, of which 22 were cows, 13 bull calves and 29 young stocks. The other households had 1-3 cattle, three households had pigs (13 head), nine households had poultry (total 102 head) and three households were also engaged in beekeeping (73 beehives). In the past 12 months, 13 head of cattle were sold by the households for a total price of AMD 4,400,000). The households consume a small amount of meat (10 kg). The main source of income is from the sale of milk.

Ten percent of the households surveyed assessed the condition of their community lands as "good", 35% as "satisfactory", and 55% as "bad". According to 40% of the respondents, there are signs of land deterioration/degradation, although most found it hard to indicate the reasons for this (5% of the respondents cited the fact that the land had lay fallow for many years as the main reason). Pasture land is rented by the community for a user fee of about 12,000 AMD ha/year.

There is a functioning granite mine within the area which employs 3 people who are residents of other villages.

The main source of drinking water for 45% of the households is the centralized water supply; the rest use spring water. Five percent of the households have a drinking water tap inside their house and 60% in their yard. 35% use the tap in the street, which is 100-400 meters from their dwelling. Eighty-five percent of the households surveyed assessed the purity, smell, color and taste of the drinking water as 'very good', while the remaining 15% assessed it as 'good'.

There are no educational or healthcare establishments in the village. Children go to school in Vanadzor and people visit Pambak health post or the healthcare facilities in Vanadzor and Gugark. The village has no administrative building or community center and lacks key infrastructure (e.g. post office, gas supply, centralised drinking water system, sewerage, etc.). There is a church in the village built in the 1860s, but this is now virtually ruined. There is no public transport operating between neighbouring communities and the roads are unpaved and become impassable during the winter and in rainy weather. There are 6 cars and 6 trucks within the village.

According to the Village Mayor, in general the community is extremely poor and face numerous problems which significantly hinder their development including:

- poor conditions of the roads and low availability of public transport linking the community with the marz centre and other nearby communities which means the village is quite isolated;
- inaccessible and unaffordable healthcare services and a lack education facilities;
- an aging and predominately female resident population;
- low quality of lands;
- natural and man-made disasters, such as earthquakes, heavy rains, rock fall, landslide, strong winds, snowstorm, hail and fires; and,

- lack of gas supply.

The Village Mayor believes that the following issues require urgent attention: road construction; provision of a gas supply; and, the construction of a community center. In the past 10 years there have been *no* activities targeted at improving the village's social-economic situation.

5.2 Karaberd Settlement

Karaberd settlement is located about 2 km below the mine site, on the slope of the mountain. They are engaged in animal husbandry and cultivate vegetables in their homestead plots. The land adjacent to the Settlement is used as grasslands and pastures. There are 12 permanent households in the settlement.

Based on the household survey 63% of households live in temporary dwelling containers or shelter, the rest live in a house. All the dwellings are owned by the households. 25% of households assessed their housing conditions as 'good', 40% as 'satisfactory', and 25% as 'very bad'. Around 37.5% of the households have a kitchen; none of the households have any other conveniences such as a bathroom, landline connection, flush toilet, radio receiver or computer.

The Settlement gets their drinking water from the mountain springs which flow from the area of the mine. Most households access water through the tap in the street, located 30-300 meters from their homes. 25% of households surveyed assessed the purity, smell, color and taste of the drinking water as 'good', 50% as 'satisfactory' and 25% as 'bad'.

For almost all households their source of income is agriculture, particularly animal husbandry. All households grow beans and potatoes for domestic consumption in their homestead plots, which range in size from 1,000 m^2 to 1,800 m^2. The average annual yield of beans is 100 kg, and the annual yield of potatoes varies between 150 and 500 kg. All households also have fruit trees and berries in their homestead plots. The majority of households use drinking water for irrigation. The following factors were cited as obstacles to the development of agriculture: lack of irrigation water; lack of agricultural machinery or limitations to its use; the high price of fertilizers and pesticides; degraded agricultural lands; lack or inaccessibility to markets; and, high production costs.

Most households (75%) engage in animal husbandry, earning an income through the sale of milk. Two households had 50 and 40 cattle; one household had 140 sheep and goats. The other households had 2-6 head of cattle. Three households were also engaged in beekeeping (91 beehives). In the past 12 months 14 head of cattle were sold by the households for a total income of AMD 1,500,000.

All the households surveyed felt that the volume of natural spring water was decreasing each year. In the opinion of the survey participants there are signs of land deterioration/degradation, although they were unable to specify the reasons for this.

5.3 Pambak village

Pambak village was established in 1894 in the vicinity of Vanadzor-Alaverdi interstate highway, in the valley left of the Pambak River. It was inhabited by people from the neighboring Karaberd village. The village is 1,375 meters above sea level and covers an area of 3.74 m^2. It is 120km from Yerevan and 7 km from Vanadzor and borders Karaberd, Gugark and Vanadzor. Pambak village is surrounded by forests and as a result enjoys mild winters and cool summers.

As of 1 January 2011 the number of households was 99, the resident population was 377 (with an official population of 404), of which 194 of were women. As of 1 January 2013 there were 86 households within the village and a population of 409. Like Karaberd, the 'official' population exceeds the resident because a certain number of people spend time in Vanadzor City for work. According to the Ministry of Territorial, between 2011 and 2013 more than 20 people migrated to the Russian Federation for work. Based on the household survey, 16% of households have a family member who has migrated abroad work. Of these households two receive money transfers of AMD 130,000 and AMD 60,000.

Based on the household survey **a**round 68% of the population over 15 years are employed; 48% (21 persons) are self-employed in agriculture, 7 people work in a state entity, one person is employed in the community municipality, and 5 people are employed in a private entity.

Villagers cultivate potatoes, cabbage and other vegetable crops on their homestead plots[7]. Crop production is dependent on rainfall – in wet years the harvest is satisfactory, but in dry years 70% of the yield is lost. There are 4 ha of arable land within the community, but this is not very fertile and hasn't been utilised since the 1960s and has turned into shrubs; only 0.5 ha is being used as meadow.

According to the household survey all households grow beans and potatoes for domestic consumption on their homestead plots, which vary in size from 500m^2 to 1,800 m^2. The average annual yield varies from 20-80 kg for beans and 150-900 kg for potatoes. All households also have fruit trees in their homestead plots, which are harvested for domestic use. Most households use drinking water to irrigate, while 25% use rainwater.

Most households are engaged in **animal husbandry** producing milk, meat, wool and eggs. Due to the shortage of grass and concentrated feedstuff it is difficult to feed livestock adequately during the winter when they are in stalls. As of 1 January 2013, based on official statistics, the village had 218 head of cattle (117 cows, 11 bulls, and 87 calves). This is an as of January 2011, when there was 202 head of cattle, of which 81 were cows.

Based on the household survey, Sixty-five percent of households are engaged in animal husbandry, with the sale of milk being the main source of income. One household has 31 head of cattle, consisting of 15 cows, one bull and 15 young. The rest of the households have 1-5 head of cattle, three households have pigs (43 head), 11 households have poultry (in total, 183 head), and 3 households are also engaged in beekeeping (29 beehives). In 2013, 2 head of cattle were sold for a total price of AMD 300,000.

To carry out agricultural activities, one household has received a loan of US$ 3,000. The rest of the surveyed households have no intention of applying for a loan because of high interest rates.

Droughts and heavy rains are frequent and cause great damage to agriculture. An earthquake in December 1988 destroyed the culture house, post-office, school and health post, and with the exception of the school, these services now function in temporary shacks.

Around 90% of the village population is provided with potable water through a centralized supply, with 45% of households accessing water through a tap within their homes. All surveyed households assessed the purity, odor, color and taste of the drinking water as 'very good' or 'good'.

The village school was built in 2000. It has 50 students (8 grades) and employees 16 people, 13 of which are teachers. The school is provided with drinking water and a boiler house. There is a culture house in the village which includes the library. The health post, located in a shack, employs one nurse who also provides services to neighbouring Karaberd.

5.4 Gugark village

Gugark village was established around 1810, with most of the inhabitants moving from Artsakh. It is 1,350 meters above sea level and is surrounded by mountains and forests. It covers an area

[7] In 2012 the village produced 780 centners of potato, 222 centners of vegetables, 770 centners of fruits and berries (416.5 centners of apple, 20 centners of pear, 315 centners of plum, 10 centner of cherries, 7 centners of walnut and 1.5 centner of berries). In 2012, 1,300 centners of sown and natural hay was accumulated (it was a dry year). The inhabitants of the village gathered 15 centners of wild mushrooms and a similar amount of wild fruits and berries.

of 21.6km^2. The village is north-east of Vanadzor and borders Vanadzor, Pambak, Lermontovo and Shahumyan. The Pambak River runs along the north-west side of the village, and is parallel to the railway and highway to Noyemberyan. Gugark is 130km from Yerevan and 5 km from Vanadzor.

According to the Ministry of Territorial Administration of the Republic of Armenia on the 1 January 2011 the population was 6,460. As of 1 January 2013 Gugark had a resident population of 5,795, and an official population of 7,011. Migration rates are said to be on the increase. Based on the household survey 25% of households have a family member who has migrated for work, and they typically receive AMD 60,000 to 100,000 a year in remittances.

The level of poverty is high – 145 households are included in the poverty family benefit system (Ministry of Territorial Administration of RA).

In terms of age structure, the 15-64 age group accounts for 78% of the population (5,078 people) and children of 0-14 age group around10% (644 children). 51.3% of the population are female.

Of the total village area of 2,158 hectares (21.6km^2), 195 ha is arable, 240 ha grasslands, 700 ha pastures, 20 ha orchards, and 442 ha 'other' land areas. 170 hectares of arable land has been privatised, and 35 hectares remain as reserve land. Dry, drought years are frequent and irrigation is lacking making agriculture difficult. According to the estimates of the Village Municipality, 70% of yield can be lost in a dry year. The village cultivates wheat, barley, potatoes, cabbage and other vegetable crops[8].

Animal husbandry is the main economic activity in the village and over the past two years the number of livestock has almost doubled. As of 1 January 2011 there were 698 cattle, 314 of which were cows compared to 1,100 of head cattle, of which 599 were cows 1 January 2013. Pigs increased from 177 to 443, sheep and goats from 275 to 362, horses from 12 to 17, and the number of beehives from 410 to 491 over the same period. However, the number of poultry fell from 4,251 to 2,548. The main products are milk, meat, wool, eggs and honey. Dry years create difficulties for cattle-breeding due to the shortage of grass and concentrated feedstuff.

In 2011, 3,291 (51%) people were unemployed, 1,560 were engaged in animal husbandry, 19 had jobs related to electricity, gas and water supply, 28 in construction, 81 in education, and 246 young men were undergoing compulsory military service (Ministry of Territorial Administration and NSS RA). Based on the household survey around 74% of the population are employed, 26% in agriculture, 17% in a public establishment, 7% in the village municipality, and 50% in a private company.

All households cultivate beans, potatoes and fruit trees for domestic consumption in their homestead plots, the size of which varies between 1000m^2 to 1800m^2. The average annual yield of beans is between 10 and 20 kg, potatoes between 100 and 300 kg (one household harvested 2 tons of potato), and other vegetables between 30 kg and 200 kg. The majority of the households use rainwater for irrigation, with 15% also using drinking water. All households surveyed were unhappy with the supply of irrigation water. Private lands are rarely cultivated due to the lack of irrigation water, poor soil fertility and high costs.

Around 70% of the households surveyed are engaged in animal husbandry, with the sale of milk being the main source of income. Two households have 2-12 head of cattle. Around 15% of the households had pigs (22 head), 60% also had poultry (total 356 head), and 10% of households were also engaged in beekeeping (79 beehives). In the 12 months prior to the survey 12 head of

[8] In 2012 the village produced 9,600 centners of potato, 242 centners of vegetables, 5,712 centners of fruits and berries (4,000 centners of apple, 600 centners of pear, 1,000 centners of plum, 40 centners of cherries, 47 centners of walnut and 20 centners of berries). In 2012, 9,000 centners of sown and natural hay was accumulated (dry year). The villages gathered 4 centners of wild mushrooms and 25 centners of fruits and berries. NSS, of RA, Lori marz Department.

cattle were sold by the households (for a total price of about AMD 3,000,000), 12 head of pigs (AMD 420,000).

Around 55% of the households surveyed assessed the condition of their community lands as 'satisfactory', and 45% as 'bad'. In the opinion of 57% of the respondents there are signs of land deterioration/degradation in their community, although they found it hard to indicate the causes of this.

Around 21% of the households have a bank loan to support their agricultural activities. Around 29% of the households expressed a willingness to take out a business loan if the interest rates were lower.

The community has a gas supply, centralised potable water system and sewerage. Around 82% of the households have a drinking water tap inside their house. The households surveyed assessed the purity, smell, color and taste of the drinking water as 'very good' (12.5%), 'good' (81%) and 'satisfactory' (6.5%).

There is a functioning interstate public transport system; most roads have an asphalt cover although their condition is poor. Postal service and other means of communication, such as landline and mobile telephone connections operate.

A kindergarten functions in a temporary building; however a new kindergarten is needed to meet the high demand for places. There is a pre-school attended by 35 children and there are two recently built secondary schools in the village accommodating 842 students. The schools provide employment for 130 people. The drinking water networks of the schools need urgent reconstruction.

There is a culture centre and library in the village which are in poor condition. The culture centre hosts the sports school and the music school. A medical outpatient facility is located in a temporary prefabricated construction. The main medical aid, tests and surgeries are carried out in Vanadzor. The construction of a children's health protection center is underway.

5.5 Vanadzor City

Vanadzor city is the center of Lori marz (region) located in the North of the Republic of Armenia, 125 km away from Yerevan. It is located in the valley between the Pambak and Bazoum mountain ranges at an altitude of 1,353 m above sea level. Pambak, Tandzout and Vanadzor Rivers flow across the city. The city covers 2,599 hectares.

Vanadzor was granted city status in 1924; formerly it was known as Gharakilisa, then Kirovakan, and ultimately renamed Vanadzor in 1992. It is the third largest city Armenia after Yerevan and Gyumri.

In Soviet times the city was a major industrial and cultural center and an important transportation hub. The local economy grew rapidly from the 1940s. Major enterprises involved in the production of machinery, and chemical, textile and food industries were built and commenced operation. In 1961, construction of Vanadzor thermal energy plant was completed; the energy produced in this plant meets not only the energy needs of the city but also of a number of communities in Lori marz. In the past, plants producing metal working machines, mechanical machinery and electronic equipment, factories producing textiles, shoes, furniture, plants for the production of meat products, bread, milk and dairy products, preserved/tinned foods, metallic and concrete products, and construction materials operated in Vanadzor city. Now only a small sub-set of these industries operate. The city was especially important in terms of the production of various types of chemical goods and materials, including artificial fiber, nitric acid, calcium carbide, melamine and other. In 1996, a production of machinery and equipment for the development of precious stones was established in the city. Currently, 3,825 commercial entities are registered, of which 598 are operational. These organizations are mainly engaged in the areas of processing industry, construction, and social services.

The city uses water from the Pambak, Tandzout and Vanadzor Rivers for irrigation purposes and as potable water, and is rich in groundwater reserves. There are forest resources to the south of the city, while in the adjacent territories there are reserves of natural construction materials, such as basalt, gypsum, clay and construction sand which are of industrial importance. There are a number of cultural artifacts in the city and the adjacent territories. In addition, there is a botanical garden in Vanadzor.

Vanadzor city is one of the most ancient dwellings in the Armenian uplands. There are a number of old churches in the city – the Armenian Church of the Holy Mother of God (St. Astvatsatsin) built with black stone, gave the city the name Gharakilisa ("Black Church"), and the Nativity of Virgin Mary Russian Orthodox Church built in 1895. An Armenian Church, St. Grigor Narekatsi, has been in use since 2005.

Part of the city's population came from Yerevan in the 19th century. The population grew from 494 in 1831 to 48,876 in 1980. The ethnic composition of the population is diverse including Russians, Ukrainians, Georgians, Greek and other national minorities. As of January 2012, the population of Vanadzor was 104,921 (NSS RA, population statistics); however, the results of a national census in October 2011 indicate that the number of *de jure* (permanent) population has significantly decreased in the last decade. In January 2013 the population was 85,700 (Census, 2011). According to the most recent data (RoA Ministry of Territorial Administration) as of the January 2011 the number of de facto population was 93,017 (26,037 households, of which 851 lived in temporary dwellings[9]) (Table 5). 7,477 households are included in the State Allowance System. According to the database of the RoA Ministry of Territorial Administration in 2010, 287 people left Vanadzor for permanent residence in Yerevan city and other marzes of the republic, while 284 persons left to go abroad. This was counterbalanced to some extent by 267 people moving from other marzes and Yerevan city to live in Vanadzor, and 89 people arriving from abroad.

[9] Vanadzor city was affected by the 1988 earthquake. Spitak community, Lori marz, was practically in the epicenter of the earthquake and was almost completely destroyed.

Table 5: De facto population by sex and by age, as of January 1, 2011, persons

Age groups	Total	% of total	Of which	
			Men	Women
0-4 years	5,769	28.7%	2,922	2,847
5-6 years	1,278		641	637
7-10 years	4,116		2,067	2,049
11-14 years	5,105		2,402	2,703
15-17 years	2,218		1,143	1,075
18-22 years	8,174		4,116	4,058
23-45 years	31,432	57%	15,691	15,741
46-64 years	21,609		10,157	11,452
65 and more years	13,334	14.3%	4,979	8,355
Total	**93,035**		**44,118** **47.4%**	**48,917** **52.6%**

Source: RoA Ministry of Territorial Administration

Women dominate representing 52.6% of the population. However, the gender balance varies significantly across age groups: in the age group 0-22, the number of men is higher, with the situation reversed in age groups above 23 years. The population demographics reflect the migrational behavior among men of employment age, who leave the city for permanent residence abroad. Twenty-two percent of the surveyed households have noted that a member of the household has migrated abroad for employment. Eighty-three percent of labor migrants have left for the Russian Federation, and 16.7% have left for other marzes of Armenia. Remittances from abroad are around 100,000 AMD to 120,000 AMD per household per year.

Despite the existence of labor migration, the labor market suffers imbalances: as of January 2011, 28,608 people were employed, and only 5,045 people were officially registered as unemployed, of which, 3,292 were women. Employment by type of economic activity is presented in Table 6.

Table 6: Employment by the types of economic activity

Type of activity	The number of employed, persons
Agriculture, hunting and forestry	3,556
Fishery and fish farming	58
Mining of minerals	64
Processing industry, including processing of agricultural produce	2,625
Production and distribution of electricity	198
Construction	2,755
Sales and repair of cars and appliances	2,839
Agricultural services	128
Hotels and restaurants	2,753
Transport and communication	1,867
Local self-governance	1,314
Education sector	3,035
Health sector	1,150
Public utilities, social and individual services	3,656
Financial services	2,610
State administration bodies	4,608

Source: RoA Ministry of Territorial Administration

Only 34% of the population surveyed is employed, of which 74% have permanent employment and the rest seasonal or occasional jobs. Among those employed, 48% work in state organizations, 20% are self-employed in sectors other than agriculture, and 30% work for private companies and organizations. Five percent of the surveyed households receive family allowances from the Government.

In 2012, 20 pre-school educational institutions operated in Vanadzor city catering for 1,961 children and employing 305 carers. There are 26 schools in the city; the number of schoolchildren in 2013 was 8,748, while the number of teachers was 938. Vocational education and training are carried out in 7 colleges and 1 vocational school, where 200 students are enrolled. Four institutions of higher education (2 state and 2 private) operate in the city; the number of enrolled students is more than 4,000, and 700 persons are employed as instructors and service personnel. Furthermore, there are nine sports schools where 232 children and young people learn and practice different sports, and seven institutions where more than 800 students study music, arts and dance.

Almost 12% of the city's land is privately owned, while 43% are community and residential lands. In terms of agricultural lands, a major portion comprises arable lands and hayfields, 100 and 200 hectares respectively. State lands are mainly utilized as pastures (111 hectares), arable land (27 hectares), and fruit orchards (10 hectares). Farmers are engaged in fruit growing, gardening, wheat and forage production, cattle breeding and poultry farming.

In terms of farming, the local population is primarily engaged in growing wheat, legumes and potato. Those engaged in animal husbandry produce milk, meat, wool, eggs, and honey. As of January 2011, 1,738 cattle (872 cows, 125 pigs, 47 sheep and goats), 23 horses, around 2,252 hens and 489 beehives were registered in Vanadzor City.

The following community development issues are considered priorities: renovation of schools, irrigation and potable water pipelines, renovation of intra-community roads, street lighting at night, renovation of cultural institutions, and provision of natural gas.

Seventy percent of surveyed households live in privately owned apartments, and 30% live in private houses. Water is supplied to all houses. The purity, odor, color and taste of the drinking water was rated as 'very good' (5%), 'good' (90%) and 'satisfactory' (5%) by respondents.

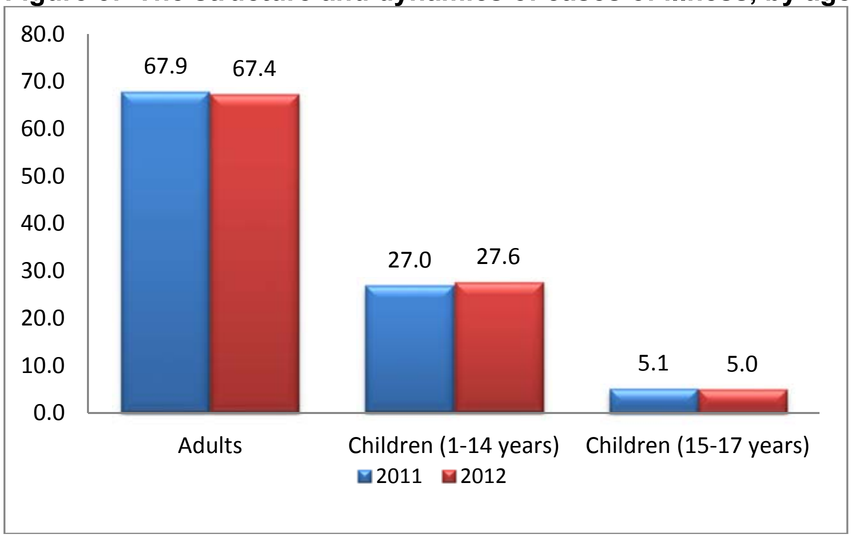
Two hospitals, five medical points and two specialized non-hospital medical centers/clinics operate in Vanadzor city. Information on the incidence of illness was provided by health care institutions operating in Vanadzor city, which serves the whole population of Lori marz. Therefore, the information not only refers to the communities under study. In the course of 2011 and 2012, the number of cases of illness registered in health care institutions operating in Vanadzor city and Gugark community alone indicates serious health problems across the Marz, although in 2012 a decrease in cases of illness was registered – 59,070 cases, compared to 59,671 cases in 2011 (Table 7).

Table 7: Distribution, by age groups, of cases of illness registered in health care institutions operating in Vanadzor and Gugark communities (*cases*)

	2011	**2012**
Adults	40,515	39,784
Children (0-14 years)	16,095	16,327
Children (15-17 years)	3,061	2,959
Total	59,671	59,070

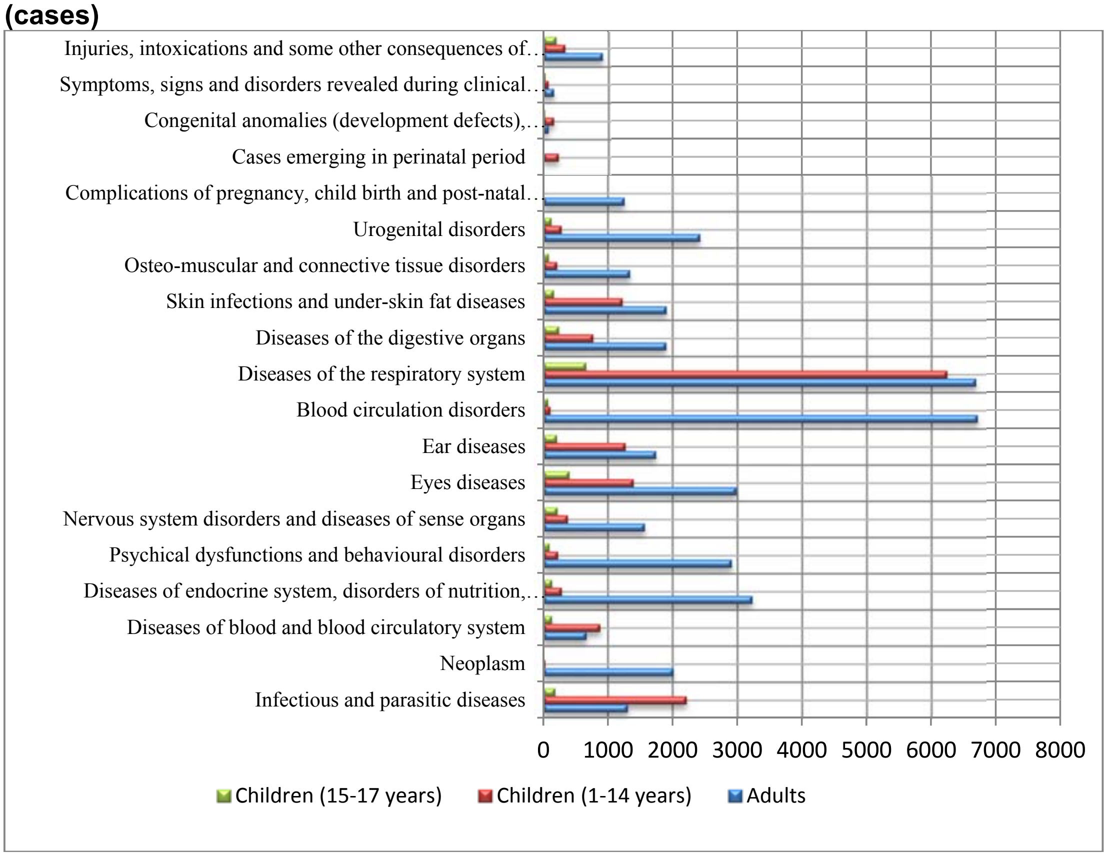
The incidence of illness is high among children aged 0-14, comprising around 27% of the total number of cases in the 2012. Further, the number of cases of illness among children aged 0-14 in 2012, compared to 2011, increased by 0.6% but decreased slightly in the other two age groups (Figure 3). Analysis of illnesses according to their type indicates that 'Diseases of the respiratory system', 'blood circulatory system diseases', 'Neoplasms', and 'Invasive communicable diseases' have the largest share within the 2012 morbidity structure among all age groups. Among children aged 0-14, 'diseases of the respiratory system', 'Infectious and parasitic diseases', and diseases affecting ears, eyes and skin are extremely widespread, suggesting a possible link with air and water pollution (Figure 4).

Figure 3: The structure and dynamics of cases of illness, by age groups



Legend: Adults; Children (0-14 years); Children (15-17 years)

Figure 4: The number of cases of illness by types and population age groups, 2012 (cases)



5.6 Stakeholder views on the mining operation

Awareness of the mine varies across the areas expected to be impacted by the mining operation. In Karaberd village and settlement all households surveyed were aware of the possible operation of Karaberd gold mine. However, only households in Karaberd village were informed of the public hearings on the mine. Based on feedback from the household survey around 50% of households participated in these discussions, which were also attended by NGOs.

For Pambak, Gugark and Vanadzor city, 40%, 0% and 16% respectively were aware of the possible operation of the mine. None of these areas were invited to participate in the public hearings on the mine.

In Karaberd Village 15% of the respondents are 'against' and 60% 'for' the mining operation (based on the negative impact on the environment and people's health, and the proximity of the mine to the pastures and meadows they use). In Karaberd settlement 50%, Pambak 15%, Gugark 52% and Vanadzor 32% of the respondents are against the mining operation compared to 12.5%, 35%, 17% and 2% who were in favor of the mine respectively. Of note is that 25%, 37.5%, 35%, 25%, 52% respectively felt their views would not be taken seriously or were willing to go along with the majority view.

In Karaberd Village both the Village Mayor and the villagers have high expectations of the Karaberd mine and support it. About 85-90% of the respondents felt that the mining operation will have a positive impact on the economic development of the community and additional sources of income will be created. The majority (70%) felt that the mining operation would reduce emigration.

According to the Village Major the mining company has stated that 2 million AMD per year will be allocated to the community, roads will be reconstructed, necessary infrastructure will be established, and, if necessary, the inhabitants will be provided with financial assistance. Mining trucks and other machinery will also be used for the community's needs.

The Village Mayor expects the following positive outcomes from the exploitation of the mine:

- Additional income to the community budget;
- Establishment and development of infrastructure;
- Funding of community needs by the mining company;
- Additional workplaces and income for the population;
- Improved demographics through a reduction in migration
- Active connection and communications with the marz center and other communities;
- Reimbursement of costs required for health protection, recovery and improvement.

In **Karaberd Settlement** around 37-87% of the respondents felt that the mining operation will have a positive impact on the economic development of the community and additional sources of income will be created. This compares to 25-50% in Pambak, 4-8% in Gugark and 26-48% in V**anadzor City**. The economic factors assessed by respondents are presented in Table 8.

In Karaberd Village 45% percent of the respondents would be willing to work in the mine, compared to 37.5% in Karaberd Settlement, 20% in Pambak, 30% in Gugark and 24% in Vanadzor City. Salary expectation ranged from AMD 100,000 (US$247) to over AMD 250,000 (US$617) per month. This can be compared with a national average salary in 2012 of about 118,000 AMD (US$291) per month in urban communities and about 90,000 AMD (US$222) per month in rural communities (NSS RA, Social-economic situation in RA, January - December 2012). In Karaberd Settlement, the area likely to be most affected by the mine, the majority of the households surveyed would accept adequate compensation for their loss of housing, property and livelihoods.

Table 8: Household views of the impact of the Karaberd Mine on the Economic situation of the community

	Positive	Negative	None	Hard to answer
Economic development of the community				
Karaberd Village	85	5	5	5
Karaberd Settlement	37.5	0	12.5	50
Pambak	20	30	15	35
Gugark	4	8	52	36
Vanadzor	40	10	12	28
Additional source of income for the community budget				
Karaberd Village	85	0	0	15
Karaberd Settlement	87.5	0	12.5	0
Pambak	25	30	5	40
Gugark	8	4	52	36
Vanadzor	48	10	10	32
Formation and development of community infrastructure				
Karaberd Village	90	5	0	5
Karaberd Settlement	62.5	0	0	37.5
Pambak	30	0	35	35
Gugark	4	4	48	44
Vanadzor	38	8	6	48
Formation and development of social infrastructure				
Karaberd Village	90	0	0	10
Karaberd Settlement	50	0	37.5	12.5
Pambak	20	0	45	35
Gugark	4	4	48	44
Vanadzor	36	8	6	52
Funding of community needs by the mining operator				
Karaberd Village	85	0	0	15
Karaberd Settlement	50	0	37.5	12.5
Pambak	25	0	5	70
Gugark	4	4	48	44

Vanadzor	36	6	8	50
Additional workplaces and additional income for the population				
Karaberd Village	90	0	5	5
Karaberd Settlement	62.5	0	25	12.5
Pambak	50	0	10	40
Gugark	8	4	48	40
Vanadzor	72	4	0	24
Reduction of emigration and return of migrants				
Karaberd Village	70	5	5	20
Karaberd Settlement	12.5	0	37.5	50
Pambak	35	0	5	60
Gugark	4	4	40	52
Vanadzor	12	24	40	24
Additional immigration of population and change of demographic picture				
Karaberd Village	55	5	20	20
Karaberd Settlement	0	0	100	0
Pambak	15	0	35	50
Gugark	4	4	32	60
Vanadzor	4	32	44	20

In Karaberd Village 35-65% of the respondents and the Village Major believe that the mine will have no environmental and health impacts since it is far from the village. This is in contrast to **Karaberd settlement** where all the respondents believe that the mining operation will have a negative impact on the environment and health. In Pambak 30-70%, Gugark around 60-72% and Vanadzor 82-86% of the respondents think that the mining operation will have a negative impact on the environment and health (Table 9).

Table 9: Household Views of the Impact of the Mine on the Environment

	Positive	Negative	None	Hard to answer
Agriculture – cattle-breeding, farming, beekeeping				
Karaberd Village	0	15	40	45
Karaberd Settlement	0	62.5	25	12.5
Pambak	0	55	20	25
Gugark	0	54	16	30
Vanadzor	0	62	0	34
Environment				
Karaberd Village	0	25	65	10
Karaberd Settlement	0	100	0	0
Pambak	0	65	20	15
Gugark	0	72	8	20
Vanadzor	0	72	0	28
Noise from machinery and blasts				
Karaberd Village	0	40	50	10
Karaberd Settlement	0	100	0	0
Pambak	0	30	40	30
Gugark	0	68	8	24
Vanadzor	0	82	0	18
Increase of air pollution, dust				
Karaberd Village	0	40	45	15
Karaberd Settlement	0	100	0	0
Pambak	0	70	10	20
Gugark	0	72	8	20
Vanadzor	0	86	0	14
Forests and vegetation				
Karaberd Village	0	35	50	15
Karaberd Settlement	0	100	0	0
Pambak	0	60	30	10
Gugark	0	60	16	24
Vanadzor	0	88	0	12

Water resources				
Karaberd Village	0	20	60	20
Karaberd Settlement	0	100	0	0
Pambak	0	45	35	20
Gugark	0	64	16	20
Vanadzor	0	88	0	12
Fauna				
Karaberd Village	0	20	60	20
Karaberd Settlement	0	100	0	0
Pambak	0	70	20	10
Gugark	0	60	16	24
Vanadzor	0	88	0	12
People's, especially children's health				
Karaberd Village	0	40	35	25
Karaberd Settlement	0	100	0	0
Pambak	0	45	20	35
Gugark	0	64	12	24
Vanadzor	0	86	0	14
Ecological purity of food				
Karaberd Village	0	25	40	35
Karaberd Settlement	-	-	-	-
Pambak	0	45	35	20
Gugark	0	60	16	24
Vanadzor	0	86	0	14
Spread of diseases				
Karaberd Village	0	25	30	45
Karaberd Settlement	0	87.5	0	12.5
Pambak	0	35	10	55
Gugark	0	52	16	32
Vanadzor	0	84	0	16
Expenses required for health protection, restoration and improvement				
Karaberd Village	0	20	35	45

Karaberd Settlement	0	87.5	0	12.5
Pambak	0	15	20	65
Gugark	8	24	16	52
Vanadzor	0	80	0	20
Expenses required for environmental restoration				
Karaberd Village	0	20	30	50
Karaberd Settlement	0	87.5	0	12.5
Pambak	0	15	35	50
Gugark	8	24	16	52
Vanadzor	0	80	0	20

6 Qualitative assessment of ecosystem services at the study site

6.1 Ecosystems witnin the study area

In the region of Karaberd gold mine a range of ecosystems are found including rivers, mountain meadows, grasslands and steppe and forest lands. These ecosystems are described below, based on published documents and site visits by the Expert Team.

Water ecosystems. Water ecosystems in the study site include **rivers** and **groundwater.**

Karaberd mine is located on the left bank of **Pambak River**. Pambak River is the upper stream and the main tributary of the Debed River which flow into the Kur River transboundary basin (shared with Georgia). The Pambak River originates at 2,100 m, on the eastern slope of Jajur mountain pass. The Pambak River basin occupies 1,370 km^2, and is 80 km in length. It is surrounded by the Bazum mountain chain in the north and Pambak mountain chain in the south. The Pambak River is mainly fed by rainwater and melting snow (62.5%), with the remaining 37% accumulated through groundwater recharge. The main flow is observed in spring and summer.

Chichekhan river is one of the major tributaries of Pambak river, which intersects with the Tandzut and Vanadzor streams near the city of Vanadzor. Several leftside tributaries of the Pambak River flow alongside Karaberd mine are are mostly shallow, and dry up during periods of drought. According to residents of Karaberd and the site assesment, one of the streams close to the mine has been dry for the past 2 years. The site assesment confrimed that there is an underground water outflow in Karaberd settlement which serves as a source of drinking water.

Within 2km south of the mine the spring of Vanadzor mineral waters is located, which is used for commercial purposes.

Groundwater. Major crack formations in the Karaberd mine rocks create favourable conditions for the absorption of surface waters, and the zones of hydrothermal, extensively modified, split rocks play a major role in the formation of goundwater in the deep horizons. Two types of groundwater have been identified in the area of the mine – exogenic fissurred waters and waters of fractured shear-vein zones.

Exogenic fissured waters are mostly fed by precipitation, and are discharged as springs as well as feeding the deepwater horizons of splitting zones, which ultimately merge with the Pambak River. The maximum outflow of springs does not exceed 1.4 l/sec (a flow of 0.5 l/ sec was observed in June). In terms of chemical composition, exogenic splitting waters have hydrocarbonate-sulfate-calcium-natrium-chlor-magnesium components with basic reaction from neutral to weak (PH=7.0-8.0) and 0.43.-0.88 g/l mineralization.

Splitting and split-vascular water zones within the area of the mine have been caused by mountain reclamation and the digging of water wells. The maximum water flow from the four mine routes observed in May 2013 by the Company's EIA team was 0.65 l/sec. The chemical composition of these waters is PH=7.2-8.3 and mineralization of 0.49-1.45 g/l.

Forest ecosystems in the region include an oak-forest covering an area of around 1 ha in the immediate vicinity of the mine, as well as Specially Protected Areas. Specially Protected Areas of the region are Gyulagarak Pine State Reserve located on the northern slope of Bazum mountain range (9.1 km from the mine), the reserves of Margahovit and Caucasian Myrth located on the northern slopes of Pambak mountain range (12.6 km and 17.0 km away from the mine respectively), and Dilijan National Park at a distance of 19.1 km from the mine.

The valleys bordering the mine are rich in forest vegetation with pine and oak species dominating. Pine, oak, ash-tree, linden tree, maple and hornbeam, rose hip and shrubs are common in the rocky areas, while wild pear, apple trees, walnut, plum-tree and sparse forests of oriental hornbeam and juniper are also observed. The surrounding area of Karaberd gold mine can be referred to as a post forest mountain zone. As a result of anthropogenic impacts and climate change, the forests have been heavily affected and only some small compartments are preserved in the relatively humid western micro-terrains of the ravines. Here the landscapes have been modified and bear features identical to steppe medium-range Mountains, and also exhibit some grassland and steppe landscape zone features

The forests are used for firewood, wood and non-timber forest products (NTFPs).

Mountain ecosystem. Karaberd mine is situated on the southern hillside of Bazum mountain range. The slopes of the mountain become steeper in the mine area, the explored area of which is 1,700-1,775 meters above sea level and has an average declivity of 10-15° on the southern and western side. The surrounding area rises from 1,300 meters to 1,850 meters, the slopes are mainly descent (10° - 20°) and slightly steep (20° - 30°). The mountains are covered with meadows, meadow-steppe, and forest lands with a rich vegetation.

Mountain meadow lands are characterized by surface, and profoundly buried, rocky features, which have a delicate granular texture and are poor in carbonate.

Grassland and steppe lands are characterized by a sub-type of black soil. These soils contain a large quantity of humus (18 - 25%). The capacity of the soil layer is poor ranging from 15-20 to 40-50 cm depending on relief conditions. It is mostly composed of clay sand, with a pH ranging from 4.5-6.4. The natural meadows and pastures are used for animal husbandry.

6.2 Biodiversity survey

A rapid survey of fauna and flora was undertaken at the study site in August 2013. The details of this survey are provided in Annex 4, while the main findings are summarized below:

- According to K.E. Husyan (1987), the flora of Bazum Mountain chain is comprised of 1,033 species of higher plants belonging to 101 families, and 436 branches. However, as a result of continuous research in the 25 years following this publication, the floristic composition is currently understood to contain more than 1,100 species of higher plants.
- Iris leaves of were discovered most probably belonging to *Iris Paradoxa*. In order to determine whether that plant belongs to one of the Iris species registered in the Red Book of Armenia it is necessary to undertake a follow up survey in early summer to record the precise genus of the plant.
- Karaberd fauna is composed of 91 animal species.
- Two species of amphibian and ten species of reptiles may be identified in the area (according to the available literature). Two of the reptile species (*Darevskia dahlia* and *Darevskia rostombekovi*) are included in the Red Book of Armenian Flora.
- The literature review and observations by the survey team indicate that there are 43 species of birds in the area, 28 of which were observed. Passerines and predatory birds are the most common. No Red Book species were identified in the area.
- Out of 36 mammal species indicated in literature sources for the study area, 12 were observed. Brown big-eared bat, Brown bear, and Red deer (*Plecotus auritus, Ursus arctos* and *Cervus elaphus maral*) are included in the Red Book of Armenia. Red deer was observed in the study area.
- The studies of macrozoobenthos of the Pambak River ecosystems indicate that in two sample sites there are 8 species of forest-floor invertebrates, among which Stoneflies (*Plecoptera*) and Chironomidae are the most common. According to the obtained data and Woodwiss index, overall, the two observation sites in the study area of Pambak River are considered to be contaminated.

6.3 Provisioning services

This section provides an overview of the key ecosystem services provided at the study site

Minerals. The area is rich in mineral deposits. Mineral objects appear on the ground in the form of crushed, veins of multi-washed minerals. Their depth varies between 1-10.8m.

Food. Nearly all households in Karaberd, Pambak and Gugark Village use their homestead plots to grow food for domestic consumption. Households in these villages also collect edible mushrooms, plants, herbs, fruits and berries from the surrounding forests and meadows (Table 10). In Karaberd village these goods are typically for household consumption, but in Pambak and Gugark they are also sold in the market.

In Pambak village three households sold 200 kg - 400 kg of edible plants in the market (the total market price amounted AMD 300,000). In Gugark two households sold around 250 kg of berries in the market (for a market price of AMD 180,000).

Table 10: Collection of forest products by the study villages

Village	Mushrooms	Wild fruits and berries	No of beehives
Karaberd	6 centners (600kg)	30 centners (3,000kg)	108
Pambak	165 centners (16,500kg)	15 centners (1,500kg)	143
Gugark	4 centners (400kg)	25 centners (2,500 kg)	491

Source: NSS Lori department, 2012 RA

The diverse vegetation and climatic conditions in the area are favorable for **beekeeping**. Apiculture is practiced by the local communities and is considered to have high potentail in the area. This activity is supported by the surrounding wild fields and pasture land which are abundant with wild flowers in the spring and summer and attract significant numbers of bees. According to the household survey 3 households in each of Karaberd, Pambak and Gugark village are involved in bee keeping.

Areas designated for beekeeping need to be far away from animal barns, waste waters and must be protected from wind. The radius of productive flight for bees is 2-3 km or 125-2,800 ha (Armenian Agricultural Support Center). In the mountains, at an altitude of 1,500-2,000 meters above the sea level, honey harvesting can start at the beginning of July and continue until early August. The honey-yielding plant species are:

- Fruit-bearing trees: apricot trees, plum trees, cherry trees, sweet cherry trees, pear trees, apple trees;
- Forest trees and bush species: willows, acacias, oaks, lime, hazel-nut trees, sea-buckthorn, Christ's Thorn, wild strawberry, raspberry, dewberry and other bushes; and,
- Alpine plants: catmint, bugloss, wild mignonette, thyme, falcate lucerne, salvia, comfrey, bird's-food trefoil, chicory, anaphalis and horehound.

Fodder / pasture. Meadows and wild pasture lands around the proposed mine are used by local comunities for animal grazing, mostly in the spring and early summer, but sometimes also in autumn. Most households rent the meadows from the community for around 14,000 AMD per ha/year. In Pambak some households have privately owned meadows.

The productivity of wild grassland / pasture on the slopes around Karaberd gold mine is not particularly high averaging around 2,500 kg/ha per year of green mass on sunny slopes with various degrees of degradation, and up to 3,300 kg/ha per year on relatively humid and shady slopes. The grazing period of farm animals (without additional feeding of the animals) in the natural-climatic zone is around 200 days. For this reason, for cows requiring an average 45 kg of feed per year, the land can support approximately 0.28 – 0.37 head of cattle per hectare, or 1.4-1.8 head of sheep and goats with a demand of 9 kg.

Water. Freshwater resources are used by the local communities for irrigation and household purposes. The potable water springs of Karaberd community are situated in the mountains of the upper part of the mine. The exploitation of the mine may drain the spring and result in a decrease in water quantity, which is the main source of water for the Settlement. There are two outflow points for underground water within the territory of Karaberd settlement beneath the mine. In addition, at a distance of 2 km south of the mine there is an outflow point for Vanadzor mineral water which is used for commercial purposes, but is not expected to be impacted by the mine.

Fuel. There is a forest area within the study site covering 1 hectare. It is illegal to cut the trees in this area, but cuttings can be taken with permission for a fee. Some illegal harvesting may be evident. Local communities collect a small amount of timber and firewood from the forests adjacent to the mine for domestic use. In Vanadzov firewood is typically used for heating and this is purchased at 120,000-150,000 AMD per 10-15 cubic meters.

6.4 Regulating services

Sink for atmospheric carbon dioxide (carbon capture). The forests and meadows around the mine absorb greenhouse gases, however their sequestration rate is not considered to be significant and has not been assessed.

Micro-climate regulation. The forests and meadows around the mine also regulate other atmospehric pollutants, thus contributing to local air quality and climate regulation. However, this function had not been assessed at the study site and so evidence of the areas possible micro-climatic regulation functions are not available.

Hydrological services. The forest and mountain ecosystems in the area contribute to the regulation of water flow and water quality. This is clearly observed in the quality, quantity and location of surface waters of the area. The mountain spring waters can be used for drinking, household and agricultural purposes, and they support the range of ecosystems of the area.

Control of erosion & sediments. The forest, water and mountain ecosystems in the study area are thought to contribute to the prevention of soil erosion. However, the provision of this service at the site has not be researched.

6.5 Cultural services

Toursim and recreation facilities and activity in the area is currently low. In Pambak and Gugark villages there are a few local and foreign tourists visiting during the summer months. Based on the household survey there is also some interest in developing home stays for tourism in these villages.

Table 11 provides an overview of the significance of the ecosystem services at the study site, in its current use and condition (i.e. under the baseline).

Table 11: Qualitative analysis of Ecosystem Services provided by ecosystems

Ecosystem Service category	Service (Benefit / outcome)	Significance under the baseline	Comment
Provisioning Services	Minerals	-	The land is considered to be rich in minerals and is the site of a proposed gold mine, but there is no mining under the baseline
	Food	++	The land is not used for growing crops, but wild mushrooms and fruits are collected and the wild flowers in the area are believed to attract bees and hence facilitate honey production
	Fodder	++	Households in the area are dependent on animal husbandry and the use of the fields as pasture and hay meadows to feed their cattle.
	Water	++	The site is important for the provision of drinking water & irrigation water
	Fuel	+	There is a forest area within the study site covering 2 hectares. It is illegal to cut the trees in this area, but cuttings can be taken with permission. Some illegal harvesting may be evident
	Biochemical and medicinal resources	?	Not considered significant based on rapid biodiversity survey, but more in-depth surveys required
	Genetic resources	?	Not considered significant based on rapid biodiversity survey, but more in-depth surveys required
	Ornamental resources	?	Not considered significant based on rapid biodiversity survey, but more in-depth surveys required
Regulating Services	Sink for atmospheric carbon dioxide (carbon capture)	+	Only 2 hectares of forest land at the study site
	Micro-climate regulation	+	*Scientific studies required to define this service at the site*
	Hydrological services (regulation of timing and volume of river flow)	+	*More information is required to understand how rivers and groundwater interact in the area*
	Flood risk regulation (protection of property, agricultural land, human lives)	-	*This is not considered to be significant at the site.*
	Protection against storms	-	*This is not considered to be significant at the site.*
	Control of erosion and sediments	?	*More information is required to define this service at the study site.*
	Regulation of pest and pathogens	?	Pasture and forest land may be important in this respect
Cultural Services	Cultural, spiritual, religious,	-	*This is not considered to be significant at the site.*
	Scientific and educational information	-	*This is not considered to be significant at the site.*
	Tourism and recreation	-	No tourism or recreational activities at the site.

Code: ++ means that the service is important; + means that the service is provided; - means that the service is not relevant; ? means that there is uncertainty surrounding the provision of a service.

7 Impact assessment

7.1 Overview of mining impacts on biodiversity and ecosystem services

Mining, while dependent of ecosystem services such as water supply for mineral processing, can impact biodiversity and ES in a variety of ways. These impacts include (UNEP, 2010):

- **Habitat loss and fragmentation** through surface mining, creation of waste rock dumps and secondary developments from roads and influx of employees. The largest direct impacts result from surface mining, in which entire habitats and the geological features underlying them are removed during the period of extraction;
- **Water Pollution** of habitats and water supplies from chemical contamination and solid waste (storage of waste / tailings);
- **Air pollution** the quarrying process can disturb plant and animal (and human) communities through dust;
- **Excessive water withdrawal** that can impact on local water systems. Alteration of creeks, rivers, and watershed regimes;
- **Noise** can disturb communities and animals and plants;
- Use and disposal of some heavy metals can have significant negative impacts on soils, water resources, animal and human health.

Less direct but nonetheless significant impacts can come from the wider footprint of mining exploration, such as access roads that bring people into ecosystems where there has previously been little or no human presence, or the ’honey pot’ effect of increased economic activity attracting large numbers of workers who may engage in other environmentally damaging activities (e.g. farming to supplement mining wages). (TEEB, 2010[10])

However, the **ecological balance sheet of the sector does not need to be all negative**. Species and habitat conservation are possible through land stewardship practices that mitigate impacts. The margins of open mines and quarries are often kept forested to reduce the visibility and noise, creating buffer zones where wildlife may be protected. Restored mines and quarries can create wildlife habitats such as wetlands, sometimes with greater biodiversity value than the land use that preceded the mining activity. Best practice is for companies to treat expenditure for restoration as a business cost (TEEB, 2010).

Figure 5 presents an overview of the impacts of mining on ecosystem services and biodiversity.

[10] TEEB, 2010. Mainstreaming the Economics of Nature

Figure 5: Examples of the intersection of project development and

POTENTIAL IMPACTS	MINING ACTIVITIES	**Exploration and construction**	Early stages of exploration	Exploration drilling	Access road construction	Land clearance (for construction, etc.)	Obtaining construction materials	Construction related infrastructure	**Construction of ancillary infrastructure**	Roads, rail & export infrastructure	Pipelines for slurries or concentrates	Energy/power & transmission lines	Water sources, wastewater treatment	Transport of hazardous materials
Impacts on terrestrial biodiversity														
Loss of ecosystems and habitats				●	●	●	●			●	●	●		●
Loss of rare and endangered species				●	●	●	●	●		●	●	●		●
Effects on sensitive or migratory species				●	●	●	●	●		●	●	●		●
Effects of induced development on biodiversity					●	●		●		●				●
Aquatic biodiversity & impacts of discharges														
Altered hydrologic regimes					●	●	●	●		●		●	●	●
Altered hydrogeological regimes				●			●							
Increased heavy metals, acidity or pollution				●		●	●	●		●		●	●	●
Increased turbidity (suspended solids)				●	●	●	●	●		●	●	●	●	●
Risk of groundwater contamination				●			●	●		●	●		●	●
Air quality related impacts on biodiversity														
Increased ambient particulates (TSP)				●	●	●	●	●		●		●		●
Increased ambient sulfur dioxide (SO_2)								●				●		●
Increased ambient oxides of nitrogen (NO_x)								●				●		●
Increased ambient heavy metals												●		
Social interfaces with biodiversity														
Loss of access to fisheries						●	●			●	●	●		
Loss of access to fruit trees, medicinal plants						●	●	●		●	●	●		
Loss of access to forage crops or grazing					●	●	●	●		●	●	●		
Restricted access to biodiversity resources						●	●			●	●	●		
Increased hunting pressures				●	●	●	●	●		●		●		●
Induced development impacts on biodiversity					●	●	●	●		●		●		●

Source: The International Council on Mining and Metals (ICMM) 'Good Practice Guidance on Mining and Biodiversity'.

7.2 Assessment of the impact of the Karaberd mine on ecosystem services

This section presents a summary of the EIA perform on behalf of the Mining Company ASSAT and a review of this EIA by the project consultants (where possible), based on site visits and expert opinion.

7.2.1 Water quality / quantity

Company EIA

In Karaberd **open pit** mine water will be used by the workers for drinking, for industrial needs and for dust mitigation (through the sprinkling devices). The quantity of water required for each purpose, as well as waste water volumes are presented in Table 12.

Table 12: Karaberd Open Pit Mine - Water Usage

Water usage needs	Water usage m^3/year			Waste water management, m^3/year		
	Total	Drinking water	Technical water	emissions	losses	Irretrievable usage
Sprinkling of roads and facilities	594.0	-	594.0	-	-	594.0
Damping of drilling facilities	118.8	-	118.8	-	-	118.8
Damping of mine	131.9	-	131.9	-	-	131.9
Drinking and technical	80.3	80.3	-	79.1	1.2	-
Total	925.0	80.3	844.7	79.1	1.2	844.7

For the **underground mine** water consumption will be: (i)drinking water - 2.55 m^3/day, 777.8 m^3/year; and, (ii) water for industrial use (mitigating dust during drilling, blasting, excavation and loading activities) - 12.6 m^3/day, 3,843 m^3/year.

The total water discharged will be 2.9 litres/second or 10.44 m^3/hour.

Analysis by the project team

The residents of **Karaberd settlement** get their drininking water from two wells, which are not very deep. There are no visible surface waters on the south-western slopes of the mine, however, according to villagers in spring several shallow surface streams can be seen following thaw and rains. The springs in the mining area may be impacted (e.g. through blasting activities) resulting in a deterioration of water quality, and a reduction in flow / possible drying out of the rivers and streams. The water streams located in the zone of direct impact may also dry up due to the erosion of the forest cover where the water resources are generated.

In terms of water usage for mining operations (mining and the settling of dust) large amounts of water will not be required and will be supplied from the Pambak River in containers / water tanks.

7.2.2 Air quality / dust

Company EIA

Opencast mining: Emissions generated at the construction phase by source are provided in Table 13. The Table integrates nitrogen oxides and hydrocarbons.

Table 13: ***The volume of atmospheric emissions during construction***

Phases of construction works	Volume of hazardous atmospheric emissions, t/capital (g/sec)					
	Inorganic dust	Carbon oxide	Hydrocar bons	Nitrogen oxides	Solid particle s	SO_2
1	2	3	4	5	6	7
1. Digging and loading works	6.4 (2.98)	-	-	-	-	-
2. Vehicles	0.22 (0.1)	-	-	-	-	-
4. Diesel fuel combustion	-	0.3 (0.138)	0.031 (0.07)	0.35 (0.16)	0.035 (0.016)	0.033 (0.015)
TOTAL	6.62 (3.08)	0.3 (0.138)	0.031 (0.07)	0.35 (0.16)	0.035 (0.016)	0.033 (0.015)

It is the Company's view that (construction) operations will be performed over a large area, such that the emissions will be diffused throughout the area of mine and external areas. However, assessments of the dispersion rates of emitted substances to air and ground were not carried out.

At the operation stage dust is caused by excavation and loading activities (e.g. ore and topsoil loading and haulage, activities of excavators and bulldozers and other heavy equipment), vehicle movement (dust from road and blown / discharge from trucks), as well from drilling activities. Hazardous gases are associated with a variety of diesel run machines (e.g. trucks, excavators, bulldozers). The routine loss of oils, kerosene, lubricants during the work of open pit equipment releases hydrocarbons. Blasting can also generate volleys of dust and gases (carbon and nitrogen oxides). However, since these volleys of emissions are assumed to disperse within 10 minutes, they are not taken into account when considering the level of atmosphere pollution in the company EIA.

The estimation of hazardous atmospheric emissions was carried out by the Company in accordance with the accepted methodology in Armenia, based on the productivity of open pit equipment and consumption of the used materials (Table 14).

Table 14: Overview of hazardous atmospheric emissions

Types of Works and facilities	Quantity of hazardous emissions in atmosphere y/year (g/sec)					
	Inorganic dust	Carbon oxide	Hydrocar bons	Nitrogen oxides	Solid particles	SO_2
1	2	3	4	5	6	7
1.Excavation and loading activities	6.6 (1.02)	-	-	-	-	-
2. Vehicle movement	2.33 (0.36)					
3. Drilling	0.71 (0.125)	-	-	-	-	-
4. Emissions from diesel combustion		0.9 (0.139)	0.2 (0.03)	1.05 (0.16)	0.11 (0.017)	0.1 (0.015)
5. Oil and lubricants storage	-	-	0.0042 (0.0006)	-	-	-
Total	8.93 (1.38)	0.9 (0.139)	0.2042 (0.0306)	1.05 (0.16)	0.11 (0.017)	0.1 (0.015)
6. Blasting	0.76 (2.67)	0.29 (1.02)	-	0.18 (0.63)	-	-
TOTAL	9.69 (4.05)	1.19 (1.159)	0.2042 (0.0306)	1.23 (0.79)	0.11 (0.017)	0.1 (0.015)

Ground-level emissions. Open pit mines can generate ground level emissions from mining equipment, excavation and loading, drilling and blasting. Calculations of the dispersion of hazardous emissions were undertaken using the computer software 'Raduga'. The calculations define: (i) calculation point coordinates; (ii) concentrations of ground-level hazardous emissions, by parts of Maximum Allowable Concentration (MAC); (iii) cluster lamp direction; (iv) wind speed in meters/seconds when the ground-level concentration at the calculation point reaches its maximum value. The maximum ground-level concentrations derived via Raduga are presented in the Table 15. The results indicate that the expected ground-level concentrations are within the norms defined for residential zones.

Table 15: ***Results of calculations of ground-level concentrations***

№ number	Contaminants	Maximum ground- level concentrations at the facility	
		mg/m^3	By parts of MAC
1	Inorganic dust	0.0555	0.111
2	Hydrocarbons	-	-

Sanitary-protection zone (SPZ). Based on 245-71 sanitary norms, SPZ for polymetallic ores is 500m. Given that the nearest settlement is located at the distance of more than 0.8 km, special measures for organizing SPZ are not envisaged.

Underground Mine. For the underground mine, drilling, blasting, excavation, loading and transportation of rocks are the main sources of atmospheric emissions. As for the open pit mine, operation of mining equipment and vehicles will involve diesal combustion and related emissions. Sources and quantities of hazardous materials generated during the operation of the underground mine are presented in the Table 16.

Table 16: Overview of hazardous emissions from underground mine operations

Stages of construction works	Quantity of hazardous emissions in atmosphere, տn/capital (g/sec)					
	Inorganic dust	Carbon oxide	Hydrocar bons	Nitrogen oxides	Solid particles	SO_2
1	2	3	4	5	6	7
1. Capital mining operations	1.14 (0.18)					
2. Excavation and loading activities	0.033 (0.003)	-	-	-	-	-
3. Vehicle movement	7.58 (0.69)	-	-	-	-	-
4. Emissions from diesel combustion		3.41 (0.31)	0.79 (0.07)	3.97 (0.36)	0.41 (0.037)	0.35 (0.034)
5. Drilling activities	0.01 (0.025)	-	-	-	-	-
6. Blasting activities	1.8 (10.8)	0.43 (2.55)	-	0.69 (4.1)	-	-
TOTAL	10.563	3.84	0.76	4.66	0.41	0.375

Total annual emissions generated during the underground mine operations (excluding the capital mining operations) are presented in the Table 17.

Table 17: Underground mine - total annual emissions

Hazardous material	ACL settlements MOT	Emissions y/year
Inorganic dust	0.5	9.423
Carbon monoxide	5.0	3.84
Hydrocarbons	1.0	0.76
Nitrogen oxides	0.085	4.66
Solid particles	0.15	0.41
Sulfur anhydride	0.5	0.375

As for the open pit, given that vehicle emissions cover a large area it was not considered practical to estimate their dipserson rate. However, excavation, loading and drilling activities are carried out at the same location and emissions from these activities are a maximum 0.003 + 0.025 = 0.028 g/sec, compared to open pit emisison of 1.38 g/sec. The EIA undertaken by the company concludes that dust emissions from underground mining operations will not generate ground-level concentrations that exceed the permissble norms.

Analysis by the project

The company does not envisage use of a crushing knot (ore crushing, breaking, sieving), which is typically the main source of dust. Also, there is a hill between Karaberd village and the mine which buffers the village from the possible impacts of dust and air pollution. However, Karaberd settlement is in the direct impact zone and the adjacent residential districts of Vanadzor may suffer indirect impacts.

The sanitary norms for air pollutants in settlements were established by Decision N160 of the Government of Armenia (2006). The defines the maximum one-time and average daily concentrations. The EIA report calculates the dispersion of emissions from stationary sources in accordance with the prescribed former Soviet Union methodology. However, given that dust emissions are considered to be a key ecological risks, this study undertook its own analysis for three potentail dust-volumes:

- Maximum dust volume 0.5 – 4.68 mg/m^3, surface 18.80 ha
- Average dust volume 0.15 – 0.5 mg/m^3, surface 76.85 ha
- Light, dust volume 0.05 – 0.15 mg/m^3, surface 189.35 ha

The results suggest that overall, dust pollution will cover an area of 285 ha, with a maximum distance of 1,622 m towards the south-west and a minimum distance of 515 m towards the north-east. Karaberd Settlement is situated within the atmospheric dust pollution impact zone, however, the expected concentration in the area is below the average daily indicator.

From the perspective of land use, pastures and grasslands, and some arable land will be impacted by dust. The Gugark forest enterprise, Vanadzor district, is also impacted, namely the 2nd section (2.7ha), the 3rd and 4th sections (9.0 ha and 3.9 ha respectively). These are areas with low forest stand, with oak being the predominant tree species. The 4th section of the forestry department is the most vulnerable due to the extent of impact.

According to estimates, the impact on air quality will be limited and will not exceed existing regulatory norms. Of note however is the fact that the impact of smaller particles has not been considered and needs to be additionally studied, especially given their potential link to respiratory problems, the incidence of which is known to be high in the area.

7.2.3 Impact on the land resources

Company EIA
The mining area covers 1.1 ha plus an external waste dump of 1.5 ha. Direct impacts to land are related to the construction of mine facilities, open pit extractions and the dumping of waste. Based on preliminary research, the volume of productive topsoil that will be removed is 120,000 m^3 given that the main part of the land take consists of basic rocks. According to Armenian legislation this has to be extracted and preserved or used for rehabilitation.

According to the Company EIA it is unlikely that acid residues from the mine blasts will settle on the soil due to their short life and the favorable climate. Usage of disturbed areas for construction and re-vegetation of disturbed lands when the work is completed are intended to promote conservation of land resources and their rational use. In addition, ore enrichment and metal production is not foreseen, therefore, a tailing will not be constructed at the site, which is one of the most significant impacts of mining operations.

7.2.4 Waste generation

Company EIA. In the process of excavating the mine and during the extraction of minerals, waste rocks will be generated. The waste rocks will be transported by truck to the waste dump. The overburden is expected to total 72,500 m^3. However, according to current legislation in the RoA, overburden is not classified as waste.

7.2.5 Impact on biodiversity

Company EIA
According to the EIA prepared for the company, biodiversity in the area may be affected by drilling, blasting, noise and dust generated from loading and transportation of the ore, atmospheric emissions, discharges of potentially hazardous materials (diesel, lubricants and cyanide), lose of land and constuction works (roads and production facilities). The potential impacts were not quantified.

Analysis by the project
The vegetation cover in the area is already damaged as a result of geological explorations (bore-holes, roads, canals). In theory, if no further activities are carried out, this vegetation restore over a number of decades. Recultivation is a possible solution; however the choice of species would need to be based on comprehensive studies.

Currently, the main threat to steppe and alpine ecosystems is intensive grazing which leads to ecosystem degradation and/or modifications as a result of the intensive growth of ruderal and weed species. Forest and steppe bush ecosystems are threatened by forest logging which can be addressed through the adoption of sustainable practices.

The continued existence of small areas of wetlands depends on maintaining the integrity of water resources. If the existing small streams (which normally dry up during the summer) disappear, the wetland ecosystem will also be lost.

Of note is that Company EIA does not specify the location of the rock dumps. Given the area of the planned mine, rock wastes will occupy quite a large area and probably be located in nearby valleys, destroying ecosystems.

Grasslands and pastures will be impacted by dust and exhaust fume emissions. While their concentrations above the ground will not exceed sanitary norms, currently no objective indicator is applied in Armenia to measures the impact of these emissions on vegetation and cultivated crops. Areas where berries grow, which are picked by locals both for their own consumption and for sale, will be impacted by land loss and dust.

Fauna will be mainly impacted through the operation of heavy machinery and the use of explosions. The areas and migratory routes of wildlife living in the area of the mine and nearby will change. Beekeeping will be negatively affected.

7.2.6 Noise

Company EIA

Noise likely to be generated by the proposed mining operations is presented in the Table 18. In the Company's view, considering the distance of the mine from settlements, noise levels will not exceed norms.

Table 18: Karaberd Mine - expected noise levels

Machines and equipment	Sound power level	Quantity
Hydraulic excavators	118 db	4
Dump trunk	123 db	15
Diesel generator	67 db	3

7.2.7 Summary

The Company EIA report is mostly in accordance with the procedures adopted by the Republic of Armenia. The main limitations of the EIA undertaken by the company are:

- The analysis is based on literature and previously conducted research, no site specific assesments were undertaken.
- Groundwater is not assessed although the risk of groundwater becoming contaminated or drying up is a key concern of local communities. It is also likely that mine explosions will impact water flow and quality.
- The impacts of fine particles, which are likely to reach Vanazdor, are not assessed. There are no standards for Suspended Particulate Matter (SPM) in Armenia and data on SPM is not collected. As a result it is not possible to find a correlation between SPM and respiratory illness, although this link has been proven in other countries.
- Noise levels during the operation of the technical machinery is presented in the report, however, no data are provided on the noise levels during blasting.
- There is only a general assessment of indigenous biodiversity and it is not clear from the Company EIA if any endangered species are present in the area. The description of the flora and fauna and land resources relates to the whole region, and a specific analysis of the immediate mining area is missing.
- The assessment only covers stationery sources. The extracted ore (prior to crushing) will be transported to Ararat by truck. Heavy trucks will be driven along rural and main roads

impacting the forest lining the road. The Company EIA does not cover the impact of such transportation on the environment and the settlements. In addition, it is not clear from the EIA that there is sufficient capacity in Ararat city to process the transported ore and a discusion of the impact of processing the ore on the environment is missing.

- The chemical composition of the ore and unfossiliferous rocks are not presented in Company's EIA.
- The EIA lacks specific data on electricity production. The operating mode of the generator and the envisaged quantity of fuel are not specified
- Data on chemicals to be used in explosions is not provided.
- The EIA does not refer to the structure of tailings.
- Closure and decommissioning procedures are absent.
- As an environmental measure creation of side ditches and construction of constraining upland rivulets are mentioned, but relevant design data (earth works, machinery to be used, etc.) are missing.
- In calculating soil damage, recultivation is mentioned as a measure to restore disturbed lands, but the cost calculated does not include biological recultivation, and it is therefore assumed that this is not envisaged.
- The mine is in the administrative territory of Karaberd, but Gugark and Pambak are also expected to be impacted. The scope of the EIA is insufficient as it only covers Karaberd. Public hearings were only held in Karaberd Villager and were not attended by residents of Karaberd Settlement who were unaware of the meetings.

8 Valuation of ecosystem services

8.1 Background on the valuation of ecosystem services in Armenia

The valuation of ecosystem services in Armenia is in its infancy. Existing studies include a study of water services in the Upper Hrazdam River Basin (Geoinfo Ltd, 2011)[11], which estimated damages due to waste water discharge with the intention of designing a Payment for Ecosystem Services (PES) scheme, a PES study of Lake Sevan (Gundimeda, H. 2012),[12] and a contingent valuation survey in Yerevan to estimate people's willingness to pay (WTP) for the protection of Lake Sevan (Wang *et al* 2004).[13]

The study of Lake Sevan explores the feasibility of PES as a solution to restore Lake Sevan. The value of Lake Sevan to the local, global and regional community is estimated as summarised in Table 19.

Table 19: Lake Sevan - valuation of ecosystem services

Service / benefit	Value (US$)	Approach
Water provision to agriculture	0.18 billion	Change in productivity approach Assuming a loss in 1% water availability leads to 1% loss in productivity. Based on Gegharkunik Marz (which forms 17% of country's agricultural output), the benefits to agriculture from the presence of Lake Sevan is estimated at 66.13 billion drams or US $ 0.18 billion (2.1% of GDP of Armenia).
Livestock	46 ha/year.	In Gegharkunik Marz, where Lake Sevan is situated, permanent pastures and grasslands comprise 60% of the total agricultural land. Grasslands are used for feeding animals in winter, while pastures are used for grazing from early spring till late autumn. Approximately 20% of the livestock in the country is raised in Gegharkunik Marz. It is assumed that 60% of the production value can be attributed to wetlands surrounding Lake Sevan. The marginal value to the economy derived from cattle grazing supported by Lake Sevan is about 46 USD/ha/year.
Fishing	0.018 - 0.108 billion (2008).	Fishing accounted for 0.1% of GDP during 2003-08, that is around US$ 0.02 billion (in 2003) – US$ 0.12 billion (in 2008). Given that Industrial fishing from the lake accounts for over 90 percent of fishing in the country, the contribution of Lake Sevan to fishing ranges from US$0.018 billion to US$0.108 billion (2008).
Cultural and Aesthetic values of Lake Sevan	US $4.6 million (at 2003 average exchange rates).	Benefits Transfer In 2004 a willingness to pay survey was carried out to assess the value to Armenians of the water level in Lake Sevan. Roughly half the respondents said they would pay a positive monthly sum, over a period of three years, to maintain the water level in the lake. The average sum offered was 201 AMD per month. Assuming half of Armenia's households would indeed be willing to pay such a sum over the course of three years, the value of maintaining Lake Sevan is estimated at US $4.6 million (at 2003 average exchange rates). Higher average sums, were offered to raise the level of the lake by 3 metres. Of note is that the lake levels have dropped by 18 metre in the past. A follow-up willingness-to-pay study of Armenian Diaspora showed Diaspora households were willing to contribute a one-time payment of between US$81 and US$281 toward the preservation of Lake Sevan. If all households of the Armenian

[11] Geoinfo Ltd, 2001. 'Introduction of Payment for Ecosystem Services Schemes in Upper Hrazdan Pilot River Basin of Armenia'.
[12] Gundimeda, H. 2012. Payments for Ecosystem Services Feasibility Study for Lake Sevan, Armenia.' GOST Advisory.
[13] Estimating willingness-to-pay with random valuation models: an application to Lake Sevan, Armenia[13], Hua Wang, Benoit Laplante, Xun Wu. Results published in World Bank Policy Research Working paper 3367 August 2004.

		Diaspora were willing to provide a one-time donation equivalent to the average willingness-to-pay estimated in this paper, this would represent between US$31 and 108 million. (Laplante, Meiser and Wang, 2005) The values represent the cultural value to the Armenian Diaspora.

Source: Gundimeda (2012)

A high level valuation of key provisioning services was undertaken at the site, **focused on Karaberd Village and settlement only**. It was not possible within the study to value regulating services. This would require more detailed bio-physical studies in the first instance in order to quantify these services and specify their links to economic activities.

8.2 Valuation of key provisioning services at the study site

8.2.1 Crop cultivation

According to the 2013-2016 Social-Economic Development program of Karaberd Village, the community has 1,719 ha of lands made up of: 1,477 ha agricultural land; 38ha under settlement; 15 ha of mining land; and, 148 ha forest and wetlands. In terms of agricultural land 108 ha is arable, 373 ha grasslands, 424 ha pastures and the rest is under 'other' land uses. The arable lands are not cultivated and have turned into pastures and grasslands. The harvest and revenue from crop cultivation is presented in Table 20.

Table 20: Karaberd - crop production and revenues, 2012

Agricultural product	Quantity, tons	Market price of 1 kg, AMD[1]	Total revenues, thousand AMD	Total revenue US$
Potato	26	130-150	3,380-3,900	8,346-9,630
Vegetables	2.1	200-300	420-630	1,037-1,555
Apple	30	300-400	9,000-12,000	22,222-29,629
Pear	7	300-400	2,100-2,800	5,185-6,913
Plum	30	200-300	6,000-9,000	14,814-22,222
Cherry	0.4	200-250	80-100	197-246
Walnut	1.2	1'200-1'500	1,400-1,800	3,457-4,444
Hay	140	30-50	4,200-7,000	10,370-17,284
Total	237	-	26,580-37,230	65,630-91,926

Note: 1/ Market price signifies the price at which the villagers sell the agricultural product to middlemen or processing entities.

8.2.2 Wild berries, fruits and mushrooms

The local residents of Karaberd Village collect berries, fruits and mushrooms as summarized in Table 21.

Table 21: Karaberd Village – collection of wild products per year

Agricultural product	Quantity, tons	Market price of 1 kg, AMD	Total revenues, thousand AMD	Total revenue US$
Mushroom	0.6	1,000-1,500	600-900	1,481-2,222
Wild fruits and berries	3	1,000-1,500	3,000-4,500	7,407-11,111
Total	3.6	-	3,600-5,400	8,884 – 13,333

Source: NSS

8.2.3 Animal husbandry

According to the 2013-2016 Karaberd community development program as of January 2013 Karaberd village had 297 cattle heads (including 131 cows, 37 heifers and 17 bulls). The number of small cattle in the community amounted to 128 heads, 6 heads of pigs and 313 heads of poultry. Only one household keeps small cattle close to the proposed mine (around 100 heads of sheep).

Revenue from animal husbandry is mainly generated from the sale of milk. Due to intensive milking practices, the young cattle grow slowly and only pick up weight at 2-3 years of age. Cattle are not bred for meat production. According to the household survey in Karaberd Village, the community members sold 13 heads of cattle in 2012 (for 4.4 million AMD in total or 338.000 AMD per head). The households living in Karaberd Settlement sold 14 heads of cattle for 1.5 million AMD in total (Table 23).

Table 23: Animal husbandry produce and revenues

Agricultural product	Quantity, tons	Market price of 1 kg, AMD[1]	Total revenues, thousand AMD	Total revenue US$
Milk and dairy (of large cattle)	260	90-120	23,400-31,200	57,778-77,037
Meat and meat products (of large cattle)	2,9	1,800-2,000	52,20-5,800	12,888-1,432
Meat and meat products (small cattle)	1.8	2,400-2,600	4,320-4,680	10,667 – 11,555
Total	265	-	32,940-41,680	81,333 – 102,913

Note: 1/ Market price signifies the price at which the villagers sell the agricultural product to middlemen or processing entities.

8.2.4 Bee-keeping

According to the 2013-2016 Karaberd community development program, Karaberd community members have 108 beehives. The productivity of one bee family in Armenia is 8-10 kg per year season (Community data base and NSS RA). Harvest levels and revenues from beekeeping in Karaberd are presented Table 23. The costs related to beekeeping have not been deducted, so the revenues presented represent gross values.

Table 23: Karaberd – Honey production and value

Agricultural product	Quantity, tons	Market price of 1 kg, AMD[1]	Total gross revenues, thousand AMD	Total US$
Honey	864-1080	3,000	2,592 – 3,240	6,400-8,000

Note: 1/ Market price signifies the price at which the villagers sell the agricultural product to middlemen or processing entities.

8.2.5 Fuelwood

Logging wastes and wood logged for sanitary purposes are purchased by locals for use as firewood. On average, one household pays around 11,000 AMD (US$27). A total of 880,000 AMD (US$2,173) is paid by all households.

9 Economic analysis of alternative mining options

9.1 Overview of Scenarios

This study has attempted to compare three possible land use scenarios for the study site. These are (i) Business as Usual Mining, under which the mine would be operated as proposed by the mining company; (ii) Best practice mining, which draws on international standards and guidance for mining operations and seeks to minimize all impacts on the environment and compensate for unavoidable impacts; and, (iii) An alternative development option, which considers how the area could develop sustainably without the mine. These scenarios are summarized in Table 24.

Table 24: Land use development scenarios analyzed

Scenario	Description
BAU Mining	Analysis based on production quantities and mining practices proposed by company
Best practice mining	Analysis based on best international practices and restoration of damage to ecosystems and equitable distribution of benefits from mining
Alternative development scenario / No mining	Development of local communities enterprises, based on best practice agriculture and bee keeping

Table 25 provides a qualitative assessment of the significance of the ecosystem services under each of the scenarios relative to the baseline. It is apparent from this qualitative assessment that each specific land use involves tradeoffs. If the area is mined, there are economic benefits from the sale of minerals; however there are potential negative impacts on food production, pastures, water availability, hydrological services and erosion and sediment control functions. Conversely, the no-mining option, while avoiding many negative impacts on ecosystem services, foregoes the revenues from mining.

Table 25: Qualitative analysis of Ecosystem Services and the expected temporal impact under the proposed scenarios

Ecosystem Service category	Service (Benefit / outcome)	Significance under the baseline[1]	Mining [2]	Best practice Mining[2]	No mining alternative[2]
Provisioning Services	Minerals	-	+/-	+/-	-
	Food	++	-	-	+
	Fodder	+	-	-	+
	Water	++	--	--	+
	Fuel	-	0	0	0
	Biochemical and medicinal resources	+	-	-	+
	Genetic resources	-	0	0	0
	Ornamental resources	-	0	0	0
Regulating Services	Sink for atmospheric carbon dioxide (carbon capture)	+	--	--	+
	Micro-climate regulation	-	-	-	0
	Hydrological services (regulation of timing and volume of river flow)	+	--	--	+
	Flood risk regulation (protection of property, agricultural land, human lives)	+	-	-	+
	Protection against storms	-	*0*	*0*	0
	Control of erosion and sediments	+	--	--	+
	Regulation of pest and pathogens	-	0	0	0
Cultural Services	Cultural, spiritual, religious,	-	0	0	0
	Scientific and educational information	-	0	0	0
	Tourism and recreation	-	0	0	0

1/ Code: ++ means that the service is important; + means that the service is provided; - means that the service is not relevant; and, ? means that there is uncertainty surrounding the provision of a service.
2/ Code: + : constant positive effect; +/- : initial positive effect but returns start to decline due to resource degradation; 0 no /neglible effect; - : negative effect; - - significant negative effect

9.2 BAU Mining

A detailed **financial analysis** of the mine, under the BAU scenario, is provided in a project report 'Economic Assesment for Karaberd Gold Mine,' and summarised below.

9.2.1 The Open Pit Mine

The annual operating costs for Karaberd open-pit are presented in Table 26. Operating costs total US$1,106.500 or US$91.31/ton of ore.

Table 26: Operating costs of Karaberd open-pit

Cost items	Annual costs, US$	Cost / tonne ore, US$
Material cost	291,700	24.1
Labour cost	116,400	9.6
Depreciation charges	125,100	10.3
Permanent repair costs	62,550	5.2
Transport costs	157,300	12.98
Government duty for mine operating license	24,100	1.99
Environmental charges and recultivation costs	6,530	0.54
Royalties	322,83	26.6
Total	1,106,500	91.31

According to article 19 of the Law of the Republic of Armenia on State Duties, an annual state duty should be paid for the authorization to utilize (operate) metal mines amounting to 10,000 times the minimum salary in the country, i.e. 10,000,000 AMD (US$24,100), which amounts to US$1.99 per ton of ore.

In addition, on authorization of a license, the legislation of the Republic of Armenia requires payment of **royalties** based on the following formula:

R = 4 + [P/(Rx8)]x100

where[14]

R - rate of the royalties in %;
P – annual profit before taxation in Armenian drams. This is determined as the difference between the royalties calculation base and the reductions prescribed by the Law of the Republic of Armenia on Profit Tax (excluding expenditures for financial activities and tax losses for previous years);
R –receipts from the sale of products, in Armenian drams, excluding VAT.

Calculations of the royalties for the Karaberd gold mine are:

R = US$ 2,550,000 /year,
P_{yr} = R-NC_f, where, NC_f – Net cost of the extraction, transportation of gold ore (i.e. US$ 783,680 /year);
P_{yr} = US$ 1,766,320 /year (US$2,550,000-783,680),
R = 4 + [1,766,320.0 /(2,550,000.0x8)]x100=4+8.66=12.66%

Accordingly, royalties will amount to US$322,830/year (2,550,000.0*12.66/100), or US$26.6/ton.

Environmental payments are legally required for waste and emissions, as well as for recultivation operations at the mine. According to the Environmental Impact Assessment Report for Karaberd gold mine, the damage to the surrounding environment caused by the project amounts to 2.71 million Armenian drams a year (US$ 6,530, or US$0.54 per ton of ore).

Based on gold prices of US$1,400 per ounce (US$45.01 per gram), and silver prices of US$22.5 ounce (US$0.72 per gram), and an average content of conditional gold in the open-pit of 5.81

[14] The law of Republic of Armenia on nature protection and nature utilization payments

gram per ton, the extraction value per ton of ore is US$261.5 (5.81*45.01), which amounts to an annual value of US$3,170,000.

The cost of gold extraction at the factory in Ararat is US$25 per ton of ore. The profits (fees) of the processing organization are taken as 10% of the extracted value. Thus, the annual proceeds from the sale of the commodity products from Karaberd gold mine will amount to US$2,550,000 ((261.5-261.5*0.1-25.0)*12,122.0 tons), or US$210.3 per ton.

The annual *net* profit of the open pit mine will therefore amount to US$1,443,500. Over its 3 years of operation the cumulative profit of the Karaberd gold mine will amount to US$4,330,500 (this does not account for capital costs).

Capital investments include the acquisition of fixed assets (US$835,000) and the requirement for working capital (accepted at the rate of 50% of fixed capital, amounting to US$417,750). Thus, the overall capital investment in the open-pit will amount to US$1,253,250. This investment can be recouped in 0.9 years[15].

9.2.2 The underground mine

The operation costs of Karaberd underground mine are presented in Table 27. Total annual operating costs are US$2,112,950, or US$70.46 per ton of ore.

Table 27: Operating costs of Karaberd underground mine

Costs	Annual costs, US$	Cost / tonne ore US$
Material cost	344,600	11.5
Labour cost	347,600	11.58
Depreciation charge	160,500	5.35
Permanent repair costs	80,500	2.7
Transport costs	389,400	12.98
Government duty for mine operating license	24,100	0.8
Royalties	766,500[16]	25.55
Total	2,112,950	70.46

The operational stocks of minerals/ore, gold and silver amount to 239,081.9 tons, 1,232.58 kg and 2,216.3 kg respectively. After the conversion of the silver stocks into gold, gold stocks amount to 1,261.4 kg; and the average content of gold equivalent in the underground mine is 5.28 g/ton.

The annual output of the underground mine is 30,000 tons over 8 years. The extracted value per ton of ore is US$237.6 (the average gold equivalent (5.28) * price (US$45.01)), which amounts to an annual value of US$7,129,000.

The ore processing costs for gold extraction per ton of ore is about US$48.81 (US$25 are processing costs and 10% of the receipts (US$23.81) are the processing Company's profit).

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[15] The formula for determination of the payback period of capital investments is:

$T=K/P_{yr}$, *where*:

T- payback period of capital investments;

K- total investments, equal to US$1,253,250;

P_{yr} - average annual profit, equal to US$1,443,500.

[16] Royalties for the underground mine are:

R= US$5,665,200/year,

NC_F= US$1,346,450/year,

P_{yr}= US$ 4,318,750 /year (5,665,200.0-1,346,450.0 thousand US dollars),

R = 4 + [4,318,750.0 /(5,665,200.0x8)]x100=4+9.53=13.53%:

Thus, the **annual revenue** from the sale of the commodity products from Karaberd underground mine will amount to US$ 5,665,200, which is equal to US$188.84 per ton.

The net annual profit of the mine is therefore US$3,551,400 or US$118.38/ton. Over the eight years cumulative net profit (3,551,400.0*8) amounts to US$28,411,200 (not accounting for capital costs).

Capital investment required for the underground mine is US$1,039,000. Hence the payback period on capital investments will be 0.3 years.

Throughout the operation period of Karaberd gold mine the cumulative profit (not accounting for capital costs) will amount to US$32,741,700 (US$28,411,200 from the underground mine and US$4,330,500 from the open-pit mine).

Sensitivity Analysis

Sensitivity analysis on a range of key variables indicates the financial robustness of the proposed mining operation. The impact of changes in operating costs (Table 28), the anticipated gold content of the ore extracted (Table 29) and the price of gold (Table 30) on the payback period suggest that even given an increase in cost by 40% or a fall in the gold price or gold content by 40% the payback period on capital invested will not exceed 2.6 years.

Table 28: Impact of increased operating costs on the capital payback period

	Operation costs	Annual profit, USD	T, Year
Operation costs (basic)	1,106,500	1,443,500	**0.9**
Operation costs increase by 20%	1,327,800	1,222,200	**1.0**
Operation costs increase by 40%.	1,549,100	1,000,900	**1.3**

Table 29: Impact of change in gold content on the capital payback period

	Annual revenue, USD	Annual profit, USD	T, Year
The gold content in ore (basic C_r=5.84g/t)	2,550,000.0	1,443,500.0	**0.9**
The gold content in ore have decrease by 20% (C_r=5.84*0.8=4.67g/t)	1,980,300.0	967,143.24	**1.3**
The gold content in ore have decrease by 40% (C_r=5.84*0.6=3.5g/t)	1,408,700.0	489,731.2	**2.6**

Table 30: The gold price change dynamics on capital payback period

	Annual revenue, USD	Annual profit, USD	T, Year
Gold price (basic P=45.01 USD/g)	2,550,000.0	1,443,500.0	**0.9**
Gold price have decrease by 20% (P=36.0 USD/g)	1,978,800.0	975,491.8	**1.3**
Gold price have decrease by 40% (P=27.0 USD/g	1,408,300.0	521,696.9	**2.4**

9.2.3 Economic analysis

The financial analysis presented above does not take into account the social impacts of the mine, both positive and negative.

The mine could contribute to the social and economic development of the country in general, and the region of Vanadzor in particular, by:

- Attracting investments of US$2,292,250 at the expense of extra-budgetary resources;
- Increasing the taxes and duties payable to the budget by US$1,374,336.88 per year.
- Creating 20 workplaces at the open-pit and 51 workplaces at the underground mine;
- Creating additional employment in the form of indirect jobs;
- Increasing the sale of local goods and services.

The negative social impacts of the mine include environmental degradation (land, forest, water) and the lost income opportunities for local residents. These costs should be taken into account when decisions are made on land use. However, it has not been possible to monetize many of the anticipated impacts of the mine, due to a lack of data. The available evidence is provided below.

Around 3,000 square meters of orchards belonging to the local community in the vicinity of the mine with an annual output of 2-4 tons are likely to be impacted by the mining project. Using a market price of 300 AMD per kg, this lost is valued at 600,000 – 1,200,000AMD (US$1,481-2,963).

The 6.4 ha of the mine includes forests and bushes where locals pick **wild berries and fruits**. These areas will be compromised as a result of mining, with an estimated 200-300kg of wild berries and fruits lost to the local communities. Based on a market price of 1,000 AMD/ kg, this lost output can be valued at 200,000 -300,000 AMD (US$494-740) per year.

Mining will not threaten the forest adjacent to Karabard Village. However 3.9 ha of forest in the territory of the mine and the small valley next to the mine will be compromised. This forest area is used by local residents, and wildlife to a limited extent. It was not possible to quantify the impact of the proposed mine on fuelwood collection or biodiversity.

The mine may affect water quantity / quality. The community receives drinking water from natural springs. It has not been possible to estimate the amount of water used for drinking, household, irrigation and industrial purposes. It is possible that the natural springs close to the mine that are used by the locals will dry up as a result of the proposed mining operation.

It is also possible that air pollution caused by the mine will contribute to health problems in the area. The area already has a high incidence of respiratory diseases, which has been linked to air pollution in other countries. The data are not available to undertake such an assessment at the site. This would require an understanding of the increased on PM10 attributable to the mining operations and a dose-response function (Box 1).

Box 1: Estimating the health impacts of pollution

Health effects from environmental pollution include mortality and various forms of morbidity in adults and children due to air pollution (elevated PM10 concentrations), and from diarrhoea and typhoid related to water pollution. Environmental pollution causes diseases that are a burden to both the individuals affected and to society as a whole. Removing such a burden is a ‘benefit’.

Site-specific valuations of the health impacts of pollution requires a complex set of data: pollutant exposure, dose-response function, consideration of cumulative effects, and mitigation efforts by households.

A diagnostic study by the World Bank assessed the costs to health of environmental degradation in India (World Bank 2013)[17]. The Bank assessment found that air pollution is the most costly environmental pollutant in the country. The assessment estimated the costs of six types of environmental damage: air pollution (outdoor and indoor), water pollution, and land degradation (soil, rangeland and forests). Of this list, the cost of air pollution to human health ranks first, accounting for 29% – Rs 1.1 trillion – of the estimated total damages of Rs 3.75 trillion (US$80 billion) from six types of environmental degradation.

Health costs can be valued using various methods.

- The World Health Organization estimates country-specific DALYs (Disability Adjusted Life Years) which are years lost to death and illness because of diseases such as diarrhoea, lower and upper respiratory infections, and pulmonary obstruction, among others. DALYs are based on exposure to the pollutant and the concentration- or dose-response. A DALY represents a lost year of productive time, therefore given the value of a lost year (per capita income adjusted to capture income differences among populations - urban versus rural, employed versus unemployed), the DALYs permit a valuation of the human health effects attributable to environmental pollutants.
- Survey work may be used to determine the amount that people would be willing to pay to avoid exposure to pollution through, for example, the installation of pollution abatement facilities.
- Surveys may also be used to collect data on days off work due to illness and expenditure on medicine / health care, which can be used as a proxy for the cost of the health impact.
- In the absence of site-specific data and original research, economic valuation of environmental goods and services often relies on "benefit transfer" methods. In these valuations, estimated values from research in regions/localities similar to the region/locality of interest, are 'transferred'. The estimated values are typically adjusted for local conditions such as population and household characteristics and the number of reported cases of different health effects.

Furthermore, the financial analysis does not consider all potential risks. For example, the Company intends to sell the ore to the processing factory in Ararat, but other companies have already experienced problems selling their ore and are planning to set up their own processing factories. Risks associated with ecosystem degradation are highlighted in Box 2.

Box 2: How ecosystems and biodiversity can impact the bottom line

ES degradation and loss can give rise to the following risks[18]:

Operational risk: Increasing scarcity of raw materials may lead to a narrowing of margins or disruption to operations and where natural defences have been compromised, greater disruption of business operations and higher insurance costs from disasters may be experienced.[19]

Regulatory and compliance risk: Risks are arising relating to new government policies, greater legislation, development of market based instruments and compensation regimes, or tightening restrictions on the extraction of resources from biologically sensitive sites[20] . The Indian government recently refused to allow mining company Vedanta to develop a US$2.7 billion mine in Orissa as a result of infringements of environmental and human rights laws.

Market risk: Purchasing preferences are shifting as consumers and companies become increasingly concerned about loss of biodiversity and certification schemes such as the Responsible Jewellery Council are developing for responsibly mined products.

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[17] World Bank, 2013. India Diagnostic Assessment of Select Environmental Challenges: An Analysis of Physical and Monetary Loses of Environmental Health and Natural Resources. Disaster Management and Climate Change Unit. South Asia Region.
[18] **UNEP** (2010) Are you a green leader?
[19] **TEEB** (2010) TEEB for business
[20] **PWC** (2010) Biodiversity and business risk. A Global Risks Network briefing World Economic Forum January 2010

Reputational risk: Association with adverse impacts on biodiversity and ecosystems can damage a company's brand and restrict its 'social license to operate.'

Financing risk: As investors and lenders put in place more stringent environmental requirements, securing access to finance will require more rigorous environmental performance. The Norwegian Government Pension Fund withdrew their euro 604 million investment from Rio Tinto over concerns that it is causing "severe environmental damage" through joint mining operations in Indonesia.

9.3 Best practice mining

9.3.1 Best practice and the mining life cycle

Environmental damage is likely to occur in the process of the gold mine operations - especially during extraction and transportation, but also during the mine closure and reclamation. A qualitative assessment of how operations at the Karaberd gold mine could be aligned with International best practice mining is provided in this section. It has not been possible within the study to quantify and monetize the costs and benefits of the proposed practices.

Ore extraction (drilling and blasting works)

Ore extraction at Karaberd gold mine is to be carried out through local drilling and blasting operations. According to the mine master plan, it is envisaged to use ammonite N6 and ammonal explosives. For the past ten years the use of such explosives for industrial purposes has been prohibited in European countries due to their toxicity. The basis of the explosives in this group is ammonia saltpeter (72-80.5%), the remaining component are aluminum dust (1.5-4.5%), TNT (trinitrotoluene) (15-21%), and some cyclonite (1.5%) (http://ru.wikipedia.org/wiki/Аммонит). The last two are considered to be strong toxins.

In general TNT detonation emits gases which are 10 times more dangerous. One kg of TNT releases 800 liters of gas, of which 300 liters is nitrogen oxide and CO. These gases mingle with water in the atmosphere and fall in the form of acid rain, which can extend to ten km. Furthermore they can cause fossil groundwater contamination. TNT explosives also have a relatively high price.

Best practice mining assumes the application of various **emulsion explosives**. Emulsion explosives are 1.5 - 2 times cheaper than TNT, they emit gases which are at least 10 times less harmful, they do not cause groundwater contamination, and, some types can be collected after the blasting activities, recycled and reused. Two companies in Armenia are currently using emulsion explosives. Greater awareness of the benefits of emulsion explosives, plus effective marketing is required to encourage greater uptake.

It would be more beneficial to apply emulsion explosives in Karaberd gold mine, as well as other mines in Armenia. However, the application of any explosives results in gas emissions which can be minimized or absorbed through:

- Optimal choice of explosive charges,
- Ventilation of underground mines and using gas absorption equipment and effective cleaning.

The blasting regime adopted is also important. Less blasting can reduce soil destruction and the cracks that will appear reducing the impact on water resources. However it is more expensive to reduce the level / number of explosions as it is more labor intensive and requires additional drills and cables.

Ore transportation

Based on the master plan for Karaberd gold mine, it is envisaged to transport the ore to Vanadzor railway station by dump trucks, after which it will be transported to Ararat gold recovery plant. The main environmental damage related to ore transportation is dust generation. According to mining practices in Armenia, ore transportation by vehicles and railway is carried out by open dump trucks and wagons which can be a source of dust. Transportation of wet ore can cause additional transportation expenses.

It is preferable to transport dry ore (a covered storehouse for ore should be designed) by **closed dump trucks** which will decrease environmental damage and cut transportation costs. In some parts of the world, liquid substances are applied during the open transportation of ore, which is also very effective.

Dust is caused by vehicle movement on dirt roads. It is envisaged that Karaberd Gold Mine will use sprinkling machines to control dust, but water treatment is not envisaged, thus sprinkling machines can lead to water contamination. According to international best practice, asphalt and concrete access roads should be constructed; this is also cost-effective in terms of minimizing machine maintenance costs. It is recommended to collect, treat and reuse contaminated water.

Mine closure

After decommissioning the mine area is rehabilitated and closed. International best practice in terms of mine closure includes the following aspects:

- Development of a mine closure plan at the initial stages of the mine's life, which considers the special characteristics of the site. For mines such as Karaberd, which have a short service life, it is desirable to develop a mine closure plan at the design stage. Typically in Armenia such plans are only developed towards the end of the mine's operation.
- The mine closure plan should be based on a risk assessment.
- The mine closure plan should be updated and revised in accordance with any changes in mine operations.
- The company should be economically prepared for the closure of the mine throughout the operational phase.
- Land use of the area should be optimized. This includes an assessment of the possible future use of the area which conserves / rehabilitates the areas biodiversity.
- Re-use of dismantled materials.
- Reviewing physical and chemical stability of the buildings designed in the master plan of the mine.
- Removal or disposal of structures and buildings.
- Removal or management of waste water.
- Minimization of negative social and economic impacts and consideration of local community needs (e.g. restrictions to recreational use).
- Open communications with all stakeholders on mine closure and rehabilitation of the area.

Reclamation of the mine area

Rehabilitation of the mine area should ensure that the area blends in with its surrounding landscape and biodiversity is maintained. The physical safety of the area (e.g. prevention of contamination caused by mine water) can be ensured by:

- making open-pit slopes stable, reinforcing open-pit area with stones or filling with water;
- preventing the collapse of underground mine openings. The process of extracting descending layers and filling extracted areas with broken lateral (waste) rocks has been chosen for Karaberd's underground mine. This reduces the possibility of surface collapse and promotes closure of openings.

The contamination of natural reservoirs caused by the mine water depends on the following factors:

- the mineralogical and chemical composition of the ore deposit, as well as hydraulic characteristics (fracturing),
- weathering of walls of the open-pit,
- hydraulic characteristics of the surrounding bedrocks,
- the mining waste materials in the processed areas and their composition.

Contamination of natural water can be prevented or reduced by:

- surfacing open-pit walls with special covers during the operational stage,
- removing all unnecessary and contaminating infrastructure, appliances and materials/reagents from the open-pit area,
- assessing and surveying the possible directions of mine water flows (blocking flow routes, water collection and treatment),
- making technical assurances that the mining waste materials available in the processed areas will not cause contamination,
- conducting biological and chemical treatment of the mine water (e.g. sulphate reducing bacteria, alkaline treatment),
- monitoring and control of water treatment effectiveness.

International best practice to mitigate mining impacts by pollutant / impact is further discussed below.

Atmospheric emissions, noise and vibration

Drilling and blasting activities, transportation of the ore and the use of ore crushers are considered to be the main source of atmospheric emissions. In order to control and reduce all sources of dust emissions, monitoring activities should be carried out in the mine area. The main methods of monitoring atmospheric emissions are:

- Regular measurement of dust particles available in the atmosphere;
- Audio recordings and video filming of the blasting activities for optimization of explosive charges.

Regular measurement is required to monitor noise levels. The best method of monitoring vibration is studying the potentially impacted object both before and in the process of mine operations. In general, noise and vibration can be mitigated through using quiet equipment and technologies, containment of noise source, construction of soundproofing buildings, proper organization of blasting activities (blasting stages, optimal choice of explosive charges) coordination of the schedule of noise and vibration generated activities with the local community.

Monitoring of contaminated water

In order to control water quality, the following activities should be carried out:

- Monitoring of water treatment,
- Collection of information on different water fractions and substances discharged into water as well as impacts of those on the downstream waterways (chemical, biochemical, physical, etc.).
- Installation of water purification systems.

Water recycling is practiced in Armenia, especially for the larger mines (Table 31). For example, Dandee precious metals company in Kapan use water recirculating systems in their enrichment plant and recycled water from tailings ponds and saves money as a result.

Table 31: Use and recycling of water: examples of metal mines in Armenia

Mine/production plant	Water intake m^3/year	Source of fresh water	Sources of recycled water	Recycling %
Armanis	2,232,870	Recirculated water	Tailings pond	88.1
Kajaran*	39,586,199	Voghji and Geghi river, dewatering water from open-pit	Collecting water from open-pit	1.8
Shahumyan	2,651,750	Recirculated water	Tailings pond	Over 90
Agarak (only open-pit)	1,261,110	Dewatering water from open-pit	Settling pond	2.0
Sotq (only open-pit)	340,830	Dewatering water from open-pit	Settling pond	3.7
Karaberd	925	Pambak river	-	0

Ore enrichment and placement of enrichment tailings

In order to safely maintain tailings, it is important to:

- apply substances that will enhance the neutralizing capacity of tailings (lime mixture, mineral powder containing carbonate);
- apply methods for breaking down harmful substances prior to disposal of tailings or reduce residues in tailings;
- promote the binding of potentially harmful microelements by adding chemical reagents; and,
- Investigate the occurrence of diverse precious 'high-tech' minerals and metals (e.g. lanthanides, Ga, In, Nb, Li), which can promote utilization of these tailing particles in the future.

Some examples of best practice management of mine tailings in Armenia are provided in Box 3.

Box 3: Kapan - Shahumyan mine and Geghanush tailings dam

In Kapan the local geology features high pyrite content, therefore Acid Mine Drainage and the subsequent mobilization of heavy metals to the environment is a problem. The mining company considers water pollution as the most relevant single environment risk facing their operations. To minimize this risk, several mine water streams, from old as well as operating mines, are collected and fed into the ore concentration process in a closed cycle, thereby avoiding the natural environment.

The company monitors the natural streams and discharges from its operations on a regular basis. These measurements are periodically checked by the environment inspectorate in Kapan. Each company has an emissions and water supply allowance, depending on the size of the operations. When the allowance is exceeded, the company is obliged to pay an environmental fine. In addition the companies pay a fee for using the natural environment; this fee is transferred to the local communities where the company is located. Fees and royalties related to mineral extraction however are transferred to the state budget and do not support the local community.

Geganush tailings dam

The Geghanush tailing dam resumed operation in 2008. It is covers an area of 200,000 m^2 and has a volume of 11mllion m^3. The dam features closed water cycles with the concentrator plant, which minimizes toxic discharges and increases economic productivity. The refurbishment of the old facility included the construction of new clay lined dam walls at both sides of the storage area, which is reportedly preventing seepage of any deposited waste to the environment. The tailings facility is located on the river, which flows in to the Voghji river shortly after the tailings dam.

Measures mitigating or reducing social impact

The following measures can be followed by Mining Companies to mitigate or reduce social impacts:

- Maintaining a dialogue / information exchange between the mining company and local communities.
- Taking care of the living conditions of employees and their families.
- Promoting public services such as education, health and social programs of the community.
- Establishing favorable conditions for social and economic development of the community and employees involved in mine operations after its closure. Very often, after the closure of a mine, communities express a wish to develop tourism - this has potential in Armenia.

9.3.2 Compensating for ecological costs[21]

Increasingly the mining sector is taking action to compensate for its ecological costs, through activities that enhance biodiversity in the regions they operate. This may include participation in biodiversity offsets or other schemes to mitigate and/or compensate for unavoidable residual

[21] This section is from TEEB, 2010

impacts. Such initiatives are encouraged by the growing realisation by mining companies that that they require a licence to operate from society, both literally through planning and permitting processes, and in a wider sense through concepts of good corporate citizenship.

As noted, some damage to ecosystems from mining activities is inevitable. In recognition of this, a few companies are exploring concepts such as 'No Net Loss' and 'Net Positive Impact', in which unavoidable, residual biodiversity impacts are offset by conservation activities (usually very close to the impact site), with the aim of being at least equal in value to damages that cannot be avoided.

For example, Rio Tinto has taken up **Net Positive Impact on biodiversity** as a long-term goal, a policy announced as a voluntary measure in 2004. This involves avoiding and minimizing negative impacts in the first instance, and then rehabilitating areas affected by the company's activities. Once the adverse impacts are reduced as far as possible using these steps, offsetting and additional conservation actions are undertaken as required to achieve a net positive result for biodiversity (TEEB, 2010).

Achieving Net Positive Impact requires the **development of reliable tools to assess and verify the biodiversity impacts** of a company's activities, both positive and negative. In association with several conservation organizations, including the Earthwatch Institute and IUCN, Rio Tinto has begun to test Net Positive Impact in Madagascar, Australia and North America. Other efforts to develop indicators and verification processes to assess business impacts on, and investments in, biodiversity include the Business and Biodiversity Offset Program (BBOP) and the Green Development Mechanism (GDM) initiative.

Some governments have introduced incentive mechanisms to encourage or require mitigation and compensation for adverse impacts. In a few cases, new markets for ecosystem services or biodiversity 'credits' have been established, in which extractive companies may be both significant buyers and sellers, due to their role as land managers as well as their responsibility for land disturbance.

Wetland Mitigation Banking in the United States was one of the first such schemes to be established. It requires developers to compensate for damage to wetlands, either directly or by purchasing credits from third parties, based on the restoration of wetlands in the same watershed. Although the approach is still evolving, the market for US wetland credits is currently estimated to be worth between US$ 1.1 and 1.8 billion annually (Madsen *et al*. 2010)[22].

Several **Australian states** have introduced similar schemes, whereby disturbance of native vegetation and impacts on species habitats may be compensated by an appropriate offset, generated by active conservation or restoration projects. Examples include the Biobanking scheme introduced in New South Wales in 2008; and the Bushbroker scheme in Victoria, which has so far facilitated more than AU$ 4 million in trades.

Approaches such as Net Positive Impact, wetland mitigation and bio-banking can help ensure that developers take responsibility for their environmental footprint, while also seeking to maintain natural capital. At the same time, there may be ecological and social limitations to applying biodiversity offsets and other forms of compensatory mitigation, especially where impacts are very large, suitable land for offsets is scarce or mechanisms for community participation are weak.

Mining enterprises may also benefit from the market advantages available for products that can be certified under **social and environmental labelling schemes**. One example is the Chocó region of Colombia, a biologically and culturally rich area with soils containing gold and platinum. Fearful of the impact of large-scale mining on fishing, wood extraction and subsistence agriculture, local communities chose not to rent out their lands to mining companies, but instead introduced their own low impact practices of mineral extraction that do not involve the use of toxic chemicals. The minerals are certified under the FAIRMINED label, giving the communities a

[22] Marsden, B., Carroll, N. and Moore Brands, K. 2010. State of Biodiversity Markets Report: Offset and Compensation Programs Worldwide.'

premium and additional income while sustaining biodiversity and ecosystem services. At a larger scale, the Responsible Jewellery Council is working on standards and assurance processes to guarantee the social and environmental performance in the diamond and gold jewellery supply chain, based on third party audits and certification (Hidron 2009; Alliance for Responsible Mining[23]).

9.4 Alternative development scenario

The alternative development scenario considers how the land could be used if the mining operation did not go ahead. The sustainable agricultural option analyzed here is based on the areas maximum potential. It is generally agreed that animal husbandry and apiculture have good potential in the area, there is also potential for developing agricultural crops given the right infrastructure investments. The potential for developing tourism is limited.

Crop cultivation

While Karaberd has 1,477 ha of agricultural land, most of the land is not cultivated and has turned into grasslands and pastures (108 ha of arable land, 373 ha of grasslands, 424 ha of pastures and the rest are of a different land uses). However, the land, as demonstrated by experiences during Soviet times, can be used successfully for animal husbandry and crop cultivation if the necessary infrastructure investments are made and access to markets guaranteed. Given the geography and climatic conditions of the area the existing 108 ha of arable land could be used to cultivate potatoes, beans and other cultivars if an irrigation system is available. The remaining 524 ha could be used for cultivating fruits, particularly apples, pears, plums, cherries, as well as walnuts. It is also possible to cultivate berries.

Table 35 presents agricultural output and revenue assuming that the agricultural lands of Lori Marz are used to their full potential[24] (based on average productivity levels in 2011 and 2012 prices)[25].

[23] Hidron, C. 2009. Certification of environmentally and socially responsible gold and platinum production, Oro Verde, Columbia.
[24] Agricultural Crop Lands and Gross Harvest, Statistical Summary, NSS, Yerevan 2012.
[25] 2012 was a drought year, so output would have been lower but prices may have been higher during this period.

Table 35: Gross potential agricultural output and revenues from crop cultivation

	Agricultural product[1]	Average productivity in Lori Marz, center/ha	Territory, ha	Quantity, ha	Market price of 1 kg[2], AMD	Total revenues, AMD (1,000s)
1	Potatoes	112.6	108	1,220	100-120	120,000 – 146,400 (US$296,296-361,481)
2	Grain and bean crops	28.1	108	302	100-120 (grain)	30,200 – 36,240 (US$74,567-89,481)
		25.5		270	150-200 (bean)	40,500 – 54,000 (US$100,000-133,333)
3	Vegetable crops	123.5	108	1,339	150-200	200,850 – 267,800 (US$495,925-661,235)
4	Fruits and berries	16.7	524	890	250-300	222,500 – 267,000 (US$549,383 – 659,259)
5	Hay	25.6	373	970	30-50	29,000 – 48,500 (US$71,605-119,753)
	Total revenues 1+4+5					371,500 – 461,900 (US$917,284-1,140,494)
	Total revenues 2+4+5 (grain)					281,700 – 351,740 (US$645,555-868,494)
	Total revenues 2+4+5 (bean)					292,000 – 369,500 (US$720,988-912,346)
	Total revenues 3+4+5					452,000 – 583,000 (US$1,116,049-1,439,506)

Notes: 1/ Estimates are based on the assumption that all the agricultural lands are cultivated for a single crop ; 2/ Market price signifies the price at which the villagers sell the agricultural product to middlemen or processing entities.

Animal husbandry

Based on statistics from the Soviet period together with data on privately bred cattle, the community is estimated to have the capacity to manage around 1,700 large and 3,200 small cattle. According to official statistics of RA, cow heads make up 45-47% of the total of large cattle heads,[26] with the remainder being young cattle and bulls. Guided by this estimation, the potential for cow heads in Karaberd is around 50. The average milk productivity of a cow according to the official statistics is 2,035 kg.[27] For meat production, up to 800 heads of large cattle can be used with an average slaughter weight of 130-150kg. The community breeds pigs in homesteads, however the lack of data on pig and other agricultural animal/poultry heads does not allow the necessary estimations.

Currently, the main source of revenue from animal husbandry is milk sales. Well organized farming, as opposed to the current practices of intensive milking which stifles the growth of young cattle, could ensure the normal growth of the young generation of cattle, and thus increase productivity. Table 36 presents potential output and revenue from animal husbandry.

[26] Armenia Statistical yearbook 2012, NSS, pp 287-307
[27] Ibid.

Table 36: Potential output and revenue from animal husbandry / year

Agricultural product	Quantity, tons	Market price of 1 kg[1], AMD	Total revenues, AMD (1,000)
Milk and milk products (large cattle)	1,526	90-120	137,340-183,120 (US$339.111-452,148)
Meat and meat products (large cattle)	112	1,800-2,000	201,600-224,000 (US$497,777-553,086)
Meat and meat products (small cattle)	45	2,400-2,600	108,000-117,000 (US$266,666-288,888)
Total revenue			446,940-524,120 (US$1,103,555-1,294,123)

Note: 1/ Market price signifies the price at which the villagers sell the agricultural product to middlemen or processing entities (physical or legal).

Beekeeping

Karaberd village has 108 beehives. Based on data from the Soviet period, it is estimated that the area has the potential for keeping up to 500 bee families. The productivity of one bee family during one season is 8-10 kg. Total revenue is estimated between US$29,629 and US$37,037 per year (Table 37).

Table 37: Potential honey production

Agricultural product	Quantity, tons	Market price of 1 kg, AMD	Total revenues, AMD (thousands)
Honey	4,000-5000	3,000	12,000 – 15,000 (US$29,629 – 37,037)

A summary of gross revenues under the Alternative Development Scenario is presented in Table 38.

Table 38: Gross revenues by type of economic activity (AMD)

Agricultural product	Baseline (see section 8) AMD (thousands)	Sustainable Agriculture AMD (thousands)
Crop cultivation	26,580 -37,230 (US$ 65,630 – 91,926)	177,000 – 229,600 (US$ 437,037 - 566,913)
Animal husbandry	32,940-41,680 (US$ 81,333-102,913)	446,940-524,120 (US$ 1,103,556 – 1,294,123)
Beekeeping	2,592-3,240 (US$6,400-8,000)	12,000 – 15,000 (US$ 29,629 - 37,037)
Wildly growing mushrooms, berries and fruits	3,600-5,400 (US$8,884-13,333)	3,600 - 5,400 (US$ 8,888 - 13,333)
Total	65,712 -87,550 (US$162,247 – 216,172	639,540 - 774,120 (US$ 1,579,111 - 1,911,407)

Costs and sustainability issues

Currently, the community uses natural spring water for household and agricultural purposes (animal husbandry) and to a limited extent for their homestead land. In order to carry out the agricultural activities described above, it will be necessary to install an irrigation system and an internal water supply network for household and animal farming purposes. In addition the comprehensive use of pastures will require pasture management and planning, water sources for animals and repair of roads, and the construction of animal barns and infrastructure. It was not possible to estimate the cost of these activities within this study.

Karaberd's community budget

In 2012, the budget of Karaberd village amounted to 4.9 million AMD, of which 1.4 million AMD was generated by the community and 3.5million AMD were subsidies or other payments from the central government. The main source of community-generated revenue is fees from leasing land.

The community's budget will increase if all privately owned and community owned lands are used. The land use fee for 1 ha of community lands is around 14,228 AMD, while the average land tax is around 15,000 AMD. The tax receipts on property (real estate) will also increase if animal barns and other buildings are constructed, however it was not possible to estimate this tax, instead, the 2012 property tax indicator was used based on budget data for 2012. The revenues from community-owned assets will amount to 7,040,100 AMD, and if subsidies are made from the state budget, based on community budget data for 2013 the total revenues will amount to 10,540,100 (US$26,025) (Table 39).

Table 39: Community budget under current and potential agricultural scenarios

Community budget	2012		Potential budget	
	AMD	US$	AMD	US$
Total Revenues	4,908,900	12,121	10,540,100	26,025
of which				
Community revenues	1,408,900	3,479	7,040,100	17,383
of which				
Tax on land	200,200	494	1,620,000	4,000
Tax on property	75,800	187	75,800	187
Fee for community-owned land use	1,132,900	2,797	5,344,300	13,196
Subsidies from the state budget	3,500,000	8,641	3,500,000	8,642

9.5 Summary of scenarios

Table 40 summarizes the quantitative data available for each of the scenarios for key ecosystem services. The data relates to Karabred village only.

Overall the impact of the mine on provisioning services is not likely to be large. Only 3,000 m^2 of orchards belonging to the local community near the mine, with an output of 2-4 tons are expected to be impacted. Further, the mine is estimated to reduce wild fruit and berry collection by only 200-300kg a year. Honey production in Karaberd Settlement is not expected to be impacted.

While air quality according to the Company's EIA is expected to remain within acceptable norms during mining operations, PM10 has not been measured and may have an impact on health. It is also not possible without further study to understand the implications of the mining operation on water flow regulation, and whether local springs will be affected and /or local streams will be at risk of drying up.

Table 40 only covers Karaberd village. Pambak village is expected to lose use of 12ha of pasture land due to the mine but the implications of this in terms of lost productivity have not been calculated

Table 40: Quantitative assessment of options of the impact of each scenario on ecosystem services, for Karabred village only

Ecosystem service		**Impact under scenarios**				
		Units	**Baseline**	**Mining BAU**	**Best practice mining**	**No mining alternative**
Provisioning	Minerals	Amount of product harvested / year	0	30,000 tons 6,4 ha	30,000 tons 6,4 ha	0
	Agricultural products	Amount of product harvested / year	237 tons	233 tons[1]	233 tons	304 tons
	Wild fruits and berries	Amount of product harvested / year	3.6 tons	3.3 tons[2]	3.3	3.6 tons
	Honey	Amount of product harvested / year	0.8-1 tonne	0.8-1 tons[3]	0.8-1 tons	4-5 tons
	Fodder [4]	Amount of product harvested / year	140 tonne 80-90 ha	140 tons	140 tons	970-1,000 tons 373 ha
	Water	Amount of water m^3 used for household, agriculture, industrial use	864 m^3	925m^3 – 3,855m^3 (industrial)	925m^3 – 3,855m^3 (industrial)	864 m^3
	Air quality regulation	Hazardous atmospheric emissions per year (g/sec)	0	9.68 tons/year –open mining 10.56 tons/year - underground mining [5]	5.8ton/year-open mining 6.34ton/year – underground mining[6]	0
	Water flow regulation	Change in river flow	0	?	?	0

Notes: 1/ Only 3,000 m^2 of orchards belonging to the local community near the mine, with an output of 2-4 tons are likely to be impacted. 2/ 6.4 ha will be compromised by the mine resulting in a reduction of 200-300kg in wild fruits and berries; 3/ there are 91 beehives and 3 families engaged in honey production in Karaberd Settlement. However, the impact of the mine is not expected to be significant enough to affect production; 4/ Pambak village is expected to lose 12ha of pasture land but the implications of this in terms of lost productivity have not been calculated; 6/ based on EIA; 7/ Based on expert opinion.

The monetized results across the three scenarios are summarized in Table 41 in terms of their expected gross and net revenue. Gross revenue under the BAU mining option exceeds that of the optimal sustainable agricultural production. It was not possible to compare net revenues across the options as the costs of the sustainable agricultural scenario were not estimated. Of note is that fact that the mining options and sustainable agricultural production options are not totally mutually exclusive. Only a small area of land is expected to be impacted to the mine. It is therefore feasible to develop agriculture alongside the mining operation, and achieve significant gains relative to the baseline.

Table 41: Overview of Scenarios (US$)

	Baseline	**BAU Mining / year**	**Best Practice Mining**	**Optimal (Sustainable) Agricultural production / year**
Gross revenue	US$162,247 – US$216, 172	Open pit mine: US$ 3,170,500 (a year for 3 years) Underground mine: 5,665,200 (for 7 years)	Assumed to be the same as the BAU scenario	US$ 1,579,111 – US$ 1,911,407 (on-going)
Net revenue	*Costs not estimated*	Open pit Mine – US$1,443,500 per year (3 years) Underground mine US$3,551,400 per year (for 8 years) (excludes capital costs)	*Additional costs / benefits of mining operation based on best international practice not calculated*	*Costs not estimated but will include investment in irrigation systems*
Net revenue *minus* environmental externalities	*Environmental externalities not estimated but overgrazing evident in some areas*	Open pit Mine – US$ 1,439,797 per year (3 years) Underground mine US$3,547,697 per year (for 8 years) [1]	*Additional costs / benefits of mining operation based on best international practice have not been calculated*	*Environmental externalities not estimated but the sustainable agriculture option should address the negative impacts under the baseline.*

Notes: 1/ This includes the lost income from agriculture and the collection of wild berries and fruits, taking the upper end of the scale of US$3,703 per year.

9.5.1 Caveats

It has not been possible to undertake a cost benefit analysis of the three scenarios, as net revenue is not estimated for the 'no mining' scenario. Furthermore, only a limited number of ES have been monetized. Impacts on water flow regimes and health may be significant but data are missing to link the impact of the mine to changes in water flow or to changes in ambient air quality. These 'costs' should be deducted from the benefits of mining.

NPVs are not calculated as it would be misleading to calculate NPVs given gross estimates are not available for all the scenarios. It should be noted however, that the benefits of mining will occur over 11 years, while ES, if sustainably managed, will continue for a much longer period.

9.5.2 International examples

Some international studies that have valued mining impacts and /or compared alternative mining options or land uses are provided below (TEEB, 2010).

In some cases, biodiversity valuations have provided arguments against mining. For example, in the early 1990s Australia's Reserve Assessment Commission (RAC) investigated the options of either opening up the Kakadu Conservation zone for mining, or combining it with the adjoining Kakadu National Park. The commission conducted a contingent valuation study to estimate the economic value of the expected damage to the site should the mining go ahead. The result, based on an average w*illingness to pay* to avoid the damage valued the area at AU$435 million, more than four times the net present value of the proposed mine, put at AU$ 102 million. The Australian government rejected the proposal to mine the conservation area. However**,** the valuation study was not used as part of the final report of the RAC – perhaps because at the time there was uncertainty about the validity of non-market valuation methods.

Valuation of ecosystem services has been used by some mining and quarrying companies to support proposals for expanding production and to guide the rehabilitation of sites once production has finished. For example, in relation to an application to extend an existing quarry into agricultural land in North Yorkshire, United Kingdom, Aggregate Industries UK proposed to create a mix of wetlands for wildlife habitat as well as a lake for recreational use once extraction is completed. An economic analysis using benefits transfer methods helped to value the expected changes in ecosystem services. The study concluded that, over 50 years and using a 3% *discount rate*, the restored wetland would deliver net benefits to the community of some US$ 2 million in present value terms, after deducting the costs of restoration and o*pportunity costs*. The benefits were mainly accounted for by biodiversity (US$ 2.6 million), recreation (US$ 663,000) and increased flood storage capacity (US$ 417,000), and **far outweighed the current benefits** provided by agriculture (Olsen and Shannon 2010)[28].

[28] Olsen, N. and Shannon, D. 2010. Valuing the net benefits of ecosystem restoration: The Ripon City Quarry in Yorkshire: Ecosystem Valuation Initiative Case Study No.1. WBCSD, IUCN, Geneva/Gland, Switzerland.

10 Distributional analysis

Table 42 presents some key indicators for Karaberd village under the baseline and the three scenarios. Given the high level of poverty in the village (perhaps as high as 55%), the distributional impacts of the proposed mine are a key concern. Employment opportunities are very limited in the villages and the open pit mine is only expected to creating 10- 20 jobs.

Table 42: Karaberd village - Key Indicators

Indicators	Baseline	Mining	Best practice Mining	No mining alternative
Level of poverty / impact on poor[1]	45-55%	+	+	7-10%
Employment for Karaberd village only	2 people work for community, 6 for private companies, others self-employed in agriculture sector	+/- 10-20 people working in the open pit mine, but communities will lose ES.	+/- 10-20 people working in the open pit mine, but communities will lose ES	60-70 persons
Fiscal impacts (tax revenues, subsidies and green taxes), (1,000 AMD)		1,337,990 per year	1,337,990 per year	
Foreign exchange (foreign investments, exports)	0	+	+	0
Contribution to community development / year	4,908,900 AMD (US$12,121)	0	0	10,540,100 AMD (US$26,025)
Rehabilitation of ecosystem damage	0	Not clear	Would require rehabilitation to previous level / offsets	Sustainable pasture management

Note: 1/ Poverty is not measured at the community level. Estimates were provided by community leader.

10.1.1 Taxes payable by the Karaberd gold mine to state and community budgets

Karaberd gold mine will be subject to a number of taxes, including income tax, royalties, duties and land taxes as described below.

Income Tax rates are defined in Article 10 of the RA Law on Income Tax (adopted 22.12.2010) (Table 43).

Table 43: Income tax rates

Monthly taxable income	Tax amount
Up to 120,000 AMD	24.4% of taxable income
120,000-2,000,000 AMD	26 % of amounts exceeding 29,280 AMD plus 120,000 AMD
Over 2,000,000 AMD	36 % of amounts exceeding 518,080 AMD plus 2,000,000 AMD

The income tax paid from salaries will amount to AMD 11,660,400 or US$ 28,791 annually (on average 24.7% of the income) for the open pit mine and AMD 36,327,000 or USD 89,697 annually for the underground mine. Therefore, total income tax payable will amount to US$ 803,949.[29]

Profit tax amounts to US$288,700.0 (US$1,443,500*20%) for the open pit mine and US$710,280 for the underground mine per year (US$3,551,400*20%). Tax on profit paid throughout the operation of the Karaberd gold mine will amount to US$ 6,548,340.

Royalties amount to US$322,830 per year for the open pit mine and US$766,501 a year from the underground mine. Over the eleven years the mine will be in operation royalties total US$ 7,100,502.

State duties paid for the issuance of Operation Authorization. State duties are categorized by mineral type and for metal minerals amount to US$24,100 year. They will therefore total US$265,100 over the 11 years the Karaberd Gold mine is in operation.

The average annual amount of **property tax** paid to the community budget amounts to US$ 616.8, totaling US$ 6,784.65 over the period the mine is in operation[30].

Land tax, payable to the community budget, is based on the cadastre value of the land. The cadastral value of the entire mine is US$40,458 (based on the Environmental Impact Assessment Report). The rate of land tax for industrial, including mine lands, is 1% of the value of the cadastre appraisal for the lands inside the settlement (RA Law on Land tax, Article 5 (adopted 14.02.1994)). Accordingly, land tax will amount to US$4,046, which over the lifetime of the mine will amount to US$445,057.

Table 44 summarizes the payments to the state and regional budgets.

Table 44: Taxes and payment to State and Regional budgets of RA

	Annual (average) USD	**Total for mine operating period, USD**
	STATE BUDGET	
Income tax	73,086	803,949
Profit tax	595,304	6,548,340
Royalties	645,500	7,100,502
Government duty for mine operating license	24,100	265,100
Total State budget	***1,337,990***	***14,717,891***
	REGIONAL BUDGET	
Property tax	618	6,785
Land tax	4,046	44,505
Total Regional budget	***4,664***	***51,289***
Total A+B	**1,342,655**	**14,769,181**

10.1.2 Household income

There are 82 households in Karaberd village. Annual household income by activity is presented in Table 45.

[29] Based on the open-pit operating for 3 years and the underground mine for 8 years.

[30] RA Law on Property tax, 26.12.2002, Article 6 – the tax on buildings and constructions used for production is 0.3%. Article 7 – property tax for trucks with 1-200 horsepower is AMD 100 per horsepower, and AMD 200 per the part exceeding 200 horsepower for 201 and more horsepower.

Table 45: Income by agricultural activity

Agricultural activity	No of hh involved in activity[1]	Income per hh, AMD/ year (thousand)	Total income, AMD / year (thousand)
Crop cultivation	82	325-454 (US$802-1,121)	26,580-37,230 (US$65,630-91,925)
Animal husbandry	82	402-509 (US$992-1,257)	32,940-41,680 (US$81,333-102,913)
Bee-keeping	32	32-40 (US$79-99)	2,592 - 3,240 (US$6,400-8,000)
Wildly grown mushrooms, berries and fruits	82	44-66 (US$108-163)	3,600-5,400 (US$8,889-13,333)
TOTAL		814-1,068 (US$2,010-2,637)	65,712-87,550 (US$162,252-216,173)

Note: 1/ Based on official statistics (in reality fewer households reside in the village).

While some households will find employment at the mine, others will lose income due to the impact of the mine on their agricultural and pasture land. If we assume that all 12 households in Karaberd settlement will suffer a loss of income, this would amount to US$24,120 a year. Some households in Karaberd village are also likely to be affected to a lesser extent but this is difficult to specify without further study (possibly 30% of households would suffer some loss).

According to the community leader, Pambak village is also likely to lose 12 hectares of grazing lands to the mine. As a result several 100 cattle will not be able to use the land affecting roughly 33 households.

It is possible that as a result of operating the mine, the population inhabiting the adjacent settlement will be resettled. There are 12 registered households in the settlement, with 10 households thought to be in residence. Most of the families live in metal wagons with side constructions, only 3 households live in stone-built houses. Given the location of this settlement and the geographic characteristics of the area, the market price of one wagon can vary between 300,000 and 500,000 AMD, while the price of stone-built constructions can vary between 1 million AMD and 2.5 million AMD.

The mining company has stated that 2 million AMD (US$4,938) will be allocated to the Karaberd community per year, roads will be reconstructed, necessary infrastructure will be established, and, if necessary, the inhabitants will be provided with financial assistance. They have also promised to support one funeral service a year and that trucks and other machinery may be used by the community. However, no formal agreements are in place. It is also not clear if the promised 2 million AMD to the community budget, is additional to the mining tax or not. While the proposed contribution would improve the village's finances (the community budget is reportedly currently only US$12,121), it is a small amount given the profit that the company will be making.

Table 46 provides an overview of the distribution of costs and benefits of mining for the mining company, local communities and state and regional government.

Table 46: Distribution of Mining benefits and costs

	Benefits	**Costs**
Mining Company		

Profits accruing to Mining Company (after paying royalties)	US$32,741,700 (over eleven years, not accounting for capital costs)	
Payments by Mining Company to State to Government		US$1,337,990 a year (US$14,717,891 over the 11 years mine is operating)
Payments by Mining Company to regional Government		US$4,664 a year (US$ 51,289 over the 11 years the mine is operating)
Proposed payment by Mining Company to Local Community		US$5,000 per year
Other *proposed* benefits to Local Communities		Road reconstruction, infrastructure, support to one funeral service a year
Karaberd Community		
Proposed payment by Mining Company to Local Community	US$5,000 per year	
Other *proposed* benefits to Local Communities	Road reconstruction, infrastructure, support to one funeral service a year	
Lost income / Livelihoods to Local communities		Around US$24,000 per year
National & Regional Government		
Payments by Mining Company to State to Government	US$1,337,990 a year (US$14,717,891 over the 11 years mine is operating)	
Payments by Mining Company to regional Government	US$4,664 a year (US$ 51,289 over the 11 years the mine is operating)	

While the national Government will receive US$1.3 million a year from the Mining Company, it is not clear how this money will be invested to develop the country and alleviate poverty. For mining to play a role in poverty alleviation payments to the State and Regional Government need to be specifically used to create new capital such as more developed human resources and infrastructure, particularly in the affected rural areas (Box 4). Furthermore mining companies must be required to reclaim land / support local communities both during and after the mining operation.

Box 4: Natural Capital Accounting and WAVES

The World Bank's Wealth Accounting and the Valuation of Ecosystem Services (WAVES) Global Partnership Programme was formed to promote comprehensive wealth measurement within national accounts, which is the prevalent system used to measure and plan for economic growth, and on which major economic decisions are based. WAVES supports countries to implement environmental accounting where there are internationally agreed standards, and helps to develop standard approaches for other ecosystem service accounts.

A comprehensive inventory and valuation of Armenia's minerals would be useful to demonstrate the country's existing mineral wealth and facilitate the design of competitive / optimal extraction rates. Such information would also inform the key policy question of how income from minerals could be invested to promote social and sustainable development. To date, the main weakness of mineral-driven development has been the inability of host governments to effectively utilize mine revenue A more sophisticated **mineral account** could include the impacts / costs of mining on the environment and support policies on land reclamation.

Mining can and should substantially benefit developing economies – including the poorest – if host governments effectively deploy mining revenues. On the broader macro-economic front, mineral exports can generate extra revenue for investment, which if efficiently applied can accelerate the national economic growth rate, plus the inflow of foreign exchange increases the capacity to import goods required to build the infrastructure of a modern economy. The depletion of the resource can also sustain increases in per capita welfare if a fraction of the rent is invested in alternative forms of capital like education, infrastructure and production goods.

Mining in Botswana

Since its first diamond mine was established in 1967, Botswana experienced strong and sustained growth that led it from being one of the poorest economies in Africa to one of the rare success cases on the continent, avoiding the problems experienced by other resource-rich countries.

The recipe for this success has been a set of policy rules grounded in avoiding fiscal deficits. The government uses a Sustainable Budget Index (SBI) in order to ensure sustainability. This measures the ratio between consumption expenditures and non-resource revenues. As long as the SBI is less than one, the government can be sure that natural-resource capital is not being consumed. This achievement has not been easy.

Public investment has often gone into low-growth sectors, such as defence and agriculture, while it has crowded out private investment slowing economic diversification. However, the overall fiscal strategy has worked. The government has avoided excessive spending in the good times and drastic spending cuts when diamond prices have fallen, as in the early 1980s and 1991 (*World Bank 2006. Environment Matters)*

11 Legal Review

A recent review of RA legislation relating to environmental protection undertaken for this project (Amirkhanian *et al* 2013), highlights a number of gaps including:

- Armenia currently does not have a law that sets criteria and standards for environmental impact assessment (EIA), although such a law is currently being drafted.[31] There is however the Law on Environmental Impact Expertise (EIE) which regulates the process of expertise, public hearings, and activities that is subject to environmental impact expertise.
- EIA in Armenia typically lacks important information (e.g. a comprehensive consideration of all environmental impacts, calculation of economic damage) as there is no law specifying EIA criteria and standards.
- In the process of an expert evaluation, it is not required that the accuracy of the EIA be verified. Furthermore it is not uncommon for the EIA to be prepared by the entity that will undertake the economic activity[32]
- While the Law on EIE regulates public hearings, it violates the Aarhus Convention in that it does not require that the expert takes into account the opinions of the affected community. Full compliance with the Aarhus Convention will require amending a number of laws and regulations
- The use of the term 'ecosystem' occurs only a few times in RA national legislation. It occurs in the Article 3 of RA Forest Code and Article 1 of the RA Law on Specially Protected Areas. It also occurs in the Laws on Flora and Fauna. But in all these instances the term 'ecosystem' is not clearly defined.[33] The terms 'ecosystem services' and 'ecosystem services valuation' do not occur in RA legislation. However, a Government Decision (No.16-8 of April 25 2013) commissions the Minister of Nature Protection to develop, within a 6-month period, a strategy for innovative financial mechanisms in the environmental sector.

To formally embed the ecosystem service approach in Armenia or introduce a new law on 'ecosystem services,' as recommended by the Attachment to the Government Decision 16-8 (April 25, 2013), several laws and regulations will need to be reviewed and may require modification[34].

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[31] A draft law on environmental impact assessment was approved by parliament but rejected by the RA President and not signed into law citing that "the standards for assessment of the impact of economic activities is not adequately substantiated." http://www.unece.org/fileadmin/DAM/env/pp/compliance/MoP4decisions/Armenia/toARM_IV9a_CC37.pdf As a result, the Ministry of Nature Protection has been requested to draft a new environmental impact assessment law. The Ministry has organized a working group, comprising civil society organizations and government agencies, to re-draft the law.

[32] The Draft Law on Environmental Impact Assessment attempts to address this gap by empowering the Ministry of Nature Protection to provide the criteria and the terms of reference for the EIA. It also introduces the requirement that EIA's be conducted by a licensed entity and sets out broad topics that should be covered by an EIA (Article 17).

[33] According to Article 6 of the RA Constitution and Article 5 of RA Law on International Agreements, ratified international treaties are part of RA legislation and have direct implementation. However, in practice, implementation and enforcement of these agreements often require additional legislative acts such as laws, codes, regulations, and governmental decrees. This is because existing national laws may not align with the international treaties and even though international agreements have a higher legal force, in practice the courts often side with the national law. Moreover, international treaties or agreements often provide general terms or condition that national laws need to further define.

[34] Legislation that would need to be modified includes: RA Law on Fines for Damages to Flora and Fauna Due to Illegal Activities; RA Law on Environment Protection and Natural Resource Use Levies; RA Law on Rates for Environmental Protection Levies; RA Law on Target Use of Environmental

RA legislation includes two broad types of economic instruments – natural resource user fees (e.g. for water and minerals) and environmental protection fees (covering air pollution, water pollution, waste disposal and environmentally harmful products). Existing laws identify complex formulas for calculating environmental harm, but the more specific methodologies for the calculation of the rates are not identified by law. Moreover, there is a lack of capacity to apply these methodologies.

The natural resource user fees and environmental protection fees stipulated by RA legislation are generally low. In addition, companies are sometimes granted additional privileges. For example in November 2010 untreated sewage of the Zangezur Copper and Molybdenum Combine was accidentally discharged into the River Voghj. The State Inspectorate estimated the damage at 650,000 AMD and issued a fine of 100.000 AMD.[35] Disproportionately low sanctions do not provide incentives for responsible behavior. Furthermore, Armenia is among the lowest ranking countries in terms of the percentage of collected funds being invested back into environmental restoration.

Mining-specific Issues

Up until the end of 2011, an estimated 99.6% of industrial waste in Armenia was mining waste. However, since 2012 mining 'waste' (including tailings) has been defined by law as 'residue' ('Isakuyt').[36] As such, they are not subject to environmental-protection fees levied against waste deposits.[37] This re-definition has had no impact on the state budget as even when mining waste was legally recognized, a zero tariff was attached to it.[38] However, mining residues (dirt, rocks, and tailings) have environmental impacts and RA legislation should be modified to account for this. Inadequate legislation on managing tailing deposits risks the contamination of water, air, and soil with heavy metals and other harmful elements.

According to Article 3 of the new RA Mining Code, **tailing deposits are 'industrial residue'** and may, after expert examination (geological and economic assessment of their content),

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Charges Paid by Companies; Government Decree on Natural Resource Use Fees No. 864-N (1998); RA Law on Fines for Damages to Flora and Fauna Due to Illegal Activities; RA Government Decree No. 1110-N (August 14, 2003) on Valuation of Impact on Water Resources Due to Economic Activity; RA Government Decree No. 91-N (January 25, 2005) on Valuation of Impact on Environment Due to Economic Activity; RA Government Decree No. 92-A (January 25, 2005) on Valuation of Impact on Land Due to Economic Activity.

[35] The violation and the fine were reported in http://news.am/arm/news/58771.html. For damage calculations see Table No. 1-16 of RA Government Decree No. 1110-N (August 14, 2003) on Valuation of Impact on Water Resources Due to Economic Activity etc. (http://www.arlis.am/DocumentView.aspx?docid=55551)

[36] There are advantages and disadvantages to the classification of tailings as waste. In some countries, such as the U.S.A, where tailings are classified as 'hazardous waste' it has been very difficult to enable further use and extraction of minerals from tailings. Nonetheless, there are environmental and public health liabilities attached to tailing deposits, which need to be reflected in laws and regulations.

[37] There is also the issue of statistical reporting of mining residues generated. With the new RA Mining Code, mining operators are no longer required to report quantities of residues deposited as tailings and so on. This means that while in 2009 the mining waste cited to be 17.8 million tons, after 2012 this figure will be stated as "0."

[38] RA Law on Rates for Environmental Protection Levies defines seven categories of waste and specified fees for each type. Four of these seven are hazardous wastes. The remaining three are nonhazardous, construction, and mining waste. The waste types and their per ton environmental-protection fees are as follows: Level 4 (least hazardous) – 1,500 AMD/ton; Level 3 – 4,800 AMD/ton; Level 2 – 24,000 AMD/ton; Level 1 (most hazardous) – 48,000 AMD/ton; Non-Hazardous Waste – 600 AMD/ton; Soil/construction nonhazardous waste – 60 AMD/ton; Mining Waste – zero AMD/ton.

be considered ‘technology-generated’ mines. Article 3 reads: ‘A man-made mine is the accumulation of minerals on the surface of the earth or in mountain chamfers or in mine dumps formed as a result of studying, extracting, processing and enriching natural resources, which, in a defined order, have been subjected to a geological and economic assessment.’ There are no regulations on how to conduct the ‘geological and economic assessment’. As a result the status of ‘industrial residues’ are in limbo and further utilization of these piles is not possible.[39] As the content of the deposit is not assessed in a manner prescribed by the Mining Code, *legally* it is not a deposit with hazardous substances. Such deposits from metal mines, commonly known as tailing dumps, have serious environmental and public health consequences.

Article 14 of the new RA Mining Code states that when mining rights expire, sole ownership of the industrial piles (technology-made mines) passes to the Republic of Armenia. The law is silent on the public health and environmental liability of these ‘industrial piles’ to surrounding communities and who bears the liability. If ownership implies liability, then the state is liable for these sites. Accepted international practice is that the entity exploiting the mine is liable for the tailing deposits *ad infinitum*. The law should thus be modified to clearly place the long-term liability with the mining companies.

The Mining Code of RA, article 3, point 34; article 50 provides for the application of Best Available Techniques (BAT) and the Best Environmental Practices (BEP), however in practice they are not used. The European IPPC (Integrated Pollution Prevention and Control) Bureau has drawn up a separate BAT reference document for the management of tailings and waste rock in mining activities (EC 2009). In addition, international guidance on best environmental practices in mining is available from various countries (e.g. Environment Canada 2009, INAP 2009, PDAC 2011).

The new RA Mining Code made a fundamental **change in the fees** collected from metal mining. Fees have been replaced by a system of “royalties,” set at 4+% on sale proceeds. This change does *not* incentivize optimal use of natural resources and the use of modern and effective extractive technologies. According to official data, 20-30% of accounted minerals are lost due to the incomplete extraction of ore and accompanying components and ore impoverishment.[40] International experience shows that the system of royalties works most effectively when the companies operating the mines are in full or majority state owned. In all other cases, a system of natural resource use fees is preferable. In a large number of countries natural resource use fees are collected in addition to royalties. The natural resource use fee is collected as payment for the use of resources exclusively belonging to the state whereas collecting royalties offers a mechanism for taxing super profits.

Finally, mining exports are exempt from customs tariffs. This should be changed so that mineral goods are exempted based on the level of processing. The more processed the good, the lower the tariff. The export of mineral ores should attract the highest tariff, while concentrates should have a lower rate, smelted metals even lower, and manufactured goods may even be exempt.[41]

Environmental and Public Health Liability

RA legislation does not adequately regulate compensation to third parties for environmental pollution, negative public health impact, and property damages. The limits set out in the RA

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[39] It should be noted that to date tailing deposits in Armenia have yet to have further mineral resources extracted from them. So, while such a provision may be forward looking, it is far removed from the current reality of Armenia. The priority issues needing attention is the public and environmental health associated with these “industrial piles”.

[40] Ministry of Nature Protection, “Second national action plan for the preservation of the environment” (2008)

[41] RA Customs Code, Article 102 (http://www.arlis.am/documentview.aspx?docid=73274)

Civil Code are insufficient to ensure compensation in such cases. One solution may be to require that environmental insurance is obtained by entities engaging in economic activity that may impact the environment or public health.

Health impacts are not compensated in any way. Although Article 33.2 of the RA Constitution states the right to live in a healthy environment, there are no preventive measures defined by the RA Law on the Medical Aid and Service of the Population or other legal acts regulating the health care sector with respect to the damages of the mining industry. According to Article 3 of the aforementioned law, medical aid and service are implemented when a sickness already exists. The legislation of the health care sector does not foresee the term ‘the right to health’, and this makes the employment of Article 33.2 of the Constitution impossible.

Articles 15 and 17 of the Mining Code state that it is one of the competences of the RA Government and the authorized body for state governance in the field of nature protection (Ministry of Nature Protection) ‘to develop the procedure for implementing monitoring in order to ensure the safety and health care of the population of communities that are near to areas of extraction of minerals and locations of industrial piles resulted from the process of extraction.’ However, no state governing body is legally bound to bear any liability for ‘ensuring the safety and health care of the population.’

The legislation that regulates the RA health care sector does not make corresponding state governing bodies liable for implementing regular medical research or check-ups in mining zones aimed at the identification of health issues and their causes. The law does not stipulate mandatory health insurance of people residing near mining zones or mechanisms for the compensation in the case of damage.

In sum, RA legislation should define mechanisms for the prevention and insurance of health damage caused as a result of environmentally polluting activities.

12 Conclusions and recommendations

This study of the impact of the Karaberd gold mine on ecosystem services and the well-being of the community aims to inform decision making at the site, while also presenting a methodology that can be adopted at other locations to ensure mining is practiced in a responsible and sustainable manner. The pilot study presents a framework for a comprehensive assessment of the impacts of mining and for comparing mining with alternative land uses and development options. More broadly the analytical framework presented in this report provides an approach that can be applied across Sectors and ecosystems for demonstrating the implications of environmental damage to the Armenia economy and poverty alleviation objectives. ***It should be borne in mind that this was a pilot study focused on capacity building through a 'learning by doing' approach, rather than on carrying out a definitive assessment.***

Karaberd gold mine can be classified as a small mine. While larger mines are likely to have more significant impacts, there are many actual and proposed small mines in Armenia, whose overall *cumulative* impact can be significant. The study is therefore useful in terms of presenting an analysis of a 'representative' small mining operation, as well as a flexible analytical methodology which can equally be applied to mines of any size.

A key objective of the study was to train a team of experts in ecosystem service valuation in Armenia and to more broadly raise awareness of the importance of considering the value of ecosystem services in decision making. To meet these objectives a national team of experts completed the pilot study of Karaberd Gold Mine and three national workshops were held to present and discuss the findings.

The valuation of ecosystem services is in its infancy in Armenia. One recent study of Lake Sevan was also similarly focused on the valuation of provisioning services, indicating the challenges associated with the estimation of regulating services. However work in this area is extremely timely given the Government's recent commitment to a law on innovative economic instruments in the environment sector and the proposed new environmental law.

Mining makes a significant contribution to the economy in Armenia, representing 5.4% GDP (2012), and has the potential to continue to contribute to development. However for this development to be sustainable and equitable a number of conditions need to be met: (i) environmental, social and economic costs need to be accounted for in the evaluation of mining projects; (ii) the country / communities must get a fair share of the value of the extracted resources; (iii) the institutional capabilities of the government to evaluate social costs and benefits and regulate mining activities need to be strengthened; (iv) money from mining needs to be specifically used to create new capital such as more developed human resources and infrastructure, particularly in the rural areas; and, (v) Mining companies must be required to reclaim land / support local communities both during and after the mining operation.

Mining projects in Armenia should only proceed when they provide an adequate return on the capital investment *and* cover the environmental and social costs of their operations. The latter includes pollution abatement and the restoration of the mined area when the mine closes.

12.1 Key findings

Socio-economic survey

- The local communities likely to be impacted by the mine are poor. There is 53% unemployment in Karaberd village, 32% in Pambak, and 51% in Gugark and migration is high and increasing across the villages. Agriculture is largely limited to the cultivation of homestead plots, where crops are grown for domestic purposes and therefore make a significant contribution to food security. Animal husbandry is the

main activity the productivity of which depends on the sustainable use of pasture land. Most households are dependent on underground water and there is limited water available for irrigation purposes, making agriculture very vulnerable to drought. Therefore any impact to the spring supplying water, located near the mine, is a serious concern. Karaberd village and Settlement have no health facilities, poor roads and no school.
- Awareness of the mine varies across the areas expected to be impacted by the mining operation. In Karaberd village and settlement all households were aware of the possible operation of Karaberd gold mine. However, only households in Karaberd village were informed of the public hearings on the mine. For Pambak, Gugark and Vanadzor city, 40%, 0% and 16% respectively were aware of the possible operation of the mine. None of these areas were invited to participate in the public hearings on the mine.
- About 85-90% of the respondents in Karabard Village (compared to Karabard Settlement 37-87%, Pambak 25-50%, Gugark 4-8%, and Vanadzor City 26-48%) felt that the mining operation would have a positive impact on the economic development of the community and create additional sources of income.
- In Karaberd Village 35-65% of the respondents and the Village Major believe that the mine will have no environmental and health impacts since it is far from the village. This is in contrast to Karaberd settlement where *all* the respondents believe that the mining operation will have a negative impact on the environment and health. In the other survey villages the percentages were: Pambak 30-70%; Gugark 60-72%; and. Vanadzor 82-86%.

Biodiversity survey

- A rapid survey of fauna and flora was undertaken at the study site in August 2013. No species listed in the Red Book of the Armenian Flora were observed in the study area. A possible exception is the species of Iris found, however to precisely identify this species it is necessary to visit the area when the plant is at an earlier stage of vegetation.

Review of the EIA process

The Company EIA report is mostly in accordance with the procedures adopted by the Republic of Armenia. The main limitations of EIA undertaken by the Company include:

- The analysis is based on literature and previously conducted research, no site specific assesments are made;
- Groundwater is not assessed although the risk of groundwater becoming contaminated or drying up is a key concern of local communities. It is also likely that the mine explosions will impact water flow and quality;
- The impacts of fine particles, which are likely to reach Vanazdor, are not assessed. There are no standards for Suspended Particulate Matter (SPM) in Armenia and data on SPM is not collected. As a result it is not possible to find a correlation between SPM and respiratory illness, although this link has been proven in other countries;
- There is only a general assessment of indigenous biodiversity and it is not clear from the Company's EIA if there are any endangered species. The description of the flora and fauna and land resources relates to the whole region, and a specific analysis of the immediate mining area is missing.
- The EIA does not refer to the structure of tailings
- Closure and decommissioning procedures are absent
- The scope of the EIA is insufficient because it only covers Karaberd Village.

Challenges to valuing ecosystem services

- The valuation of Ecosystem Services is limited by data avialbility. In most cases this is physical, rather than economic data. As a result it was not possible to estimate the value of any of the regulating services at the site.
- Bio physical data is needed, which can relate the environmental impact of the mine to a change in the provision of ecosystem services that can then be linked to an economic activity. Important regulating services at the site to consider are:
    - There is an underground water outflow in Karaberd settlement which serves as a source of drinking water. The springs in the mining area may be impacted (e.g. through blasting activities) resulting in a deterioration of water quality, and a reduction in flow / possible drying out of streams and rivers. The relationship between underground and surface water has not be studied in any detail at the site.
    - Diseases of the respiratory system and invasive communicable diseases are among the largest contributors to morbidity across all age groups in the area. However, there is no monitoring of SPM or dose response studies available rendering it impossible to analyze the relationship between air emissions from the mine and the risk of an increase in respiratory illness.

Scenario Analysis:

- BAU Mining. Throughout the eleven year operational period of Karaberd gold mine the cumulative profit (without accounting for capital costs) will amount to US$32,741,700 (US$28,411,200 from the underground mine and US$4,330,500 from the open-pit mine). The overall capital investment in the open-pit will amount to US$1,253,250. This investment can be recouped in 0.9 years. The capital investment required for the underground mine is US$1,039,000, which can be recouped in 0.3 years.
- Sensitivity analysis on a range of key variables indicates the ***financial*** robustness of the proposed mining operation. That is from the Company's perspective, without having to consider the social costs of the mine, the mine is a highly viable investment. The impact of changes in operating costs, the anticipated gold content of the ore extracted and the price of gold on the payback period suggest that even given an increase in cost by 40% or a fall in the gold price or gold content by 40% the payback period on capital invested will not exceed 2.6 years
- A **social (economic) assessment** includes the broader impacts on society. This factors in the damage and / or loss of ecosystem services at the site. In the case of the Karaberd Gold mine, the impact on provisioning services were not found to be significant. However, it was not possible to quantify impacts on key regulating services.
    - Overall the impact of the mine on provisioning services is not likely to be large. Only 3,000 m^2 of orchards belonging to the local community near the mine, with an output of 2-4 tons, are expected to be impacted. Further, the mine is estimated to reduce wild fruit and berry collection by only 200-300kg a year. Honey production in Karaberd Settlement is not expected to be impacted.
    - While air quality according to the Company's EIA is expected to remain within acceptable norms during mining operations, PM10 has not been measured and may have an impact on health. It is also not possible without further study to understand the implications of the mining operation on water flow regulation, and whether local springs will be affected and /or local streams will be at risk of drying up.
    - The assessment only considers Karaberd village. Pambak village is expected to lose use of 12ha of pasture land due to the mine but the implications of this in terms of lost productivity have not been calculated.
- A qualitative description of mining based on **international practices** indicates that there are a number of measures that can be adopted to mitigate the impact of the

mine. These measures have not been costed, but would enable mining companies to better externalize their impacts on society. Some international companies are exploring concepts such as ‘No Net Loss’ and ‘Net Positive Impact’, in which unavoidable, residual biodiversity impacts are offset by conservation activities (usually very close to the impact site), with the aim of being at least equal in value to damages that cannot be avoided.

- The **alternative development scenario** considers how the land could be used if the mining operation did not go ahead. It is generally agreed that animal husbandry and apiculture have good potential in the area, and agricultural crops may also be developed. The potential for developing tourism is limited. In order to develop agricultural it will be necessary to install irrigation systems while the comprehensive use of pastures will require pasture management and planning, water sources for animals, repair of roads and the construction of animal barns and infrastructure. It was not possible to estimate the cost of these measures within this study. The gross annual benefit of a sustainable agriculture option is estimated at US$1,579,111 - 1,911,407, compared to US$162,247 – 216,172 under the baseline.
- It was not possible to compare the options within a Cost Benefit Analysis as the costs of the sustainable agricultural scenario were not estimated. However it is worth noting:
    - The mining option and sustainable agricultural production option are not totally mutually exclusive. Only a small area of land is expected to be impacted by the mine. It is therefore feasible to develop agriculture alongside the mining operation, and achieve significant gains for the local community relative to the baseline.
    - Only a limited number of ES have been monetized. Impacts on water flow regimes and health may be significant but data are missing to link the impact of the mine to changes in water flow or to changes in ambient air quality. These ‘costs’ should be deducted from the benefits of mining.
    - While it would be misleading to calculate NPVs given gross estimates are not available for all the scenarios, it is important to note that the benefits of mining will occur over 11 years, while ES, if sustainably managed, will continue for a much longer period.

Distributional analysis

It is important to understand who will ‘win’ and who will ‘lose’ as a result of a development or management decision, and how those that lose may be adequately compensated to promote an equitable development path that acts in favor of poverty alleviation.

The mining company has stated that 2 million AMD (US$4,938) will be allocated to the Karaberd community per year, roads will be reconstructed and necessary infrastructure established. However, no formal agreements are in place. While the proposed contribution would improve the village’s finances (the community budget is reportedly currently only US$12,121), it is a small amount given the profit that the company will be making.

While the national Government will receive US$1.3 million a year from the Mining Company, it is not clear how this money will be invested to develop the country and alleviate poverty. For mining to play a role in poverty alleviation payments from money to the State and Regional Government need to be specifically used to create new capital such as more developed human resources and infrastructure, particularly in the affected rural areas. **This recommendation is pertinent for the pilot study site, where the analysis indicates that investment in agriculture could greatly enhance productivity and income relative to the baseline**. Furthermore mining companies must be required to reclaim land / support local communities both during and after the mining operation.

Institutional and legal

- Key gaps in Armenia’s environmental protection legislation include:

- Armenia currently does not have a law that sets criteria and standards for environmental impact assessment (EIA), although such a law is currently being drafted. There is however the Law on Environmental Impact Expertise (EIE) which regulates the process of expertise, public hearings, and activities that are subject to environmental impact expertise.
    - EIA in Armenia typically lacks important information (e.g. a comprehensive consideration of all environmental impacts, calculation of economic damage) as there is no law specifying EIA criteria and standards.
    - In the process of an expert evaluation, it is not required that the accuracy of the EIA be verified. Furthermore it is not uncommon for the EIA to be prepared by the entity that will undertake the economic activity.
    - While the Law on EIE regulates public hearings, it violates the Aarhus Convention in that it does not require that the expert takes into account the opinions of the affected community. Full compliance with the Aarhus Convention will require amending a number of laws and regulations.
    - The use of the term 'ecosystem' occurs only a few times in RA national legislation, while the terms 'ecosystem services' and 'ecosystem services valuation' do not occur at all. However, a Government Decision (No.16-8 of April 25 2013) commissions the Minister of Nature Protection to develop, within a 6-month period, a strategy for innovative financial mechanisms in the environmental sector.
- Mining specific issues include:
    - Up until the end of 2011, an estimated 99.6% of industrial waste in Armenia was mining waste. However, since 2012 mining 'waste' (including tailings) has been defined by law as 'residue' ('Isakuyt'). As such, they are not subject to environmental-protection fees levied against waste deposits.
    - Article 14 of the new RA Mining Code states that when mining rights expire, sole ownership of the industrial piles (technology-made mines) passes to the Republic of Armenia. The law is silent on the public health and environmental liability of these 'industrial piles' to surrounding communities and who bears the liability

12.2 Recommendations

This section highlights recommendations for developing the ecosystem services approach in Armenia.

Awareness & capacity building

- The concept of ecosystem services is a novel approach to environmental accounting and protection in Armenia. Environmental education and awareness building on ES across all stakeholders is important to ensure a broad understanding of their importance.
- It is important that senior Government Ministries (e.g. Ministry of Finance), with budget responsibilities across sectors, are aware of the importance of incorporating an ESA into decision making.
- If 'mainstreaming' of ES into laws and government policies and actions plans is to be successful it is necessary to interact with Government from the very beginning to ensure that the technical work is demand driven and policy makers are on board.
- While senior decision makers need to have an understanding of the approaches and results, to have confidence in the project outputs, such high level officials are liable to change following elections. Therefore in order to ensure continuity in the project's outputs technical staff should be trained in the use of the tools.

- It was intended that the expert group formed under this project would be sustainable beyond the duration of the PEI TA project. However it is evident that more in-depth training is required to build up an expertise in ES valuation and economic assessment. Possible considerations are - funding Armenia students on overseas

Master courses so that a real understanding and knowledge of the subject is built up and sending participants on short (regional) courses. Participants should be carefully selected and preferably have a background in economics and in environmental management.

- Training is also needed in approaches to estimate environmental impacts and how to link changes in the environment to changes in ecosystem service provision and health, which can then be valued.

- It is necessary to develop the Government's expertise in EIA so that they are able to properly evaluate EIAs that companies submit.

Building up biophysical data

- The valuation of regulating services in particular is underpinned by bio-physical data, which is generally lacking in Armenia. For example to estimate the extent to which downstream hydropower and irrigation schemes depend on upper catchment protection services it would be necessary to relate catchment deforestation to a particular rate of soil erosion, consequent siltation of a hydropower dam and reduced power outputs. To be able to specify these kinds of relationships typically involves consultation with experts, and situation-specific laboratory or field research, controlled experiments, detailed modeling and statistical regression.
- ES valuation in Armenia would benefit from better spatial mapping / GIS data, water balance models (that convey the relationship between underground and surface water and current uses of water), seasonal testing of water quality, and studies that link levels of air and water pollution to impacts on ecosystems services and health. This information is currently extremely limited in Armenia.
- The EIA process has a role in building up the required physical data. However, more stringent standards and a review process need to be attached to the EIA process to facilitate this.

Further ecosystem valuation studies

Mining

There are a number of ways further study of Armenia's mining sector could support decision making. These include:

- Given the significance of land degradation in Armenia, it is important to understand the cumulative impacts of mining. The impact of a (small) mine looked at in isolation can be misleading if it does not take into consideration others mines (or activities) contributing to environmental impacts in a given watershed or area.
- To fully understand the impact of a given mine a life cycle approach should be adopted (from exploration through to reclamation of the site). The pilot study only considered the excavation stage of mining.
- Large mines will inevitably have a larger environmental footprint and significant tradeoffs. A study of a large mine would be useful as a benchmark of these impacts and tradeoffs, and the economic and social implications.
- In step with the World Bank's Wealth Accounting and the Valuation of Ecosystem Services (WAVES) Global Partnership Programme a comprehensive inventory and valuation of Armenia's minerals would be useful to demonstrate the country's existing mineral wealth and facilitate the design of competitive / optimal extraction rates. Such information would also inform the key policy question of how income from minerals could be invested to promote social and sustainable development. To date, the main weakness of mineral-driven development has been the inability of host governments to effectively utilize mine revenue. A more sophisticated **mineral account** could include the impacts / costs of mining on the environment and support policies on land

reclamation. Wealth accounting in Armenia would need to be supported by training and capacity building.

Other sectors

- A consultation on potential study sites undertaken for this project indicates the range of issues that could benefit from the valuation of ecosystem services in Armenia. In addition to further studies on mining these include studies of wetlands, agriculture, water pricing, forestry and tourism. These are discussed in more detail in Annex 6.

Legal

- The new EIA law should include a CBA requirement (scenario analysis), which promotes the use of internationally recognized valuation approaches such as market based approaches, productivity approaches, travel cost approach and contingent valuation.
- Given the general international trend towards more public disclosure, public hearing reports should be made available.
- More generally, it is recommended to consider that the legal basis of ecosystem management and conservation may be strengthened through the integration in appropriate laws and/ or regulations of: legal definitions of ecosystems and ecosystem services; the recognition of the principle of ecosystem management; the recognition of the importance of ecosystems in environmental planning; the requirement to collect and assess ecosystem data in environmental monitoring and information systems; the recognition of ecosystems and their services in EIA and SEA; and a framework for financial instruments including charges and fees for uses of ecosystem services and payments for ecosystem services where necessary and appropriate to landowners and others as remuneration of their efforts to conserve ecosystem and their services. A first step may be the consideration of these issues in the process of preparation of general environmental protection legislation for Armenia.

13 Annexes

13.1 Annex 1: General Methodology

The methodology is based on seven key steps as presented in Figure A1. While examples are focused on Mining, the methodology can be generally applied to value all types of ecosystems and sectors (uses).

Step 1 introduces the project to stakeholders and ensures their buy- in.

Step 2 provides background on the study area and the context for the economic assessment. This step involves building up an understanding of the area under study (its physical characteristics and the type of pressures it faces under current management regimes) and an identification of alternative sustainable management options.

Step 3 defines the scope of the assessment. Under Step 3 the key ecosystem services at the site such as – crops grown, carbon sequestration benefits and tourism are identified through a qualitative assessment. The scope of the assessment is based on the significance of the service, data and resources available for the assessment.

Step 4 quantifies in bio-physical terms the impact of the selected scenarios on the ecosystem services provided. This is an important step underpinning the valuation of the impacts.

Step 5 values those ecosystem services identified in Step 3 and 4 as being significant and possible to value given available data and resources, using the most suitable valuation approaches.

Step 6 analyses the valuation undertaken in Step 5. For example: unit values need to be aggregated based on the appropriate population, or by the number of hectares benefiting from the land use, to derive total values; sensitivity analysis is required to highlight to decision makers the confidence that may be attached to the values; and, discounting of annual values and one off costs over an appropriate timeframe is undertaken to derive net present values (NPV). A distributional analysis is an essential part of the analysis. This is used to draw out who wins from current and potential scenarios and who loses (taking into account both on-site and off-site costs and benefits). This information can be used to illustrate the links between ecosystem services and poverty alleviation and to develop mechanisms to compensate those who lose under a particular scenario.

Step 7 involves a discussion of the institutional barriers to achieving optimal economic development.

Figure A1. Key Steps in the economic assessment

Step 1: Stakeholder consultation and site selection	• Consult on project and potential study sites • Select pilot site • Specify & agree the policy issue with stakeholders
Step 2: Characterize the study and determine the context for the assessment	2a. Develop a conceptual understanding of the physical characteristics of the area to be studied e.g. its size, soil type, typography, hydrology 2b. Undertaken a socio-economic analysis 2c. Define the issues. What are the main threats to ecosystem services, who is being affected and how? 2d. Define scenarios to be analyzed
Step 3: Define the scope of the economic assessment	• Undertake qualitative assessment of ecosystem services • Determine data availability (scientific / quantitative) • Select ecosystem services to be valued. • Select key economic indicators
Step 4: Quantification of impacts	• Quantify (in bio physical terms) the impacts of each scenario, taking into consideration both on-site and off-site impacts
Step 5: Undertake valuation of ecosystem	• Derive monetary estimates of the ecosystem services under the selected scenarios using appropriate valuation approach
Step 6: Analysis of economic evidence	• CBA (economic & financial perspective). Aggregation, discounting, sensitivity analysis • Impacts of different scenarios on key indicators – e.g. employment, income, tax revenues • Distributional analysis and implications for poverty alleviation
Step 7: Understanding the institutional requirements	Specify the institutional barriers to achieving sustainable and equitable economic development

It should be noted that the 7 steps often have feedback loops and do not need to be always followed in sequence. Earlier steps may be refined as new information comes available as the study progresses.

Step 1: Initial stakeholder consultation and site selection

The study site should be selected based on discussions with key stakeholders and an initial site visit. It is important to get stakeholder buy-in to the project at the outset, and to include them in the process of collating evidence on the site's ecosystem services.

Step 2: Defining the issue and context for the economic assessment

Step 2a: Define the physical characteristics of the study area

The first step is to define the physical characteristics of the study site e.g. its area, soil type, hydrology. This can be collated from existing studies, maps and statistics on the site and / or through discussions with land managers / scientists familiar with the site.

The geographical (spatial) scale of the assessment is a key consideration and should be clearly specified. The scale of the study can either be an ecologically defined system such as a forest or watershed / catchment, or an institutionally defined system, such as a municipality, region or country. The area can be relatively homogeneous, including only one main ecosystem type (e.g. forest), or it can be heterogeneous (e.g. comprising a mix of forest and agricultural lands). If the area comprises different systems these systems are likely to supply different services and the assessment will be more complex.

Step 2b: Undertaken socio-economic analysis

The collation of socio-economic data is recommended for all assessments. Socio-economic data provides important contextual information for the valuation exercise in terms of the population characteristics (size, composition and growth), household income, employment levels and opportunities, levels of education, health status, development infrastructure, food security, vulnerability and coping strategies, water and sanitation.

This information can be used to help understand pressures on ecosystem services and their likely trends, economic opportunities associated with ecosystem services, who benefits from the ecosystem services and who will be impacted by a change in its quality or quantity. This information is key to understanding the links between ecosystem management and poverty alleviation.

Household surveys may be necessary when key socio-economic data is missing or out of date (e.g. at the village level).

Socio-economic information can also be used to design stratified samples, which are recommended for use in primary valuation approaches that involve surveys such as the stated preference approaches and the travel cost approach[42].

Step 2c: What issues are facing the site's ecosystem services?

Key questions to consider are:

[42] Stratified sampling is a type of probability sampling where the initial population is divided into unique subsets according to clearly defined attributes such as age, sex of household income. Each subset is then randomly sampled.

- *How are ecosystems currently used*? For example, what crops are currently grown, what non-timber forest products are collected, what management practices are in place, what development activities are proposed for the area (e.g. Mining)
- What are the current institutional arrangements (e.g., land tenure)?
- *What type of ecosystem degradation is evident / likely as a result of proposed activities and what are the underlying causes / pressures?*
- *Where and when will change happen*? Effects may be evident at local, regional and/or national scales in the short term or longer;
- *Who will the change affect and how*? The benefits of an area may accrue to stakeholders at different scales – local communities, regional traders, national investors or the global community. The assessment should attempt to cover all stakeholders with a specific focus on poor communities.

These questions can be addressed through a review of the available literature, a site visit and interviews with stakeholders.

For example, for a mining study, relevant literature on the study area includes Environmental Impact Assessment (EIA) for the proposed mining area, any other EIAs for mines in the region, independent studies on the impact of mines in area, scientific studies on ecosystem services, any valuation studies of ecosystem services, tourism potential studies, information on agricultural land use in area, studies of Protected Areas within the study site.

Step 1d: Define the scenarios to be analysed

The comparison of scenarios allows viable options for the area to be compared and where costs and benefits can be identified for each option the optimal option may be identified. Some example scenarios related to mining are provided in Table A1.

Table A1: Example Scenarios

Scenario	Description
Mining (as currently proposed)	Analysis based on production quantities and mining practices proposed by company
Best practice mining	Analysis based on best international practices and restoration of damage to ecosystems and equitable distribution of benefits from mining
Alternative use of ecosystems / No mining	Development of local communities enterprises, based on best practice agriculture and bee keeping

Step 3: Defining the scope of the economic assessment

Step 3: Select ecosystem services for valuation based on a qualitative assessment of the services provided and an understanding of available data and resources to undertake the assessment.

Identification of ecosystem services

Monetization of ecosystem service initially requires a qualitative description and quantitative measures of that service in its current use (the baseline). Table A2 provides a check list of the possible benefits provided ***by*** ecosystems. The provision of these benefits will change under different scenarios / management practices.

In order to gain an overview of the services provided at the study site/area under Business as Usual (BAU) / baseline a *qualitative* assessment of the ecosystem services it provides and their significance can be undertaken, where:

- ++ means that the service is important;
- + means that the service is provided;
- - means that the service is not relevant; and,
- ? means that there is uncertainty surrounding the provision of a service.

Table A2: Qualitative analysis of ecosystem services provided by ecosystems

Ecosystem Service category	Service (Benefit / outcome)	Significance under the baseline	Comment
Provisioning Services	Minerals		
	Food		
	Fodder		
	Water		
	Fuel		
	Biochemical and medicinal resources		
	Genetic resources		
	Ornamental resources		
Regulating Services	Sink for atmospheric carbon dioxide (carbon capture)		
	Micro-climate regulation		
	Hydrological services (regulation of timing and volume of river flow)		
	Flood risk regulation (protection of property, agricultural land, human lives)		
	Protection against storms		
	Control of erosion and sediments		
	Regulation of pest and pathogens		
Cultural Services	Cultural, spiritual, religious,		
	Scientific and educational information		
	Tourism and recreation		

Code: ++ means that the service is important; + means that the service is provided; - means that the service is not relevant; ? means that there is uncertainty surrounding the provision of a service.

Step 3 also involves a qualitative assessment of the impact of the proposed scenarios on the ES provided by the site ***over time***. It gives an overview of which ecosystem services will be positively or negatively affected by each scenario and which will remain unchanged (Table A3).

The baseline analysis is static and provides a snap shot of current use and impacts, while the scenario analysis projects output and impacts over the project timeframe. The analysis should start therefore with understanding the baseline.

Table A3: Qualitative analysis of Ecosystem Services provided by ecosystems and the expected temporal impact under the proposed scenarios

Ecosystem Service category	Service (Benefit / outcome)	Significance under the baseline[1]	Mining [2]	Best practice Mining[2]	No mining alternative[2]
Provisioning Services	Minerals				
	Food				
	Fodder				
	Water				
	Fuel				
	Biochemical and medicinal resources				
	Genetic resources				
	Ornamental resources				
Regulating Services	Sink for atmospheric carbon dioxide (carbon capture)				
	Micro-climate regulation				
	Hydrological services (regulation of timing and volume of river flow)				
	Flood risk regulation (protection of property, agricultural land, human lives)				
	Protection against storms				
	Control of erosion and sediments				
	Regulation of pest and pathogens				
Cultural Services	Cultural, spiritual, religious,				
	Scientific and educational information				
	Tourism and recreation				

1/ Code: ++ means that the service is important; + means that the service is provided; - means that the service is not relevant; and, ? means that there is uncertainty surrounding the provision of a service. 2/ Code: + : constant positive effect; +/- : initial positive effect but returns start to decline due to resource degradation; 0 no /neglible effect; - : negative effect; - - significant negative effect.

Selection of key economic indicators

In addition to undertaking a Cost Benefit Analysis (CBA) of the proposed scenarios, which will indicate which scenario is superior in terms of Net Present Value (NPV), the assessment can be supported by an assessment of how each scenario impacts key indicators such as employment, income levels, tax flows and their distribution. Information on these key indicators should be provided to decision makers alongside the CBA results so that fully informed decision can be made (Table A4).

Table A4. Key Indicators

Indicators	Baseline	Mining	Best practice Mining	No mining alternative[2]
Level of poverty / impact on poor				
Employment				
Income (Average, Range)				
Fiscal impacts (tax revenues, subsidies and green taxes)				
Foreign exchange (foreign investments, exports)				
Contribution to community development				
Rehabilitation of ecosystem damage				

Step 4: Quantify (in bio physical terms) the baseline and impacts of scenarios

This step requires that the scenarios are defined in some detail, and assumptions are made on how the ecosystem services will improve or decline under each scenario over a given time frame. Where published information is limited, the information could be built up based on expert opinion or through a steering group or focus group. Table A5 provides a template for recording quantitative data / indicators for the scenarios.

Table A5: for undertaking quantitative assessment of options of the impact of each scenario on ecosystem services

Ecosystem service		Impact under scenarios				
		Units	**Baseline**	**Mining**	**Best practice mining**	**No mining alternative**
Provisioning	Minerals	Amount of product harvested / year (e.g. x tons ore l); inputs required for harvesting (e.g., time, equipment, land)				
	Fodder	Amount of product harvested / year (e.g. x tons hay); inputs required for harvesting (e.g., time, equipment, land)				
	Food (honey)	Amount of product harvested / year (e.g. x tons hay); inputs required for harvesting (e.g., time, equipment, land)				
	Water	Amount of water m^3 used for household, agriculture, industrial use				
	Air quality regulation	PM10 Respiratory illness in the area				

Step 5: Undertake Valuation of Ecosystem Services

The main categories of valuation approaches are as follows:

Market price approaches: Consider *use values* associated with products that are bought and sold in actual markets. Market price approaches include the use of market prices to value traded ecosystem services and also the so called cost based approaches (e.g. change in productivity approach, replacement cost, market prices, opportunity cost).

The use of market prices for ecosystem services that are traded reflect a lower bound estimate of its value, as they do not capture the consumer surplus element of value. They are therefore only proxies of welfare value. However, such estimates are still very informative and relatively straightforward to derive. They can be used to capture direct and indirect use values, but not non-use values.

Cost based approaches take the cost of replacing a service or averting a damaging impact as a proxy for the value of the benefits provided. Values that may be derived from these approaches do not represent true valuations as the assessment only considers whether the non-market good is of greater value than the opportunity cost (Bateman, 1999)[43]. They suffer from the same complications as market prices and risk under-valuation of non-market goods; the price reflects the cost of obtaining a good, not the actual benefit derived from its 'consumption'.

The values derived from cost based approaches such as the replacement cost, cost of alternatives, mitigation costs and cost of illness are a benchmark set by the market. However, market prices can over-estimate the true opportunity cost of an action due to distorted market structures which reflect political objectives rather than competitive relationships. Highly intervened markets, such as agriculture, imply a certain degree of complexity in the link between market prices and underlying costs, suggesting that it may be difficult to assess the value of non-market goods in this manner.

Replacement cost methods can be used to estimate the cost of restoring productivity of degraded land to their pre-erosion level. For example, what would be the cost of chemical replacements to replenish nutrients lost to erosion? This requires information on soil nutrient concentrations and the prices of chemical fertilizers. For land degradation on eroded slopes replacements costs can include the cost of stabilization works, reseeding and restoring soil fertility, and could also include lost production if stock that would have grazed the eroded site need to be excluded during the restoration period (Jones *et al*, 2008)[44].

Productivity approaches: Productivity approaches look at the way in which changes in the quantity or quality of ecosystem services affects the production of other marketed outputs or income flows (e.g., agricultural crops or hydropower). The *use value* is inferred by changes in production that result from changes in an input to production (e.g. soil quantity or quality). Often detailed physical data is required. For example to estimate the extent to which downstream hydropower and irrigation schemes depend on upper catchment protection services it would be necessary to relate catchment deforestation to a particular rate of soil erosion, consequent siltation of a hydropower dam and reduced power outputs. To be able to specify these kinds of relationships typically involves consultation with experts,

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[43] Bateman, I.J. 1999. 'Environmental Impact Assessment, Cost- Benefits Analysis and the Valuation of Environmental Impacts', in Petts, J. (ed.) (1999). Handbook of Environmental Impact Assessment, Volume 1- Environmental Impact Assessment: Process, Methods and Potential, Blackwell Science, Oxford

[44] Jones, H, Clough, P, Hoch, B, and Phillips, C. 2008. Economic Costs of Hill Country Erosion and benefits of Mitigation in New Zealand: Review and Recommendation of Approach. SCION, December 2008

and potentially situation-specific laboratory or field research, controlled experiments, detailed modeling and statistical regression.

Revealed preference methods: Estimate the *use value* of non-market goods and services by observing behavior related to market goods and services that can be linked to an ecosystem in some way. For example the travel cost method may be used to estimate the cost (both money and time) incurred in undertaking recreation and tourism activities.

Stated preference methods: These survey based approaches create hypothetical markets to determine the value of non-market goods and services. Individuals are typically asked what they would be willing to pay or accept for a specified change in the provision of a service Stated preference techniques are the only approaches that can estimate all the various components of Total Economic Value (TEV) - direct and indirect use value and non-use value.

Broadly speaking market price and productivity approaches are ordinarily applied to value *market goods and services*, while revealed preference and stated preference approaches are applied to value *non-market goods and services*. However, there can be overlaps between methods and often combinations of methods are required to inform decision-making.

In addition to the valuation evidence, the assessment should also collect information and data that is likely to be important to decision making. This includes the number of jobs associated with a given practice (such as mining or agriculture), the importance of ecosystems to local livelihoods and the role ecosystems play in maintaining the health of local communities.

Value Transfer

Value transfer (also called benefits transfer) involves the application of values from an existing study (often called the 'study site') to a new study (often referred to as the 'policy site') where conditions are similar and a similar policy context is being investigated.

Value transfer is a practical means of demonstrating the monetary value of ecosystem services. It is cheap and quick relative to primary research, but there are a number of factors which influence the reliability of the transfer exercise. They are particularly useful for estimating regulating services, where site specific bio-physical data may be missing.

The quality of the original study is obviously a key consideration for value transfer applications. In order to minimize errors / uncertainty, the primary research study should be based on adequate data and a theoretically sound approach. The degree of similarity between the study site and the policy site is also a major factor. Value transfer will be more reliable if the policy site is located within the same region / country as the study site, and displays similar site characteristic (e.g. size, services and availability of and distance to substitutes). Other factors affecting the reliability of the value transfer exercise include: the reference condition[45] (i.e., how closely the baseline at the study site matches the baseline at the policy site); the proposed change in the provision of the service (i.e., the magnitude of the change and whether the valuation is of a change in the quantity or the quality of an attribute); and the range/ scale of the commodity being valued (e.g., one site or many sites valued and physical area).

The same benefits realized in different geographical areas may have different values due to the differences in socioeconomic characteristics of the relevant population and their

[45] Valuation responses are non-linear, therefore interpolating values for similar percentage changes occurring at different points on the response curve may lead to significant error.

cultural preferences. It is important then to understand the population size and density of the study site and to what extent the relevant socio-economic variables for the study site match the policy site. It is also possible that two sets of the population with similar socio-economic profiles within a country could have quite different tastes and preferences, which would influence their values for goods and services.

The choice of valuation approach to use will be influenced by the data available (physical and monetary) and the expertise available to a carry out the assessment. While it is not possible to specify what approach might be best applied across the range of ecosystems and their services, ***as this would be site specific***, some support Tables are provided below indicating the types of approaches and data requirements suitable across sample ecosystems:

- Table A6 provides an overview of when the valuation approaches discussed above might be appropriate to use;
- Table A7 provides an overview of the impacts of different types of land degradation and possible valuation approaches;
- Table A8 provides an overview of the physical data requirements;
- Table A9 provides an overview of what (selected) ecosystem services can be valued using market prices, given that market prices if available present the quickest route to monetizing ES.

Table A6: Scope of Economic Valuation Methods

Valuation Method	Scope – Component of TEV	Scope – types of goods and services
Market pricing methods	Use value (direct and indirect)	*Market goods and services and market substitutes (for non-market goods and services)* Direct use value: mostly limited to commodities (e.g. food, forest products, the spending on bottled water as a proxy for the value of drinkable public supply) or the contribution of an ES such as water provision to marketed products (e.g. agriculture, forestry, fisheries, manufacturing, power generation, mining) Indirect use value: estimating avoided damage (e.g. from flooding) or marketed substitutes (e.g. cost of water treatment, soil nutrients) or tangible impacts (e.g. cost of illness)
Production input methods (e.g. production function approach)	Use value (direct and indirect)	*Market goods and services* Use value: Limited to the role of ES as an input to production processes (e.g. the effect of water quality on agriculture).
Revealed preference methods		
Hedonic pricing (e.g. hedonic property pricing)	Use value (direct and indirect)	*Non-market goods and services* Use value: The contribution of an ES to an environmental amenity that can be observed from markets (e.g. contribution of landscape or water to property prices (market)).
Travel cost method	Use value (direct and indirect)	*Non-market goods and services* Use value: The contribution of ES to recreation activities that is revealed by the travel costs incurred by recreation users.
Multi-site recreation demand models	Use value (direct and indirect)	*Non-market goods and services* Use value: The contribution of ES to recreation activities that is revealed by the choice decisions (i.e. whether to visit a specific site or not) and travel costs incurred by recreation users.
Stated preference methods		
Contingent valuation	TEV (use and non-use value)	*Non-market goods and services* TEV: Non-market goods and services can be captured by contingent valuation.
Choice modeling (e.g. choice experiment)	TEV (use and non-use value)	*Non-market goods and services* TEV: Non-market goods and services can be captured by choice modeling approaches.
Benefits transfer		
Unit value transfer / function transfer	*TEV (use and non-use value), depending on evidence used*	*All of the above depending on the type of study from which evidence is sourced.*

Source: Adapted from Worley Parsons Canada Ltd and eftec (2009). Water Valuation Guidance Document. CCME Water Agenda Development Committee.

Table A7: Overview of the impacts of different types of land degradation and approaches to their monetization

Type of land degradation	High level physical impact	Specific impacts	Possible monetary approaches	Data requirements
Overgrazing	Soil erosion	**On site**: • Reduced fodder available leading to lower milk / livestock productivity • Loss of land available for grazing • Reduced carbon sequestration	• Cost of substitute fodder • Present and future ∆ in milk production × market price • Present and future ∆ in meat production × market price • ∆ in carbon sequestration function × market price of carbon	• Time series data on loss of soil cover on pastures • Relationship between soil cover and fodder available • Time series data on the change in milk / milk production • Time series data on the number of livestock / ha • Market price fodder / milk / meat products (over past 10 years)
	Sedimentation	**Off site**: • Siltation of reservoirs resulting in loss energy output • Changes in runoff leading to flooding / landslides • Reductions in water quality and ecological diversity	• Loss of energy output as a result of the reduce life time of reservoir × market price of energy • Impact of flooding on property damage / loss of agricultural land / human life estimated based on replacement cost/ market prices/ Value of life assessments	• Area of reservoir capacity loss as a result of siltation • Lost power capacity over lifetime of reservoir • Market price of energy / kWh • Change in runoff as a result of erosion • Probable incidence of flooding / landslide as a result of increase in run off • Replacement cost / damage cost avoided of likely damage
Poor water management / inadequate drainage infrastructure	Salinization and water logging which affect soil fertility and	**On site**: • Reduced productivity due to reduce soil fertility • Reduced productivity due to loss of area available for agricultural production	• ∆ in productivity × market price of affected crop • Cost of replacing loss nutrients to maintain soil fertility	• Area of land affected by salinization and water logging • Scientific evidence of change in fertility levels • Lost production /year

Type of land degradation	High level physical impact	Specific impacts	Possible monetary approaches	Data requirements
	land available for agriculture			• Market price of key crops
		Off site: • Siltation of reservoirs resulting in loss energy output and water supply • Low flow rivers resulting in impacts on biodiversity and water available for agriculture	• Loss of energy output as a result of the reduce life time of reservoir × market price of energy • Loss of water supply × Δ in productivity × market price of affected crops	• Change in runoff as a result of erosion • Probable incidence of flooding / landslide as a result of increase in run off • Replacement cost / damage cost avoided of likely damage • Change in river flow / incidence of low flow • Impacts of low flows on water supply, biodiversity etc
Intensive agriculture on steep slopes / marginal lands	Soil erosion	**On site**: • Reduced productivity due to reduce soil fertility • Loss of area available for agricultural production	• Δ in productivity × market price of affected crop • Cost of replacing loss nutrients to maintain soil fertility	• Time series data on soil fertility levels • Time series data productivity per ha for key crops • Market price of key crops • Area lost to agriculture as a result of soil erosion • Market prices of replacing soil nutrients lost

Type of land degradation	High level physical impact	Specific impacts	Possible monetary approaches	Data requirements
		Off-site: • Siltation of reservoirs resulting in loss energy output and water supply	• Loss of energy output as a result of the reduce life time of reservoir × market price of energy • Loss of water available for irrigation × Δ in productivity × market price of affected crops	• Change in runoff as a result of erosion • Probable incidence of flooding / landslide as a result of increase in run off • Replacement cost / damage cost avoided of likely damage

Table A8: Selected Water ES - Physical Data Requirements

Benefit / outcome	Physical / Scientific Data requirement
Public water supply	m^3 of water available / abstracted per year Sustainable extraction rate Number of households using the water supply
Private / community water supply	m^3 of water available / abstracted per year Sustainable extraction rate Number of households using the water supply
Agriculture	m^3 of water available / abstracted per year Sustainable extraction rate Quantity and types of crops produced per year
Industrial Abstraction	m^3 of water available / abstracted per year Sustainable extraction rate Quantity of products produced per year
Energy provision	Kwhs of energy provided Service needs to be clearly defined
Protecting the benefits of surface water for consumptive and non-consumptive (e.g. water abstraction, recreational, non-use)	Need to understand the recharge function and map the economic benefits of the surface water supported by groundwater. Tourism and wildlife / ecological / conservation benefits may be captured here, which can be valued using a variety of approaches
Reduced flood risk	Need to quantify extent to which a ecosystem (forest, land, groundwater, wetland) reduces flood risk, and how that service would change given a change in the ecosystem
Sink for atmospheric carbon dioxide	Need to understand the amount of carbon stored.
Reduced impact of contaminants	Need to describe and quantify extent to which an ecosystem (land, wetland, forest) reduces impacts of contaminants, and how that service would change given a change in the ecosystem
Prevent subsidence	Relationship between an ecosystem and risk of subsidence and potential damage related to different levels subsidence
Non-use values	Need to define non-use benefit associated with an ecosystem and the population deriving non-use value

Table A9: What water related ecosystem services can be valued using market prices?

Benefit / outcome	Potentially Applicable Market Pricing Approaches
Public water supply	Market prices, e.g., cost per unit volume supplied Replacement borehole / alternative source cost Treatment cost
Private / community water supply	Market prices Cost of conversion to mains supply Treatment costs
Agriculture	Market prices Replacement borehole / alternative source cost Treatment cost Change in land use value
Industrial Abstraction	Market prices Cost of conversion to mains supply Treatment costs
Energy provision	Market prices for energy generated Avoided damage from pollution from alternative energy sources like fossil fuels
Protecting the benefits of surface water for consumptive and non-consumptive (e.g. water abstraction, recreational, non-use)	Markets prices and other market pricing approaches
Reduced flood risk	Damage cost avoided
Sink for atmospheric carbon dioxide	Market prices of carbon Damage cost avoided
Reduced impact of contaminants	Cost of alternative to land spreading landfill
Prevent subsidence	Damage costs avoided (to building, drainage systems etc)
Non-use values	*Not applicable*

Overview of costs and benefits

Table A10 summarizes the types of benefits and costs that should be included in the analysis. Benefits include the key ecosystem services provided by the study area monetized where possible and a quantitative description of the key social benefits associated with a land use (e.g., jobs created). The costs associated with each scenario also need to be identified in order to derive the net benefit of each option. Operating costs include: labor, infrastructure development, seeds, fertilizers, pesticides etc. Offsite environmental costs include water pollution and the sedimentation of waterbodies.

Table A10: Key Categories of Costs and Benefits

Benefits	Costs
Key ecosystems services – food, carbon sequestration	On-site financial costs – labour, seeds, fertilizers, pesticides
Social benefits – jobs, health (quantified)	Off-site environmental costs – water pollution, sedimentation of water bodies

Step 6: Analysis of Economic Evidence

Step 6 focuses on the analysis required to complete the economic assessment: the unit values derived from the valuation exercise need to be aggregated to derive total values and in order to be input into a **cost benefit analysis**; sensitivity analysis is undertaken in order to draw out uncertainties around the monetary evidence; streams of benefits (and costs) over time need to be discounted to derive present values; and, **distributional analysis** is undertaken to draw out the key beneficiaries and cost bearers associated with current practices and alternative management options, and implications for poverty alleviation. **Emphasis should be placed on how different scenarios contribute to poverty alleviation**. Distributional weights might also be considered for the cost benefit analysis.

Step 7: Understanding the institutional requirements

Under step 7 the institutional context is specified and the barriers to the adoption of the optimal economic scenario analysed.

13.2 Annex 2: Overview of mines operating in Armenia

N	Name of mine	Deposits of ore, 1000 t.	Deposits of metal,		Ownership	Annual ore productivity, 1000t
NON-FERROUS METALS ***Copper mines***						
1	Alaverdi	1,268.0	Cu 66,200 t		Walex Group (ACP), (Armenia&Lichtenstein)	Inactive (underground mine)
Copper-molybdenum mines						
2	Agarak	30,930.7	Mo- 7,500 Au-640.3 kg Re-6.81 t Bi-50.13 t	Cu-117.1 Ag-29.7 t Se-83.52 t S-323.8	GeoProMining, (Russian Federation)	Active-about 3,000.0-3,500.0 (Open-Pit)
3	Teghut	453,796.0	Mo-97,940t Au-4,776 kg	Cu-1,609,700t Ag- 303.8 t	Walex Group (ACP), (Armenia&Lichtenstein)	Inactive (under construction) (Open-Pit)
4	Ajgedzor	124,208.0	Mo-41,320t	Cu-207,300t	Tatstoun LLC: Txkut place (Armenia) Aktiv Lernagorc: Central place (Armenia)	Inactive (Open-Pit: prepared for operation with 600,0 (Txkut) 500,0 (Central) annual productivity)
5	Dastakert	18,345.6	Mo-10,400t	Cu-127,500t	Molibdeni Ashkharh-branch: Global Metals Group Neva Rus Copmany (Russian Federation)	Inactive (Open-Pit: prepared for operation in 2015 with 2,000.0 annual productivity)
6	Lichq	34,065.0	Mo -480 t Cu-214,200t Se 35.0 t S 110.0 t	Au 584.0 kg Ag 43.6 t Te 20.1 t	Tatstoun LLC	Inactive (Open-Pit: prepared for operation with 500,0 annual productivity)
7	Hanqavan	127,742.0	Mo- 39,053 t Re 22.6t Se 5.43 t Te 2.7 t	Cu 129,300 t Bi 10.23 t Ge 269.55 t Au 31,894 kg Ag 112.31 t	Golden Ore LLC	Inactive (Open-Pit)
8	Kajaran	2,244,000.0	Mo-737,000t	Cu-5,274,000t	Zangezur Copper-Molybdenum Combine CJSC (Main Shareholder: Cronimet Mining AG (60%) Germany	Atcive (Open-Pit: annual productivity is about-17000)
NON-FERROUS METALS ***Copper-pyrium mines***						
9	Kapan	3,684.0	Au-433.84kg	Cu-142,700t	Conserved	Inactive
10	Shamlugh	4,462.0	Cu-152,500t Pb- 4,900t Zn-14,200t	Au-1798.0 kg Ag-28.0t	Metal Prince Ltd British Nevis Island	Active-about 200.0 (Combine: Open-Pit; underground mine)
Gold-polymetallic mines						
11	Shahumian	18,000.0	Au-42,500kg Ag- 882.12 t Cu-110,300t	Zn-447,900t Pb-33,7t	Dundee Precious Metals Inc. (Canada)	Active (underground mine: annual productivity 550.0-600.0)
12	Azatek	8,307.4	Au-19,558kg Ag-434.0 t Pb 40,200.0 t Se- 52.6 t Bi-254.8 t Ga-133.5 t S-418.4 t	Cu-14,800t Sb-5,400t Zn 24,100t Te-12.9t Cd-113.7t As-28.5 t	Azatek Gold CJSC Anglo-African Minerals plc & Alrosa	Inactive (underground mine: annual productivity should be 200.0)
13	Lich-vaz tey	3,026.0	Au-17,870kg Ag- 97,7t	Cu-11,980t	LV Gold mining CJSC: Global Metals Group Neva Rus Copmany (Russian Federation)	Inctive-about 400.0 (Combine: Open-Pit; underground mine)
14	Terterasar	174,700.0	Au-2,016.4kg Ag-16,2t	Cu-1,038.9	Sipan-1	Inactive (underground mine: annual productivity should be 50.0)

15	Armanis	14,833.3	Cu-160,000t Zn-381,300t Pb-178,900 t	Au-12547kg Ag-163.7 t	Sagamar CJSC Global Metals Group Neva Rus Copmany (Russian Federation)	Active-about 300.0 (Open-Pit)
16	Marjan	4,707.8	Au-19,998kg Ag-435,1t Cu-6,240t	Pb-56,900t Zn-46,700t	Marjan Maninig LLC, Global Gold Corporation (USA)	Inactive (Open-pit 150.0)
Polymetalic mines						
17	Akhtala	1,293.0	Cu-7,100t Zn-55,000t Ag-118,8t	Pb-20,500t Au-1,552 kg	Metal Prince Ltd British Nevis Island	Active-about 200.0 (Underground mine)
18	Gladzor	3,780.0	Pb-169.7 t Zn-159.1 t Cd- 669.0 t	Cu-36.9t Ag-224.4t Se-28.9 t Te-24.0 t	GeoProMining, (Russian Federation)	Inactive (underground mine: annual productivity should be 250.0)
PRECIOUS METALS **Gold Mines**						
19	Sotq	31,141.2	Au-133,533 kg Ag-175.6 t	Se-56,3 t Te-280 t	GeoProMining, (Russian Federation)	Active (Open-Pit : annual productivity is about 850.0)
20	Amulsar	56,434.5	Au-52,664kg	-	GeoTeam Lidian International LTD Canada	Inactive Is under exploration
21	Meghradzor	410.6	Au-4,968.4 kg	Ag-407 t Te-9.35 t	Meghradzor Gold Armenia rented from GeoProMining	Active (underground mine; open-pit 7,2)
22	Mghart	-	-	-	Multi Group Armenia	Inactive (is under exploration)
23	Tuxmanuk	1259.4	Au-8,007.3 kg	Ag-44,7 t	Mego Gold LLC, Global Gold Corporation (USA)	Inctive (is under exploration)
24	Karaberd	303,3	Au-1,631.9kg	Ag-2,92t	Asaat LLC Armenia	Inactive (Open-Pit-by annual productivity-12,5; underground mine-by annual productivity-30,0)
25	Barcradir (Mazra)	917,7	Au-9,643kg Ag-14,4t	Te-4.6t S-53.2t Bi-14.5t	Ophuland Trading Solituions	Inactive (Open-Pit-by annual productivity-30,0)
Nephelyne sienits **(Alluminium raw materials)**						
26	Teghsar	457,000.0	Al-98,255.000t	-	Alumina Corporation LLC	Inactive (Open-Pit-by annual productivity-3000,0-11,000)
FERROWS METALS **Iron mines**						
27	Abovian	260,800.0	Fe-67,788.000t	-	Bounty Resources Armenia Limited& Fortune Oil Armenia-Virgin Islands-China	Inactive
28	Hrazdan	50,061.0	Fe-16,000.000t	-	Bounty Resources Armenia Limited& Fortune Oil Armenia-Virgin Islands-China	Inactive

13.3 Annex 3: The four principle phases of mining and practices in Armenia

Phase 1: Ore exploration

The objective of exploration is to discover and locate a mineral deposit in the ground which can be shown to be commercially viable in order to initiate mining activities. Exploration is a long-term effort which proceeds in phases from regional studies to site-specific investigations. In the phase of areal exploration, interpretation of potentially ore-bearing zones draws on data for the entire country that has been produced by geological surveys and studies carried out by the Geological Fund (cadastre) of Armenia (GFA).

- **Exploration methods**

  Targeted exploration is based on geological field studies, that is, direct observations and measurements of outcrops, boulder prospecting, as well as samples taken from outcrops and till and their analysis (GFA).The vast majority of exploration activities are terminated if the indications of ore reserves prove insufficient in site-specific studies. Very rarely does exploration lead as far as exploratory excavation or applications for a mining permit. On the other hand, investigation of the same sites may be reactivated as a result of new research findings, changes in world market prices for the metals or developments in metal extraction techniques. Exploration activities do not hinge exclusively on the resources in the bedrock; they must take into account economic, environmental and social factors as well.

- **Emissions during prospecting**

  The emissions in prospecting are generally limited to the exhaust emissions caused in drilling and in moving around in the field. Emissions (e.g. oil from machines) may also affect watercourses, primarily when accidents occur.

  Pilot mining in the prospecting phase causes emissions, the extent and significance of which varies depending on the amount of material excavated and the location of the pilot pit. In pilot mining, excavation, loading of vehicles and transport can cause noise, dust and exhaust emissions. Pilot mining often requires the pumping out of water that collects in the excavations. With the discharge of dewatering water, water bodies in the vicinity may receive emissions of suspended solids and metals as well as nitrogen emissions originating from explosives.

  The possible emissions of a pilot concentration plant are similar to those coming from the plant during proper production. These are dealt with in more detail in later sections.

Phase 2: Construction of mine

- **Mine opening**

  Opening a mine requires that extraction and processing of the ore deposit will be economical. The discovery of an ore deposit does not always lead to the start-up of a mine. Assessments of the feasibility of the deposit will take into account, among other factors, the location of the deposit, its size, mineralogical composition, concentrations of valuable minerals, bedrock mechanics, concentrating and further processing, as well as opportunities to market the concentrate, the costs of constructing the mine, and the environmental and other permits that apply to the project. The assessment and other reports required may take a number of years to complete.

  Construction of a mine generally begins promptly after the decision is taken to establish the mine. Constructing a mine normally takes some two years if a concentrating plant is built along with the mine. When construction is started, the first facilities built are normally roads and, in consideration of the work in the start-up phase, the provision of a sufficient electrical supply is ensured. In the initial phase work and storage facilities are usually arranged using temporary buildings. The construction of permanent structures (concentrating plant, maintenance, storage, office and others) and of other infrastructure (including tailings ponds, water treatment systems, lining of waste rock areas) is begin in order of urgency.

- **Emissions during mine construction**

When a mine is being built, construction work and increased traffic can cause noise as well as emissions to air, water and soil.

In the construction phase, dust raised by the roads and earthworks (including tailings dams and reservoir dams, as well as areas where the overburden is removed) causes the emission of fine-grained particle into the air (dust emissions). These emissions may, particularly during dry and windy periods, be considerable and very conspicuous if no attention has been paid to reducing them. Dust emissions are also caused by the excavation and crushing of rock needed in construction.

The most significant gaseous emissions into the air during construction occur at different sites from the exhaust produced by equipment used in excavation and crushing and the heavy vehicles used to transport rock and earth materials and construction materials (particulate SO^2, CO^2 and NOx emissions). Exhaust emissions are greater, the more overburden is removed and the greater the dimension of stone and waste rock excavated and transported from the pit to the sites where they will be used and to the storage areas.

As a result of increased erosion, emissions of suspended solids, for the most part, may pass into watercourses near the mine site through drainage waters, particularly during rainy periods and the spring snowmelt. The drainage waters come from dewatering and water channeling systems, dams and other earthworks sites, storage areas, as well as areas where the overburden has already been removed.

During construction, noise emissions are caused primarily by the blasting required in excavation, by the machinery used in excavating, crushing rock and different types of construction work, and by the heavy vehicles used for transporting overburden, crushed rock and blasted rock at the mine site.

Mining wastes may also be produced during construction, mainly in the form of waste rock. Where this is the case, a waste management plan for mine waste and a plan for the management of rock material must be presented, implementation of which is required at the latest when massive excavation of waste rock is begun.

Phase 3: Production

- **Excavation / Mining** – ore is removed from the bedrock through excavation. It is not considered acceptable to waste natural resources by, for example, exploiting only the richest part of the ore deposit and leaving poorer and less profitable parts untouched or removing them along with waste rock. Adhering to this principle requires constant optimisation of excavation on the basis of the prices of metals and the costs of mining, concentrating and extraction wastes. In **open pit mining**, the technique used generally results in large quantities of waste rock being excavated, as ensuring safe walls in the pit requires that the pit be widened as it becomes deeper. The ore-to-waste rock ratio (strip ratio) in Armenian metal ore mines varies from 1:1 to 1:20. Open pit mining may use a number of techniques: bench excavation, buffer or massive blasting, excavation by hammer drill. Of these, buffer blasting is the most common in Armenian mines (e.g. it is used at the Sotq, Agarak mine). The advantage of the technique is the selective nature of loading, which ensures maximum recovery of ore and minimum dilution by gangue (minerals with no economic value). The maximum depth of open pits at metal ore mines in Armenia varies as a rule between 100 and 200 m, with the bench height typically 10–15

m. Depth for the open pit at the Kajaran copper-molybdenum mine is more than 300m, here a massive blasting excavation method is used.

- **Transportation**. At Karaberd mine it is proposed to transport the ore haulage by dump truck (КрАЗ 65032) to Vanadzor railway station (11.5km from the mine). From here it will be transported 295 m by train to Ararat gold recovery plant. If the ore is transported from the mine to the concentrating plant by truck, oversized pieces of ore are broken up before transport and the first phase of actual crushing is carried out in a crushing plant on the surface. The first phase of crushing is called pre-or rough crushing and it is typically done using jaw crushers or gyratory crushers.
- **Crushing and screening / milling.** The ore is crushed and ground to an appropriate size for further processing. The crushing and screening circuits are sometimes built outdoors without protective buildings. This approach poses challenges for environmental protection and operations under extreme weather conditions.
- **Grinding.** During grinding, the ore is fractured to a grain size where the valuable minerals contained in the ore occur as sufficiently pure, discrete particles that can be separated from the particles of waste rock in the concentrating process. In metal ore mines, ore is typically ground in horizontal rotating mills in a slurry using either metal grinding balls or larger pieces separated from the ore (in what are known as autogenous grinding methods). Grinding usually consumes more energy than any other phase of mineral processing (30–50%). For this reason, optimisation of the grinding circuit is frequently a focus of continuous development in mining works.
- **Concentrating Plant.** In concentrating, the valuable substances and minerals in the ore are removed chemically or mechanically from gangue, the resulting material is known as concentrate. The most common concentration methods used in metal ore mining are – flotation, gravity concentration, magnetic concentration and leaching methods). The Ararat Gold Recovery Plant (owned by Geo Pro Mining Company-GPM) is planning to build a new plant based on the Albion technology of gold extraction (leaching method). The Albion technology was developed in Australia by Xstrata Technology with the support of Core Process Engineering. GPM expects the process to significantly increase gold recovery from sulphide-bearing ore produced at the Sotq mine. The goal is to increase gold production to an estimated 150,000 oz/a.
- **Drying, storage and transportation of concentrate.** The concentrates that form the end-product of the concentration process at metal ore mines generally consist of dry, finely ground mineral material that contains precious metals. Gold mines may also produce doré bars. The concentrates are stored until they can be transported to clients for further processing. Before being stored, concentrates are dried using drum, disc or compressed air filters. Filtration makes it possible to reduce the moisture content to some 10%, which is sufficient for storage and transportation. Thermal drying is also an option.

Emissions in the production phase

- **Emissions into the air: Excavation and transport**

The excavation and transport of ore causes mineral dust, exhaust and blasting gas emissions. In both open-pit and underground mines, haulage of ore using trucks causes dust and exhaust emissions typical of vehicle traffic, particularly when the ore is brought to the surface to be stored. Mineral dust rises from the ore, road surfaces, tires and truck beds.

In blasting the explosives used in excavation (e.g. emulsion explosives, ANFO) become, as a rule, water vapor, carbon dioxide and nitrogen. In addition, blasting gases contain small quantities of harmful gases, such as carbon monoxide and nitrous oxides. Blasting also creates smoke. The quantity of gases produced in blasting is some 0.7-1 m^3 of gas per kilo of explosive.

The hot gas produced in blasting always raises a certain quantity of rock material into the atmosphere. The amount of dust rising into the air depends on the charge and rock material involved. For the most part, the rock material settles in the immediate vicinity of the mine but the finer matter may travel father from the site.

The haulage of ore and waste rock at the mine site takes place on unpaved roads, on which ore and waste rock fall during transport. This rock material is ground into a fine dust under the weight of heavy vehicles, with a muddy sludge often forming on the road surface. The dust and exhaust gases from traffic increase with number of intermediate loadings and unloadings and the distance travelled when the concentrating plant is relatively far from the mine.

In underground mining the allowable emissions into the surrounding air from the ventilation exhaust are restricted by occupational safety regulations, whereby the emissions are generally low. Humidity in the mine also reduces the spread of dust into the outside air from ventilation exhaust. In open pit mining dust and exhaust emissions are often clearly greater than in the case of underground mining due to the vehicle traffic involved. These emissions are also limited through occupational safety regulations.

Phase 4: Rehabilitation of site. Under current mining legislation, operations are deemed to have ceased when the mining permit expires or is revoked. The principal aim in mine closure is to restore the mining works to a condition where they pose no detriment to human health or the environment. The closure plans must also take into account the need to use the area again. According to the Mining Code (28.11.2011) the planning of closure is begun at an early stage in the life-cycle of a mine. The first plans for closure and for the related rehabilitation measures are to be made already during planning of the mining activities and feasibility study or, at the latest, when the permit application is submitted. This way the closure costs can be taken into account in determining the overall costs of the mine. Early planning also helps to reduce potentially detrimental environmental impacts from the activities.

13.4 Annex 4: Biodiversity survey

Flora

According to the verified floristic zoning (Tamanyan, Fayvush, 2009), the section of Bazum Mountain chain within the study area is part of Ijevan floristic zone, and the main florocoenotype of the zone is broadleaf forests (Fagaceae, Oak groves, Hornbeam). The forest flora is dominated by Caucasian Oak (*Quercus macranthera*). In addition to forest flora, southern slopes of Bazum mountain chain are widely covered by tragacanth (dominant plant - *Astragalus aureus*) and Festuca (dominant plant - *Festuca valesiaca*). At the highest section of Bazum Mountain chain (outside of the area studied) limited portions of subalpine and alpine vegetation can be found. Intrazonal vegetation in the studied area is represented by petrophyte vegetation of steppe zones. Wetland vegetation on southern slopes of Bazum Mountain chain is almost non-existant, which is because there are almost no rivers. There are a small number of rivulets and water springs, which completely dry out in the summer period.

According to K.E. Husyan (1987), the flora of Bazum Mountain chain is comprised of *1,033* species of higher plants belonging to 101 families, and 436 *branches. However, as a result of continuous research in the 25 years following this publication, the floristic composition is currently understood to contain more than 1,100 species of higher plants.*

As part for this study detailed studies of the flora in the territory proposed for the future mine was undertaken, as well as adjacent territories located at the distance of 300-400 m from Karaberd mine.

Certain geological investigations have already been conducted in the study area, and entrance routes excavated, which in future will become part of the mine infrastructure. Drilling has also been conducted and exploratory water canals excavated at the site. Natural ecosystems in these territories are either completely devastated and replaced with ruderal vegetation, or, in cases where there are natural ecosystems, ruderal plant species dominate. The following plant species extensively grow in these territories: Achillea millefolium – Common yarrow; *Cirsium vulgare* – Spear thistle; *Tussilago farfara* – Coltsfoot; *Echium vulgare* – Blueweed; *Poterium polygamum* – Sanguisorba minor; *Cichorium intybus* – Blue daisy; *Anchusa arvensis* – Small bugloss; and *Arctium palladinii*.

Among plant species of natural ecosystems, the following are found in the area: Hypericum perforatum; *Campanula alliariifolia* – Cornish bellflower; *Campanula glomerata* – Clustered bellflower; *Carlina vulgaris* – Carline Thistle; *Thymus kotschyanus*; *Xeranthemum squarrosum*; *Melica taurica*; *Cephalaria gigantean*; Glaucium corniculatum; and, *Papaver fugax*.

In plant growing locations damaged as a result of mineral exploration activities and in territories outside the borders of the proposed mine, **meadow-steppe ecosystems** can be found, which are used as grasslands and pastures; in addition, limited sectors of oak tree forest and steppe brushwood ecosystems exist in the territory. In one of the forest sectors, a streamlet flows in spring and early summer time, and on its two sides distinct representatives of wetland flora have persisted. The meadow-steppe sectors that are used as pastures bear marks of overgrazing, and these sites are characterized with excessive growing of such species, as *Filipendula vulgaris* and *Euphorbia seguieriana*, as well as *Tanacetum chiliophyllum*.

Meadow-steppe ecosystems are mainly represented by the following plant genera and species: sedge (Carex) (dominant - *Festuca valesiaca*), feather-forb (meadow-steppe or steppe) (dominants - *Stipa capillata* and *Stipa tirsa*)[46]. In stony sectors certain elements of

[46] In addition the following plant species can be found: *Cephalaria gigantean; Hypericum perforatum; Poterium polygamum; Geranium ibericum; Campanula glomerata; Thymus kotschyanus; Carlina*

petrophyte vegetation grow: *Melica taurica; Erigeron acer; Dianthus cretaceous; Thymus kotschyanus; Teucrium polium; Sempervivum transcaucasicum; Sedum tenellum; Helichrysum plicatum; Dianthus orientalis; Cotoneaster integerrimus; Linaria genistifolia; and, Silene compacta.*

In a comparatively even and not large sector located above the future mine, an integrated cohabitation of steppe shrubbery was noticed, where *Rosa corymbifera* dominated (the latter is in fact the only dominant species in steppe shrubbery cohabitations). The following plant species can be found in the grass layer of this territory: *Campanula glomerata; Medicago sativa; Onobrychis radiate; Rhynchocorys orientalis; Cephalaria gigantean; Scabiosa caucasica; Convolvulus arvensis; Falcaria vulgaris; and, Agrimonia eupatoria.*

Iris leaves were discovered most probably belonging to *Iris Paradoxa*. However, since the flowers and fruits were no longer evident it was not possible to determine the precise genus of this plant. It is necessary to survey in early summer to conclude whether the plant belongs to an Iris species registered in the Red Book of Armenia for plants.

In the two forest areas located in the valleys of the study area *Quercus macranthera* is widespread. These forests were probably cut by the local communities; a number of stubs with offshoots were found. In the tree rows a very limited number of *Ulmus elliptica, Ulmus Glabra*, and *Fraxinus excelsior* also grow, while at the forest edge *Prunus Divaricate* can be observed. In areas that are more or less open and in areas located at the forest edge, *Rosa Corymbifera, Rosa spinosissima*, *Rubus buschii* grow, while the following grass species grow in the grass layer and on the forest edges: *Primula macrocalyx; Fragaria vesca; Geranium robertianum; Melilotus officinalis; Agrimonia eupatoria; Cephalaria gigantean; Thalictrum minus; Silene Alba; Sanguisorba officinalis; Betonica macrantha; and, Eryngium campestre.* A very beautiful and rarely found fungus, *Macrolepiota procera*, was discovered in the area.

Fauna

An expedition was carried out to survey the fauna of the area, during which the composition of vertebrates (amphibian, reptilian, birds, mammalia and macrozoobenthos) was observed and identified, taking into consideration all the possible habitats of these animals. The survey of fauna also builds on published literature. Faunistic observation (method of route recording) was applied to identify species. The animals were studied directly in their natural conditions. In order to identify animals leading secret lives feces were traced. Account was also taken of the sounds made by birds and mammals, a trapping net was used for birds and traps and bait for small animals, including rodents. The movements of the animals were registered using GPS equipment, which was also used to identify the locations of nests and hiding places. In general the number of direct observations of birds and mammals are very limited: more frequently traces of life of these animals are observed.

Amphibian**.** In the studied territory of Karaberd (according to data found in literature), two species of amphibian can be found: Green toad *(Pseudepidalea variabilis)* and Caucasus frog *(Rana macrocnemis)*. These two species were not recorded during the brief field studies undertaken.

Reptilia. In the course of conducted studies, no species of reptiles was observed. Nevertheless, the altitude of this territory above the sea level and existence of relevant biotopes makes it possible that the species listed in Table A12 exist in the surroundings of the studied area. Long-term seasonal studies are needed to more concretely understand species composition.

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vulgaris; Xeranthemum squarrosum; Anthyllis boissieri; Potentilla recta; Koeleria cristata; Euphrasia pectinata; Origanum vulgare; Allium saxatile; Allium karsianum; Agrimonia eupatoria; Fragaria vesca; Gentiana gelida; Hieracium umbellatum; Erigeron venustus; Centaurea rhizantha; Campanula alliariifolia; Dianthus raddeanus; Scabiosa caucasica; Echinops pungens; Grossheimia macrocephala; Eryngium billardieri; and, Psephellus somkheticus.

Two of the reptiles are species included in the Red Book of the Armenian Fauna: (i) *Darevskia dahli* (Darevsky, 1957), which is included in the IUCN Red List of Threatened Species (ver. 3.1) with the “Near Threatened” status. According to criteria set by the IUCN Red List of Threatened Species, this species is identified as “Endangered” - EN B1a+2a; and, (ii) *Darevskia rostombekovi* (Darevsky, 1957), included in the IUCN Red List of Threatened Species (ver. 3.1) with the “Endangered” Blab (i,iii) status. According to criteria set by the IUCN Red List of Threatened Species, this species is identified as “Endangered” - EN B2 ab (i,iii).

Table A12: The species of amphibian and reptilian found in the study area (based on literature review)

Order	Family	Species (name in Latin)	Reference in literature	Red Book of Armenia
Amphibians	*Bufonidae*	*Pseudepidalea variabilis* Pallas, 1769	+	
	Ranidae	*Rana macrocnemis* Boulenger, 1885	+	
Reptilia	*Anguidae*	*Anguis fragilis* Linnaeus 1758	+	
	Agamidae	*Laudakia caucasia* (Eichwald, 1831)	+	
	Lacertidae	*Lacerta strigata* Eichwald, 1831	+	
		Darevskia dahli (Darevsky, 1957)	+	+
		Darevskia rostombekovi (Darevsky, 1957)	+	+
		Darevskia armeniaca (Mehely, 1909)	+	
	Scincidae	*Ablepharus bivittatus* (Menetries, 1832)	+	
	Colubridae	*Hemorrhois ravergieri* (Menetries, 1832)	+	
		Natrix tessellata (Laurenti, 1768)	+	
		Coronella austriaca (Laurenti, 1768)	+	

Birds. **Ac**cording to literature sources and field observations, 43 species of birds can be found in the study area (Table A13) of which 28 were observed. Passerines are most typical, and predator birds are also widespread. No species included in the Red Book are found among birds typical to the area.

Table A13: Species of birds found in the study area

Order	Family	Species (name in Latin)	Reference in literature	Personal observation
Falconiformes	*Accipitridae*	*Circus cyaneus* (Linnaeus, 1766)	+	
		Accipiter nisus (Linnaeus, 1758)	+	
		Buteo buteo (Linnaeus, 1758)	+	+
	Falconidae	*Falco tinnunculus* (Linnaeus, 1758)	+	
Galliformes	*Phasianidae*	*Coturnix coturnix* (Linnaeus, 1758)	+	+
		Perdix perdix (Linnaeus, 1758)		+
Apodiformes	*Apodidae*	*Apus apus* (Linnaeus, 1758)	+	
Columbiformes	*Columbidae*	*Streptopelia turtur* (Linnaeus, 1758)	+	
Cuculiformes	*Cuculidae*	*Cuculus canorus* (Linnaeus, 1758)		+
Coraciiformes	*Meropidae*	*Merops apiaster* (Linnaeus, 1758)	+	+
	Upupidae	*Upupa epops* (Linnaeus, 1758)	+	+
Piciformes	*Picidae*	*Picus viridis* (Linnaeus, 1758)	+	
		Dendroscopos major (Linnaeus, 1758)	+	
Passeriformes	*Hirundinidae*	*Hirundo rustica* (Linnaeus, 1758)	+	+
		Delichon urbica (Linnaeus, 1758)	+	
	Motacillidae	*Motacilla alba* (Linnaeus, 1758)	+	+
		Antus trivialis (Linnaeus, 1758)		+
	Laniidae	*Lanius collurio* (Linnaeus, 1758)	+	
	Troglodytidae	*Troglodytes troglodytes* (Linnaeus, 1758)	+	
	Turdidae	*Erithacus rubecula* (Linnaeus, 1758)	+	+
		Turdus merula (Linnaeus, 1758)	+	+
		Turdus viscivorus (Linnaeus, 1758)	+	+
		Phoenicurus phoenicurus (Linnaeus, 1758)	+	
	Sylviidae	*Phylloscopus syndianus* (Brooks,WE, 1880)		+
	Muscicapidae	*Oenanthe isabellina* (Pallas, 1764)		+
		Muscicapa striata (Pallas, 1764)		+
	Paridae	*Parus major* (Linnaeus, 1758)		+
		Parus ater (Linnaeus, 1758)	+	+
		Parus caeruleus (Linnaeus, 1758)	+	+
	Aegithalidae	*Aegithalos caudatus* (Linnaeus, 1758)	+	
	Sittidae	*Sitta neumayer* (Michahelles, 1830)		+
		Sitta europaea (Linnaeus, 1758)	+	+
	Emberizidae	*Emberiza cia* (Linnaeus, 1766)		+
	Fringilidae	*Carduelis carduelis* (Linnaeus, 1758)		+
		Carduelis cannabina (Linnaeus, 1758)	+	+
		Fringilla coelebs (Linnaeus, 1758)	+	+
		Pyrrhula pyrrhula (Linnaeus, 1758)	+	
	Certhidae	*Certhia familiari* (Linnaeus, 1758)		+
	Ploceidae	*Passer domesticus* (Linnaeus, 1758)	+	+
	Corvidae	*Pica pica* (Linnaeus, 1758)	+	
		Garrulus glandarius (Linnaeus, 1758)		+
		Corvus corax (Linnaeus, 1758)	+	+
		Corvus corone (Linnaeus, 1758)	+	

Mammals. The mammal survey was based on a literature review as well as field observations of animal traces and hiding places. Many mammals are nocturnal, but the fieldwork was only carried out during the daytime, when temperatures were high, and as a result few observations were made. However, many traces and signs of activity were found in the forested area of site, namely of *Vulpes vulpes and Canis aureus.* Nests of mouse-like rodents were also found. Only 12 of the 36 species of mammals specified in the literature to be living in this area were observed (Table A14). There are three Red-listed species:

- Brown Big-eared Bat *(Plecotus auritus)* (Linnaeus, 1758) a rare species included in the IUCN Red List of Endangered Species (ver. 3.1) with a status of “Least Concern”. According to the IUCN Red List criteria, this species is considered “Vulnerable” - VU B1a.

- Brown Bear *(Ursus arctos)* (Linnaeus, 1758), listed in the former Soviet Union Red List of Endangered Species and currently listed in the IUCN Red List of Endangered Species (ver. 3.1) with a status of “Least Concern”. According to the IUCN Red List criteria, this species is considered “Vulnerable” - VU B2ab(iii,iv). Although not observed, Brown bear could potentially be found in the area as the conditions are favorable in terms of food availability (the area is rich with berries, wild pears, rosehips).
- Red Deer *(Cervus elaphus maral)* (Gray, 1758), is listed in the IUCN Red List of Endangered Species (ver. 3.1) with a status of “Least Concern”. According to the IUCN Red List criteria, it is “critically endangered” CR D. Unlike the other two species, this species was seen during field observations in the morning time and is thought to have come from the Gyulagarak Planatus Sanctuary.

Table A14: Species of fauna in the area studied

Order	Family	Species (name in Latin)	Reference in literature	Personal observation	Red Book of Armenia
Insectivora	*Soricidae*	*Crocidura gueldenstaedti Pall.*, White-Toothed Caucasian Shrew	+		
		Crocidura leucodon, Bicoloured White-toothed Shrew	+		
		Crocidura suaveolens, Lesser White-toothed Shrew	+		
		Sorex satunini , Caucasian Satunini shrew	+		
		Sorex volnuchini Ognev, Caucasian pygmy shrew	+		
	Erinacedae	*Erinaceus concolor Martin*, Southern White-breasted Hedgehog	+	+	
	Talpidae	*Talpa levantis*, Levant Mole	+		
Chiroptera	*Vespertilionidae*	*Myotis blythi Tomes*, Lesser Mouse-eared Bat	+		
		Plecotus auritus, brown long-eared bat	+		+
		Barbastella leucomelas, Asian Barbastelle	+		
		Miniopterus schreiberi, Common bent-wing bat	+		
		Pipistrellus pipistrellus Schreber, Common Pipistrelle	+	+	
		Pipistrellus nathusii, Nathusius' pipistrelle			
		Eptesicus serotinus, Serotine bat	+		
Carnivora	*Canidae*	*Vulpes vulpes L., Red fox*	+	+	
		Canis aureus L., Common jackal	+	+	
		Canis lupus L., Gray wolf	+	+	
	Mustelidae	*Martes foina Erxleben, Stone marten*	+	+	
		Mustela nivalis L., Least wease	+		
		Meles meles (Linnaeus, 1758), European badger	+	+	
	Ursidae	*Ursus arctos L., 1758 , Brown Bear*	+		+
Artiodactyla	*Suidae*	*Sus scrofa L., Wild boar*	+		
	Cervidae	*Capreolus capreolus L., European roe deer*	+		
		Cervus elaphus maral Gray., 1758, The Caspian Red Deer	+	+	
Lagomorpha	*Leporidae*	*Lepus europaeus Pall., European hare*	+	+	
Rodentia	Cricetidae	*Microtus arvalis* Common vole		+	
		Microtus majori Thomas, Major's pine vole	+	+	
		Microtus daghestanicus Shidl., 1919 Daghestan pine vole	+		
		Mezocricetus brandti Nehring, 1898 Brandt's Hamster	+		
		Cricetulus migratorius Pall., Gray Armenian hamster	+		
		Chionomys nivalis Mart., 1942, European snow vole	+		
	Muridae	*Mus macedonicus petrov et Ruzic, 1983*, Macedonian mouse	+		
		Sylvaemus ponticus Sviridenko, 1936 , Caucasus Field Mouse	+		
		Sylvaemus uralensis Pallas, Pygmy wood mouse	+	+	
		Rattus norvegicus Berkenhout, Norway rat	+		
	Gliridae	*Driomys nitedula Pall., 1778*, Forest dormouse	+		

Species Composition of Macrozoobenthos in Pambak River.

In order to assess natural and man-made impacts on watersheds and their catchment areas, the distribution and composition of macrosoobenthos were studied at two pilot sites. A total of 6 samples were taken (three at each site). Sampling was carried out in accordance with accepted hydrological methods with samples collected with a scoop net and Sarber's device (surface - 0.04 m^2). Processing of samples and determination of types was conducted in the laboratory. The species composition of macrozoobenthos is summarized in Table A15 by sampling sites. For each site the ecological condition of water was calculated based on an averaged Woodiwiss biotic index made up of a scale from 0-10.

Table A15: Distribution and composition of macrozoobenthos in 2 sites studied in Pambak River

Taxon	**1st Site**			**2nd Site**		
	1	**2**	**3**	**1**	**2**	**3**
Crustacea						
Gammarus pulex (Linnaeus, 1758)	3	1				
Insecta						
Ephemeroptera						
Baetis gr. *Luthei*	2	3	1			
Ecdyonurus sp			2			
Plecoptera						
Perlodes sp	5	3	1	1		
Diptera						
Chironomidae						
*Cricotopus sp (*Meigen, 1818)	4	3	2	1		
Thienemanniela gr. *Clavicornis*	1					
Chironomus sp		3	2		1	
Total	15	13	8	2	1	-
TBI Index (Woodiwiss assessment)		3			1	

The Woodiwiss system (Trend Bitoic Index – TBI), more commonly referred to as Trent biotic index assess the extent of pollution by diversity of organisms and value of taxons in the biotic indices, which is assessed through a special table (Table A16):

Table A16: TBI calculation by Woodiwiss

Existence of indicator-species	**N of indicators-species**	**Total number of groups of benthos organisms**					
		0-1	*3-5*	*6-10*	*11-15*	*16-20*	*More than 20*
Stonefly (*Plecoptera*)	More than 1	-	7	8	9	10	11-...
	1 species	-	6	7	8	9	10-...
Ephemera fly (*Ephemeroptera*)*	More than 1	-	6	7	8	9	10-...
	1 type	-	5	6	7	8	9-...
Caddis fly (*Trichoptera*)	More than 1	-	5	6	7	8	9-...
	1 species	4	4	5	6	7	8-...
Gammarus sp.		3	4	5	6	7	8-...
Aquatic sowbug (*Asselus aquaticus*)		2	3	4	5	6	7-...
Oligochaeta		1	2	3	4	5	6-...
All mentioned groups are missing		0	1	2	-	-	-

* With the exception of the species *Baetis rodani* (Large dark olive).

Taxa are macrozoobenthos organisms, the order and larger class category of which are often easily determined, namely: Crustaceans (gammarus, aquatic sowbug), flies of Plecoptera, Ephemeroptera, chironomids, Trichoptera, and oligochaeta (tubificidae). The quality of the biotic index depends on the number and diversity of existing taxa. For example, if 2 to 5 genus groups are discovered and only one species of plecoptera is found, the index will equal 6. If the population of taxa in the same group consists of flies of tubificidae and chironomidea, the index will score 2. The separated number of various taxa is not taken into account here. The Trend Biotic Index has scores from 0 to 10. The lower the index, the higher is the pollution. An index scoring 5 and less indicates significant pollution.

TBI has a scaling grouping of 4 groups (Table A17) and describes the type of waterbed and extent of water pollution.

Table A17: TBI scaling

Scores	Type of waterbed	Extent of pollution
0-2	Polysaprobic polluted	Very polluted
3-5	alpha-mesosaprobic	Polluted
6-7	beta-mesosaprobic	Clean
8-10	oligosaprobic	Very clean

One of the major shortcomings of this index is the small scale and belonging of species-indicators to larger taxonomic groups. Nonetheless, this index is one of the key bioindex systems in many countries, including in CIS.

13.5 Annex 5: The primary technical and economic indicators for Karaberd gold mine

Table A18: Key technical and economic indicators for Karaberd mine

Name of index	Unit of measure	Value
The mine operation method	--	Combine
The basic metal of mine ore	--	Au, Ag
The price of gold (per gram)	USD/t	45.01
The price of silver (per gram)	USD/t	0.72
Gold equivalent conversion factor, K^{i}_{nep}	--	0.013
Land allotment area	hectare	17.49
Karaberd mine area	hectare	1.1
Commercial ore reserves of open-pit	t	36,366.2
The volume of overburden rocks	m^3	71,343.1
Average operating ratio of overburden	m^3/t	1.5
Open-pit lifetime	year	3
Metals reserves of open-pit		
Au	kg	206.5
Ag	kg	359.4
Average content of gold at open-pit extracted ore	g/t	5.81
Reserves of gold equivalent at open-pit	kg	212.25
The open-pit annual ore productivity	t/year	12,122.0
Operation mode of open-pit:		
the number of working days in a year	day	180
the number of relay in a day	relay/day	1
The duration of working day	hour	10
Annual operation costs of open-pit	USD	1,106,500.0
Costs of one tonne of ore (including royalties)	USD/t	91.31
The recovered value per ton of ore	USD/t	261.5
The recovered value per ton of ore, after processing	USD/t	210.35
Annual revenue from open-pit	USD	2,550,00.0
Annual profit from open-pit	USD	1,443,500.0
The open-pit capital investment	USD	1,253,250.0
Capital payback period of open-pit	year	0.9
Commercial ore reserves underground mine	tone	239,081.9
Underground mine lifetime	year	8
The underground mine annual ore productivity	t/year	30,000.0
Metals reserves of underground mine		
Au	kg	1,232.58
Ag	kg	2,216.3
Average content of gold at underground mine extracted ore	g/t	5.28
Reserves of gold equivalent at underground mine	kg	1261.4
Operation mode of underground mine:		
the number of working days in a year	day	305
the number of relay in a day	relay/day	3
The duration of working relay	hour	8.0
Annual operation costs of underground mine	USD	2,113,800.0
Costs of one tonne of ore (including royalties)	USD/t	70.46
The recovered value per ton of ore	USD/t	237.6
The recovered value per ton of ore, after processing	USD/t	188.84
Annual revenue from underground mine	USD	5,665,200.0
Annual profit from underground mine	USD	3,551,400.0
The underground mine capital investment	USD	1,039,000
Capital payback period of underground mine	year	0.3

Name of index	Unit of measure	Value
Reserves of gold equivalent at Karaberd mine (open-pit and underground mine)	kg	1472.54
The lifetime of Karaberd mine	t	11.0
Karaberd gold mine profit over the lifetime	USD	32,741,700
Annual taxes and payments from Karaberd mine (average), in which:	USD	1,342,654.58
State budget	USD	1,337,990.1
Regional budget		4664.48
Karaberd gold mine payed taxes and paymanets over the lifetime	USD	14,769,180.83

Exchange rate: 1 USD=405 AMD

13.6 Annex 6: Consultation report on selection of case studies

Economic valuation study Armenia - UNDP-UNEP Poverty and Environment Initiative (PEI)
Consultation report on selection of pilot study site
Camille Bann, May 2012

Introduction

The United Nations Environment Program (UNEP) and the United Nations Development Programme (UNDP) joint Poverty Environment Initiative (PEI) in the Republic of Armenia aims to contribute to poverty reduction and improved well-being of poor and vulnerable groups through mainstreaming the environment into national development processes.

A key issue identified during the August 2010 scoping mission as being of great importance to poverty reduction and better informed environmental decision making is the economic valuation of ecosystem services (ES) in terms of their influence on human-well being. Such valuation provides policy makers with key information that facilitates environmentally sustainable decision making. A PEI Technical Assistance project (TA) has been prepared together with UNDP Country Office in Armenia that will seek to achieve this by strengthening the knowledge base and capacity at the national, provincial and local levels on the links between ecosystem services and development.

A National Group of Independent Experts is to be formed under this TA project in order to provide scientifically based, neutral evidence and information to various stakeholders, facilitate discussions, and build consensus among conflicting views on economic growth, environment and poverty reduction. The intention is that this group will be sustainable beyond the one year duration of the PEI TA project. The project is due to complete in April 2013. The group will work closely with an International Consultant and develop their capacity in ecosystem valuation through undertaking a pilot study (i.e. learning by doing approach). The group will be inter-disciplinary and will consist of economists, scientists, policy specialist and lawyers. The precise composition of the group will be determined following the selection of the pilot study.

Ecosystem Services Approach

The pilot project will adopt an ecosystem services approach. The ecosystem service approach (ESA), is based on the Millennium Ecosystem Assessment (2005) classification of ecosystem services into the following four categories (Table A19):

- ***Provisioning services*** relate to the tangible products, such as fish and timber provided by ecosystems;
- ***Regulating services*** refer to the natural processes of ecosystems such as waste assimilation and carbon sequestration that contribute to social wellbeing;
- ***Cultural services*** may be associated with both use and non-use values and relate to the non-material benefits obtained from ecosystems, for example, through tourism and educational use the environment; and,
- ***Supporting services*** are necessary for the production of all other ecosystem services (e.g. soil formation or nutrient cycling). They differ from the other services in that their impacts on people are either indirect (via provisioning, regulating or cultural services) or occur over a very long time.

The ESA explicitly recognizes that ecosystems and the biological diversity contained within them contribute to individual and social wellbeing. Importantly it recognizes that this contribution extends beyond the provision of goods such as fish to the natural regulating functions of ecosystems such as carbon sequestration. The ESA therefore provides a framework for considering whole ecosystems in decision making and for valuing the services they provide.

It is important to note that economic valuation is focussed on the 'final benefits' or 'outcomes' realised by society from the services ecosystems provide, not the services and functions that contribute to those outcomes. This is to avoid double counting. The benefits generated by supporting services, while fundamental to the provision of final benefits, are not valued independently as they are intermediate benefits which contribute to the provision of a range of final benefits. Their value is captured in the valuation of the final outcomes associated with the services they support. Supporting services include soil formation and retention, primary production and habitat provision.

Health is also not explicitly listed as an ecosystem service as health benefits are considered to be provided by a range of services such as fish, flood protection benefits and a clean environment for recreation. The health cost associated with deterioration in these services may be used to measure the benefits provided by an ecosystem. **Biodiversity** is also considered to be cross cutting, the final benefits of which could be associated with a range of services. An exception is biodiversity non-use which is listed as a separate service. Table A19 provides an overview of potential ecosystem services. The range of services will vary between ecosystems and between sites. A range of established economic valuation methods exist to estimate the monetary value of these ecosystem services.

The Economics of Ecosystems and Biodiversity (TEEB) 2010 outlines six steps to undertaking economic analysis, which will be broadly followed by the pilot study. The six steps are:

1. Specify & agree the policy issue with stakeholders
2. Identify which services are most relevant
3. Define information needs and select appropriate methods
4. Have ecosystem services assessed
5. Identify and appraise policy options
6. Assess distributional impacts

This consultation report relates to step 1.

Table A19: Overview of potential Ecosystem Services

ES Type	Service	Benefit / outcome
Provisioning Services	Food	Wild meats, fruits, freshwater fish and seafood harvested for commercial and subsistence purposes.
	Wood	Timber, fuelwood and fibre
	Water	Public water supply, water for industrial and agricultural usage
	Natural medicines and biochemicals	Natural medicines
	Source of energy (fuel etc)	Energy provision e.g., hydropower
Regulating Services	Regulation of GHGs	Carbon sequestration
	Micro-climate stabilization	Air quality
	Water regulation (storage and retention)	Flood and storm protection
	Waste processing	Detoxification of water and sediment / waste
	Nutrient retention	Improved water quality
Cultural Services	Spiritual, religious, cultural heritage	Use of environment in books, film, painting, folklore, national symbols, architecture, advertising
	Educational	A 'natural field laboratory' for understanding biological processes
	Recreation and ecotourism	Bird watching, hiking, canoeing
	Landscape and amenity	Property price premiums due to views
	Biodiversity non-use	Enhanced wellbeing associated for example with bequest or altruistic motivations

Consultation on pilot study selection

The immediate need for the project is to identify a **pilot study**. The methodology to be applied will then be designed based on an understanding of the pilot site, including the threats and management and policy issues facing the site.

Key questions to be addressed through valuation study are:

- How do ecosystem services in Armenia support economic growth, employment and prosperity?
- What risks / costs are associated with their damage / loss?
- What are the links between ecosystem services and poverty alleviation?

The following consultation process has been followed to select the pilot study.

Step 1. An inception workshop was held for the project on the 17 May at which the project objectives and work plan were presented along with an overview of best practice principles in ecosystem services valuation and appraisal. A consultation was held on potential study sites at the inception workshop. Participants were invited to provide suggestions on possible case studies. This resulted in six possible pilot study ideas:

- A study of the mining sector, with a possible focus on Jermuk (Amulsar)
- A study of wetlands (Ramsar site or river system)
- A study of the agricultural sector
- A study of water pricing
- A study of the forest sector
- A study of the tourism sector

Step 2. A follow up workshop was held on the 18 May, with a smaller group of experts, to discuss the proposed pilot studies in more detail and assess them against an agreed set of criteria. The criteria used were:

- **Contribution of the pilot study to management of a national priority**. While the key objective of the project is capacity building (adopting a learning by doing approach), the pilot study can also start to generate economic evidence on an issue of national importance.
- **Data availability to undertake the study**. It is recommended to select a site where some data already exists and / or other on-going initiatives are in place. While the pilot study may be able to generate some primary data, e.g. through surveys, in order to evaluate a broad range of ecosystem services, existing scientific and economic data is required. However, a view was also expressed that the pilot study should focus on an ecosystem or sector that has not already been widely studied or where there are a lot of on-going activities. This is an argument against selecting the agriculture sector where there are reportedly many past and on-going initiatives.
- **Links to poverty**. A key objective of the pilot study is to demonstrate the links between sustainable environmental management, economic performance (at the local, regional or national scale) and poverty alleviation (employment, income levels, better opportunities, reduce (environmental) risks). The pilot study should therefore illustrate a link between poor and vulnerable communities and natural resource use and management. This is likely to be easier to do if the pilot site is well populated.
- **Non-contentious**. Different views were expressed over this criterion with some feeling that contentious issues should be avoided and others feeling that contentious cases are where objective information and evidence is most needed to inform decisions and therefore should be prioritized.
- **Multi dimensional in terms of coverage of ecosystem services and sectors**. The pilot study should allow the evaluation of a range of ecosystem services, and cut

across a number of different sectors. This would ensure a broad methodological base and highlight a range of challenges and potential solutions.

Step 3. The experts at the 18 of May workshop were asked to select their top two potential studies. This resulted in a short list of three potential studies – **Mining (Jermuk); Eco-tourism (Protected Areas) and Agriculture.**

Step 4. Further consultation will be undertaken, based on this document, with key Government institutions and stakeholders to select the final pilot study from the short list:

- Mining (Jermuk);
- Eco-tourism (Protected Areas)
- Agriculture.

An overview of the proposed pilot studies in provided in Table A20.

Further questions for consultation

For the selected case study we would be grateful for your views on the following:

- What are the key policy issues / threats facing the site?
- What data / information is available relevant to the selected case study?
- Are there any on-going initiatives related to the selected pilot study?
- What experts and institutions should we work with in undertaking this study?

Table A20: Overview of proposed pilot study sites

Criterion	Mining	Wetland / Ramsar site	Agriculture Sector	Water Pricing	Forest Sector	Tourism (Protected Areas)
National Priority	High	High (Lake Severn)	High	Medium	Medium	High
Data availability	EIA available for site	Baseline work available for Lake Severn	Good data on water use; Limited cadastral data; no data on land quality on soil erosion. A lot of on-going initiatives.	Data on the volume of water consumption	Data on hectares of forest, but not forest quality. Synergies with RECC project and UNDP Climate change adaptation project	Good data on foreign visitors, but not on domestic
Link to poverty alleviation	Yes Many people benefit from mining	? Maybe not at Ramsar sites	Yes 46% of population employed in agriculture; high levels of rural poverty	Yes (distributional impacts of tariffs / ability to pay)	Yes, links to fuelwood use, rural energy, NTFPs, forest communities	Yes, important source of income and employment opportunities
Contentious	Yes	No	No	Could be as tariffs need to increase	?	No
Coverage of ecosystem services / sectors and issues	Potentially very cross cutting, could be designed to include tourism (protected areas), forests, water (mineral water provision).	Could cover many ES and could be linked to many productive sectors	Would incorporate many ES	Focus on water provision and generating data to inform tariff system	Could be linked to productivity of many different sectors and include assessment of many ES	Protected Areas could be linked to productivity of many different sectors (e.g. forestry) and include assessment of many ES
Potential study site	Jermuk (Amulsar)	Lori region, Khor Virap area, Lake Severn	Tavush region		South – trade off with Mining Sector, North illegal logging	Syunik and Vayots Dzor regions
Possible Context for study	Sustainable versus unsustainable mining practices, considering impacts of mining on other sectors	Contribution of wetlands to economy under different scenarios	Cost Benefit Analysis Business as Usual versus Sustainable Use of land and water. Could link to a forested province	Willingness to pay for tariff increases	Cost Benefit Analysis of Sustainable versus unsustainable forestry practices, Land use (Mining versus forestry)	Cost Benefit Analysis of Sustainable versus unsustainable tourism, protected area management