UNDP/GEF Kura II project

Estimating the Costs of Water Degradation in the Kura River Basin

A report for the UNDP-GEF Kura II project

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1. Introduction

The aim of the report is to derive high level estimates for the costs of environmental degradation in the Kura River Basin (in Georgia and Azerbaijan). As the analysis should inform water resource management policy decisions, the focus of this work will be the consequences of water pollution and water resources depletion, along with economic impacts of extreme events (i.e. floods and droughts). These damages are not only related to environmental degradation, but also to the lack of resilience to the effects of climate change. Nonetheless we have considered them because considering response to natural hazards together with natural environment protection is necessary to ensure that resilient society is built. Other aspects of environmental degradation such as air pollution, wildlife, waste production and cultural heritage have not been considered.

The methodological approach chosen for this study was affected by the lack of reliable quantitative information on the extent of environmental degradation. We derived high level estimates of the costs of environmental degradation by using secondary data sources, indicated below. Results should be interpreted as high-level estimates, which could be refined once more detailed information is available.

The report is structured as follows. The next session briefly describes how the cost of environmental degradation should be considered in a benefit sharing framework. In section 3 methodological aspects, including the steps of the analysis, are spelled out, along with the impacts included in this study. In section 4 the available evidence on impacts of water degradation is described. Section 5 clarifies the unit economic values used in the analysis. Finally, in section 5 results will be presented. In the concluding session the main policy implications are summarised.

2. Understanding the cost of environmental degradation in a benefit sharing framework

The Kura is under increasing pressure due to increased water demand, driven by population growth, and expansion of irrigated land and HPP installed capacity. Azerbaijan and Georgia are in the process of finalizing the bilateral agreement under negotiation on the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention hereafter). A pillar of the Water Convention is the consideration of the benefits from transboundary cooperation, and their sharing, rather than how water should be allocated between riparian countries. This shift in perspective made it possible to consider adopting a holistic perspective to water conservation, and consider ecosystems and water quality aspects, rather than the sole maintenance of minimum river flows.

This policy perspective is particular useful in the case of the Kura River Basin, which experiences several environmental water issues, such as insufficient water flows, poor water quality, lack of resilience to extreme events and ecosystems degradation (UNECE,2015; World Bank, 2015).

Understanding the consequences of environmental degradation is a prerequisite for effective and fruitful cooperation. In this respect, the benefit of integrated waters resource management can be intended as the avoided environmental damages associated with unsustainable water use practices. These benefits can be compared with remediation costs, in order to understand whether it will be cost-beneficial for each individual country to put in place remediation actions. In a transboundary context, benefit-cost analysis should be considered at basin level, to ensure that a broader perspective is adopted (UNECE, 2015). So for instance, whilst it might not be cost-beneficial for a single country to implement environmental protection measures, once we consider the benefits at river basin level, actions are economically justifiable once policy costs are outweighed by the avoided damages elsewhere, and adequate compensation mechanisms are put in place.

3. Impacts considered and methodological aspects

Whilst the main water degradation issues are well known in the Kura river basin, their quantification is not straightforward, due to an inadequate monitoring system. Table 1 summarises main environmental concerns in the region. It should be noted that Baku and the heavily populated Absheron Peninsula (which are not part of the Kura river basin) have been considered in the analysis for some impacts, due to the existent water transfer from the Oguz- Gabala aquifer.

Table 1 – Main water degradation issues in the Kura river basin

	Water degradation issue
Georgia	• Poor surface water quality, due to historical industrial pollution and inadequately treated wastewater discharges • Groundwater contamination due industrial activities • Soil salinity, due to irrigation practices (Kakheti region) • Low resilience to flash floods events • Soil erosion • River morphological alterations
Azerbaijan	• Low river flows due to over-abstraction and climatic conditions • Groundwater contamination due to oil spills and industrial activities • Poor surface water quality, due to historical industrial pollution and inadequately treated wastewater discharges • Continued degradation of pasturelands, due to poor management • Soil salinity, due to irrigation practices • Decreasing fishing stocks • Low resilience to extreme events (flood and droughts) • River morphological alterations

In general, an environmental valuation exercise is structured in three stages:

1. The extent of environmental degradation is quantified, by taking into account the results of monitoring activities, through indicators;
2. Once environmental degradation is characterised, its consequences are identified in terms of impacts on socio-economic activities. The main negative impacts considered in this report are spelled out below.

3. A monetary valuation of the consequences of such impacts is carried out.

The main consequences of water resources degradation considered in this study were:

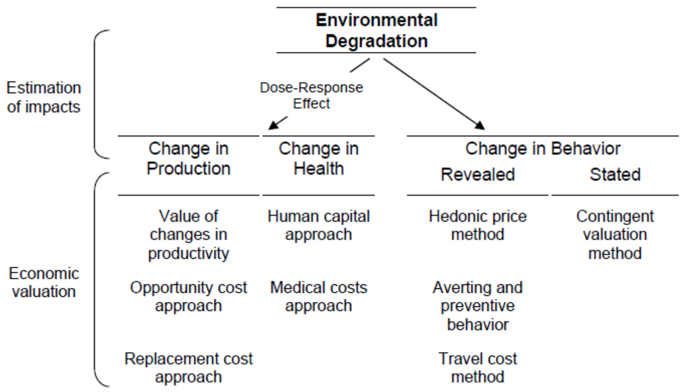
- Impacts on health and human welfare;
- Impacts on fisheries;
- Change in land productivity due to soil salinity;
- Other additional costs to the society entailed by poor water quality;
- Damage cost entailed by extreme events such as floods and droughts;
- Loss of Ecosystem Services (ES).

We did not consider impacts of dam sedimentation and groundwater depletion.

Then to estimate the economic costs of environmental degradation, it is necessary to put a monetary value to the consequences of such degradation. The estimation of environmental degradation costs is a multi-disciplinary exercise involving natural scientists, epidemiologists and economists. In the case of water degradation, several methodologies and approaches have been developed by environmental economics and resource economics literature, which could be applied to provide a quantitative estimate of its consequences,. Figure 1 provides an over view of valuation techniques, according to the impacts that have to be assessed. It should be noted that the choice of an environmental valuation technique depends on the impacts being evaluated. In cases where impacts can be directly quantified (i.e. a physical effect can be identified) a dose-response method could be adopted (Calthrop and Maddison, 1996), and every impact category valued by multiplying the number of cases by unit monetary values.

For time and budget constraints we did not collect any primary data through surveys, but relied on secondary sources, published by National Statistical Offices or scientific and grey literature.

Figure 1 – Impacts and relative evaluation method



Source: World Bank (2005)

For impacts for which markets exist we estimated unit monetary values by referring to market prices or by deriving market prices using current information. In cases no direct market impacts can be observed, we evaluate environmental consequences by adopting defensive behaviour and damage costs approaches. "Defensive behaviour" refers to actions that society or individuals can adopt to reduce environmental degradation consequences, both in terms of reducing exposure to pollution or actions that mitigate adverse impacts of exposure (Dickie, 2003). The **increased cost of drinking**

water treatment is an example of defensive behaviour proxy. The additional cost to potable water disinfection processes, entailed to guarantee that drinking water complies with drinking standard, were also considered in this study. Investment costs in disinfection technologies could be considered and depreciation costs calculated, to derive an annual cost indicator. As an alternative, the expenditure in bottled water is a proxy of environmental degradation costs, as people might decide to switch to tap water in case drinking water quality is not adequate. This second approach has also been considered in this study, as not the entire population is covered by improved drinking water treatment and no information of additional potable treatment cost is available.

Another example of consequence of environmental degradation quantified with observed costs are the economic impacts of **past flood events**. For this specific impact, we refer to historical information on damages to properties and agricultural land, but also considered the costs of emergency services, when available. Health impacts related to past flood events have not been considered due to lack of information. Fatalities have just been recorded, but not ex-post assessed.

Similarly, impacts on **fish stocks** can be assessed by considering the market value of the fish caught which is lost due to environmental degradation.

Finally, the impacts of **salinity on agricultural yields** could be assessed by considering the market prices of crops produced, as published by National Statistical Offices. As we have just very general information on the area affected by salinization, but lack data on crop cultivated on saline soils, very high level estimates have been derived.

Regarding impacts whose costs are non-observable, we considered **health impacts,** i.e. all effects on human health such as disease, injury, death and quality of life that can be determined by physical factors, such as poor or inadequate water supply and sanitation services, or behavioural factors, such as poor personal hygiene (World Bank, 2005). Human health impacts can be evaluated by using a "dose-response approach"[1], which makes it possible to translate a given level of water degradation into the number of cases of morbidity or mortality. As no sufficient costing information is available for the Kura, we referred for health cost valuation to estimates derived by published research with regards to medical treatment costs, averting behaviour and the human capital approach (WHO, 2009). As an indicator of the health lost due to environmental degradation, we considered the disability-adjusted life year (DALY), defined as the loss of one year of "healthy" life[2]. We did not adopt the contingent valuation approach as no studies are available for the Kura river basin. Besides impacts on health and wellbeing, we also considered the financial resources spent to tackle the poor water quality effects. So for instance, if water pollution causes illness, then the cost of medicaments has been considered as a proxy of the cost of such degradation.

The **loss of ES**, in terms of habitat destroyed by unsustainable water and soil management practices) is well documented by several research and policy papers (World Bank, 2015; UNECE, 2016), but it also linked to climatic conditions. Some anecdotic evidence is available on reclamation costs, which has been used to derive high level estimates. Some estimates exist of use and non-use values of

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[1] The steps of the analysis are as follows: 1. Hazard Identification, e.g. bacteria due to lack of sanitation; 2. Dose-response analysis, i.e. identifying the impacts of the pollutant on health; 3. Exposure analysis, i.e. who is exposed to water pollution

[2] http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/

aquatic ecosystems in Georgia, but have been derived as contribution to existing ES to the national economy, not as the loss of ES due to environmental degradation. No estimates exist for Azerbaijan. Therefore, we evaluate the loss of biodiversity based on the annual costs to restore environmental wetlands. Another indicator for the loss of ES is the cost of extreme events, which in this region are exacerbated by excessive anthropogenic pressures. As noted by the World Bank (2015: 7) land degradation wreaks the loss of ES in terms of flood control and prevention of frequent disasters.

Table 2 summarises the impacts considered, and the level of confidence on our costing estimates.

Table 2 – Summary of impacts considered in this study

Impact Considered	Assessed	Level of Confidence
Increased treatment costs	No	-
Past flood events	Yes	High
Fish Stocks	No	-
Agricultural Yields	Yes	Low
Health Impact	Yes	Medium
Loss of Ecosystem Services	Yes	Low

It should be noted that estimates measure the annual cost of environmental degradation, by considering current impacts occurring in one given year. This cost refers to 2016, the latest year for which much of the environmental data were available. Therefore or this study the reference year is 2016. For consistency with previous studies (Croitoru and Sarraf, 2010), this assessment considers a time horizon of 25 years and a discount rate of 4 percent to compute future water degradation cost. Results are presented as absolute values and as percentage of the country's gross domestic product (GDP) for the year of reference, to make the results comparable to the other economic indicators and similar studies (Croitoru and Sarraf, 2010). The net present value (NPV) of future water degradation cost is also accounted for use, e.g., in impact assessment. We show results for the cost of environmental degradation of different types of environmental damage within each country and the entire Kura river basin. Due to data limitations, we were not able to assess the whole range of damages. Results should then be interpreted as order of magnitude, instead of exact estimates of the damages of water resources degradation. This might lead to underestimation of the true value of economic impacts of such degradation (Croitoru and Sarraf, 2010). A range of estimates has been provided to reflect this uncertainty.

4. The extent of environmental degradation in the Kura river basin and its consequences

This section describes the consequences of water resources degradation, by considering different damage categories. The results of the evaluation of these impacts are presented in the next session.

4.1 Ecosystems loss

The cost of ecosystems loss has been inferred by considering remediation costs incurred to clean up contaminated sites. We then adopted a replacement cost approach but, as we only have anecdotic evidence on this aspect, estimates should be considered with caution.

For Azerbaijan, the rehabilitation of the Boyukshor lake on the Absheron peninsula started in 2015 with support from the World Bank, and costed 100 million USD[3]. The estimated cost for reclaiming all lakes in the Absheron peninsula might reach 1 billion USD (Elchin Mamedov, pers. comm.).

For Georgia, we refer to two projects implemented in 2015, on restoring damages of soil erosion and by secondary waterlogging in in Gurjaani Municipality. Total projects' cost is 1,033,700 USD. This is clearly an underestimation of the loss of ES.

4.2 Human Health

Regarding human health impacts, data on incidence of infectious diseases potentially related to water can be found on the Protocol of Water and Health Report (2016), for Azerbaijan, and on the website of the National Centre for Disease Control and Public Health, for Georgia. Information on morbidity and incidence for several years is summarised in Table 3 and 4, for Georgia and Azerbaijan, respectively. Data in Table 3 refer to various infectious diseases, but the contribution to morbidity caused by water contamination is not known. For Azerbaijan the incidence of water related infections is known, and number of cases can be estimated (see Table 5).

Table 3 – Morbidity caused by some infectious diseases, Georgia

	2005		2012		2016	
	Total	of which children	Total	of which children	Total	of which children
Acute intestinal infections	9574	6261	33079	22133	27832	17987
Salmonella infections	344	112	176	76	74	43
Typhoid fever and paratyphoid fever	-	-	-	-	-	-
Diphtheria	10	6	-	-	-	-
Rubella	1842	1596	75	67	12	7
Virus hepatitis	1376	526	2913	24	8042	20
Influenza and acute respiratory infections	209793	138150	355837	218205	458357	245734

Source: National Center for Disease Control and Public Health

With data from table 4, by considering the population living in Azerbaijan and in the Kura river basin we can estimate the outbreak estimates (see table 5). Given the population size, this morbidity data seem to underestimate the incidence of water-borne diseases in Azerbaijan.

Table 4 – Incidence of main water related infections (cases/10,000 in.) - Azerbaijan

	2005	2012	2015
Cholera	0	0	0

[3] http://documents.worldbank.org/curated/en/931611468005092100/pdf/PIDISDS-CON-Print-P157091-03-10-2016-1457650712092.pdf

Bacillary dysentery (Shigellosis)	3.4	0.65	0.31
Viral Hepatitis A	15.3	2.42	0.72
Typhoid Fever	0	0	0
Rotavirus Enteritis	-	1.70	1.22
Giardiasis	-	16.1	9.1
Legionella bacterioses	0	0	0
Yersiniosis	0.08	0.17	0.2

Source: Water and Health Report (2016)

Table 5 – Estimated cases of main water related infections - Azerbaijan

	Baseline (2005)	Previous Report (2012)	Last Report (2015)
Bacillary dysentery (Shigellosis)	1.992	381	182
Viral Hepatitis A	8.962	1.417	422
Rotavirus Enteritis	-	996	715
Giardiasis	-	9.430	5.330
Yersiniosis	47	100	117

Source: Own elaborations on Water and Health Report (2016)

The use of these statistics to assess health impacts of water degradation is problematic for two reasons. First, the Georgian statistics do not make it possible to identify the cases related only to water degradation. Second, statistical data for Azerbaijan do not indicate the number of fatalities for water related infections. In order to guarantee consistency between Georgia and Azerbaijan data sources, estimates for morbidity and mortality related to diarrhoeal diseases caused by water contamination have been taken from GDB collaborators (2017), which give an indication of the total DALY lost in the two countries in 2015. Table 6 summarises the main indicators for global diarrhoeal diseases in the two countries, considered in this assessment.

Table 6 - Deaths, episodes, and DALYs attributable to diarrhoeal disease in 2015, by country

Country	Children younger than five years			All Ages		
	Deaths	Episodes (100,000s)	DALYs	Deaths	Episodes (100,000s)	DALYs
Azerbaijan	177	9.2	17,642	201	16.9	20,400
Georgia	12	2.1	1,623	24	5.1	2,483
Total	189	7.3	19.265	225	22	22,883

Source: GDB collaborators (2017)

For the purposes of this study, the number of cases reported at National level by GDB collaborators (2017) have been adjusted to take into account the Kura river basin population (adjusted factors are 0.6 and 0.56 for Azerbaijan and Georgia, respectively) and the fact that not all diarrhoeal diseases are caused by water contamination. The study reported the global aetiology for different diarrhoeal diseases; an adjustment factor was derived (0.72) and applied to total number of cases in the Kura river basin to get an estimate of number of cases in the river basin attributable to water contamination only.

Additional health costs due to environmental degradation are those related to flood events. It should be noted that, although in the 2010 and 2015 floods (in Azerbaijan and Georgia, respectively) a number of fatalities occurred; these impacts have not been monetised in this report. Other health impacts relate to injuries and mental health impacts following the trauma of having to cope with calamities such as flooding. For health impacts related to floods no disaggregated information on medical and other mental health costs are available, that can be used to derive the relative impacts.

4.3 Water treatment costs

The world largest Ultra-Filtration (UF) surface water treatment plant was commissioned in Azerbaijan in 2013, to contribute to the treatment of drinking water from the Jeyranbatan Reservoir. The plant daily capacity is 520,000 m^3 and contributes to drinking water supplies for Baku city population.

As there are not figures available for the additional potable water costs, we refer to expenditure to purchase bottled water.

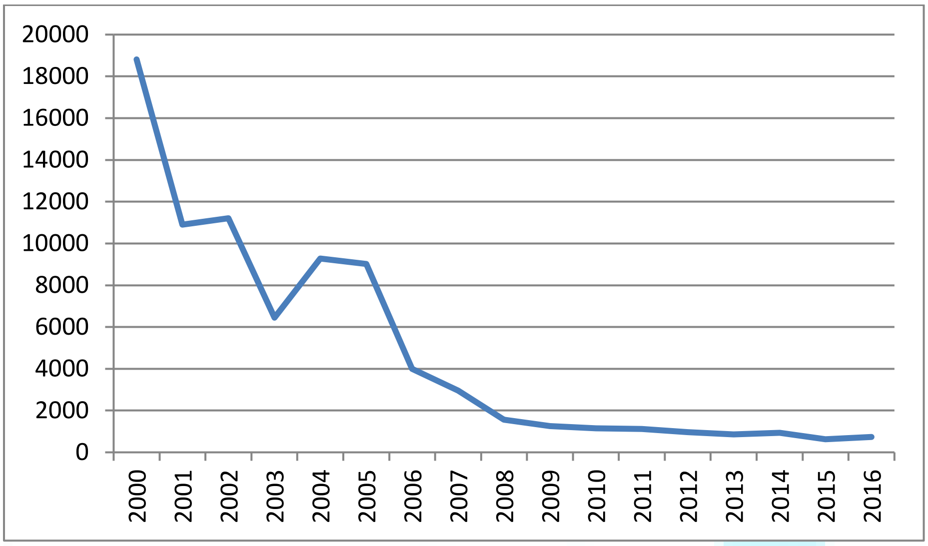
4.4 Fishing

The Kura and Mingachevir and Shamkir reservoirs are currently used for commercial fishing. Smaller river stretches are only used for recreational fishing. Therefore these water bodies all have a use value, which makes it possible to measure environmental degradation in terms of the value of the declining fishing stock due to alteration of natural river flows.

Fishing stocks have been declining since mid-1930s in Azerbaijan. At the beginning of 1930s fish caught amounted to almost 33 thousand tonnes. This dropped to around 10 thousand tonnes in the following decade and to 1.5 thousand tonnes at the beginning of the 1990s (Salmanov et al., 2013). Figure 2 shows recent trend of total fish caught in Azerbaijan.

A report to the European Commission (UNEP-WCMC, 2010) indicates the main causes of declining stocks for sturgeons, namely overexploitation, poaching and illegal trade, habitat destruction and environmental degradation (p. 2), together with salinity changes in the Caspian Sea. Poaching and illegal fishing, in particular, have intensified since early 1990s. The same report also quotes figures from Traffic (2007) on illegal catches, which amounted at 10-12 thousand tonnes in all Caspian States between 2004 and 2006.

Figure 2 – Fish caught (tonnes), Azerbaijan, 2000 - 2016



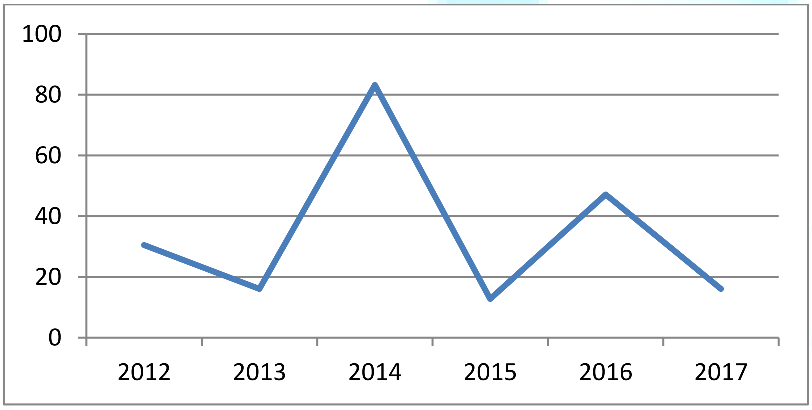
Source: State Statistical Committee

Mingachevir reservoir was constructed in 1953 and Shamkir reservoir in 1982. After construction of the Mingachevir reservoir total fish caught decreased by 23%, and by 13% after Shamkir was built. Other factors might have contributed to the diminishing fish stock though. Therefore we cannot infer that this trend is only imputable to the physical alterations to the Kura river and the consequent impact on river flows.

As it is not possible to identify a causal link between environmental degradation and declining fish stocks, as other factors have contributed to the decrease in fish caught, the effects of such degradation on fish stocks have not been estimated.

In the Georgian side of the Kura river basin we cannot identify a clear trend, as shown in Figure 3. The average fish caught between 2012 and 2017 was 34 tonnes per year (minimum is 16 tonnes, maximum 83).

Figure 3 – Fish Catch (tonnes), Kura Basin, Georgia 2012-17



Source: Fishing department

4.5 Agricultural Yield

Agriculture is the largest water user in both countries. The impacts of water degradation on productive processes have been assessed, with the "change in productivity" method, i.e. they have been evaluated by estimating the loss in yield entailed by environmental degradation. According to the World Bank (2013) salinity is caused by over-irrigation and lack of drainage. Table 7 shows the extent of salinity in irrigated areas (World Bank, 2013) in Azerbaijan. For Georgia, salinity problems are concentrated in the Kakheti region, which accounts for 38% of Georgia's agricultural land (i.e. 631,100 ha). Elizabarashvili et al. (2016) estimate that 54 thousand hectares are affected by salinity.

Table 7 – Extent of salinity in irrigated areas

Salinity of Irrigated Area	Area (ha)	Percentage
Non-saline	564,700	38%
Slightly saline	406,300	27%
Moderately saline	292,300	20%
Strongly saline	477,600	32%
Very strongly saline	319,000	21%
Total	**1,495,200**	**100%**

Source: Azerbaijan Geological Atlas, 2001

In agriculture, for instance, soil salinity impacts the agriculture yield, as it interferes with plant nutrient and water uptake. For an exhaustive summary on the impacts of soil salinity on plants see Shrivastava and Kumar (2015). As a result, most crop plants are sensitive to salinity and consequent yield losses are between 20% and 50% of recorded yields. For the purpose of this study, we assume a reduction in yield for irrigated areas according to table 8.

Table 8 – Adjustment factor (loss of yield) due to salinity

Salinity of Irrigated Area	Adjustment factor
Moderately saline	20%
Strongly saline	30%
Very strongly saline	50%

Due to lack of detailed information on crops cultivated on saline land, the impacts of salinity on agricultural yields have been estimated only for wheat that is the most common crop in the two countries.

4.6 Flood events

Since its independence in 1991 Azerbaijan has been affected by many severe flood events, namely in 1995, 1997, 2003 and 2010. The most severe flood was that of May 2010. That was caused by heavy rains and impacted 40 districts, causing three fatalities and affecting 70,000 people and their 20,000 houses. More than 2,000 have been either destroyed or demolished, as a result of the damages of flooding. 60,000 hectares of irrigated land were also affected, and crops lost.

Previously, other flood events occurred in September 2009, when heavy rainfall caused flooding of 2,300 houses and roads in central parts of Azerbaijan, affecting more than 5,000 people. The Hajigabul district was most impacted, with some 70 per cent of the territory flooded[4].

In October 2003 snow and heavy rainfalls caused flooding to 11 district in the South eastern part of Azerbaijan: whilst preliminary assessments reported that 6,000 families were affected, some 2,000 houses were damaged and 3,000 hectares of agricultural land was submerged, with consequent harvest losses, the damages estimation was later updated and confirmed that 115 villages and 8,066 households were affected, and 18,141 hectares of house yards and sown areas damaged[5].

The Eastern part of Georgia is prone to flash flooding. Since its independence in 1991, major flood events were reported in the Kura river basin in 1997, 2004, 2005, 2012 and 2015. GFDRR (2017) state that about 100,000 people are affected on average each year by flood events. The most important recent flood event in Georgia was the 2015 Tbilisi flood, when 100 mm of rain felt in two hours, causing a flood and a landslide in the village of Akhaldaba. As a result, 19 people lost their life (3 people were missing), 67 families were displaced (as their houses were completely destroyed), and 93 families had their homes partially destroyed. Around 700 people directly affected and the entire Tbilisi population indirectly suffer the effects of the flooding. Public and private transport were disrupted, the zoo almost completely destroyed, along with infrastructure and communication systems.

Prior to this event, the southern and eastern parts of Georgia were severely hit by heavy rains and floods in July 2012[6], affecting houses, farmlands, orchards, and vineyards. Over 75,000 people have been severely affected, roads were blocked, and communication and electricity networks have been disrupted. Estimates of 2012 flood damage vary from GEL 32 million (NEA) to GEL 202 million (World Bank, 2015).

4.7 Droughts

Occurrence of droughts has intensified in the last decades. The State of the Environment report of Georgia gives details of the economic consequences of past events, which have been considered in this study. In Azerbijan the most severe drought occurred in 2010, but others followed in 2010 and 2014. For Azerbaijan no comprehensive study on the impacts of droughts exists, and the impacts have been monetise by referring to estimates by EM-DAT (2017).

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[4] https://reliefweb.int/report/azerbaijan/azerbaijan-floods-dref-operation-no-mdraz001
[5] https://reliefweb.int/report/azerbaijan/azerbaijan-floods-information-bulletin-n-2
[6] https://reliefweb.int/map/georgia/georgia-flash-floods-dref-operation-n%C2%B0-mdrge005

5. Monetary Valuation

5.1 Health Impacts

Regarding health impacts, we evaluate the health costs of water related infections by referring to published research. Impacts on health of environmental degradation can be estimated by referring to two components:

- The pain and suffering from illness is evaluated with the Disability-Adjusted-Life-Years (DALYs) approach. A year lost for premature mortality attributed to environmental degradation represents one DALY. Future years are discounted at a rate of 3%. Illnesses are weighted so that to mild illness is attributed a small fraction of DALY, whilst a severe illness receive a bigger fraction of DALY. In case of mortality, DALY is valued at GDP per capita (according to the lost future income at the time of death).
- The total health impacts of environmental degradation are then estimated by considering also the cost of illness (COI) approach, which includes treatment costs and the cost of work days lost by the caregiver.

Table 9 summarises the COI unit values we used for this analysis.

Table 9 – Unit values for cost of illness

Cost of Illness	US$
Cost of Treatment - Lower value	62
Cost of Treatment -Higher value	157
Unit cost of lost time for caregiver (USD/day)	2
Total cost of lost time per case	12

Source: Own calculations from World Bank (2004) and Flem et al. (2008)

Regarding DALYs monetary values, following World Bank (2004) we consider a range where the low value is half the annual GDP per capita and the high value is actual GDP per capita, see Table 10.

Table 10 – DALYs unit values for Georgia and Azerbaijan (US$)

DALY	Low	High
Azerbaijan	1,938	3,877
Georgia	1,927	3,854

Source: Own elaborations on World Bank data

5.2 Additional cost to society entailed by water degradation

Moreover, as people can also adopt protective measure to avoid illness, avertive expenditure (such as the purchase of bottled water) has be included, as people might decide to switch to tap water in case drinking water quality is not adequate. We include this cost category, by referring to data quoted in Ciloglu and Gogoladze (2014), for Georgia, and in Qnoema[7], for Azerbaijan.

[7] https://knoema.com/xjxrncb/bottled-water-consumption-and-market-value

5.3 Agricultural Yields

To estimate the impacts of salinity on agricultural yields, we assumed an adjustment factor of 30% for Georgia and between 20% and 50% for Azerbaijan, to reflect the different soil salinity level. This means that, without salinity, agricultural yields would be 30% higher in Georgia and 20% - 50% higher in Azerbaijan. Impacts have been monetised by referring to gross margins as reported in the Irrigation Strategy for Georgia (Ministry of Agriculture and Georgian Amelioration, 2017: 24) and by gross margins estimated by Paccagnan (2018).

Table 11 - Gross Margins for wheat (USD/ha)

	Low	High
Azerbaijan	149	170
Georgia	105	125

Source: Ministry of Agriculture and Georgian Amelioration, 2017: 24; and Paccagnan (2018)

In this report we considered only impacts of soil salinity, which might lead to an underestimation of the total environmental damage costs. For example, a study from the World Bank (2015: 19) estimated total agricultural losses (i.e. crop production) due to land degradation for Georgia were at USD17–USD56 million, with a midpoint at USD37 million.

5.4 Flood and drought damages

According to Hasanova and Imanov (2010) on average each flood event causes damage to the economy of Azerbaijan in the order of 20-30 million USD, with more extreme events causing even more extended damage. GFDRR estimates are even higher, as they state that "the annual average population affected by flooding in Azerbaijan is about 100,000 and the annual average affected GDP about USD300 million" (GDDRR, 2017). UNISDR (2015) estimated that the Average Annual Loss (AAL)[8] amounts at **44 million USD**. This data is taken as the maximum expected damage and apportioned to the Kura river basin according to the population.

We also considered estimates for past flood events, to get a minimum expected damage figure. Assessment of past flood damage has been conducted for the most severe events. In 1995 the country was hit by three major flood events, causing 5 fatalities and leaving 3,000 people homeless, as 100 houses were destroyed and 450 houses flooded. Damage to industrial premises was also reported. The government estimate for damage caused by these floods is 4 million USD[9]. EM-DAT(2017) estimates for the 1995 floods are higher, at 16.2 million USD.

In August 1997 heavy rains affected several regions of the country and subsequent flood caused 11 fatalities and damage to properties, infrastructure and agricultural land. At that time, the government allocated about USD 8 million and NGOs and donor agencies have contributed approx.

[8] The AAL is the expected loss per annum associated to the occurrence of future events.
[9] https://reliefweb.int/report/azerbaijan/azerbaijan-torrential-rains-and-floods-situation-report-no2

USD 1 million. The total estimated damage for that event is USD 60 million[10], according to Government estimates, and 25 million USD, according to EM-DAT (2017).

Regarding the 2003 floods, precise estimates of total damage do not exist. According to local authorities total damages for 2003 floods amounted at US$ 30 million[11]. Hasanova and Imanov (2010) estimate damage cost at more than 60 million USD, whilst GFDRR quote a 70 million USD figure, and EM-DAT 55 million USD. Circa 400,000 US$ was paid as compensation to families affected only. Moreover, total assistance provided through the Red Crescent was estimated at USD 68,374 (IFRC, 2003).

Estimates of economic impact of the September 2009 floods are not available.

The last major flood calamity in Azerbaijan was reported in 2010. By considering the data on budget allocated to the Ministry of Emergency Situations[12], between 2010 and 2013 almost 650,000 AZN were assigned to the Ministry of Emergency Situations to repair the flood damages of 2010 events. Details are summarised in the table 11.

Table 12 – Allocated funds for covering damages of 2010 Floods (AZN)

Date	Allocated Fund (AZN)
09.07.2013	252,140
29.05.2012	50,000
30.11.2011	18,000
Others	323,557

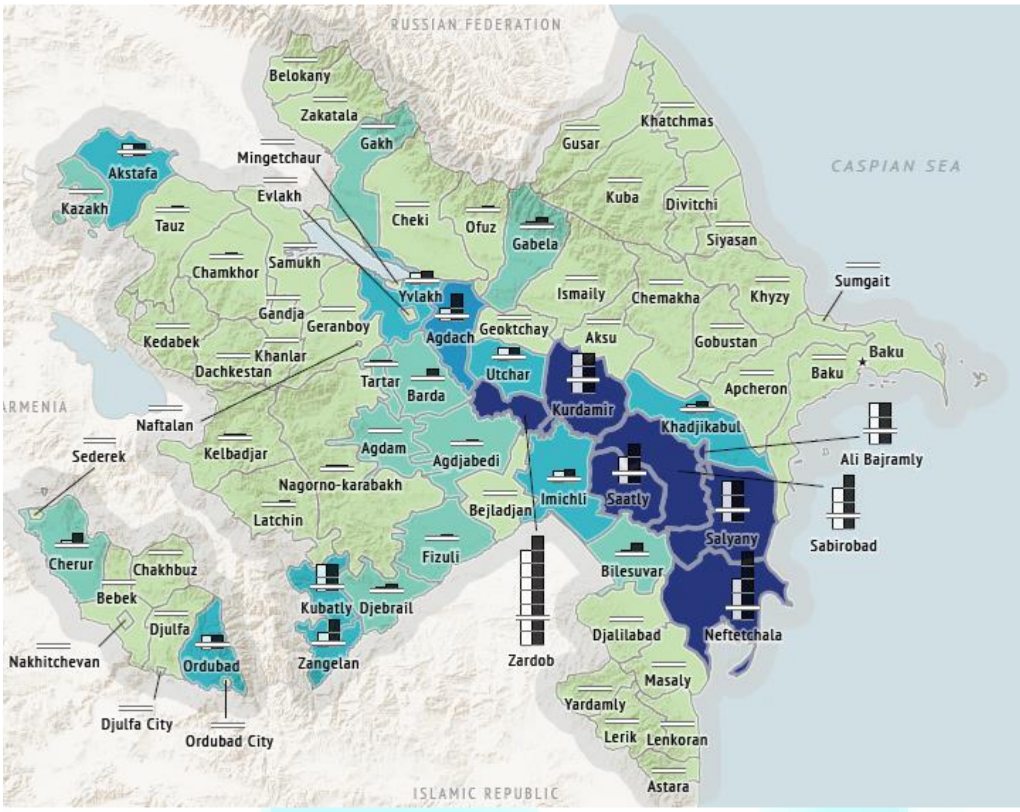
Source: Ministry of Emergency Situations of Azerbaijan

Emergency costs were also borne by the Red Crescent (more than 150,000 US$), which in the three months following the extreme events provided food-and non-food items to the villages affected by the flood. The funds came from its International Federation's Disaster Relief Emergency Fund (DREF). These figures are an underestimation of the real damages costs, as they do not consider the damages to agricultural land (approximately 60,000 hectares). In this respect, these were estimated at 50 million AZN by the Ministry of Agriculture at that time. Total damage estimates for the 2010 floods are **61.7 million USD** (EM-DAT, 2017).

The following map summarises how the Azerbaijan is affected by flood risk. The darker areas indicate that total damage (expressed as a % of GDP) is higher. The most affected provinces are Zardob (with flood damages estimated in 24% of local GDP), Ali Bajramly (11%), Sabirobad (10%) and Kurdamir (10%). It also shows that the incidence of different floods (10 and 100-years return period) does not differ much, indicating that estimates of average damage might vary considerably.

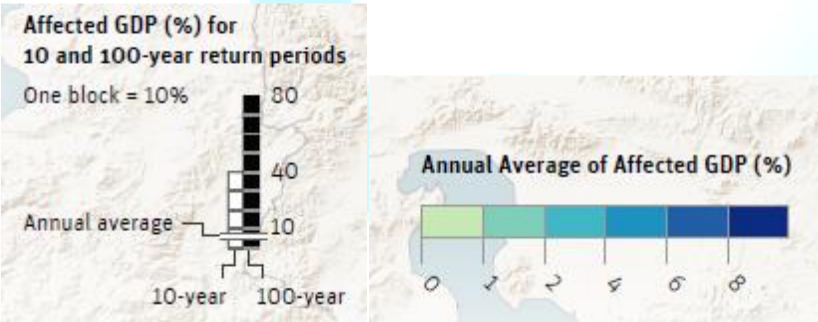
[10] https://reliefweb.int/report/azerbaijan/azerbaijan-floods-situation-report-no3
[11] https://reliefweb.int/report/azerbaijan/azerbaijan-floods-cause-damage-30-million-azerbaijan
[12] http://www.fhn.gov.az/index.php?eng/pages/33

Figure 4 – Annual flood damage as a percentage of GDP, Azerbaijan



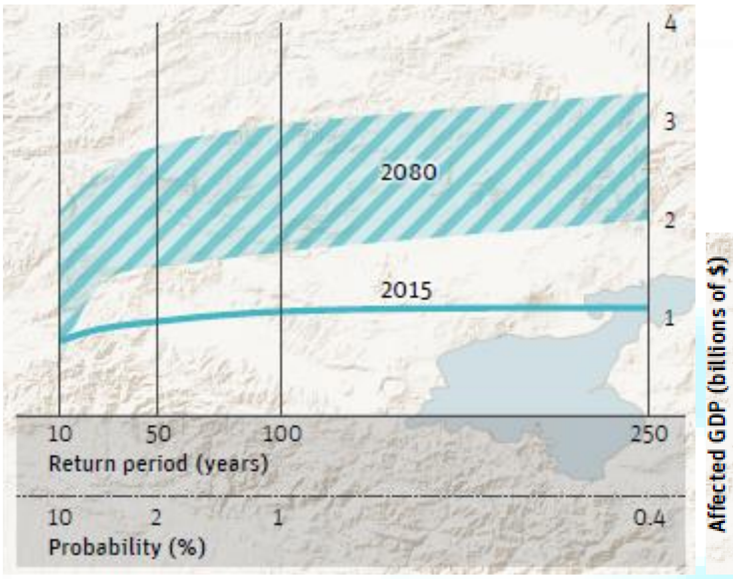
Source: GFDRR

Legend:



These impacts are expected to increase as a result of climate change, as depicted in Figure 5, which sketches an exceedance probability curve, showing for different flood events (i.e. the return period, in the x-axis) the related damage (expressed as USD billion, on the y-axis). This indicates that an extreme event in present days would cause 1 USD billion damage, whilst for the same event in 2080 economic impact would be in the range 2-3 billion USD.

Figure 5 – Expected flood damages, Azerbaijan, 2015 and 2080



Source: GFDRR

Floods are frequent in Georgia as well, whose Eastern part is prone to flash flooding. Since its independence

The most recent, severe flood event in Georgia happened in June 2015. The estimated damage amounted at over 55 million GEL (24 million USD), as shown in table 13.

Table 13 – Impact of 2015 Tbilisi flood, millions

Sector	Damage - GEL	Damage - USD
Housing	16.1	6.9
Transport	33.2	14.8
Zoo	3.2	1.4
Water and Sanitation	2.7	1.2
Total	55.2	24.3

Source: GFDRR et al. (2015)

To this damage an additional 4.3 million USD should be added, to take into account the indirect effects in terms of financial losses (e.g. the income lost by the zoo, which remained closed several months) and the time lost because of traffic disruption.

Great numbers of cattle and poultry were killed. The total damage estimates by the Government amount at 150 million GEL.

The State of Environment Report for Georgia quantifies the economic losses due to floods or flash floods from 1995-2013 at almost 654 million GEL (that is, around a third of total economic losses caused by natural disaster in the same period). In the same period 38 people lost their lives – see Table 14. By considering only flood event occurring in the Kura river basin, on average a flood event caused damage worth almost 10 million USD.

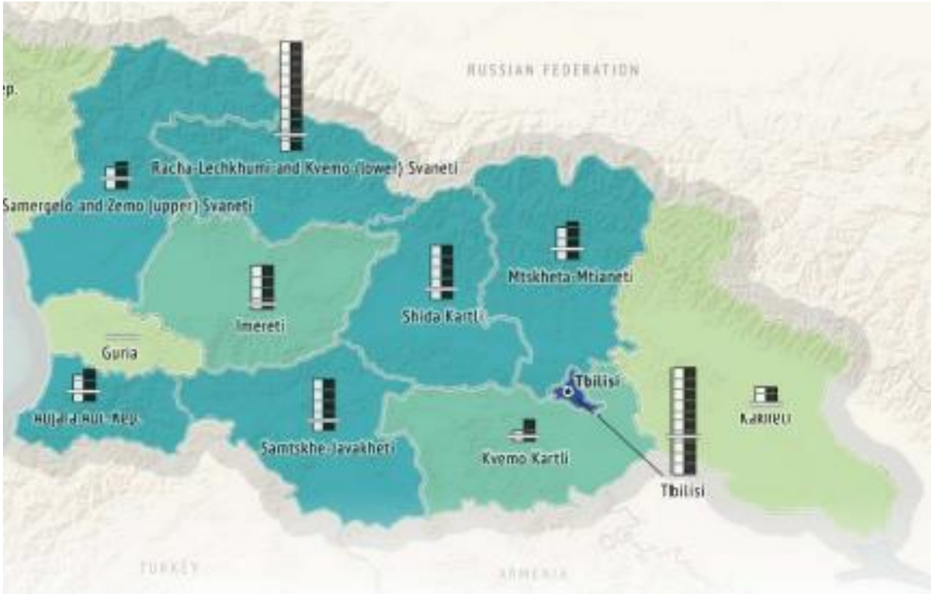
Table 14 – Economic consequences of flood and flash floods in Georgia

Year	Number of Events	Damages (Mln GEL)	Fatalities
1995	4	3.2	1
1996	11	28.5	1
1997	12	38	0
1998	2	2	1
1999	8	30.5	1
2000	2	2	0
2001	4	4.1	0
2002	16	78.7	0
2003	6	4.2	2
2004	10	20.5	1
2005	20	80	4
2006	8	15	1
2007	7	40.3	1
2008	16	38	3
2009	20	30	5
2010	18	20.7	3
2011	23	35.1	9
2012	15	32	5
2013	8	20	0
2014	13	10	3
2015	11	112	22
2016	18	10	1
Total	**252**	**654.8**	**64**

Source: State of Environment Report

Flood damage information is available for Georgia from GFDRR. Figure 6 depicts flood impacts as percentage of annual GDP and shows that the most affected area is the capital, Tbilisi, whose estimated annual flood damages amount at 6% of its GDP.

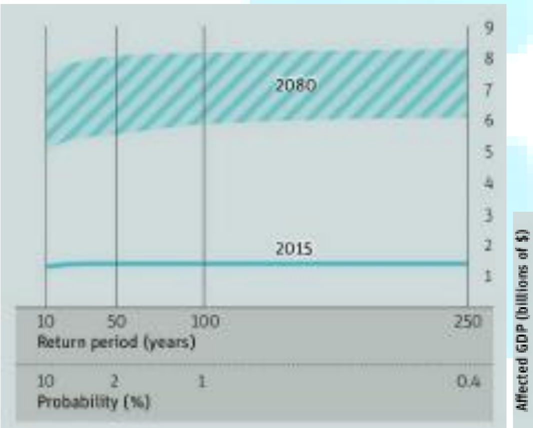
Figure 6 - Annual flood damage as a percentage of GDP, Georgia



Source: GFDRR

The effects of climate change in Georgia will be even more severe, according to GFDRR – see Figure 7. Whilst a flood event in present days would cause an estimate damage of 1.5 billion USD, the same event in 2080 can have an economic impact of 6-8 billion USD.

Figure 7 – Expected flood damages, Georgia, 2015 and 2080



Source: GFDRR

Estimates for economic impacts of the 2000 drought are provided by EM-DAT (2017). Drought costs are 100 and 200 million USD, for Azerbaijan and Georgia, respectively. The State of Environment Report for Georgia also provides estimates of historical droughts, see Table 15. Since 1995, drought caused damage worth 445 million GEL (183 million USD).

Table 15 – Economic consequences of droughts in Georgia

Year	Duration (Months)	Damages (Mln GEL)	Fatalities
1995	0	0	0
1996	1,5	17	0
1997	2	26	0
1998	1	6	0
1999	0	0	0
2000	6	300	0
2001	2,5	21	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	1,5	5	0
2007	0	0	0
2008	0	0	0
2009	1,5	6	0
2010	3,5	45	0
2011	1	3	0
2012	1	1	0
2013	0	0	0
2014	2	15	0
2015	1	0	0
2016	0	0	0
Total	**24.5**	**445**	**0**

Source: State of Environment Report

6. Results

The unit values presented in previous session have been used to monetise the impacts of environmental degradation. Total costs have been calculated, for each impact category. These estimates likely underestimate the true cost of environmental degradation, as some impacts, such as impacts of dam sedimentation and groundwater depletion, have not been monetised. Moreover, they represent the consequences of current water degradation. The total damage might be much higher once the effects of climate change are taken into account.

Results are shown in Table 16, for the whole Kura river basin, and in the following tables the total costs are disaggregated for Georgia and Azerbaijan (only the costs pertinent to the Kura river basin have been considered). Total damage costs of water degradation are in the range of **0.92-1.60% of GDP of the Kura river basin** (482-832 million USD in 2017), with health costs accounting for more than 40% of total damage, and agricultural yield loss for almost a quarter of total losses (high estimates). Water degradation costs are in the range 1.04%-1.63% of GDP, for Azerbaijan, and between 0.61%-1.01% for Georgia.

Table 16 – The cost of environmental degradation in the Kura river basin, 2016, Azerbaijan and Georgia

	Method	Total thousand USD/year		%GDP	
		Low	High	Low	High
Water pollution					
Health/Quality of Life	DALYs Children 0-5	18,286	76,196	0.04%	0.15%
	DALYs All Ages	22,981	87,364	0.04%	0.17%
	Cost of Illness	65,092	172,447	0.12%	0.33%
Inadequate WSS	Avertive Expenditure (bottled water)	75,314	75,314	0.14%	0.14%
Water Depletion					
Biodiversity	Replacement Cost	51,034	101,034	0.10%	0.19%
Agricultural losses	Change in Productivity	168,414	191,882	0.32%	0.37%
Flood Damages	Historical Costs/AAL	41,913	89,290	0.08%	0.17%
Drought damages	Historical Costs (Average/Max)	39,395	39,395	0.08%	0.08%
Total Damage Cost		***482,429***	***832,922***	***0.92%***	***1.60%***

Source: Own calculations

Table 17 – The cost of environmental degradation in the Kura river basin, 2016, Azerbaijan only

	Method	Total thousand USD/year		%GDP	
		Low	High	Low	High
Water pollution					
Health/Quality of Life	DALYs Children 0-5	16,536	70,443	0.04%	0.19%
	DALYs All Ages	20,201	78,838	0.05%	0.21%
	Cost of Illness	50,497	135,209	0.13%	0.36%
Inadequate WSS	Avertive Expenditure (bottled water)	52,716	52,716	0.14%	0.14%
Water Depletion					
Biodiversity	Replacement Cost	50,000	100,000	0.13%	0.13%
Agricultural losses	Change in Productivity	164,662	187,441	0.44%	0.44%
Flood Damages	Historical Costs/AAL	20,281	44,200	0.05%	0.12%
Drought damages	Historical Costs (Average/Max)	20,000	20,000	0.05%	0.05%
Total Damage Cost		***374,893***	***668,848***	***1.04%***	***1.63%***

Source: Own calculations

By considering the estimates of the cost of water degradation in the two countries, it is worth noting that Azerbaijan bears a much higher cost than Georgia, given the fact that this side of the basin is more populated.

Table 18 – The cost of environmental degradation in the Kura river basin, 2016, Georgia only

	Method	Total thousand USD/year		%GDP	
		Low	High	Low	High
Water pollution					
Health/Quality of Life	DALYs Children 0-5	1,750	5,753	0.01%	0.04%
	DALYs All Ages	2,780	8,525	0.02%	0.06%
	Cost of Illness	14,595	37,238	0.10%	0.26%
Inadequate WSS	Avertive Expenditure (bottled water)	22,598	22,598	0.16%	0.16%
Water Depletion					
Biodiversity	Replacement Cost	1,034	1,034	0.01%	0.01%
Agricultural losses	Change in Productivity	3,752	4,441	0.03%	0.03%
Flood Damages	Historical Costs/AAL	21,632	45,090	0.15%	0.31%
Drought damages	Historical Costs (Average/Max)	19,395	19,395	0.14%	0.14%
Total Damage Cost		***68,142***	***124,679***	***0.61%***	***1.01%***

Source: Own calculations

Consequences on human health are the most important impact in Georgia, representing 0.13%-0.36% of GDP. The second most important effects of poor water quality is the avertive expenditure for water degradation, which accounts for 0.16% of GDP. In Azerbaijan, the most severe impact is the loss in agricultural yield due to salinity of soil (0.44 % of GDP), followed by health costs (0.22-0.76% of GDP).

Biodiversity losses have been partially estimated in Georgia, and therefore it is likely that these impacts are much greater in economic terms.

These estimates are consistent with results of similar studies. Croitoru et al. (2010) found that the cost of environmental degradation was 0.6% for Tunisia in 2004. Hussein (2007) considered several aspects of environmental degradation for countries in the Middle East and North Africa, and found that the lack of adequate water supply and sanitation caused a loss in GDP which varied between 0.6 for Tunisia and 2.82 for Iran. Finally, Sarraf et al. (2004) estimated the costs of water degradation are between 0.96%-1.17% of GDP for Lebanon.

It is interesting to note that tackling water degradation would entail win-win solutions for both countries. In Georgia a major effort will be needed in terms of upgrading existing wastewater treatment systems to reduce health impacts of water degradation. Whilst this will ensure that water quality improve locally, it would also benefit water users downstream. It is acknowledged that the Gardabani WWTP is one of the major pollution hotspots in the Kura river basin.

Similarly, in Azerbaijan the major water degradation impact is produced by inefficient local irrigation practices. Improving agricultural water productivity might produce wider benefits, in terms of food security, and relieving stress on local water sources.

The following table shows the discounted water degradation costs arising over the next 25 years, in the two countries. Overall, in the Kura river basin future water degradation costs exceed 8.5 billion USD, in PV terms. These figures could also be interpreted as the potential benefits of reducing water degradation in the Kura river basin, and should be compared to proposed measures, to understand whether policy proposals are economically justifiable.

Table 19 – Total NPV costs of water degradation in the Kura river basin over the next 25 years (thousand USD)

Water Degradation Cost	Total Azerbaijan	Total Georgia
Health Impacts	1,362,776	298,784
Inadequate WSS	823,538	353,027
Biodiversity	352,387	16,149
Agricultural losses	2,572,357	58,619
Flood Damages	316,833	337,939
Drought damages	312,442	302,990
Total NPV	***5,740,332***	***1,367,502***

Source: own elaborations

7. Financial instruments to tackle water degradation

The benefits of improving water quality and enhancing water ecosystems arise to society such that no one may have the incentive to put the effort required. The public good dimension of environmental quality requires that public authorities introduce a series of instruments (either command and control or economic) to achieve a desired level of environmental quality. Also adapting to climate change and improving resilience to extreme events require collective decisions.

Economic Instruments (EI) include incentive pricing, trading schemes, cooperation (e.g. voluntary agreements), and risk management schemes (Delacámara et al., 2013). Given the scope of this report, we discuss briefing incentive pricing only. Currently, the following EI are applied in Azerbaijan and Georgia (OECD-EUWI, 2012): tariffs for PWS; tariffs for irrigation; abstraction fees and penalties for water users that do not comply with existing environmental regulation. The preconditions for applying this type of instruments is that a system of regulation of water use should be in place and that monitoring system have to measure water flows and water use at the level of any individual water user. These two conditions are not always met in the Kura river basin, as for example agricultural water uses are not measured, and the surface water licensing system is not in place in Georgia.

Investments in infrastructure such as wastewater treatment plants are necessary to reduce impacts of human activities on water environment. As such, there is a need to find financial resources for infrastructure development, upgrade or rehabilitation.

Whilst development of water infrastructure has been historically financed by central governments through subsidies, constraints on public finances and the need to give water users incentives to consume water more wisely have pushed the adoption of economic instruments for water resources management. In regards to public water supply, the application of full cost recovery implies that water tariffs for water services supply should be set as to cover all water provision costs (i.e. O&M and capital expenditure). A separate report (Paccagnan, 2018) has analysed the water provision costs for PWS and agriculture and highlighted the financial implications of applying the FCR principle in the Kura river basin. It concludes that current water tariffs cover a small fraction of total provision costs, in both countries. Affordability considerations might limit their applicability to improve the efficiency of water use.

In cases where water services cover wastewater collection and treatment, the application of FCR principle also guarantees that external costs related to water use are internalised. Therefore, whilst the primary objective of water tariff is normally to raise the revenues necessary to run the service, they might also give users incentive to consider their impact on the water environment. Their effectiveness as a demand management tool will depend on the way the tariff is structured: flat rates not based on actual consumption will not give any incentives to reduce demand, whilst increasing tariff structures or two-part tariffs (with the variable component based increasing blocks) will send scarcity signals to water users. As highlighted by some studies, increasing block tariffs might have regressive effects, thus favouring wealthier households (GWP, 2016).

Sewage charges are not the only means to make polluters pay for their environmental impacts. The alternative instrument is a pollution charge. This should be design to reflect the financial and economic costs imposed on society and the environment from discharging wastes and pollutants into water bodies. The most common example applied to water resource is the nitrogen tax, in its three variants: tax on nitrogen fertilizers, tax on fodder nitrates and tax on nitrates losses. Whilst few pollution charges are set at levels high enough to encourage firms to encourage firms to abate pollution, the existence of a charge raise awareness of the costs of environmental degradation. Pollution fees are only applied in Azerbaijan, as in Georgia they have been abolished in 2005.

Besides internalising the external costs produced by water use, economic instruments also can potentially signal the scarcity of water resources, e.g. to internalise resource costs. By making water users aware of the financial resources needed to supply water, incentive pricing might also avoiding costly expansion of water supply via a reduced need of heavily engineered infrastructure (Delacámara et al., 2013).

Abstraction charges could be designed to incorporate water scarcity information. They are applied in both countries, but in Georgia charges cover groundwater only. Moreover, these are normally set to cover administrative cost, and do not give any incentive to use water more wisely, nor they give any scarcity signals to water users.

Fines and penalties are applied in both countries. They are particularly high in Azerbaijan.

The following table summarises how the different economic instruments can contribute to the application of polluter pays and user pays principles.

Table 20 – How economic instruments contribute to the application of UP and PP principles

Economic Instrument	User pays principle	Polluter Pays principle

Tariffs for water supply, sanitation & sewerage	Partially applied, as current water tariff do not reflect the full provision costs	Partially applied only in cases where wastewater is treated
Irrigation charges	Partially applied, as current water tariff do not reflect the full provision costs	Not applied, as farmers do not pay for the environmental consequences of irrigation practices
Abstraction charges	HPP do not pay any abstraction charges Not applied to surface W in Georgia Other sectors pay a small fee, not based on value of water	Not applied, as current abstraction charges do not reflect any impacts of current water uses on river flows
Pollution charges	NA	Applied only as penalties for not complying with discharge limits

As noted by OECD-EUWI, current economic instruments do not make it possible to tackle water degradation issues, as described in Table 21.

Table 21 – Water management issues not addressed by existing economic instruments

Water Management Issue	Azerbaijan	Georgia
Illegal waste dumping into rivers		X
Excessive gravel extraction	X	X
High water losses in distribution network	X	X
Water pollution from PWS and other economic activities	X	X
Soil erosion due to deforestation and overgrazing		X
Extreme floods	X	X
Environmental Impacts of HPP		X
Excess surface water abstraction	X	X
Inefficient water use	X	X
Modified river flows	X	X
Seasonal Water Scarcity	X	X

Source: Adapted from OECD-EUWI 2012:19.

The same study then gave some recommendations for reforming economic instruments, namely:

- For Georgia
  - Extend abstraction fees to surface water;
  - Re-introduction of pollution fees;
  - Introduce fines for illegal waste dumping
  - Reduced VAT for companies adopting water saving technologies
- For Azerbaijan:
  - Adjusting water tariffs according to water flows and water availability
  - Nitrogen Tax (charge on imported fertilisers)
- For both countries:
  - Extension of water fees to HPP
  - Introduction of payment for ecosystem services for upstream reforestation or other nature-based water pollution mitigation measures.

Finally, there are several instruments that can be used to increase resilience to extreme events. First, water insurance systems against drought and floods may increase the willingness to invest in infrastructure or adopt measures to reduce risk and adaptation to climate change impacts. They also give provide revenue security and therefore reduce vulnerability to extreme events.

A second type of instrument is the payment for flood mitigation, where public authorities, instead of using expropriation, pay landowners for the right to create flood storage areas (Delacámara et al., 2013). They might consist on one-off or regular payments, or easement to compensate for the loss of land value or the flood damages. Besides flood protection, this instrument can also entail wider societal benefits, such as pollution control and biodiversity conservation.

Water scarcity during drought conditions could also be accounted for by the tariff system, as an alternative to water restrictions. Drought tariffs can be introduced during drought periods, to incentivise a more efficient water use. The disadvantage of this type of charging mechanism is that price signals are sent too late. Nonetheless, tariff could be set to take into account the availability of natural resources, as shown in Lopez-Nicolas et al. (2017).

8. Conclusions and recommendations

Our estimates reflect the order of magnitude of the damage associate with water degradation. They show that the cost of environmental degradation in the Kura river basin can be considerable, between 0.92% and 1.60% of the GDP (considering Azerbaijan and Georgia together). This figure is conservative, and might represent an underestimation of the total costs, as we did not include costs related to groundwater depletion and dam sedimentation, due to lack of data. Moreover, the impacts of climate change have not been taken into account, as the analysis refers to current water degradation. Once these impacts are taken into account, future water degradation costs are likely to be much higher. Our estimates are in line with previous studies, which show that lack of access to water supply and sanitation cost between 0.48 and 2.82% of GDP (Hussein, 2007; Saraf et al., 2004).

The extent of water degradation costs in the two countries justifies the implementation of policy measures locally to tackle water pollution issues. It also shows the potential for transboundary cooperation, through the introduction of payment for ecosystem services. For a discussion of the key principles and implementation issues of PES the reader can refer to OECD-EPIRB (2016).

In this study we focus on qualitative aspects of water resources management, i.e. pollution, and we did not consider the quantitative issues related to over-abstraction. It is recommended that these aspects are further considered in future research, as they are relevant to tackle Lake Jandari and Alazani-Agrichay aquifers problems.

Also the value of ecosystem services related to water resources protection should be further investigated, to derive more robust estimates.

9. References

Ciloglu I. and Gogoladze A. (2014), Dynamics of Georgian mineral water market, Journal of Social Sciences; ISSN 2233-3878; Volume 3, Issue 1.

Croitoru L. and M. Sarraf (eds.), 2010, The Cost of Environmental Degradation. Case Studies from the Middle East and North Africa. The World Bank, Washington DC.

Delacámara, G., Dworak, T., Gómez, CM., Lago, M. Maziotis, A., Rouillard, J., Strosser, P., 2013. EPI-Water Deliverable 5.3: Guidance on the design and development of Economic Policy Instruments in European water policy. EPI-Water - Evaluating Economic Policy Instruments for Sustainable Water Management in Europe. Available at: http://www.feem-project.net/epiwater/docs/epi-water_guidance_v2.pdf [Accesses 23 July 2018]

GBD Diarrhoeal Diseases Collaborators, 2017, Estimates of global, regional, and national morbidity, mortality, and aetiologies of diarrhoeal diseases: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet – Infectious Diseases. Volume 17, No. 9, p909–948. DOI: http://dx.doi.org/10.1016/S1473-3099(17)30276-1

GFDRR et al. (2015), Tbilisi Disaster Need Assessment. Final Draft.

GFDRR, 2017, Disaster Risk Profile: Georgia. Country Note.

GFDRR, 2017, Disaster Risk Profile: Azerbaijan. Country Note.

EM-DAT, 2017, The Emergency Events Database - Université catholique de Louvain (UCL) - CRED, D. Guha-Sapir - **www.emdat.be**, Brussels, Belgium.

Hasanova and Imanov (2010), Flood Management in Azerbaijan. Report to the Commission of Technical Rural Infrastructure, Polish Academy of Sciences, Cracow Branch.

Jagannathan N.V., A. Shawky Mohamed, A. Kremer (eds.), 2009, Water in the Arab World: Management Perspectives and Innovations. IBRD-WB. Available at [Accessed 24.05.2018]

Lopez-Nicolas, A., Pulido-Velazquez, M., Rougé, C., Harou, J. J., and Escriva-Bou, A. (2018). Design and assessment of an efficient and equitable dynamic urban water tariff. Application to the city of Valencia, Spain. Environmental Modelling & Software. 101:137–145.

OECD-EUWI (2012), Strengthening the economic and financial dimension of integrated water resources management in Azerbaijan, Georgia and Armenia - Final report ENV/EPOC/EAP(2012)10. Available at [Accessed 24.07.2018]: https://www.oecd.org/env/outreach/Kura%20EIs%20TWC.pdf

Paccagnan V., 2018, *Water Provision Cost in the Kura river basin*. A report to the UNDP/GEF Kura II project.

Salmanov, Z., Qasimov, A., Fersoy, H. & van Anrooy, R. 2013. *Fisheries and aquaculture in the Republic of Azerbaijan: a review*. FAO Fisheries and Aquaculture Circular No. 1030/4. Ankara, FAO. 42 pp. Available at: www.fao.org/docrep/017/i3113e/i3113e.pdf

Shrivastava P. and R. Kumar (2015), Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. *Saudi Journal of Biological Sciences*. Mar; 22(2): 123–131. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4336437/

UNECE, 2016, *Third Environmental Performance Review of Georgia*. Environmental Performance Reviews Series No. 43. ECE/CEP/177. United Nations Publication.

UNECE, 2015, Policy Guidance Note on the Benefits of Transboundary Water Cooperation. Identification, Assessment and Communication. ECE/MP.WAT/47. United Nations Publication.

UNEP-WCMC, 2010, Review of four sturgeon species from the Caspian Sea basin, A report to the European Commission Directorate General E – Environment. Available at: ec.europa.eu/environment/cites/pdf/reports/caspian_sea_sturgeon.pdf

UNISDR (2015), GAR – Global Assessment Report on Disaster Risk Reduction. [Accessed 8 February 2018]

WHO, 2009, Guide to identifying the economic consequences of disease and injury. Geneva. ISBN 978 92 4 159829 3.

World Bank, 2004, Cost of Environmental Degradation - The case of Lebanon and Tunisia. Environmental Economic Series No. 97. Available at (accessed November 2017): http://documents.worldbank.org/curated/en/445831468760782622/pdf/299020Cost0Env1isia0EDP19701public1.pdf

World Bank, 2005, Estimating the Cost of Environmental Degradation - A training Manual in English, French and Arabic. Environment Department Paper no. 106. English version available at: http://documents.worldbank.org/curated/en/652751468138260264/Estimating-the-cost-of-environmental-degradation-a-training-manual-in-English-French-and-Arabic

World Bank, 2015, Georgia Country Environmental Analysis. Institutional, Economic, and Poverty Aspects of Georgia's Road to Environmental Sustainability. World Bank Group Report Number ACS13945