Assessment of the contribution of Fresh Water Ecosystem Services to the Hydropower Sector in the Kura-Aras River Basin in Azerbaijan

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Rovshan Abbasov and Marlon Flores

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Acronyms

AZN	Manat (Azerbaijan currency)
BAU	Business as Usual
GDP	Gross domestic product
GEF	Global Environmental Facility
GIZ	German International Cooperation
HPP	Hydropower plant
KfW	German government-owned development bank (Reconstruction Credit Institute)
MV	Market value
NPP	Nuclear power plant
RoA	Republic of Azerbaijan
SEM	Sustainable ecosystem management
SHPP	Small hydropower plant
SCS	State Committee of Statistics of Azerbaijan
TPP	Thermal power plant
UNDP	United Nations Development Program
USAID	United States Agency of International Development
USD	United States Dollar
WWF	World Wildlife Fund

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The Study Team:

ROVSHAN ABBASOV
Economist, National Consultant
Environmental Research Centre,
Khazar University, Azerbaijan
abbasov@fulbrightmail.org

MARLON FLORES
Senior Advisor, Environmental Economics & Finance
Ecologic Institute, Washington DC
marlon.flores@eius.us

MAKA BITSADZE
Reginal Project Manager, Regional Project Coordinator
"Promoting Sustainable Dam Development at River-Basin-Scale in the Southern Caucasus"
WWF-Caucasus Programme Office
mbitsadze@wwfcaucasus.org

Executive summary

The study focuses on freshwater ecosystem services that support hydropower plant/dams (reservoirs) development in the Kura-Aras River Basin (KARB) in Azerbaijan. It is part of a regional study that includes Armenia and Georgia, which is being implemented in the framework of the regional project – “Promoting Sustainable Dam Development at River-Basin-Scale in the Southern Caucasus” financially supported by the Ministry of Foreign Affairs of Norway and led by WWF Caucasus Programme Office, WWF Armenia and WWF Azerbaijan. The study focuses on demonstrating the value of contribution of biodiversity and ecosystem services to hydropower/dams development in the Kura-Aras River Basin. To this end, the study assesses the HPP/dams sector, and reviews additional sectors including nature based tourism, drinkable water supply, irrigated agriculture, and natural hazards.

Section 1 provides an introduction to the study and the methodological approach Targeted Scenario Analysis (TSA). TSA assesses current “business as usual (BAU)” ecosystems management practices and its current value of ecosystems services under BAU. It uses sector output indicators and compares with potential “sustainable ecosystems management (SEM)” outputs to assess losses and potential gains (or losses) of shifting from BAU to SEM. Section 1 also discusses the key ecosystems supporting HPP/Dams development; and the threats to these ecosystems in the upper river basin.

Section 2 provides an overview of the HPP/Dams sector in the Kura-Aras River Basin (KARB).Dams in Azerbaijan are used for several purposes; for instance, municipal water supply, hydropower, irrigation, fisheries and recreation purposes; however, energy production is the most important use of dams. State owned Azenergy Company, which operates dams and produce electricity. Fresh water ecosystems play a vital role in power generation. In 2010 the production of electricity was 3,100 million KW/h. There are 8 HPPs in the Kura basin with various power capacities.

Deforestation and unsuitable agricultural practices (extensive/over-grassing) in the upper KARB are considered to be one of the most important factors that threat HPP/dams development. These unsustainable practices caused by poorly planned agriculture and land use result in increased erosion and change in water flows; this situation, in turn, affects the productivity of HPP/Dams.

The study shows that the actual production of HPPs in Azerbaijan is much lower than the installed capacities of all HPP. E.g. the Mingechaur HPP the installed capacity is 402 MW/h, while actual production in 2012 was only 159 MW/h. This difference may be explained by the impact of various factors including poor ecosystems management. The large difference between installed capacity and actual production is considered as an indicator that HP dam management in Azerbaijan is under BAU.

The study estimates that the economic loss 2000-2012 under BAU at USD 6.4 billion (market value), which is considerably higher than market value of produced electricity for that period.

Section 3 discusses other benefits derived from HPP/Dams development including nature based tourism, drinkable water supply, irrigated agriculture, and the cost of natural hazards

Man-made natural attractions such as reservoirs that feed water into HHPs could enhance the tourism. For example, the recreational potential of the Mingechaur dam/reservoir is important. Mingachevir reservoir was one of the biggest Olympic rowing centers in the former Soviet Union. Recently, a new rowing center with modern standards has been built. The new center's hotel may host 250 people simultaneously and it can accommodate 500 people to watch rowing games simultaneously. Local experts suggest that this center could host over 200,000 tourists every year. To date, due to the lack of a tourism strategy, few people visit the center and the consequently estimated annual loss of revenue is roughly USD 180 million. In addition the study estimates USD 30 million from tourism based enterprises lost. Attractions such as the new Kura Olympic Rowing Center, combined with other local natural attractions, are key to sustain the economic benefits of nature-based in the region in the future.

Drinkable water supply also is considered as a BAU practice. For example, the City of Baku is the second major user of the regulated Kura water. Nearly 25% of the Greater Baku area that has more than 4 million of residents benefit from water withdrawal facilities located in a downstream part of the Mingechaur reservoir. The current water supply systems operated under several deficiencies such as a high percentage of waste (60%) and lack of metering. The study estimated that under the current BAU practices, the total economic loss in market value (MV), over the period of 2000-2012, reached USD 1.1 billion.

Irrigated agriculture is highly important and depends on healthy fresh water ecosystems. Most of the territory of Azerbaijan has rather dry climate, and therefore, irrigation very important in the Kura-Aras plain that occupies nearly 40% of the country's territory.All the dams in Azerbaijan have an irrigational function. In the KARB, water from Mingechaur, Shamkir, Yenikend and Aras reservoirs are extensively used for irrigation. The most important threat to irrigated agriculture is fresh water shortages, which may be partly caused by poor ecosystems management in the upper KARB.

Poor ecosystems management is partly responsible for the estimated high annual maintenance costs of canals and reservoirs (silt and trash removal), estimated at USD 20 million; mainly spent on canals cleaning; such high cost may be reduced by shifting from BAU to SEM practices. Insufficient water for irrigation is resulting in lower agricultural productivity and high cost to the economy.

For example, the Aran Economic District is the biggest producer of meat, wheat and cotton. Productivity has declined in the last decade. When comparing these two scenarios (BAU and SEM) the loss in market value (MV) is estimated at USD 3.1 billion for 2003-2012.Further, considering the average 2012 market value of agriculture products from irrigated lands of the KARB (water for irrigation is exclusively supplied by reservoirs) the total gross economic benefit (market value) is estimated at USD 4.8 billion. This benefit will not be possible and it is not sustainable if poor investment in fresh water ecosystems continuous as BAU.

Sustainable fresh water ecosystems management could also help to reduce the costly impact of natural hazards. The most common hazard in Azerbaijan that could be linked to poor dam management is floods. For example, downstream part of the Mingechaur dam is often suffers from floods caused as a result of a combination of poor dam management an unsustainable management of ecosystems in the upper KARB. Although flood events were almost entirely eliminated during the first 16 years after construction, floods started since 1993. For example in May 2010, floods destroyed 50,000 hectares of farmland. According to the National Budget Group, the damage was estimated at $591 million.

In 2010, the GoA increased its state budget up to USD 425 million to eliminate consequences of flooding. In 2013 USD 180 million has been spent to reduce consequences of floods, and in 2014, the projected costs was USD 185 million. The total spending over the last four years slightly exceeds USD 1 billion. The high cost of the 2010 flood is linked to BAU. This cost could be reduced by shifting to SEM management.

The study reached several important conclusions on why it is important to shift from BAU to SEM practices in the HPP/Dams sector and other related sectors such as agriculture and forestry. For example;

- BAU practices in fresh water ecosystem management have a high cost to the economy of Azerbaijan. Part of this high cost can be avoided by shifting to low cost SEM practices.

- Despite the availability of several laws and regulations governing the administration and management of HPP and Dams in Azerbaijan, enforcement is weak. The legal framework is also incomplete, there are no means for law enforcement, and no measurable indicators or means to collect and evaluate it. Therefore no results of evaluation are fed into policy making or to improve HPP/Dams management.

- Because of different priorities, poorly planned BAU management generates conflict amongst fresh water ecosystems' stakeholders.

- The current environmental impact assessments of HPP/Dam projects (small and large) neglect to assess the potential impact of current ecosystems management practices in the upper river basin. This in turn will have a negative impact on HPP/Dams performance that may result in additional negative externalities affecting other sectors such irrigated agriculture, tourism, fisheries, and drinkable water supply. The aggregated cost of these negative externalities often surpasses the current benefits deriving from the HPP/Dams sector.

- Because improving ecosystem management in the upper watershed requires the participation of multiple sectors, e.g., HPP/dams, agriculture, forestry, fisheries, tourism, water supply, a comprehensive package of interacting policy reform measures is needed, both at national and at regional level. This is defined as a "policymix" package that is indispensable to introduce sustainable HPP/Dams development in the Southern Caucasus.

- The lack of information and data limited the scope of this study; therefore, further research is needed, and it may include developing of primary data baselines. However, basic scenarios (BAU/SEM) were constructed where possible to inform policy makers and businesses about the economic risks and opportunities of undertaking productive activities that impact ecosystem services.

- It is evident that BAU scenario causes huge economic losses in all sectors, reducing long-term gains. In contrast, the SEM could help to gradually increase ecosystem values and related benefits.

Finally, Section 4also includes a set of recommendation to address: a) the development of a policymix package and b) some specific technical consideration to improve HPP/Dams development policy.

1. Introduction

This study focuses on the ecosystems services (ES) in the upper Kura Aras river basin (KARB), the section above the HPP/dams. The purpose of this study is not to assess the impact of HPP/Dams development on the environment. It is recognized however, that HHP/DAM development can be significantly damaging to ecosystems below the HPP/dam if not managed following rigorous environmental standards (BAU practices).

This study focuses looks at ecosystems management as the most important input (other than capital) to sustain HPPs/dams development; and discuss the potential losses of productivity of HPPs in case of unsustainable management or "business as usual" (BAU) and compare with sustainable ecosystem management practices (SEM). Details of the methodology are presented in Section 2.1.

The study does not carry out conventional cost-benefit analysis of energy projects, which amongst other inputs, it will require analysis of externalities caused by HHP/dams on site and in the downstream part (below the HHP/DAM). For example, potential costs of resettlement, livelihood loss, and impacts of coastal erosion.

There is a network of more than 43,000 rivers and numerous lakes in the biodiversity rich eco-region of the Southern Caucasus. Freshwater ecosystems, representing highly important areas for biodiversity conservation, play a vital role in humans` life providing key ecosystem services and benefits. Freshwater ecosystems in this region are one of the most threatened habitats due to anthropogenic pressures mainly stemming from unsustainable urban water use, industry and infrastructure development projects, agriculture and increasingly the development of the hydropower sector. Sectors such as agriculture and forestry contribute by supporting unsustainable forestry, farming and husbandry (extensive/over-grassing) practices in the upper watershed including catchment areas; these unsustainable practices have a negative impact on freshwater ecosystems and in turn they also have a negative impact on HPP/Development.

1.1 Objective and Scope

This study focuses on freshwater ecosystem services that support hydropower plants (HPP)/dams development in the Kura-Aras River Basin in Azerbaijan. It is part of the regional study that includes Azerbaijan and Georgia; and the Black Sea Catchment Basin (Georgia) being implemented in the framework of the regional project – "Promoting Sustainable Dam Development at River-Basin-Scale in the Southern Caucasus" financially supported by the Ministry of Foreign Affairs of Norway and led by WWF Caucasus Program Office, WWF Armenia and WWF Azerbaijan. The regional project aims at:

I. Demonstrate the value of contribution of biodiversity and ecosystem services to hydropower/dams development in the Kura-Aras River Basin;
II. Support the introduction a Sustainable Dams Assessment and Planning Methodology; and,
III. Mobilize key stakeholders, secure their support and launch the Caucasus Sustainable Dam Initiative.

The project stresses that joint-effort of key stakeholders at the river-basin-scale can support sustainable ecosystems management to ensure that the benefits of the hydropower sector, both financial and economic are secured for the long-term.

The study assesses the HPP/dams sector, and reviews additional sectors including nature-based tourism, irrigated agriculture, and drinkable water supply. In addition, the study briefly discusses the role and value of ES that help to mitigate natural hazards related to poor ecosystems management.

1.2 Methodology

The study used a basic Targeted Scenario Analysis (TSA) approach. The TSA assesses current "business as usual (BAU)" ecosystems management practices and its current value of ecosystems services under BAU. It uses sector output indicators and compares with potential "sustainable ecosystems management (SEM)" outputs to assess losses and potential gains (or losses) of shifting from BAU to SEM. The BAU approach is characterized by a focus on short-term gains (e.g., < 10 years), externalization of impacts and their costs, and little or no recognition of the economic value of ES, which are typically depleted or degraded. Under SEM, the focus is on long-term gains (> 10 years); also under SEM, the costs of impacts are internalized. Ecosystem services are maintained, thus generating potential for a long-term flow of ecosystem goods and services that can enter into decision making. SEM practices tend to support ecosystem sustainability as a practical and cost-effective way to realize long-run profits.

It is expected that the TSA approach will serve multiple purposes:

1. Analyze the HPP/dams sector and determine the potential economic gains or losses of undertaking productive activities by comparing "poor" with "sound" environmental management practices.
2. Inform policy makers and businesses about the economic risks and opportunities of undertaking productive activities that impact ecosystem services.
3. Assist government officials and the private sector to incorporate ecosystems' management policy into economic planning, corporate business plans, and investment policies at sectoral level.
4. Provide economic (and social) arguments to mobilize political will to increase financial support to improve fresh water and forestry ecosystems management.

Depending on the availability of data, the selected indicators are used to assess BAU and SEM impact (Table 1). Not all indicators are suitable for all the selected sectors or subsectors; therefore, indicators are used when applicable.

Table 1. Sample Indicators used to construct BAU/SEM Scenarios

Sector Indicators (5-10 year trends)	Applied in the study
Employment increase (# of jobs) by sub-sector (direct, indirect and induced)	
Income, average annual increase by sub-sector	√
Fiscal impacts (annual tax revenues to governments)	
Annual revenue from green taxes	√
Foreign exchange earnings (annual, from exports)	√
Opinion polls	
Sector investment (government)	√
Sector investment (private sector)	√
Damage costs (as a result from BAU practices	√
Avoided damages costs (as a result from SEM practices)	√
Production trend (volume and value)	√
Sector production trend (as percentage of GDP)	√
Changes in natural capital (e.g. # Ha under protection or SEM practices)	

Depending on the availability of information, the following steps are included:

1. Definition of the scope of the analysis: Fresh water ecosystems/ HPP and reservoirs.
2. Definition of sectors in agreement with stakeholders.
3. Assessment of data availability vis-à-vis potential indicators to be used in collaboration and agreement with stakeholders.
4. Use of indicators to define the BAU baseline and potential SEM intervention based on available information and first hand research.
5. Construct BAU and SEM scenarios and values.
6. Formulation of informed policy and management recommendations.

The sector-level approach and the BAU and SEM analysis have some limitations for instance:

- The analyses draw on technically economic and ecological data from the published material available. Such date is still scarce in Azerbaijan, just a handful of studies are available.
- The sectoral approach disaggregates the economic value of each type of ES and fragments system-wide values to show specific sectoral inputs.
- The integration of the overall effects of ecosystems and their services on the economy as a whole is left to the conclusions chapter.
- Lack of national and sector-level data has limited the applicability of the selected range of indicators used to assess the impact of BAU and SEM practices.

- The available data to support the TSA is commonly limited in developing countries and economies in transition. Therefore the values obtained may be partial.

The summary of the methodological approach is included in Annex 1.

1.3 Definitions: biodiversity, ecosystems and ecosystem services

There are three major interrelated elements that need to be considered when assessing ecosystems services: biodiversity, ecosystems and ecosystems services.

The term **biodiversity** refers to "the variety of life on Earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it. Biodiversity includes not only species we consider rare, threatened, or endangered, but every living thing — even organisms we still know little about, such as microbes, fungi, and invertebrates. Biodiversity is important everywhere; species and habitats in your area as well as those in distant lands all play a role in maintaining healthy ecosystems. We need biodiversity to satisfy basic needs like food, drinking water, fuel, shelter, and medicine. Much of the world's population still uses plants and animals as a primary source of medicine, and in the United States alone, about 57% of the 150 most prescribed drugs have their origins in biodiversity.

An **ecosystem** is a natural unit consisting of all plants, animals and micro-organisms (biotic factors) in an area functioning together with all of the non-living physical (abiotic) factors of the environment; it is a completely independent unit of interdependent organisms, which share the same habitat. **Ecosystem services refer to** direct and indirect contributions of ecosystems to human wellbeing (UNEP, 2014. The concept ''ecosystem goods and services'' is synonymous with ecosystem services[1]. There are number of definitions of ecosystem services. According to Schroter et al., (2005), ecosystem services (ES) are the conversion of natural assets – such as trees, snow cover, and soil fertility – into valuable benefits such as wood products, winter tourism, and arable land. ES can be described as a "services provided by the natural environment that benefit people" (DEFRA, 2007: 10).

Ecosystems provide services such as water supply, pollination, seed dispersal, climate regulation, water purification, nutrient cycling, and control of agricultural pests. Many flowering plants depend on animals for pollination, and 30% of human crops depend on the free services of pollinators"[2].

Ecosystem services are classified as provisioning, habitat, cultural and regulating services (TEEB in Local and Regional Policy and Management, 2012).

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[1] www.teebweb.org

[2] http://www.amnh.org/our-research/center-for-biodiversity-conservation/about/what-is-biodiversity

1. Provisioning Services are ecosystem services that describe the material or energy outputs from ecosystems. They include food, water, construction materials and other resources.
2. Regulating Services are the services that ecosystems provide by acting as regulators eg: regulating the quality of air and soil or by providing flood and disease control.
3. *Habitat/support services* are directly linked to the habitats that support species and they have indirect influence on human wellbeing and other ecosystem services.
4. *Cultural services* are the non-material benefits including the *recreation and tourism* and specifically eco-tourism. (See Annex 2)

These ES provide indispensable input to sectoral productivity enabling the development of HPP/Dams, agriculture and livestock, fisheries, tourism; and human well-being; as shown in Table 2 below. With such input from ES sectors can be productive and support the economy.

Table 2. Ecosystem Service's input to selected sectoral development

Ecosystem (Natural Asset)	**Ecosystem Service's input to selected sectoral development**				
	HHP/Dams	**Agriculture**	**Fisheries**	**Nature-based tourism**	**Human well-being**
Fresh water	• Hydro-power	• Water for irrigation • Soil fertility	• Fish Stock	• Outdoor/ adventure tourism • Aesthetic appreciation • Recreation	• Drinkable water supply
Forests	• Erosion control	• Flood control • Soil fertility	• NTFP • Game • Timber	• Outdoor/ adventure tourism • Aesthetic appreciation • Recreation	• Local climate and air quality • Moderation of extreme events • Carbon sequestration

1.4. Ecosystems and ecosystem services supporting HPP/Dams development

Many essential goods can be derived from ecosystems (Daily et al., 1997). Ecosystems are the only sources of natural resources, which are very important to human well-being and survival (Costanza et al.,1997; Pearce and Atkinson, 1993, Flores and Adeishvili, 2011).

Freshwater ecosystems provide a range of services that improve living conditions in societies. Fresh water ecosystems include rivers, lakes, streams, and wetlands. The ecosystem services (ES) linked to hydropower and dams development are classified under the category of ‘‘provisioning’’. This refers to the human use of fresh water for domestic use, irrigation, power generation, and transportation (Millennium Ecosystem Assessment, 2005). Table 3 below shows the classification of these ecosystem services.

Table 3. Services Provided by Fresh Water Ecosystems

Provisioning Services	*Regulatory Services*	*Cultural Services*	*Supporting Services*
Water (quantity and quality) for consumptive use drinking, domestic use, and agriculture and industrial use)	Maintenance of water quality (natural filtration and water treatment)	Recreation and tourism (river-rafting, kayaking, and hiking, and fishing as a sport, river viewing)	Role in nutrient cycling (role in maintenance of floodplain fertility), primary production
Water for non consumptive use (for generating power and transport/ navigation)	Buffering of floods erosion control through water and land interactions and flood control infrastructure	Existence values (personal satisfaction and free flowing rivers) Option values	Predator/prey relationships and ecosystem resilience
Aquatic organisms for food and medicines			

Provisioning services are the goods that can be obtained from freshwater ecosystems. The main provisioning service of the freshwater ecosystems is the water taken for consumptive use. Consumptive water use is water withdrawn from rivers, lakes, and reservoirs without return to a water source. Non-consumptive water use includes water that is not consumed. This includes uses such as power generation and navigation, where the water is still available for other uses at the same site. Provisioning services also include fish and seafood production that can be considered as the sustained income source for societies. Provisioning services are the essential drivers of economic development, where advanced methods of water management are implemented.

Regulatory services include the benefits obtained from ecosystem processes (Millennium Ecosystem Assessment, 2005). E.g. natural purification considerably improves quality of water in rivers and streams. It affects quality of water within filter layers and in the subsurface through filtration, sedimentation, precipitation, oxidation-reduction, and sorption-desorption etc.

Buffering of floods, erosion control through water and land interactions and flood control infrastructure are also considered as regulatory services. Reservoirs play an important role in prevention of floods capturing water during high seasons and reducing flow peaks. E.g. after construction of the Mingechaur reservoir in Azerbaijan, floods was eliminated during the first 15 years (Figure 1).

Forests have a vital role to maintain regulatory ecosystem services at the watershed level. Forest vegetation makes soil more porous that may store large amount of water. In order words, forests are the natural regulators of stream flows and considerably reduce flow peaks that may result in flash floods. It is recognized that forests increase infiltration and interception, considerably storing a larger percent of incoming precipitation in the basin.

Cultural benefits of freshwater ecosystems include a board palette of values. It would be very hard to imagine most of recreational activities without contribution of freshwater ecosystems. Generally, freshwater ecosystems have important functions that support tourism and recreation. River-ratting, kayaking, hiking, swimming and fishing are the most important peculiarities that freshwater ecosystems have. Cultural services are becoming increasingly important as incomes and leisure time off people increase. Existence value is a willingness to pay for only the existence of environmental resources. For example, donation of people for protection of the Caspian Seals can be considered as the existence value of these species. Option values are related to uncertainty and irreversibility and concern primarily water as an asset rather than as a flow of services. The option value has the value of the freshwater ecosystems as a potential source of benefits that can be taken in the future.

Supporting services support ecosystems and are necessary for the production of all ecosystem services. Impact of supporting services on people occurs over the long time. For example, forests have direct and non direct impact on the climate that supports health of people over the long periods.

Development concept "Azerbaijan-2020: outlook for the future" and National Program on Sustainable Socio-Economic development" stipulate that socioeconomic development must be environmentally sustainable. According to the development concept, further measures will be taken to preserve biodiversity, restore green areas and effectively protect the available resources. These documents consider that the establishment and restoration of forests, protection of freshwater ecosystems should coincide with any development actions. Water Code of Azerbaijani Republic also supports sustainable development of dams and water reservoirs.

1.4. Threats to fresh water ecosystems that support HPP/Dam development

In the last several decades the protection and management of freshwater sources became one of the major issues of modern societies. Threats to freshwater ecosystems have reached global scales and require urgent actions from water managers and policy makers (Gleik et al., 2001). These threats include climate changes, contamination of surface and groundwater sources, degradation of freshwater ecosystems and deforestation (Table 3). The impact of these threats at the upper watershed level, where the catchment point is located, can severely affect HPP/Dams productivity; as well as other sectors depending of fresh water ecosystems such as irrigated agriculture.

For the purpose of this study, only threats to forest and water ecosystems in the upper Kura Aras River basin (KARB) are considered. These threats in turn affect the productivity of the HPP/Dams sector.

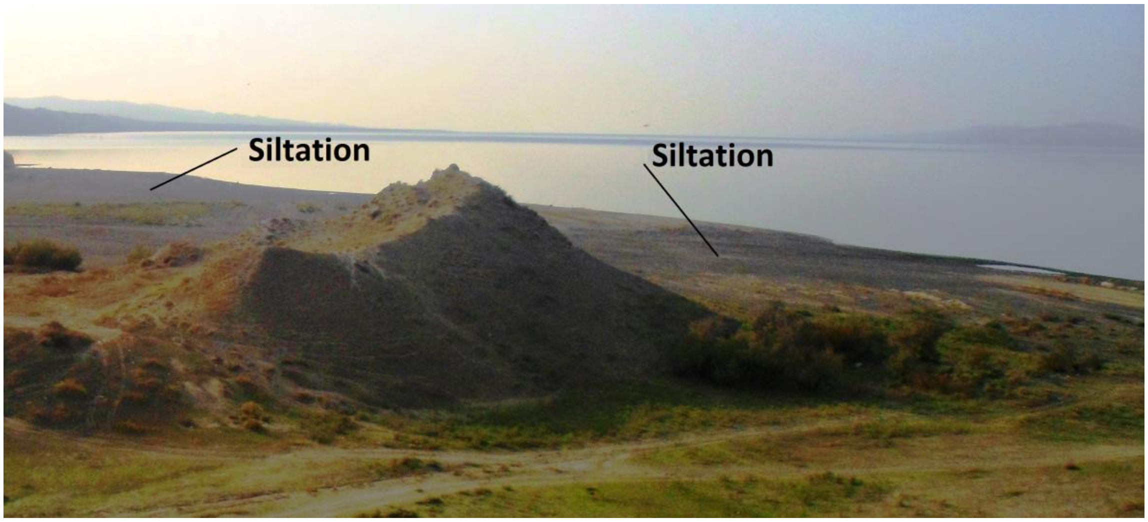
Deforestation and unsuitable agricultural practices (extensive/over-grassing) in the upper KARB are considered to be one of the most important factors that threat HPP/dams development. These unsustainable practices caused by poorly planned agriculture and land use result in increased erosion and change in water flows. In addition, there are other threats such as contamination of surface and groundwater; Table 3 provides an overview of threats to fresh water/forest ecosystems and its economic impact.

Table 3: Overall threats to freshwater/forest ecosystems

Threats to freshwater ecosystems	***Caused by***	***Environmental consequences***	***Economic impact***
Climate changes	Industrial and urban air pollution	Increased evaporation from water surfaces, reduced stream flows, reduced quantity and quality of water	Reduces production of hydropower and agriculture. Reduced revenue Loss of jobs Power shortages Reduced foreign exchange gains from exports Less revenue from taxes to government Reduction of pro-poor investments and poverty increase
Contamination of freshwater ecosystems	Industrial, agricultural and urban effluents	Habitat pollution, reduced quality of water, eutrophication	
Degradation of freshwater sources	Agricultural, industrial and municipal water withdrawals	Reduced flows, narrowing and extinction of migration routes for fish, habitat degradation	
Deforestation	Urbanization, agricultural development, mass removal of forests	Erosion, landslides, riverbed sedimentation, increased turbidity, increased temperature, reduced oxygen, increased BOD levels	

Source: Abbasov and Flores, 2014

Figure 1: Siltation in Mingechaur reservoir



The mass removal of forests makes slopes more vulnerable to prevent erosion and increase turbidity in water, adversely changing water quality. Increased turbidity considerably reduces water quality in freshwater ecosystems adversely changing healthy environment. Increasing capacity of total suspended solids along the length of the rivers supports intensive accumulation in the mouth area. Sediment accumulation in the riverbed over a long period of time may lead to the reduction of channel capacities and reduce quality of life in ecosystem.

In turn, unsustainable dams/HPP development threats ecosystems below the dams. Currently, dams development face rather serious problems in Azerbaijan. Large areas, forests and irrigated lands were inundated during the development of dams. Most of the rivers in the Kura basin are the preferred spawning grounds for valuable sturgeon fish and serve as migration routes. However, as noted before, assessing the environmental impact of HPP/Dams development is not the objective of this study.

Climate change can also have a slow but long-term impact on ecosystems that support hydropower sector. In particular, water cycle can be affected by warmer temperatures of the climate change resulting in misbalance of evaporation and precipitation. As a result, in some areas there can be drought led by excess evaporation and lack of precipitation, and too much precipitation on other areas. Besides, warm temperatures in winter cause more rain then snow and early melting, which alters water flows into rivers. Natural disasters, like floods, drought, and storms directly affect water resources to be used by different sectors, including hydropower. As water from HPP reservoirs can be used in different sectors, e.g., agriculture, recreation, and fishing. Water scarcity often results in conflict between sectors (UNEPA 2014).

The study recognizes that dams and HPPs are indispensable to sustain economic development and shifting from BAU to SEM practices could improve upper and lower watershed management and reduce the unavoidable negative impacts of dams/HPPs.

2. Economic benefits from ecosystems services to the hydropower and dams sector

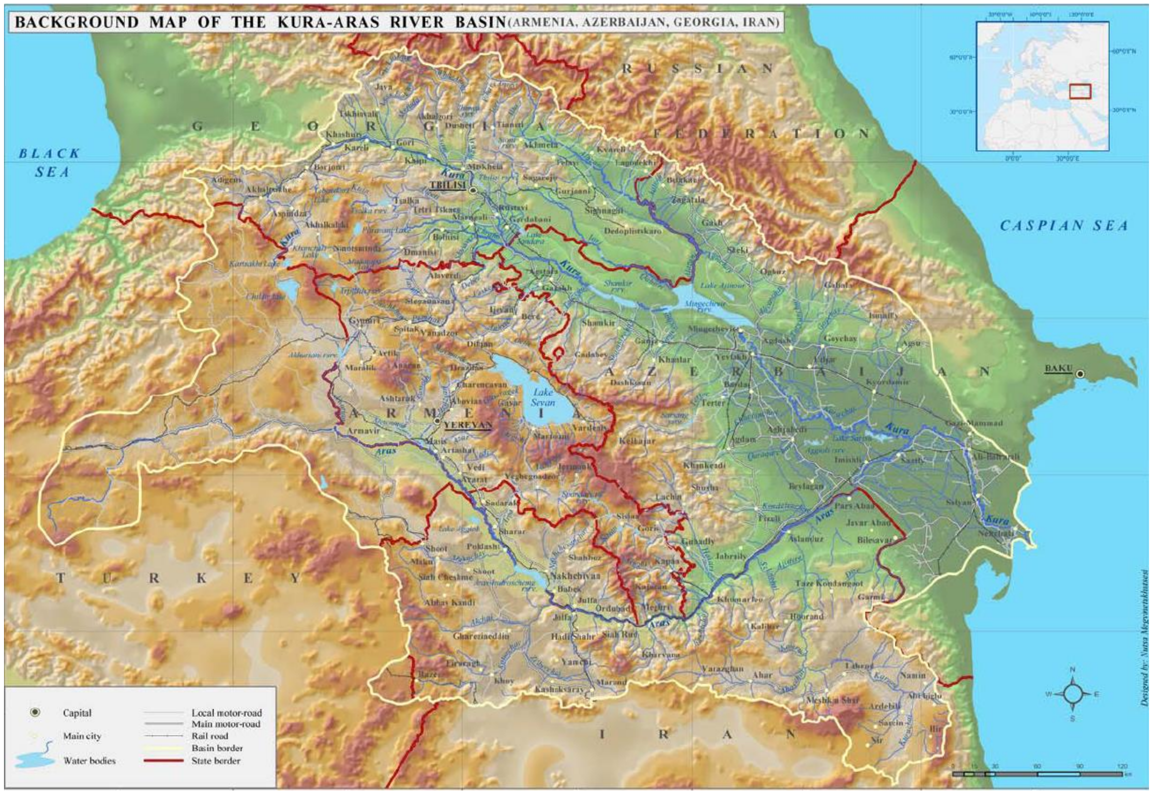
2.1. Overview of the hydropower and dams sector in the Kura-Aras Basin

Kura and Aras forms the largest trans-boundary river system of the South Caucasus region. The origins of the Kura can be found in east Turkey, and it flows across the Ardakhan plateau through Georgia and enters Azerbaijan. In Azerbaijan, the Kura crosses the Kura-Araks plain, where it joins with the Araks and finally flows out into the Caspian Sea (map 1). The length of the river is 1,364 km; the basin is 188,000 km.

The source of the river is located at a height of 2,740 m, while the outlet is at -27 m below the sea level. The slope of the upper basin is equal to 4.2%, while the slope of the lower basin is very low and equal to 0.09%. The average slope of the basin is equal to 2.03%. About 45% of the basin is plains' territory, and the rest of consists of high and low mountains.

The Kura River plays a vital role in both local and regional economies and has been used to generate energy, irrigation, and water supply in Azerbaijan and Georgia. Recently, there are 63 water reservoirs in Azerbaijan Republic, 46 of them are located in the Kura-Araz basin. This section reviews the contribution of fresh water ecosystems to economic development in the hydropower sector.

Map 1. Kura-Araz River Basin



Azerbaijan has an old, but powerful, electric power system. The hydropower sector plays an important role in the energy sector, contributing a considerable amount of electricity produced. The installed capacity of all power generations, in 2013, was 5,742 MW; out of which 1,047 MW came from the hydropower sector (or 18,2 %). While the country has been successful in constructing new thermal power plants over the last 10 years, importance of hydropower generation is getting increased. Recent predictions have shown that Azeri oil and gas resources may be exhausted in the next 50 years.

Dams in Azerbaijan are used for several purposes; for instance, municipal water supply, hydropower, irrigation, fisheries and recreation purposes; however, energy production is the most important use of dams. Fresh water ecosystems play a vital role in power generation. Only 10% of the total electricity production comes from HPPs. In 2010 the production of electricity was 3,100 million KW/h.

The State Program on Use of Alternative and Renewable Energy Sources stipulates national commitments to develop environment friendly energy sources. The program recognizes hydropower generation as one of the most reliable and sustainable energy sources. According to UNDP 2009, it is estimated that hydroelectric power resources of Azerbaijan equals 16 Billion kWh (UNDP, 2009)

There are 8 HPPs in the Kura basin with various power capacities. In the Table 4 the information regarding capacity and hydropower capacity of these reservoirs is given. This information is introduced by state owned Azernerji Company[3].

Table 4. Characteristics of reservoirs that have HPP

#	Water reservoir	Area, km^2	Capacity of reservoir, km^3	Installed capacity of HPP, Mw	Area of irrigated lands, ha	Production in 2012, Mw/H
1.	Mingachevir	605	15.73	402	970,000	1,400,000
2.	Shamkir	116	2.68	380	46,000	1,200,000
3.	Yenikend	23.2	1.58	150	6,000	447,000
4.	Varvara	22.5	0.06	16	-	75,720
5.	Sarsang	14.2	0.565	50	120,000	-
6.	Araz	145	1.254	22	400,000	55,690
7.	Bilav		0.1	22	-	75,230
8.	Vaykhir		0.1	5	16,800	19,460

Source:Azernenrji Company[4]

[3]http://www.azerenerji.gov.az/)
[4]http://www.azerenerji.gov.az/)

The largest HPP/dam is the Mingechaur, which was operational in 1953. The main aim of the reservoir is an agricultural water supply and power generation. The maximum height of the Mingechaur dam is 83 m, whereas the volume is 15.73 km^3. Maximum depth is nearly 75 m. The length of the coastal lines of the reservoir is more than 347 km, the overall area is 605 km^2.The reservoir is used for hydropower generation and irrigation. Third purpose of the Mingechaur dam is to reduce the frequency and severity of the floods that are very usual for the downstream part of the Kura River river.

The Shamkir HPP/dam was operational in 1982. The maximal area of the reservoir is 116 km^2, the total volume is 2,7 km^3. The height of the dam in its highest point is 70 m. The reservoir provides irrigation water to 46,000 ha of land in Shamkir, Samukh, Goygol and Goranboyrayons. The dam is also used to produce hydropower.

The Yenikend HPP/dam was fully operational in 2000. The dam has four turbines with total capacity of 150 megawatt.It has been built mainly to produce electricity. The Yenikend reservoir also provides water for 6000 ha of irrigated land.

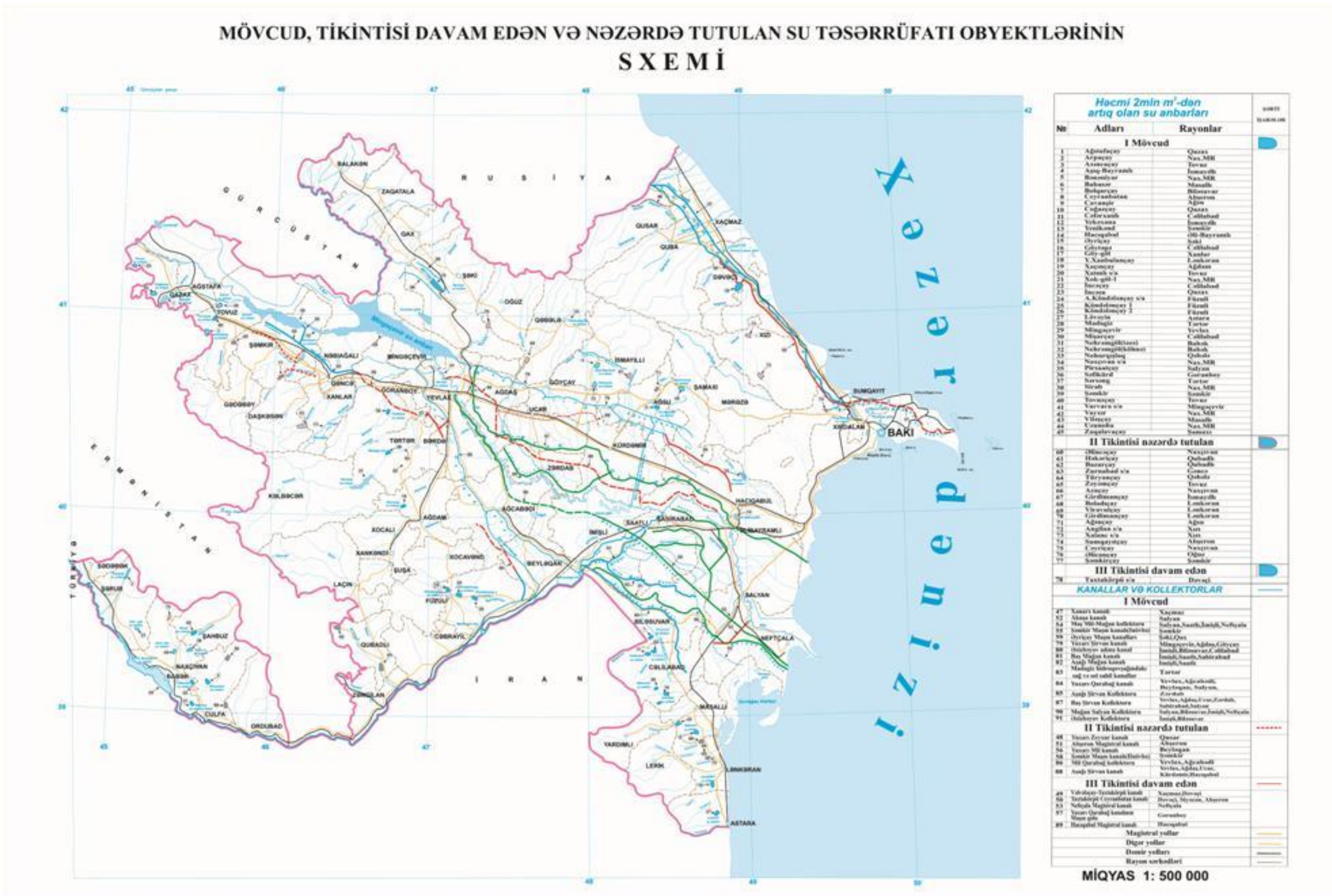
The Varvara HPP/dam's capacity is 128 Mwt. This dam is located in the dowanstream part of the Mingechaur dam and contributes to manage water level in the Mingechaur HPP.

The Sarsang HPP/dam is operational since 1976. The purpose of the reservoir was to produce electricity and irrigate agricultural fields in Tartar, Barda, Goranboy, Yevlakh and Agjabedi districts of Azerbaijan. Total area of irrigated lands was 120000 ha.

The ArasHPP/dam is located on the border of Iran and Nakhichevan exclave province of Azerbaijan. This dam is operational since 1971 and used jointly with Iran, for agricultural water supply and power generation. The height of the dam is 40 meters. The area of the Araz reservoir is nearly 144 $km^2$and the maximum capacity of the reservoir is 1.45 km^3. Araz reservoir irrigates more 400000 ha of the land in Iran and Azerbaijan. Irrigated agriculture is discussed in Section 3.3

Other HPP/dams that produce hydropower within the territory of Azerbaijan are Bilav and Vaykhir. These dams have small reservoirs and located in the Nakhichevan as well. Map 2 provides the location of HPP/dams in the Kura-Araz river basin.

Map 2. Existing HPP/dams in the Kura-Araz river basin and Azerbaijan



As indicated in Section 2.1, in order to assess the current characteristics of HPP management vis-à-vis economic impact, the study uses two scenarios; BAU and SEM. Below we give characteristics of BAU and options for the SEM interventions for the HPP in the Kura basin (Table 5). This table demonstrates potential benefits from SEM approaches. In order to define BAU baselines and possible SEM interventions, several indicators were used; for example, silting reservoirs, power generation, fishing and recreation.

BAU include all types of activities that damage or depletes ecosystems or policies that neglect to include ecosystem's management in the area and focused only on short-term gains. BAU approach may increase gains in a short-term period, reducing long-term gains. E.g. Surface water pollution by enterprises may avoid treatment costs for the producers, simultaneously causing negative externalities for public health and fishing for long-term period. SEM interventions usually make resource management more sustained and give economic gains over the long-term period.

Table 5.Characteristics of BAU and SEM practices in the hydropower sector

BAU	SEM
• Lack of a HPP sustainable development strategy, including watershed management plans and funding; • Poor/absence of spatial planning policy • Deficient monitoring system • Outdated system to assess availability of water resources ("sanitary flow" - 10% of average annual water flow) • Development of HPPs in pristine ecosystems, including ecosystems in protected areas. • Absence of fresh water ecosystems management plans; • Deforestation and erosion in riverbeds in the upper and mid basins; • Overgrazing causes erosion in upper and lower watersheds; • Deteriorated or obsolete infrastructure (reservoirs, intake points and water canal network, pumping stations, silting control); • Lack of metering for domestic and industrial users, and water fees for irrigation; • Poor investment in maintenance and renovation; • Limited institutional capacity. • Weak law enforcement (forest and water management, etc.). • Absence of dam safety standards	• Sustainable HPP development strategy, including watershed management plans and funding; • Updated system for water availability criteria for sustainable development of HPPs • Inventory of and monitoring of hydro-resources • Introduce spatial planning policy • Fresh water and forest ecosystems management is an integrated part of the sector policy and funding to implement is available • Deforestation and erosion control programs are available and regulations are enforced. • Grassland use and agriculture is planned and managed in river basins; • Measures to eliminate illegal logging are enforced; erosion and sediments is water are decreasing; • Adequate zoning and land use policies and enforcement. • Infrastructure is maintained (reservoirs, intake points and water canal network, pumping stations, silting control); • Metering for domestic and industrial users, and water fees for irrigation are applied and collected; • Adequate investment in maintenance and renovation; • Increasing institutional capacity. • Strong law enforcement.

A typical example of BAU practices is the management of the Mingechaur reservoir, which is operation since 1953. In the current BAU scenario, sustainable ecosystem management is excluded. Land use modifications, deforestation, erosion, bed silting are the main factors that reduce effectiveness of the dam. This pattern may be a result of intensive deforestation occurring in the upstream regions, where forests are the only source for fire wood used for heating and cooking. Mass removal of vegetation decreased infiltration and evaporation/transpiration, leaving a larger percent of incoming precipitation to generate surface runoff.

The removal of vegetation also makes steep slopes much more unstable and susceptible to erosion (Balyuk and Kondratyev 2004). Deforestation and the mass removal of vegetation in the KARB increased the speed and intensity of soil erosion in the catchment areas of small rivers belonging to the Kura basin. Eventually, the sediment is transported through the channel of the Kura, where the most accumulation takes place (Abbasov and Kondratyev 2006; Abbasov and Mahmudov, 2010). The average silting of the Mingechaurreservoir is approximately 10 cm/year. The area of the reservoir is 605 km^2. Amount of annually accumulated silt is nearly 6 km^3. This means that power generation will gradually be reduced or require additional costs.

2.3. Economic benefits from ES to HPP/Dams development

This section includes information on existing and planned, large and small, HPPs; and the annual trends and forecast of electricity production of existing HPPs, and its average market value (MV)[5].

Figure 2 below shows HHP output under BAU and SEM. BAU is defined as the current output. SEM, on the other hand, is calculated using the installed capacity level. However, considering fluctuations in annual rainfall, siltation, and well managed dams a discount rate of 10% is applied to further define SEM. The current HPP output is estimated using HPP output data provided by HPPs or government statistical information.

[5]5 Market value refers to the highest estimated price that a buyer would pay and a seller would accept for an item in an open and competitive market. In accounting, it refers to the replacement cost of an item arrived at by deducting estimated carrying, delivery, and selling costs from its estimated selling price. http://www.businessdictionary.com/definition/market-value.html#ixzz3L4UK72iw

Figure 2. HPPs output under BAU and SEM

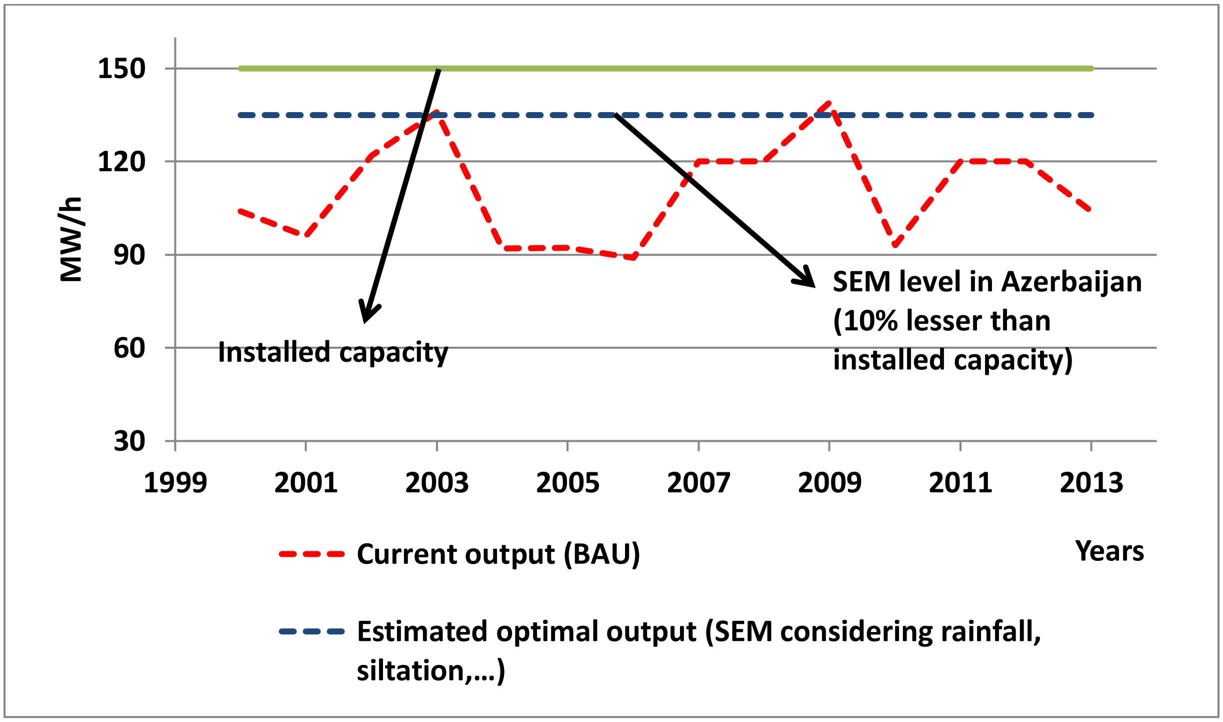


Figure 3 below shows the current market value (MV) based on actual HPP output and average electricity price (price per KW/h). It assumes that the current MV is similar to the gross revenue. In this example, the estimated loss during the period 2000-2013 is equal to the aggregated potential MV (SEM) minus the current MV under BAU.

Figure 3: Estimated loss and potential gain in gross market value (GMV), under BAU and SEM

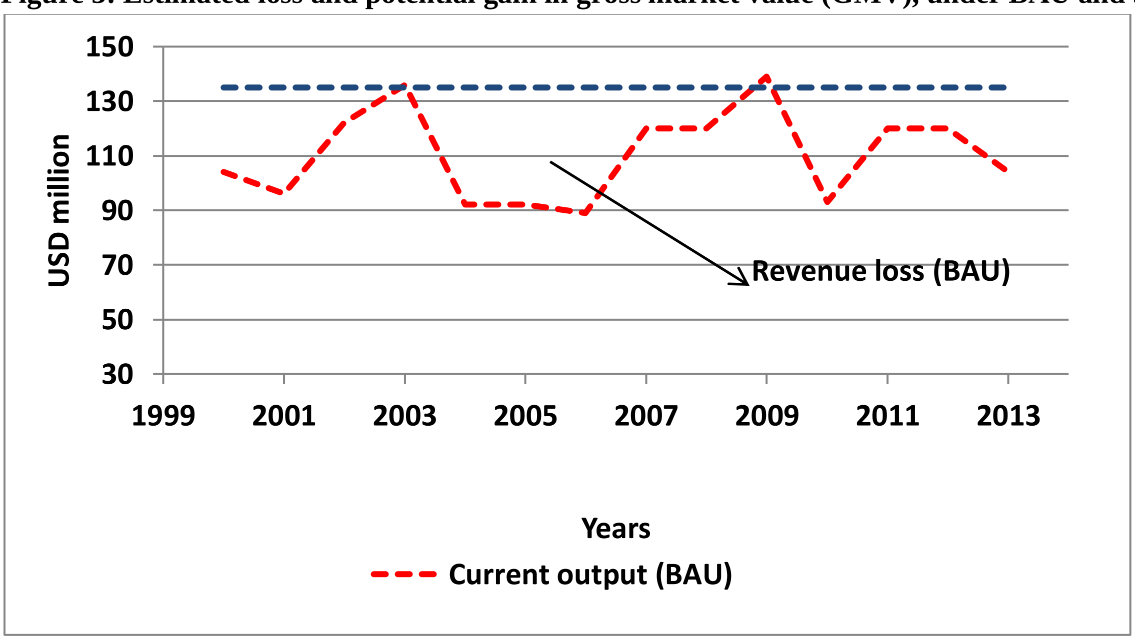
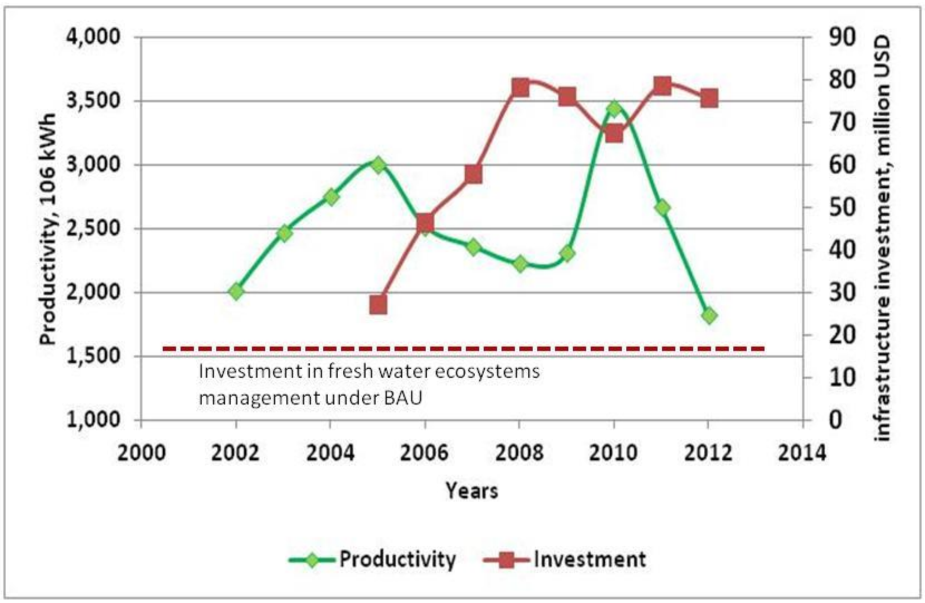


Figure 4 below shows the electricity output from HPP in Azerbaijan over the last ten years, based on data provided by the SCS[6]. During 2005-2009 large investments were made in HPP sector[7], including new and advanced generators installed in several HPP. Contribution of these new generators rapidly increased electricity production, however, over the last two yearsa considerable reduction of the electricity produced is noticeable. However, during this period, little or nothing was invested in watershed management (the water factory). This is typical BAU scenario; it may include deforestation, intense silting and poor dam management. Figure 4 describes level of investment in HPP/Dams infrastructure over the last 10 years. Despite the increasing trend for this period, total amount of investments are rather low.Under BAU, investment in infrastructure and equipment is high; however, productivity is not sustained as illustrated in Figure 4.

Figure 4. Estimated productivity and infrastructure investment under BAU



Source: State Committee of Statistics, 2014, and authors' estimate.

Figure 5 below illustrates economic losses in electricity production for the period of 2003-2012. It shows that the actual production of HPPsin Azerbaijan is much lower than the installed

[6]www.stat.gov.az
[7]http://www.azerenerji.gov.az/

capacities of all HPP. E.g. the Mingechaur HPP the installed capacity is 402 Mw, while actual production in 2012 was only 159 Mw. This difference may be explained by the impact of various factors. One and very simple explanation is related to the effective dam management. This large difference between installed capacity and actual production is considered as an indicator that HP dam management in Azerbaijan is under BAU.

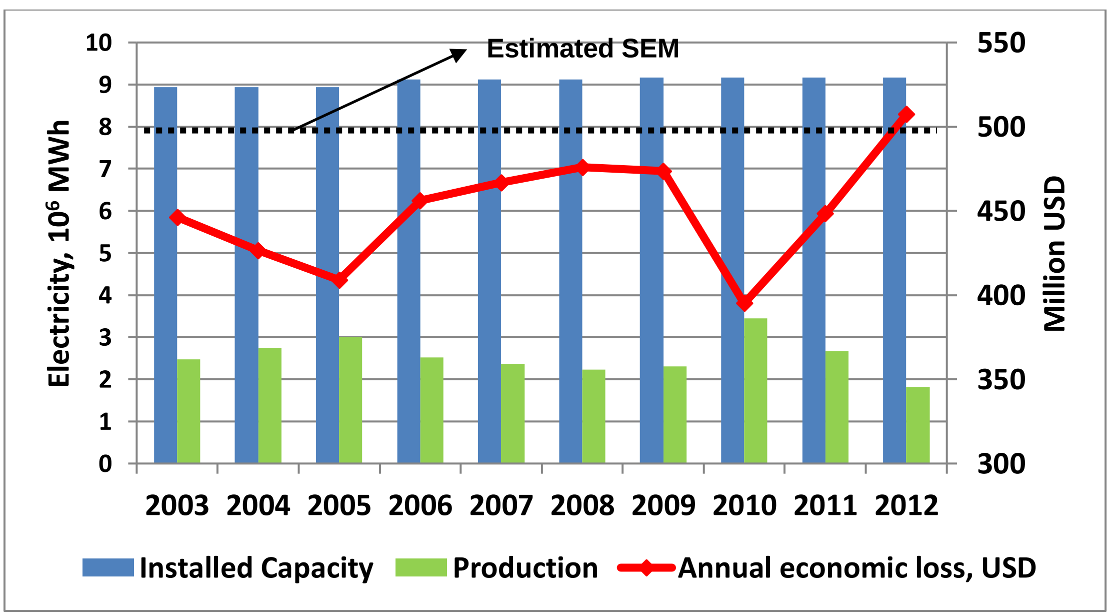
In order to estimate economic losses in electricity production, we used this formula:

EL =MP(IC-AP)

Where, EL –is the economic losses for one year, MP-is a market prices for the electricity in 2012, IC-is a total installed capacity of all HPP in Kura basin, and AP- is average price.

Figure 5 illustrate economic loss under BAU. This is estimated as a difference between installed capacity of HPP and actual electricity production is given. A total economic loss 2003-2012 under BAU makes nearly 4.5 billion USD (for 2000-2012 it makes 6.4 billion USD), which is considerably higher than market value of produced electricity for that period. The optimal annual level of productivity assumed under SEM is nearly 2000 kWh per year, while under BAU we observe sharp fluctuation of productivity.

Figure 5. Comparison of total actual productions and total installed capacity of HPP and Economic loss from reduced HP generation sector 2003-2012 under BAU



The current BAU situation contributes to create conflict amongst stakeholders; i.e. reduced electricity production, less water available for irrigation leads to a decrease in agricultural output, and inadequate flood management that leads to flooding in downstream regions. For instance, the Mingechaur dam and reservoir has a purpose of hydropower generation, irrigation and flood management. So, at least three stakeholders have an interest on management of the dam and reservoir.

Flow regulation is the most effective method to manage floods effectively in downstream part of the rivers. Reservoirs can be used to balance the flow in rivers with spring high flows, taking in water during high flows and releasing it again during low flows. Seasonal regulations enable to accumulate water in reservoirs and reduce peak flows during high seasons. In an effort to reduce the frequency and severity of these floods, the Mingechaur reservoir was constructed.

After the dam and reservoir were constructed, the highest peak flows was reduced. Regulated flow from the reservoir altered the annual flow distribution of downstream, and flood events were almost entirely eliminated during the first 15 years after construction. Although this considered a shift to SEM, it was not sustainable, and mismanagement of the upper KARB, combined with other determining factors resulted in increased floods and economic loss.

Well-managed reservoirs should be operated in order to be able to storage water during high flows. However, state owned HPP/Dams operators are interested in maintaining energy flow and little is invested in maintenance on dams. For example, during the high flow seasons, Mingechaur Reservoir serves as a flood prevention depository, reducing the risk of floods. However, in 2010, before high flow season, Mingechaur reservoir was not emptied to prevent reduction in electricity generation. Thus, during the high flow the reservoir did not function as a depository and it resulted in floods and inundation of 50 ha of irrigated lands, and destruction of homes. By the end of 2013, Azerbaijani hydro power plants decreased electricity generation by almost 75%[8]. This is a strong case for promoting a shift from BAU to SEM.

Simultaneously, The SCS reported that the hydropower plant crisis in Azerbaijan started in the end of 2012 and continued in 2013. According to the information, power generation at HPPs for January-October 2013 reached only $1.209\bullet10^{6}$KW/h that is by 24.5% below that for the 2012 same term[9]. According to estimations, this makes additional economic loss equal to USD 184,292.000 only in 2011-2012. Estimated total economic loss in hydropower sector over the period of 2002-2012 is nearly USD 4.5 billion.

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[8] http://en.trend.az/capital/energy/2212280.html
[9] http://abc.az/eng/news/77487.html

3. Other benefits and risk of hydropower development

3.1. Nature-based tourism

Nature-based tourism is an important part of world tourism industry (Lindberg et al., 1988). Growing interest and diminishing areas of open spaces make reservoirs very attractive in terms of nature-based tourism. They may be very important for tourism both in mountain and lowland regions. Reservoirs can be used for all types of recreational activities including rowing, surfing, swimming and recreational fishing. Reservoirs of the Kura basin that support hydropower generation may be used for all the aforementioned purposes.

Man-made natural attractions such as reservoirs that feed water into HHPs could enhance the tourism. Following safety standards, HPP reservoirs are used for outdoor water-sports such as kayaking, canoeing, rowing, sport fishing, water skiing.

The assessment of nature-based tourism in any sector require detailed analyses of all resources, including location, natural peculiarities, quality and quantity (Prishkina, 2001).Unfortunately, at the time of this study there was no information available on tourism in the targeted reservoirs.

Therefore, in order to evaluate the current recreational potential, a survey with 5 tourism experts was conducted. The survey was based in a very simple methodology that reflects subjective opinions of these experts regarding real conditions around the reservoirs. Their opinions are included in Table 6.

Table 6. Tourism potential and challenges related to HPP/ reservoirs

Reservoir	Potential	Key challenges
Mingechaur	The rowing center near the reservoir has a great potential. The reservoirs can be used for rowing, fishing, and surfing. Suitable climate conditions prevent freezing of water throughout the year that makes reservoir very attractive for tourists and sportsmen from Russia and Ukraine. The potential annual number of tourists is 150,000 with an average of 2-day stay.	High prices for lodging. Limited number of budget hotels. The absence of general services like restaurants, car rental, trains from other cities etc.
Shamkir and Yenikend	Attractive for fishing, surfing and boating. Mountains and natural extremes are rather close. The proximity of such amenities makes the greatest contribution. The potential annual number of tourists is 50,000 with and average 2-day stay.	Slight remoteness from the residential areas. No lodging opportunities. Not easily accessible.
Araz	Attractive for fishing, surfing and boating. Mountain areas and many types of natural springs are very close. There are opportunities for extreme tourism. Could be accessed from mountain regions of Turkey. Potential number of tourists is 150,000 with two days stay	Located directly on the border. Not easily accessible from the Baku.
Sarsang	Attractive for fishing, surfing and boating. Mountain areas and many types of natural springs are very close. Potential number of tourists is 150,000 with two days stay	High risk, war zone. Not accessible.

For example, the recreational potential of the Mingechaur dam/reservoir is important. Mingachevir reservoir used to be one of the biggest Olympic rowing centers in the former Soviet Union.

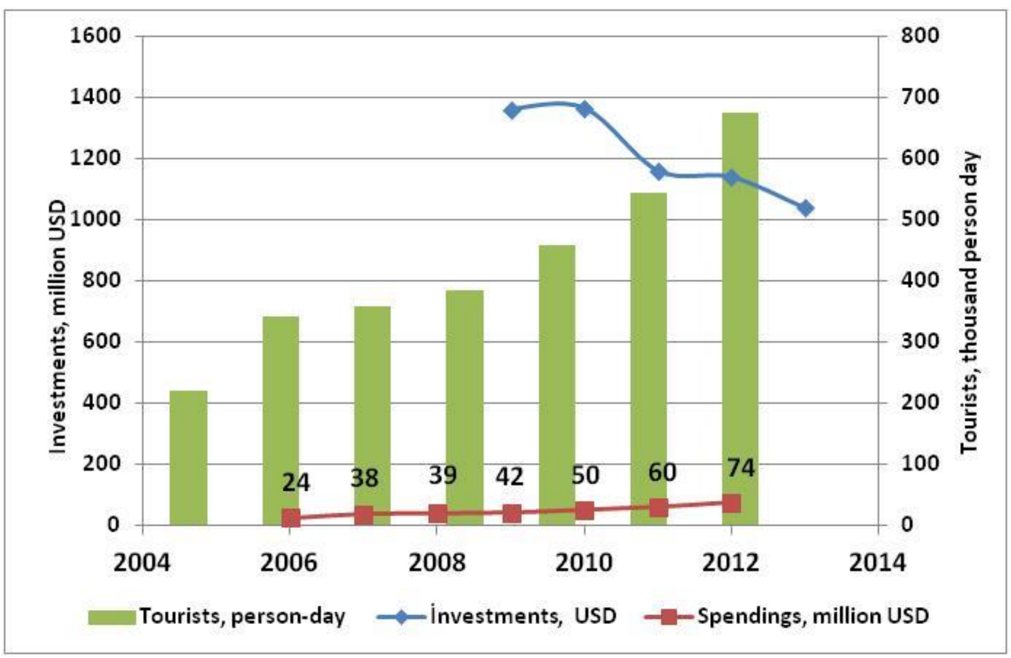
During the Soviet time, Kura Olympic Rowing Center located in Mingechaur used to be one of the biggest Olympic rowing centers in the Soviet Union. The rowing center every year hosted nearly 45,000 tourists from different countries[10] (). However, after collapse of the Soviet Union, rowing importance of the dam decreased. Over the long time, this rowing center became a shelter for war refugees.

[10] **http://www.worldrowingmagazine.com**

Recently, a new rowing center with modern standards has been built. This center will likely increase rowing importance of the Mingechaur. In 2010 the new rowing center opened. The total area of the rowing center is 7.2 ha. The center's hotel may host 250 people simultaneously and it can accommodate 500 people to watch rowing games simultaneously. However, the hotel is only directed to serve sportsmen and prices considered too high for the ordinary tourist. Local experts suggest that this center could host over 200,000 tourists every year. In Azerbaijan, the average tourist daily spending is higher than USD 150. This number can be used to produce a rough estimate of potential income from tourism.However, given the fact that these reservoirs are not used for tourism purposes, the estimated annual loss of revenue is roughly USD 180 million[11].

According to official statistics, number of tourists coming to Azerbaijan is considerably increased over the last 7 years. In 2006, Number of served foreign tourists was 218,982 person-days, while in 2012 this rate has reached 674,435 [12]. Investments in tourism sector have been growing as well. This growth was accompanied by a gradual reduction of investments in the tourism sector. Moreover, investments in tourism sector include mainly government expenditures in large infrastructure;nothinh on fresh water ecosystems management. This is s typical unsustainable BAU practice that undermines the potential long-term development of the tourism sector. This trend is illuistrated in Figure 6 bellow.

Figure 6. Trend of investment and person/days served in tourism sector in the KARB in Azerbaijan, BAU scenario.



Source:State Committee of Statistics

[11]**www.amaf.az**

[12]www.stat.gov.az

It is worth noting that current tourism investments cover only central city of Baku and are made by international hotel companies. So far, there were no considerable government investments in regions, while number of tourists continues to increase. This is a typical BAU approach that results in additional pressure on ecosystems threatening potential long-term economic gains.

Assuming that at least 30% of this people could be interested in nature based tourism in the target region and average amount of daily spending would be USD 110. These spending include hotel (nearly $70), food ($20), transport ($10) and some non-expected costs ($10). Then, total income of touristic enterprises from nature-based tourism is estimated at USD 30,000.000. Attractions such as the new Kura Olympic Rowing Center in Mingechaur, combined with other local natural attractions, are key to sustain the economic benefits of nature-based in the region in the future. However, in addition to poor investment in tourism, the Mingechaur reservoir tourism potential is at risk because of water pollution and sedimentation.

These estimated values show only part of the existing total spending and do not reflect the full potential of this sector. Generally, tourism sector in Azerbaijan is still weak and has poor incentives to develop. A shift to SEM, in addition to additional investment, includes changes in visa policy, making new regulations concerning tourism and creation market driven mechanisms.

3.2. Drinkable water

The increase in demand in drinkable water, in response to the growing population, indicates the important of this sector in Azerbaijan. Water is indispensable for economic growth and poverty reduction (Scandizzo and Abbasov, 2012).

The largest city that is completely supplied from the reservoirs is Mingechaur, which is the fourth-biggest city in Azerbaijan with a population of about 100,000. The water for Mingechaur is taken directly from the Mingechaur reservoir and then distributed to residential users in urban areas with no treatment.

Shirvan and Karabakh canals are not only major sources of irrigation water, but also main sources of drinking water in most of places of Aran Economic District they cross.

The main water sources in Azerbaijan are the traunsboundary Kura and Araz rivers, that are affected by permanent pollution in the territory of neighboring Turkey, Iran, Georgia and Armenia (Abbasov and Smakhtin, 2009; Suleymanov et al., 2010). The quality of the drinking water is poor both in source and distribution points. The rivers of Kura and Araz, which is the main sources of water supply for Aran, is highly polluted and pollution with oil produced and sulphates in most cases exceeds the maximum allowed concentration by 4-5 times. E.g.

concentrations of As in the Araks river were 11.8 -151.3 mg/l, which is more than two times higher than accepted standards.

Most of the small streams of the Kura basin are highly polluted by the mining industry. Over the past 50 years, metal (Cu, Fe, Al) concentrations in some streams have been increasing due to the growth of the mining operations in Azerbaijan and Armenia. According to studies done by Blacksmith Institute in 2012, new gold mines in Azerbaijan threat to health of thousands people (www.az.dbisa.org).

Water sources in Azerbaijan also are polluted by discharges of poorly treated or untreated waste water from the 11 million people living in the catchment area. The major pollutants are heavy metals (Cu, Zn, Cd, As) from mining industry, and ammonia and nitrates from the fertilizer industry. Concentrations exceed norms up to nine times. Phenols exceed the norms six times and mineral oil, two to three times.

The Araz River is claimed to be one of the most turbid in the world, with high turbidity increasing the cost of treatment for drinking water. Sediment flows of these rivers are conspicuous, so that the water quality of the rivers requires large facilities to reduce sediment load near the withdrawal site and conventional treatment to meet drinking water standards. The Kura withdrawal sites were built just after the junction of the Kura and the Araz rivers. Due to heavy pollution in upstream regions of the Kura basin, waterborne diseases in the downstream regions of the Kura basin ravage the health of thousands of rural people and result in huge economic losses (Scandizzo and Abbasov, 2012).

The City of Baku is the second major user of the regulated Kura water. Nearly 25% of the Greater Baku area that has more than 4 million of residents are supplied by water withdrawal facilities located in a downstream part of the Mingechaur reservoir. The whole system has a total capacity of nearly 13,5 m^3/c (Baku water allocation study, 2012).

Water losses are a major issue in developing countries, seriously undermining efforts to develop sustainable water supply systems. Current estimates show that average water losses in Asian cities are around 50-60% of total water released to the networks, while for European countries these losses range between 10% and 40% of the total water supply.

Several estimates agree on an average consumption in Baku of 400 liters per capita per day. However, a WorldBank survey (Scandizzo and Abbasov, 2012) confirms that real consumption is nearly 170 l/day. Nevertheless, the apparently high individual water consumption rate is the result of several factors, mostly related to the poor condition of the transmission and distribution pipe network, domestic pipes and taps, well as the absence of metering. As noted before, the current system provides little or no incentive for consumers to conserve water; this in turn reduces water available in other parts of the network, and imposes higher operational costs on the systems. Since water leaks are very common, nearly 60% of the total water input is not used and directly being mixed with wastewater. This is a t typical BAU scenario.

The amount of water loss from a system can be determined by constructing a water balance. This is based on the measurement or estimation as to the amount of water produced (taking account of any water imported and/o exported), consumed and lost. In its simplest form the water balance is:

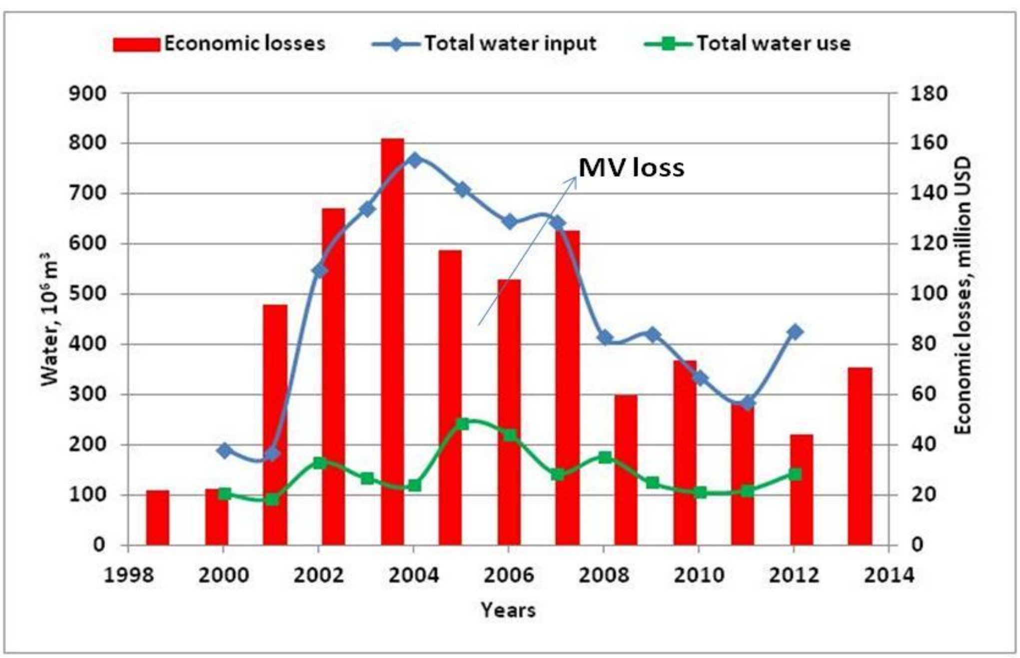
TL =SI – C

Where, TL-is a total loss of water, SI is a distribution network system input, C –is a consumption.

By estimating the difference between the amounts of water distributed and invoiced, it is possible to estimate total losses at the distribution network (Figure 7). This information is presented by state owned Azersu JSC.

Using aforementioned information and average cost of water (0.25 USD/m^3, economic losses can be estimated. Total economic loss over the period of 2003-2012 reaches USD 1 billion 68 million. These losses include maintenance and operational costs related to water transport, including treatment costs as well. This is shown in Figure 7 below.

Figure 7. Difference between total water input and water use and economic losses under BAU 2000-2012



These losses are the manifestation of BAU scenario and may be partially avoided by SEM interventions. The implementation of a SEM strategy could considerably reduce these losses. Particularly, to control pollution sources and decrease water treatment costs.

3.3. Irrigated agriculture

Most of the territory of Azerbaijan has rather dry climate where the average amount of rainfall is not more than 300 mm/year. This pattern makes irrigation very important in the Kura-Araks plain that occupies nearly 40% of the country's territory. Therefore, irrigation water management with advances dam development has significant economic implications in Azerbaijan.

All the dams in Azerbaijan have an irrigational purpose as well. In the KARB, water from Mingechaur, Shamkir, Yenikend and Aras reservoirs are extensively used for irrigation.

As discussed in Section 3 (Table 2.1) The Mingechaurreservoir enables to irrigate more than 970,000 hectares of land in a central part of Azerbaijan. The largest water withdrawals from the reservoir occur through Upper Karabakh and Upper Shirvancanals.The Upper Karabakh Canal 172 kilometers long and it provides a vital link between the Araks River and the Mingachaur Reservoir on the Kura River. There are 119 hydraulic establishments and 20 pumping stations in this canal. It irrigates 82856 ha of land in KarabakhPlain, where most of agricultural goods of Azerbaijan are produced. Part of the water is transferred to Mugan Plain via Araksriver.

The Upper Shirvan Canal is the second most important canal,it is 123 km long and irrigates about 100,000 ha.It irrigates lands of Shirvan Plain in the left cost of the Kura. The annual maintenance costs of canals and reservoirs are estimated at USD 20 million[13]; mainly spent on canals cleaning. Although this shows the importance of irrigation in Azerbaijan, such high cost may be reduced by shifting from BAU to SEM practices.

The biggest agricultural region of Azerbaijan is an Aran Economic District that completely depends on irrigation, the main water source of which is Mingechaur reservoir. Water shortages in this area are the common issue that faces farmers. Other big economic districts in the Kura basin that largely depend on irrigation are Absheron, Nakhichevan, Shaki-Zaqatala and Ganja-Gazakh. All of these districts produce important agricultural goods, like wheat, grape, cotton, fruits and vegetables. These products are used not only in Azerbaijan, but also exported to neiboring countries, including Russia, Kazakhstan and Ukraine. Table 7 shows area of irrigated lands in these districts for the last 10 year

[13]http://www.mst.gov.az/

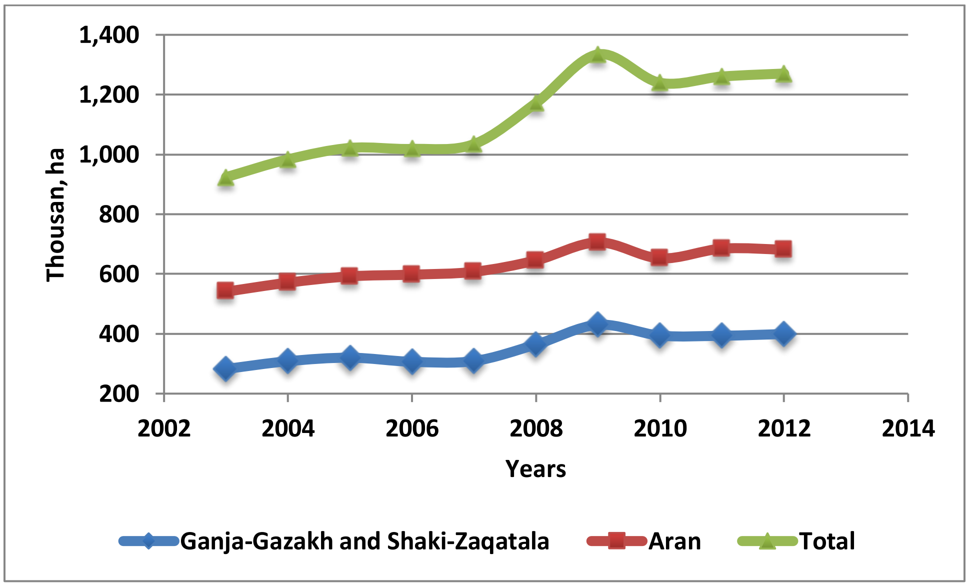
Table 7 Area of irrigated lands for the period of 2003-2012 in the KARB in Azerbaijan (thousand ha.)

Economic Districts	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Ganja-Gazakh	154,994	162,063	164,651	160,473	168,690	180,546	208,402	193,293	195,160	197,525	191,525
Shaki-Zaqatala	127,582	146,313	155,496	145,929	140,336	183,665	221,672	200,806	198,413	201,811	197,811
Aran	540,996	571,081	592,145	597,887	607,421	645,544	705,738	652,339	684,938	681,107	641,107
Karabakh	53,702	56,451	60,679	64,768	68,687	103,379	139,578	133,750	121,991	129,863	115,863
Nakhichevan	46,644	47,552	48,810	49,275	49,397	58,910	59,200	59,199	60,020	60,118	61,118
Total	**923,918**	**983,460**	**1,021,781**	**1,018,332**	**1,034,531**	**1,172,044**	**1,334,590**	**1,239,387**	**1,260,522**	**1,270,424**	**1,207,424**

Source: **www.stat.gov.az** (2014**)**

Figure 8 below shows long-term trends in the area of irrigated lands in a sample several economic districts. In 2005, the Government of Azerbaijan (GoA) started to implement what was considered a long-term development program in the agricultural sector, which is reflected in the increase of the area under agriculture. However, investments came mainly for rich "urban farmers", who temporarily owned large territories in the central part of Azerbaijan and cultivated wheat. These large territories were originally owned by the State Fund. However, this measure gave only short-term gains, increasing wheat production for a while. Recently, production has already started to decline since many of these urban farmers have left the region.

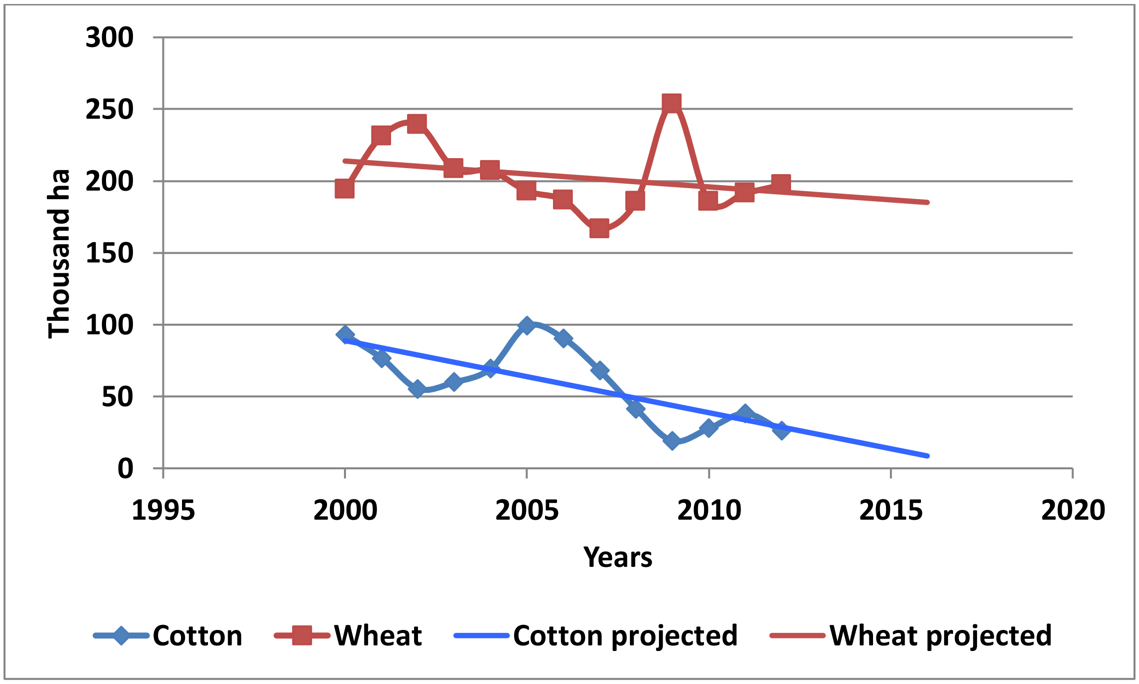
Figure 8. Trends in the area of irrigated land in several economic districts, 2003-2012



As shown in Figure 8 above, the total area of irrigated lands in the Kura Araks basin has been increasing over the last 10 years, which indicate importance of proper dam management. In 2010 area of irrigated land in the Kura-Aras basin was more than 1,300 thousand ha. However, starting in 2009 the irrigated area has started to decline. This may be the result of the traditional BAU approach in reservoir management and poor upper KARB management. This trend is mainly observed in Aran and Shaki-Zaqatala districts.

The Aran Economic District is the biggest producer of meat, wheat and cotton. However, there're are several concerns related to land management, water supply and loss in market value. This is a result of the traditional BAU approach in Azerbaijan that does not allow long-term and sustained use of resources. Changes in the area of irrigated lands cultivated for wheat and cotton in Aran Economic District for the period of 2000-2012 is given in the Figure 9. The area cultivated with cotton has reduced from 254,000 ha in 2009 to 197,000 in 2012. The reduction in the production of wheat and cotton and directly related to a major flood in the lower basin of the Kura river, that happened as result of mismanagement of Mingechaur reservoir. This is a typical BAU practice that has caused large economic losses.

Figure 9. Decline or stagnation of productivity under BAU in irrigated lands cultivated with wheat and cotton, Aran Economic District (2000-2012).



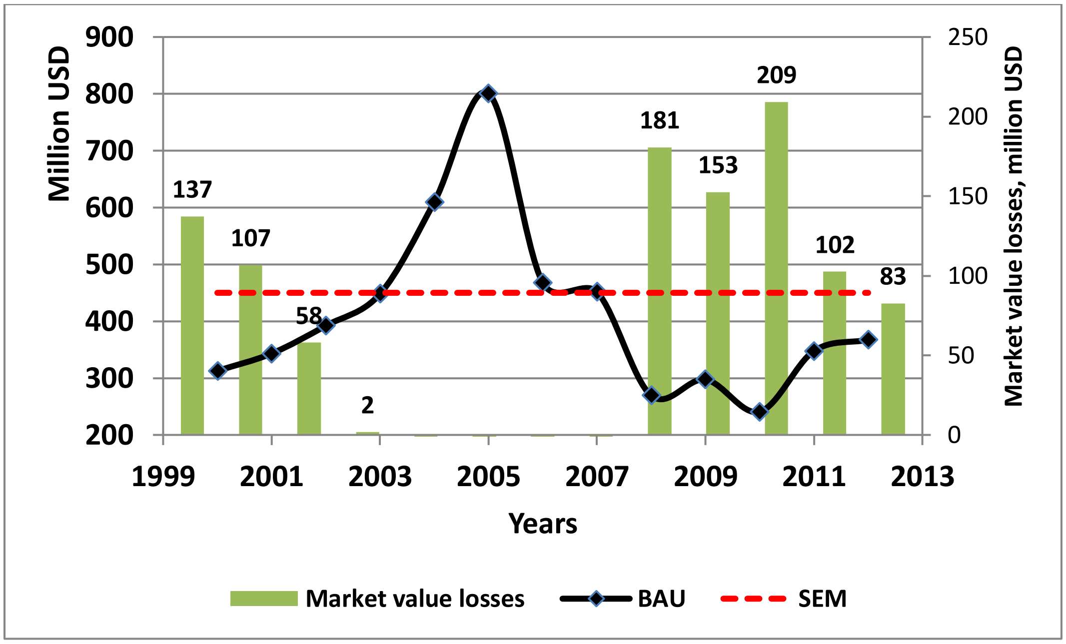
In order to estimate changes in market value, an average 2012 market price of cotton and wheat were used. Total Market value of these goods was estimated using this formula:

MV =AMP*∑p

Where, MV- market value, AMP- average market price in 2012, P-produced agricultural product, in tones.

Upon estimating market values for the period of 2000-2013, BAU/SEM scenarioswere developed (as shown in Figure 10). Clearly, under the BAU scenario,MV has decreased. For the SEM scenario, an average of 2 tones/ha for cotton and 4 tones/ha for wheat were considered. When comparing this two scenarios the loss in MV is estimated at USD 1 billion and 30 million for the 2000-2013 period.

Figure 10. Market value loss in cotton and wheat in Aran Economic District under BAU and potential loss reduction in SEM



Uneven distribution of the network is an additional problem of the irrigation. Most of the areas close to water sources are well supplied; while some of the agricultural regions and remote towns are still do not have regular access to water.

The current irrigation water supply system in Azerbaijan provides little or no incentive for farmers to save water, reduces water available for others, and imposes higher operational costs on the systems. Where available, water fees for irrigation are based on a flat rate consumption price of about 3 AZN per ha. The same situation is observed in the drinking water supply system, where the tariff of drinking water also is based on a flat rate consumption rule.

In order to improve fee collection in irrigation, in the early 2000, the Water Users Association (WUA) has been created. The main goal of WUAs is to supply farmers by water and collect irrigation fees. However, there are conflicts between WUAs and among WUA members that rise as a result of insufficiencies in a water sector. This is considered a shift to SEM in relation to tariffs.

Most of the small towns are better supplied by the distribution network, while some of the agricultural regions and remote towns are still not connected to the network and are supplied only by local groundwater resources.

Importance of SEM dam management is illustrated in Table 8. Irrigated agriculture activities in Azerbaijan make more than 90% of total agricultural production in the country.

Table 8. Production of most important agricultural goods in irrigated lands (2003-2012).

Products, thousand tones	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Wheat	1,210	1,284	1,234	1,177	1,066	1,395	1,825	1,081	1,338	1,523
Cotton	99	135	196	130	100	55	32	38	66	57
Rice	2	2	3	1	1	2	3	3	3	3
Potatoes	63	70	72	74	79	79	83	76	90	90
Corn	143	153	151	146	158	162	151	136	152	182
Soy bean	1,657,443	1,774	1,742	1,702	1,678	2,140	2,593	1,703	2,075	2,393

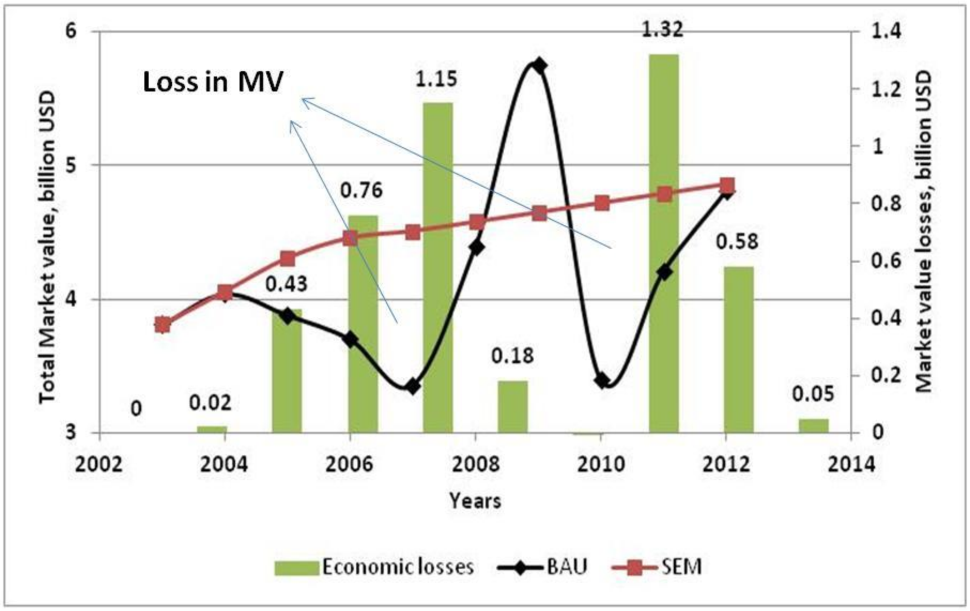
Source: SCS

Considering the average 2012 average market value of agriculture products from irrigated lands of the Kura basin (water for irrigation is exclusively supplied by reservoirs) the total gross economic benefit is estimated at USD 4.8 billion in 2012[14].

In order to estimate the total market value for the last 10 years, the study used average market prices for the period of 2000-2012 provided by SCS. The estimated MV shows that there was reduction of the MV in 2012. This is a manifestation of floods that have been observed in the downstream part of the Kura River. Comparison BAU and SEM scenarios enables to assess the total economic losses for the period of 2000-2012 (Figure 11). The losses for this period are estimated at USD 3.1 billion, while short-term gains under BAU in 2009 were only USD 1.4 billion. This is a very good example that may be used to demonstrate importance of shifting from BAU to SEM in dam management including better management of the upper KARB.

[14] http://www.indexmundi.com/azerbaijan/economy_profile.html

Figure 11. Estimated total market value and loss of agricultural goods produced in Azerbaijan (2003-2012)



Source: Authors estimates based on official data.

Water shortages are the second most frequent disaster in Azerbaijan that face agriculture. Permanent water shortages appear as a result of BAU dam management. Most frequent water shortages are observed in a downstream part of the Sarsang dam. Unfortunately, due to Armenian-Azerbaijani conflict this dam is under military dispute. The Dam and reservoir are controlled by Armenian Military Forces.

Permanent winter water releases from the reservoir create man made floods during the winter time. During the summer time, when downstream farmers need water, dam is completely closed. Due to this conflict, severe water shortages are very common in aforementioned districts. Efforts to find another source of water are failed. Permanent water shortages sharply reduced agricultural input. The economic losses from the water shortages in downstream areas are high. In order reduce water shortages, local governments spend an estimated USD 25 million every year in pumping artesian wells. This spending mainly go to capital and maintenance costs of sub-artesian wells. Despite this, nearly 100,000 ha of the arable land remain waterless, and there are no estimations concerning these economic losses.

In order to sample economic losses, considering that only 20% of this land (12.000 ha) would have wheat with productivity of 4 tone/ha, at recent market prices, the loss is estimated at USD 44,000.000. The irrigated agricultural sector in Azrbajan is considered to be in severe BAU situation.

3.4. Incidence of natural hazards

The most common hazard in Azerbaijan that could be linked to poor dam management is floods. For example, downstream part of the Mingechaur dam is often suffers from floods caused as a result of poor dam maintenance. As we have noted, one of the goals of the construction of Mingechaur dam was to reduce the frequency and severity of the floods. After the completion of the dam and reservoir, the highest peak flows were reduced. Regulated flow from the reservoir altered the annual flow distribution of downstream, and flood events were almost entirely eliminated during the first 16 years after construction (Abbasov and Mahmudov, 2009).

However, according to studies related to investigation of the watershed erosion and channel silting confirm that the riverbed and reservoir silting was the main driver of the last year floods. (E.g. Abbasov, 2011; Abbasov and Mahmudov, 2009). Intensive deforestation and non sustainable agricultural practices in upper watersheds increase turbidity of water in rivers and streams. This increased volume of suspended sediments entering to the reservoirs from the upstream watersheds causes the reduction of the capacity of the reservoir; and during high water seasons,floods affect downstream areas.

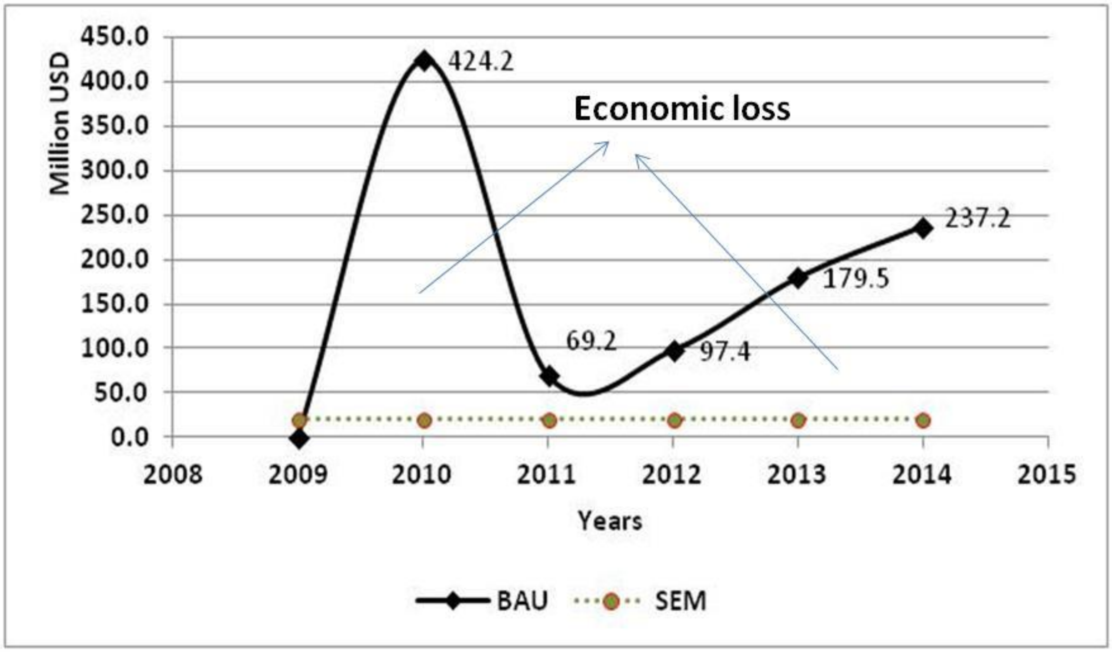
Poor dam and watershed management started to cause big floods since 1993. Recently, floods in the target region affect lives of 200,000-250,000 people on average per year. E.g. in May 2010, more than 240,000 people were affected, with tens of thousands of homes flooded or destroyed and 50,000 hectares of farmland inundated. The damage was estimated at $591 million[15].The main reason for this flood damage was a combination of poor upper basin management and dam management (flow regulation).

In 2010, the GoA increased its state budget up to USD 425 million to eliminate consequences of flooding[16]. In 2013 USD 180 million has been spent to reduce consequences of floods. In 2014, the projected costs will be nearly USD 185 million. Total spending over the last four years slightly exceeds USD 1 billion. The Figure 12 shows the annual costs for elimination floods. The high cost of the 2010 flood is linked to BAU. This cost could be reduced by shifting to SEM management; for instance, only USD 20 million annually. The data to support this estimation was provided by the SCS, Ministry of Finance and National Budget Group (Figure 12).

[15] www.budget.az

[16] www.budget.az

Figure 12. Annual costs of floods under BAU and SEM and SEM 2008-2015.



Source: Author's estimates based on official data.

In addition to compare BAU and SEM scenarios, a comprehensive and yet simple cost benefit analysis (CBA) can be used to guide management interventions. The first requirements of CBA are data on costs and benefits of an integrated SEM management program. Costs may include: forest management, erosion prevention, dam management, canal cleaning and construction of dykes along the canal. However, the GoA does not investment on upper watershed management. As a reference, the total investment on nature protection, in 2012, slightly exceeded USD 4 million and mainly covered recurrent costs of central and local offices of the environmental departments.

4. Conclusions and recommendations

4.1. Conclusions

- BAU practices in fresh water ecosystem management have a high cost to the economy of Azerbaijan. Part of this high cost can be avoided by shifting to low cost SEM practices.

- Despite the availability of several laws and regulations governing the administration and management of HPP and Dams in Azerbaijan, enforcement is weak. The legal framework is also incomplete, there are no means for law enforcement, and no measurable indicators or means to collect and evaluate it. Therefore no results of evaluation are fed into policy making or to improve HPP/Dams management.

- Because of different priorities, poorly planned BAU management generates conflict amongst fresh water ecosystems' stakeholders. This is illustrated in Table 9 below

Table 9: Fresh water ecosystems stakeholder interest and potential conflict

Stakeholder	Interest	Issue
Ministry of Emergency Situations	Flood protection	Need for low levels in reservoirs before high spring runoffs and respective potential floods (March-May)
Amelioration and Water Economy OJSC / Irrigation Water User Associations	Irrigation	High water withdrawals needed mainly during growing season (April to September).
Azersu OJSC	Domestic water supply	Constant demand year round, peaking with dry season (June-September)
Azerenergy OJSC	Hydropower production	Constant demand for high reservoir levels and high reservoir inflows
Municipalities	Irrigation, Domestic, Industrial, Wastewater discharge dilution	Year round demand, peaking with irrigation season (April to September)
Ministry of Ecology and Natural Resources	Environmental flow	Low level replication of natural flow regime with peaks in spring

- The current environmental impact assessments of HPP/Dam projects (small and large) neglect to assess the potential impact of current ecosystems management practices in the upper river basin. This in turn will have a negative impact on HPP/Dams performance that may result in additional negative externalities affecting other sectors such irrigated agriculture, tourism, fisheries, and drinkable water supply. The aggregated cost of these negative externalities often surpasses the current benefits deriving from the HPP/Dams sector.

- Because improving ecosystem management in the upper watershed requires the participation of multiple sectors, e.g., HPP/dams, agriculture, forestry, fisheries, tourism, water supply, a comprehensive package of interacting policy reform measures is needed, both at national and at regional level. This is defined as a "policymix" package that is indispensable to introduce sustainable HPP/Dams development in the Southern Caucasus.

- The lack of information and data limited the scope of this study; therefore, further research is needed, and it may include developing of primary data baselines. However, basic scenarios (BAU/SEM) were constructed where possible to inform policy makers and businesses about the economic risks and opportunities of undertaking productive activities that impact ecosystem services.

- It is evident that BAU scenario causes huge economic losses in all sectors, reducing long-term gains. In contrast, the SEM could help to gradually increase ecosystem values and related benefits. For illustration purposes, a rough aggregate of the economic losses in various sectors under BAU and shows how costly BAU management can be, USD 18,6 billion (Table 10 below). It also shows how economic losses may continue to increase, unless SEM management is provided.

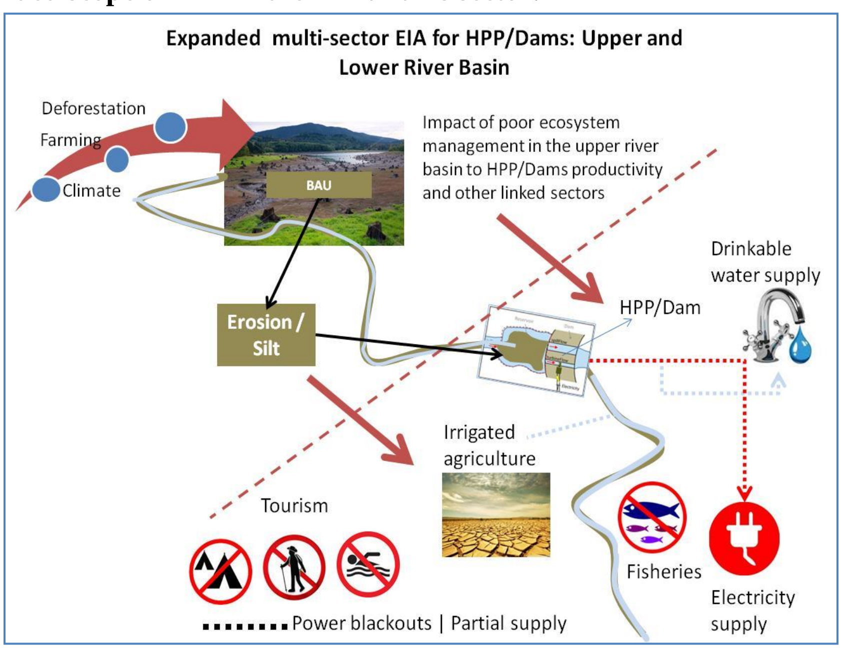
Table 10. Estimated economic losses under BAU in selected sectors (2000-2010)

	MV losses over the 2002012 period, million USD												
Sectors	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Hydropower	487	466	446	497	475	456	508	520	530	528	440	500	565
Nature based tourism	180	180	180	180	180	180	180	180	180	180	180	180	180
Water Supply	22	23	96	134	162	118	106	125	60	74	58	44	71
Irrigated Agriculture	0	0	0	0	20	430	76	1,150	180	0	1,132	58	50
Natural Hazards					20						74	56	90
Total	1,108	1,088	1,142	1,232	1,257	1,603	1,290	2,396	1,370	1,202	2,304	1,258	1,376

4.2. Recommendations

- Develop a poly mix reform package to promote the shift from BAU to SEM practices in the HPP/Dams sector. To this end it is recommended that:
  - ✓ Establish a multi-sector policymix working group.
  - ✓ Define sector and policy priorities using complexity vs. investment viability analysis; key laws and regulation are included in Table 11 below.
  - ✓ Develop an annual action plan and its cost; and seek funding to implement the action plan.
  - ✓ Develop and implement a communications strategy to disseminate the results of this study and other similar documents, and progress with the policymix package. The communications strategy should address decision makers at the executive and legislative levels, and the public in general.
  - ✓ Establish a communications support group formed with high-profile members of the Azerbaijan society, who are willing to support ecosystems management and sustainable development (sportsmen, media and communications figures, artist, and controversial individuals)
  - ✓ Establish a coordination mechanism to interact with similar policymix working groups in Armenia and Georgia.

Figure 13. Expanded scope of EIA in the HPP/Dams sector.



Source: Flores, M. 2014.

Table 11. Key regulatory framework to be considered in the policymix package

Law/regulation/policy by sector	Critical issue or gap	Proposed amendment
Water code	Lack of ecosystems vision, non-realistic goals, absence of river basin management principles and strategy. No opportunity for community participation	River basin management principles should be applied
Law on water supply and sewage	Low enforcement	Develop enforcement mechanisms, including fiscal incentives.
National Energy Action Plan/Azerbaijan	Less priority for small HPP Obstacles for private sector to construct HPPs	Increase small scale HPPs through private business
Law on Environmental Protection	Law enforcement, no public ownership on natural resources, weak institutional structure	Better institutional structure, participatory approach
Law on Amelioration and Irrigation	Weak participatory approach	Role of communities in water management should be identified. Local communities have no rights in terms of water withdrawals
Law on water economy of municipalities	Discrepancy between water code and law on water economy, No basin principles	Municipalities has no capacity to take benefits from existing law
Forest Code	No opportunity for community participation. No options for private business. Low enforcement	Timber production for private business, using SEM approach. Improve enforcement
Nature based tourism	No access of tourists directly to reservoirs. No encouragement for private sector participation	Introduce tourism strategy for reservoirs, with incentives for local governments and private sector participation
Law on Water Economy of Municipalities	No basin principles, No private ownership on water supply, Not realistic goals	Role of municipalities in water management should be increased
Environmental impact assessments (EIA) in the HPP/Dams sector	Current EIA guidelines are randomly applied and exclude ecosystems managements in the upper river basins.	Enforce rigorous EIA and expand scope of EIA to include ecosystems management in the upper and lower river basins (above and below the HPP/Dam. Figure 13 below illustrates an expanded scope of EIA.

Other specific technical recommendations to be included in the policymixpackage:

- Development of better management system for hydropower reservoirs, which are also used for irrigation, against natural disasters, especially, floods, mudflows, and landslides.
- Incorporate fresh water and forest ecosystem management in HPP/Dams management policy.
- HPP generation may be increased through correct flow regulation that may reduce negative externalities for downstream water users as well.
- Improved dams management may considerably improve flood management. Introduce updated seasonal flow regulations and fragmentations to reduce flood and drought risks below dams.
- Improvement of the investment climate for tourism and touristic attractions in regions would increase opportunities in nature based tourism, including nature-based tourism in HPP's reservoirs.
- Introduce better land used guidelines to reduce overgrazing and deforestation; for instance, rigorous enforcements of forest laws and implementing quotas in cattle-breeding.
- Trans-boundary management of water resources would increase effectiveness of SEM policies. These would improve migration fish routes, reduce pollution and would help to create integrated water management policies between Armenia, Azerbaijan and Georgia
- Creating incentives to save water in agricultural sector and implementation of advanced methods of irrigation would protect interests of downstream water users and reduce water shortages
- Reduction of water losses in a distribution network, through strong investments. Implementation of metered payments both in drinking and irrigation water supply.
- Improvement of the legal ground for SEM development will be reflected in increasing opportunities for all sectors

Annexes

Annex 1. TSA Approach

This study used a basic "Targeted Scenario Analysis" (TSA). It is not a traditional ecosystem-centered valuation approach. TSA is sector-centered and it builds on the approach used by UNDP for the valuation of ecosystems services in the Latin American and Caribbean Region, more recent PA/Ecosystem valuations studies in Central and Eastern Europe, and in the UNDP draft guideline to Targeted Scenario Analysis to be available in early 2014. TSA is a sector-oriented approach which is relevant to policy makers responsible for sector development and investment policies.

The valuation approach focused on a productive sector, mainly HPP/Dams linked to fresh ecosystems services (ES) in the KARB in Azerbaijan. It is recognized that the economic impact of ecosystems services may extend beyond the limits of the KARB.

TSA explores the economic relations between production practices, ES, other inputs, and their respective sectoral outputs (values). The approach addresses for example: a) how ecosystem degradation lowers outputs and discusses the associated costs; and, b) ecosystem-friendly management practices that avoid damages and its economic benefits are highlighted. These two different approaches, "Business as Usual" (BAU) and "sustainable ecosystems management" (SEM), are used to facilitate the analysis and demonstrate the value of ES to productivity. A sample of typical characteristics of BAU and SEM is included in the Table 13 below.

Table 13. **Characteristics of BAU ecosystems management that may affect HPP/Dams development**

Poor water ecosystems management; Lack of sustainable agricultural strategy, including watershed management plans (currently being developed); Deforestation and erosion in deforested areas and riverbeds; Unregulated use of pesticides and fertilizers; Overgrazing; Surface water pollution; Erosion (high content of sediments); Outdated agricultural techniques and practice; Lack of adequate zoning and land use policies and enforcement.	Deteriorated or obsolete infrastructure (reservoirs, intake points and water canal network, pumping stations, silting control); Lack of metering and water fees for irrigation; Poor investment in maintenance and renovation; Illegal construction in agricultural land; Small farm size and fragmented production and processing; and, Limited institutional capacity.

Source: Adapted from Flores M., 2011

2. Steps and information flow

Depending on the availability of information, the following steps are recommended to apply the TSA valuation approach:

1. Definition of the scope of the analysis: KARB and HHP/Dams development sector; and other related benefits in other secondary sectors.
2. Definition of BAU baseline and potential SEM intervention based on available information and first hand research.
3. Selecting indicators (based on available information and agreement with stakeholders).
4. Constructing BAU and SEM scenarios and values.
5. Formulation of informed policy and management recommendations.

3. Indicators

Depending on the availability of data, selected indicators are used to assess BAU and SEM impact. Sample indictors are shown in the Table 14 below. Not all indicators are suitable for all the selected sectors or subsectors. Therefore, indicators are used when applicable.

Table 14. Sector Indicators used to construct BAU/SEM scenarios
Employment increase (# of jobs) by sub-sector (direct, indirect and induced)
Income, average annual increase by sub-sector

Fiscal impacts (annual tax revenues to governments
Annual revenue from green taxes
Foreign exchange earnings (annual, from exports)
Opinion polls
Sector investment (government)
Sector investment (private sector)
Damage costs (as a result from BAU practices)
Avoided damages costs (as a result from SEM practices)
Production trend (volume and value)
Sector production trend (as percentage of GDP)
Changes in natural capital (e.g. # Ha under protection or INC practices)

4. Constructing BAU and SEM scenarios

Traditional data on the value of fresh water ecosystems to the HPP/Dams development sector is organized based on this BAU/SEM framework. The values of biodiversity and ecosystems are not seen as static (time-bound) data points, but, rather, as variables that respond to degradation, sustainable management, and other interventions.

The term BAU refers not to all current activities but those activities that damage or depletes ecosystem services. The BAU approach is characterized by a focus on short-term gains (e.g., < 10 years), externalization of impacts and their costs, and little or no recognition of the economic value of ES, which are typically depleted or degraded. Under SEM, the focus is on long-term gains (> 10 years); also under SEM, the costs of impacts are internalized. Ecosystem services are maintained, thus generating potential for a long-term flow of ecosystem goods and services that can enter into decision making. Activities labeled as SEM practices tend to support ecosystem sustainability, not for ideological reasons, but, rather, as a practical, cost-effective way to realize long-run profits. Common SEM practices include watershed management, agro-forestry and silvo-pastoral production methods, low-impact logging and mining, nature-based income diversification, and organic farming (adapted from Bovarnick et al, 2010).

An example of a TSA analysis in the hydropower sector, following the steps proposed in Section 2, is included in Section 8 below.

5. Formulation of informed policy and management recommendations

Once the relationship between the policy interventions (BAU or SEM) and outcomes and the magnitude of the outcomes that may result from each of the policy interventions has been estimated, the information could be presented to decision makers in order to assist them at choosing among different the policy options; the choice between BAU and SEM.

Some decision makers may want to know the analyst's opinion or seek a direct recommendation as to which policy intervention to choose on the basis of the TSA. Decision makers may promote debate before supporting one policy intervention over another. Others may prefer a more "factual approach" in order to come to their own conclusions as to the choice among policy interventions.

In both cases, the analysis should present the results of all indicators, for all affected stakeholders, in a way that enables the decision maker to compare and contrast the pros and cons of the different interventions in terms of different criteria and the consequences on different groups. The main trade-offs between indicators and stakeholders should be highlighted, without presenting a dominant intervention or single number that indicates which intervention "should" be chosen (UNDP TSA)[17].

7. Limitations

The sector-level approach and the BAU and SEM analysis have some limitations for instance:

- The analyses draw on technically economic and ecological data from the published material available. Such date is still scarce in Azerbaijan, just a handful of studies are available.
- The sectoral approach disaggregates the economic value of each type of ES and fragments system-wide values to show specific sectoral inputs.
- Lack of national and sector-level data has limited the applicability of the selected range of indicators used to assess the impact of BAU and SEM practices.
- When available data is mostly out-dated, few current data from recent years is likely to be available.

8. Example of TSA

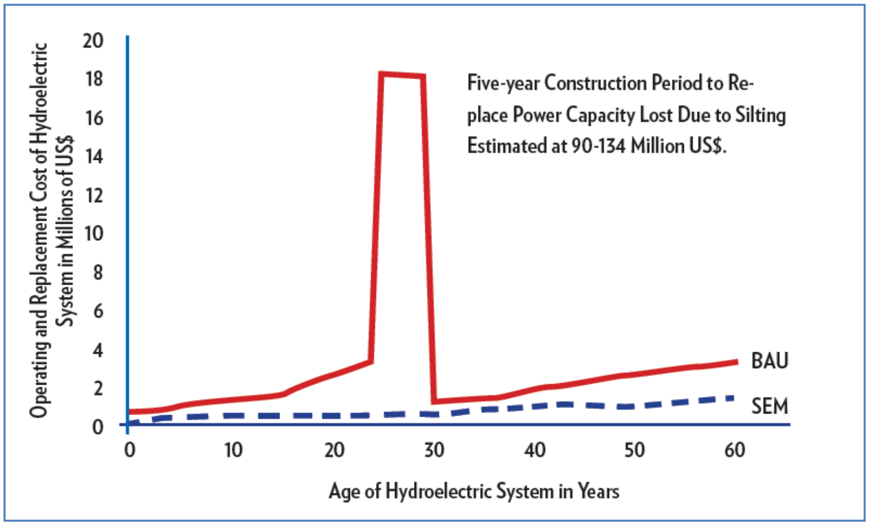
The following example[18] describes a TSA for the Guri Dam in Venezuela. The **Caroni** River is the second most important river of Venezuela. The higher basin of the Caroni River is situated in the **Canaima National Park**, which produces the water that feeds the dam. The Guri Dam is the largest hydropower system in Venezuela. A TSA conducted on options for the dam led to generation and presentation of the following results:

1. Power generation will be reduced by about 10-15 percent by siltation resulting from a BAU scenario of moderate deforestation.
2. The hydroelectric system has an expected life of 60 years, and the loss of power generation capacity is expected to peak halfway.
3. The cost of operating and recovering the lost capacity under this BAU scenario is captured in Graphic 2. Investment costs would be about $90 million to $134 million and span five years, starting in year 25.
4. Figure 14 also shows an alternative SEM scenario in which deforestation is reduced at a much lower, albeit constant, annual rate.

Figure 14: Cost of maintaining hydroelectric power capacity under BAU and SEM

[17] UNDP TargetedScenario Analysis (2013)

[18]From UNDP Targeted Scenario Analysis, December 2013.



Source: Flores in UNDP (2010), based on Gutman 2002.

Finally, in order to generate these TSA results in the example above, the following steps were taken:

1. *Define the purpose of analysis:* Siltation of the dam used for hydropower generation is leading to a reduction of generation capacity, which will require a large investment at some point around the dam's midlife. High erosion rates are linked to moderate deforestation under the BAU scenario. Can this scenario be avoided by implementing sustainable ecosystem management practices?

2. *Define the BAU baseline and SEM intervention:* BAU is understood as the current level of deforestation. The alternative SEM scenario includes reduced deforestation, as well as land-use practices that reduce erosion rates within the dam's catchment area.

3. *Select indicators:* The analysis is done at the level of the hydropower generation facility (which makes it sectoral), and the main indicator is the cost of maintaining the dam's generation capacity as planned by design. There is no attempt at incorporating positive or negative externalities and no attempt to value economically the benefits to society of electricity production.

4. *Construct the BAU and SEM scenarios:* The consequences in terms of the relevant indicator (cost, as defined above) of the BAU and SEM policy interventions are based on a projection that uses engineering principles and a dose response function that links observed deforestation to erosion rates to siltation of the dam. The change in productivity method is used to generate the costs under the two scenarios. This analysis focuses only on financial costs.

5. *Make an informed policy recommendation:* Results are presented both graphically and numerically, and focus on the relevant stakeholder, namely the hydropower plant manager. Decision-makers can easily see the evolution of costs in time and, as such, do not have to act on a single number (e.g. Net Present Value).

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