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Guidelines on EIA of the Hydropower Projects

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Guidelines
on EIA of the Hydropower Projects

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The *Guidelines* were prepared under the "European Union for Environment" (EU4Environment – Green Economy) Action by the consultants to the UNECE secretariat to the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) and its Protocol on Strategic Environmental Assessment (Protocol on SEA): Martin Smutný, Tamar Gugushvili and Michal Musil, in close cooperation with the National Environmental Agency of Georgia. Valuable comments and inputs were provided by Jerzy Jendrośka, Ioseb Kinkladze, Lia Megrelidze and Kakha Artsivadze.

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Disclaimer

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1. INTRODUCTION

1.1. Background

Hydropower represents a particularly important part of the energy production in Georgia, with approximately a 16% share in the total primary energy supply and representing around 80% of the country's electricity production. With a large potential of hydropower energy production still unexplored, extensive further development in this sector can be expected. At the same time, the use of water resources for energy production is connected with certain impacts on the environment and health, which – considering the hydro-morphological characteristics of the country – may also have effects on the territory of the riparian countries (i.e. transboundary impacts).

The likely environmental and health impacts, including transboundary ones, along with mitigation measures, should be addressed in an environmental impact assessment (EIA) and, for governmental plans and programmes related to hydropower, in a strategic environmental assessment (SEA).

To support the proper application of an EIA in the hydropower sector (i.e. for the projects to construct hydropower plants in Georgia), the Ministry of Environmental Protection and Agriculture (MEPA) requested technical assistance from the United Nations Economic Commission for Europe (UNECE) for preparing the Guidelines on EIA of the hydropower projects with a special focus on the transboundary aspects (EIA HP Guidelines).[1] UNECE provided the assistance under the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) within the framework of the EU-funded EU4Environment programme.

1.2. Purpose and focus of the Guidelines

The Guidelines are intended to enhance EIA practice in Georgia, including the transboundary consultations. They should also support Georgia in implementing recommendations outlined in the assessment of nexus issues in transboundary basins under the UNECE Water Convention.[2] In particular:

- developing and applying guidelines and drawing upon international experience to improve sustainability in the location, design and construction of hydropower plants
- ensuring that new hydropower plants, driven by hydropower generation, are designed to maximize the benefits of multiple uses, as well as minimizing impacts on the environment.

1 As the EIA HP Guidelines take into account the provisions of the Espoo Convention, it should be noted that small hydropower plants are not covered in Appendix I of the Convention, which lists those activities that fall under the Convention if they are likely to cause significant adverse impacts across borders.

2 UNECE (2015) "Reconciling resource uses in transboundary basins: Assessment of the water-food-energy-ecosystems nexus": http://www.unece.ory/index.php?id=42935 The Georgian version (an extract on the Alazani/Ganykh River Basin) is available at: https://unece.org/sites/default/files/2021-04/ece_mp.wat_46_chapter-5_Georgian.pdf

The Guidelines mainly address substance-related aspects of EIA, while following the procedural requirements of the Environmental Assessment Code (EAC) of Georgia, as well as the steps outlined in the general EIA Guidelines. They also take into account the experience of EIA application in the hydropower sector in Georgia and in other countries in the UNECE region (e.g. in South-East Europe) and relevant guidance documents relating to the Espoo Convention, its Protocol on SEA, as well as sustainable hydropower development (see the Annex for a list of guidance documents).

Linkages between EIA and SEA in the hydropower sector

Besides EIA, which addresses specific activities (i.e. individual projects), the EAC also sets out provisions regarding the application of SEA, which is to be applied to strategic documents prepared by public authorities. Both SEA and EIA are forms of environmental assessment – both are procedural instruments of preventive environmental policy and have similar goals and many similar features, particularly regarding the procedural elements.

By its nature, the analysis in an EIA focuses on the physical impacts of the project on the environment and health; whereas an SEA should consider the wider context – for instance, how the implementation of the strategic document contributes to achieving environmental and health objectives, its likely effect on long-term trends, and potential cumulative impacts.

Concerning hydropower development, the SEA should be applied to the strategic documents in the sectors of energy, industry, water resources management or planning and spatial arrangements, which may directly or indirectly relate to hydropower development.

Direct

The direct relation can be represented by the national energy policy, which develops a future energy production scenario, or the spatial plan, which determines the location of the dam.

Indirect

The river basin management plans, which primarily address improving the status of water bodies, can be considered as indirectly related to hydropower as these plans do not deal with hydropower development. But they do provide a basis for the overall management of a river basin, which has to be considered in the further development of hydropower.

In other words, hydropower development should take into account river basin management plans, objectives and measures to ensure that the planned hydropower development no way conflicts with the expected improvement of the status of the water bodies.

The results and conclusions of the SEA should be considered at the project level – when it comes to location, capacity or design of a specific hydropower project and related EIA.

2. EIA FOR HYDROPOWER PROJECTS

2.1. Scope of EIA application

The EAC includes in Annex I the following types of project relevant to hydropower development, listing the types and thresholds of the project requiring an EIA:

- No. 21. Construction and operation of dams and/or other structures designed for the holding back or permanent storage of water and where the amount of water held back or stored exceeds 50,000 cubic metres;
- No. 22. Construction and/or operation of hydroelectric stations with a capacity of 5 megawatts or more;
- No. 28. Construction of overhead and/or underground electrical power lines with a voltage of 220 kV or more and a length of more than 15 km.

Annex II, which lists the types and thresholds of the project requiring screening, includes the following types of project relevant to hydropower development:

- No. 3.4. Construction of overhead and/or underground electrical power lines with a voltage of 35 kV or more, and construction of electrical substations with a voltage of 110 kV or more;
- No. 3.8. Construction and/or operation of hydroelectric stations with a capacity from 2 to 5 megawatts;
- No. 9.9. Construction of dams and/or other structures/installations designed to hold water or store it on a long-term basis, where the amount of water held or stored is more than 10,000 cubic metres.

'Installations for hydroelectric energy production' are included only in Annex II of the EIA Directive, which lists the project requiring the screening. Annex I of the EIA Directive (mandatory EIA) includes:

- No. 15: Dams and other installations designed for the holding back or permanent storage of water, where a new or additional amount of water held back or stored exceeds 10 million cubic metres;
- No. 20: Construction of overhead electrical power lines with a voltage of 220 kV or more and a length of more than 15 km.

The Espoo Convention, in Appendix I, under the list of types of activities falling under the scope of the Convention, includes only 'Large dams and reservoirs'. It does not specify 'hydropower development'.

2.2. Screening

For hydropower projects (HPPs) listed in Annex II of the EAC and for modifications of already existing HPPs, screening has to be carried out in order to determine whether or not a full EIA procedure is required.

The screening should be conducted at an early stage of the planning, when the basic information about the project is known. The developer submits a screening application to the National Environmental Agency (NEA), which, in addition to the information requested by Article 78 of the General Administrative Code of Georgia, must include brief information about the project.

In the case of modification of the operating conditions of existing HPPs, the application must also include information about the given activity subject to an 'environmental decision' regarding the planned modification and its potential impact.

So that the public can access the information, the Agency ensures that the screening application is placed on its official website and on the information board of the executive and/or representative body of the relevant municipality, and should it be requested, that a printed copy is available.

The public has the right to submit opinions and comments regarding the screening application to the Agency in writing within 7 days after the screening application has been posted on the website and information board. All opinions and comments, if found relevant, will be taken into account in the decision-making process. Following the screening, the Agency issues a screening decision. The screening procedure is stipulated by the EAC and detailed in the general EIA Guidelines.

The information to be enclosed in the screening application is outlined in the general EIA Guidelines. In relation to HPPs, the following issues should be addressed in the application:

- Information about all stages of the project – construction, operation and decommissioning
- The description of the project has to clearly outline the following:
  - Type and size/capacity of the HPP
  - Ancillary elements (see section 2.3.3)
  - Scope of the earthworks, construction works and demolition works – not only directly related to the HPP, but also including the ancillary elements
  - Location of the HPP and ancillary elements and the surface area to be used
  - Predicted quantities of the water, soil, biodiversity, raw materials, intermediate materials, fuels and energy to be used, land to uptake (including agriculture and/or forest land)
  - Waste generation
  - Environmental pollution and noise
  - Expected period of construction, operation and demolition/decommissioning
  - Number of staff needed for the construction and operation phases
  - Information about the transport related to the HPP and the ancillary elements for the construction, operation and decommissioning stages;
- The description of the location has to include information about the existing status and potential environmental sensitivity of the likely affected areas (both by the HPP and the ancillary elements);
- The description of the likely impacts should consider (see also section 3.1.2):
  - Existing status of the river and the basin, as well as the likely development of other HPPs on the same river/river basin and potential cumulation of the impacts of this development
  - Likely consequences of climate change
  - Direct as well as secondary impacts; in particular, those related to potential hydrologic change.

The information about the HPP and its likely impacts on the environment and health should enable the Agency to decide if such impacts could be significant and thus require a full EIA procedure.

In the screening process, the likely impacts can often only be presented as a general assessment, since dedicated studies may not yet be available. However, in case of uncertainty about whether a given potential environmental or health issue may be significantly affected or not, a full EIA should be required following the precautionary principle.

2.3. Aspects to be considered in EIA

Several aspects must be considered when analysing the likely environmental and health impacts of hydropower projects. These mainly include the type of the hydropower plant (and related operation regime), its size/capacity, ancillary elements and location.

2.3.1. Types of HPP

The following are the four main types of hydropower plant:

Storage reservoir HPP

A storage reservoir hydropower plant involves the construction of a dam to store large volumes of water and sustain stable hydraulic head for power generation. Residence time of water upstream of the dam could be months or several years. Such a plant retains water during high flows (i.e. rainy season) and releases water for hydropower generation during low flows (i.e. dry season) or throughout the entire year, resulting in high fluctuation in the storage reservoir elevation. Storage reservoir hydropower plants can be used either as a base load or peaking plant, depending on the demand of the regulating authority.

According to the design configuration and topographic conditions of the area, storage reservoir dams can significantly change the existing flow conditions of the river network and inundation of a portion of the watershed as well as disturbing or blocking fish migration routes. Storage dams alter natural sediment flow in the river and are usually designed to have flushing tunnels to periodically release sediment accumulated at the upstream reservoir. Flooding of adjacent territories can, for instance, result in the destruction, transformation or degradation of natural habitats and the elimination of propagation sites.

Changes of the hydrological regime can also affect terrestrial habitats and species. Construction of the dam may also require the resettlement of local communities – one of the most important social issues related to HPPs.

Pumped storage HPP

A pumped storage hydropower plant involves building two water containment structures to create an upper and a lower reservoir. Water is pumped from the lower reservoir to the upper reservoir during low electricity demand. Water from the upstream reservoir is then released during peak demand. This back-and-forth pumping and power generation cycle provides the advantage of maximizing the water resource for power generation, particularly during daily peak demand. The impacts associated with this type of power plant are similar to those of the storage dams.

Run-of-river/diversion HPP

This plant consists of a relatively small diversion structure or weir, a diversion tunnel or penstock and a downstream powerhouse. The weir diversion structure is of relatively lower height with relatively minimal water retention upstream of the intake structure. These projects are typically used as base load, which allows the use of available water for power generation at any time. Water diverted from the weir intake structure to the powerhouse is then returned to the river through the tailrace. The river section between the diversion structure and the powerhouse/tailrace is deprived of its natural flow when water is diverted to the powerhouse during power generation.

Considering the usual practice in Georgia, the minimal amount of water to be left in the river comprises approximately 10% of the average annual flow, which often results in the so-called "isolated" areas (i.e. those remaining without water) and thus fragmentation of freshwater habitats, also significantly affecting fish migration. It is therefore necessary to assess the impacts of this diversion and reduction in natural flow at a certain section of the river during operation.

Run-of-river reservoir HPP

This scheme creates a storage reservoir upstream of the diversion structure or weir to create substantial hydraulic head and resulting power generation capacity. Water retention capacity of the upstream reservoir is usually several hours, or days, to maintain a stable supply of water volume for hydropower generation. Similar to "run-of-river diversion" hydropower plants, the reservoir type will also result in depriving a certain section of the river of natural flow ('dewatered segment') during power generation. This section is also called the 'curtailed reach'.

Impacts associated with this type of scheme include inundation of reservoir areas and changes in instream flows, as well as negatively affecting fish migration and leading to the fragmentation of freshwater habitats.

2.3.2. Categorization by size/capacity

HPPs are commonly classified based on installed capacity P (MW). Although criteria and thresholds that separate individual classes may vary among countries, the following classification is widely accepted:[3]

- Micro HPPs – $P < 0.1$ MW
  Micro hydropower projects can supply electricity for an isolated industry, or small remote community. They are usually stand-alone – i.e. not connected to the grid – and are always run-of-river type. Small water storage tanks are sometimes constructed so that hydro generation is guaranteed for a minimum period per day, even during low-water flow conditions.
- Small HPPs – 0.1 MW $< P <$ 10 MW (up to 30–35 MW in some countries)
  Small HPPs are considerably smaller than medium and large HPPs because they usually exploit low discharges. Most are of the run-of-river type that are connected to the grid.
- Medium HPPs – 10 MW $< P <$ 100 MW
  Medium hydropower schemes are either of the run-of-river or storage type and almost always feed into the grid. Their layout may include a dam to create a head pond.
- Large HPPs – $P >$ 100 MW
  Large hydropower schemes are always connected to a large grid; large HPPs can be of the run-of-river or storage type.

According to Article 23, paragraph 11 of the "Network Rules" approved by Resolution №10 of the Georgian National Energy and Water Supply Regulatory Commission of 17 April 2014, power plants are classified into A, B, C and D categories according to the installed capacity and the requirements imposed on them, according to which the power plants Installed power limits (MW) are differentiated as follows:

- Category A: $P<1.5$
- Category B: $1.5<P<10$
- Category C: $10<P<30$
- Category D: $P\geq30$

Also, in accordance with the first paragraph of Article 21 of the "Rules of the Electricity Distribution Network" approved by the Commission's Resolution №19 of 28 June 2021, the capacity of a micropower plant does not exceed 500 kW. In addition, according to Article 3, paragraph "338" of the Law of Georgia "On Energy and Water Supply", the capacity of a small power plant does not exceed 15 MW.

3 Based on IFC, 2018: Good Practice Note: Environmental, Health, and Safety Approaches for Hydropower Projects.

2.3.3. Ancillary elements

Ancillary elements are activities, facilities and infrastructure directly related to and usually funded by the hydropower projects. These usually include:

- Access roads and bridges
- Riverbank protection or reinforcement structures
- Disposal areas for waste rock generated during construction works (stockpiles)
- Crusher plant
- Waste disposal areas
- Construction worker's camps
- Site office
- Warehouse areas
- Maintenance areas
- Oil products storage
- Concrete production plant.

The likely impacts of ancillary elements also have to be addressed in any EIA to be carried out for a given HPP.[4] Such an approach makes it possible to address the full scope of the likely impacts, including synergistic and cumulative ones, of the HPP and all related elements, and to formulate the necessary mitigation measures. Therefore, the screening and all other steps in the EIA and related documents (i.e. in particular the screening and scoping applications, EIA report and the environmental decision), should cover both the HPP itself and the ancillary elements.[5]

2.3.4. Location

The location of the HPP is a very important aspect. It predetermines not only the likely impacts of the specific project, but also the significance of the impacts and their territorial extent, including the likely transboundary impacts.

2.3.5. Project phases

An EIA has to consider the likely impacts of all phases over a lifecycle of a project. The typical main phases of the hydropower projects are as follows:

Pre-construction phase

The pre-construction phase usually involves engineering investigation to determine the feasibility of installing a hydropower facility in the selected areas (typically determined by the spatial plans). The activities in this investigation include hydrological studies, geological and geotechnical investigation, site surveys, seismic investigations, identification of potential quarry sites, construction of new access roads, initial environmental investigations, stakeholder mapping activities, as well as securing approvals and permission processes to get the final decision on whether or not a project can be implemented – also, an EIA is usually carried out at this stage.

4 The interpretation suggested by the European Commission as regards the application of the EIA Directive to ancillary/associated works (European Commission, 2012) is available at: https://circabc.europa.eu/ui/group/3b48eff1-b955-423f-9086-0d85ad1c5879/library/0c214726-db18-48f1-ad4d-e0156e3db3dd/details?download=true). It provides that although the associated works should not be automatically considered as a part of the main project, in the case that the associated works are inextricably linked to the main project, represent a location-specific part of the construction phase of the main project, or are exclusively and entirely intended to serve the main project, then the likely impacts related to such associated works should be considered in the EIA for the main project.

5 The notice of the European Commission regarding application of the EIA Directive to changes and extension of projects (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021XC1203(01)&from=EN) provides that '*where several projects, taken together, may have significant effects on the environment within the meaning of Article 2(1) of the EIA Directive, their environmental impact should be assessed as a whole and in a cumulative way*.'

BOX 1

Georgian context

According to the rules for issuing a construction permit for facilities of special importance[6] – such as high-voltage transmission lines, HPPs and reservoirs – at the second stage of the construction permit procedure (i.e. approval of an architectural-construction project), a developer has to attach the environmental decision to the application.

This means that an EIA needs to be carried out before applying for the second stage of the procedure.

Considering that the first stage of issuing of a construction permit is approval of the conditions for the use of a given land plot for construction, which presumably pre-determines the location of the HPP project, it would be reasonable to apply for an environmental decision at this first stage.

However, this is not legally required.

Also, Georgia's national EIA legislation does not distinguish between pre-construction and construction phases, and activities such as the construction of access roads are also considered part of the construction phase.

At the pre-construction stage, the communities affected by the project should be consulted and engaged. The project proponent is responsible for providing sufficient information about the project development activities so as to facilitate better understanding and informed decisions by the community and relevant authorities. This is often carried out as part of the EIA procedure.

Land acquisition and negotiation, if relevant for a given project, is also undertaken during this stage, which may potentially cause involuntary resettlement, and livelihood and economic displacement. Land acquisition, resettlement and livelihood restoration plans have to be prepared, as necessary, depending on the social impacts identified.

The EAC does not require the preparation of these plans, which – in current Georgian practice – are usually developed for projects funded by international financial institutions (IFIs) according to their policies and requirements.

Geological and geotechnical testing and investigation may require bringing in drilling rigs and constructing access roads. Road surfaces and bridges may need to be reinforced when planning project pre-construction and construction phase logistics due, for instance, to the challenge of transporting heavy equipment along small, mountainous roads with low overpasses and hanging cables.

Construction phase

The construction phase often causes significant environmental impacts, which have to be properly considered in an EIA.

Activities include building the major components of the hydropower facility. Such components may include a diversion structure, weir or dam, water intake structure, headwork such as penstock and tunnels, powerhouse, tailrace pipeline or tunnel, substation or switchyard, power transmission lines and access roads.

6 According to 'The Rules for Issuance of a Construction Permits for the Facilities of Special Importance, Including Radiation or Nuclear Facilities, and the Permit Conditions' (approved by Resolution #257 of the Government of Georgia of 31 May 2019), facilities of special importance (listed in Article 50 of the regulation) are those characterized by an increased risk factor.

During this phase, a construction worker camp, waste disposal areas, a wastewater treatment plant, a solid waste management site and a crushing plant/concrete plant can also be set up. Depending on the size and capacity of the HPP, the construction phase can take several years.

Site preparation activities include removal of top soil, and earthmoving activities may involve blasting, filling, and/or tunnelling. Quarrying and transport of filling materials may also be needed. Hydropower facilities are usually built in remote areas requiring the opening up of new access roads. Weir and dam construction require careful foundation filling and concreting work to ensure building according to structural design plans.

Construction site preparation and laying out the diversion system (tunnels and/or pressure pipeline) generate spoils that should be properly disposed of in a designated spoils disposal area. Headwork and tailrace work include laying of conveyance pipes from the point of diversion to discharge. Powerhouse construction involves civil works and the installation of hydropower turbines and other electro-mechanical equipment.

Commissioning phase

Extensive testing and commissioning work is required prior to the full hydropower project operation. Tasks such as reservoir preparation, coffer dam removal, waterway filling, fish ladder/fish passage operation and electrical/ mechanical device testing require detailed planning, consultation and coordination during the commissioning process.

Immediately upon satisfactory commissioning, a trial operation and reliability run of between three and 30 days may begin.

If the project includes establishing a reservoir, this will result in the inundation of areas of the same elevation as the operating level of the dam, including vegetation and potential farmlands or areas of economic value to local communities. If settlements are present, these structures will be submerged.

Operation phase

A hydropower plant has a full operating lifespan of 50 to 100 years. Turbines are designed to continuously operate with regular routine maintenance checks. The powerhouse serves as the main control room/office for operating the generators. The operation of the hydropower facility will result in fluctuation of flow releases downstream while the section between the toe of the dam and the tailrace may see reduced flows depending on the operational rules of the hydropower operator.

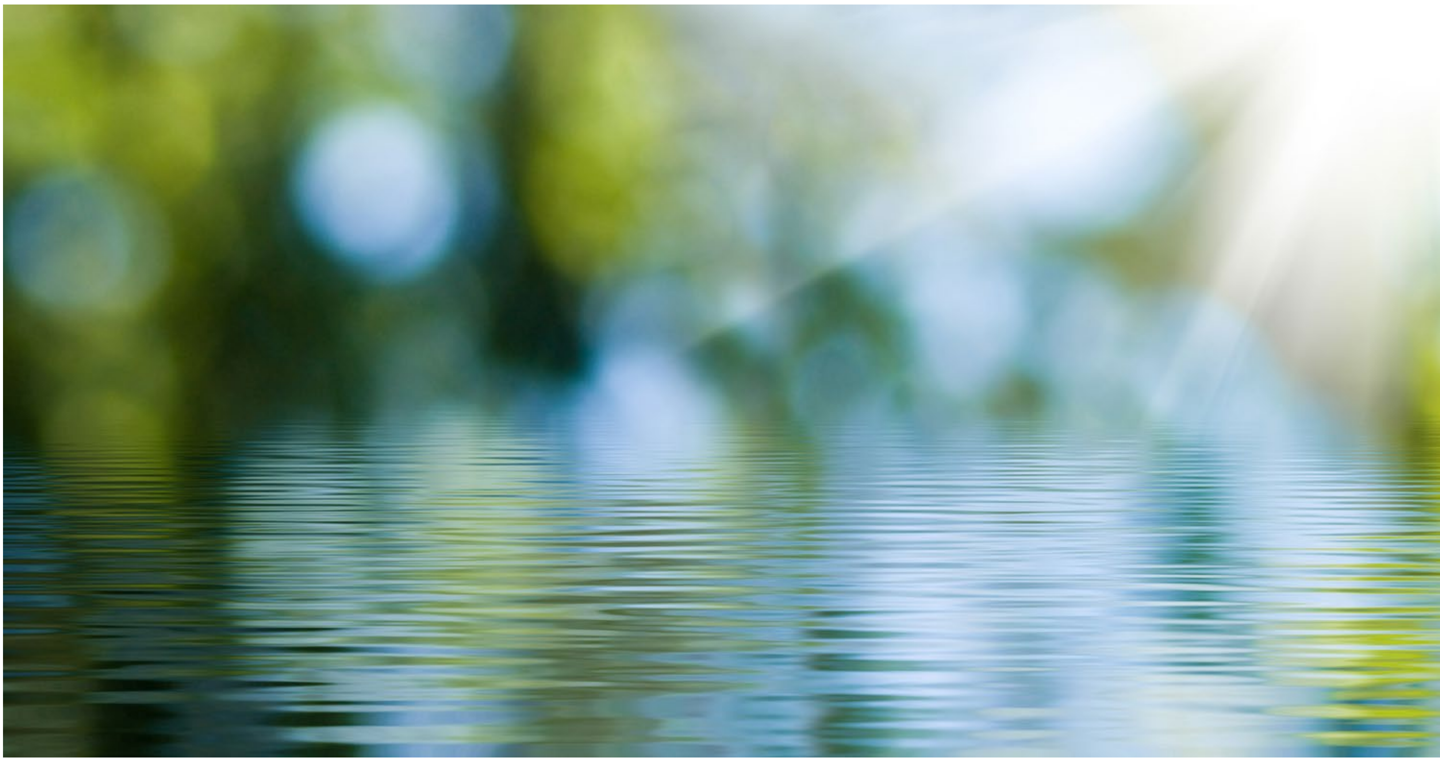
Decommissioning and rehabilitation phase

Decommissioning of a hydropower plant is usually done after the planned lifetime of the facility. It should be carried out in accordance with a dedicated decommissioning plan, usually drafted as part of the detailed design package. Decommissioning of a facility during its planned lifetime is not common, unless there is a need to replace it owing to damage resulting from a natural disaster or if sedimentation build-up upstream of the weir/ dam has significantly reduced the storage capacity.

Should the plant have to be decommissioned, the activities will depend on the hydropower scheme in question but may include demolishing the powerhouse, weir, penstock and/or pipelines; and storing, reusing, reselling or disposing of materials in a responsible manner (e.g. in an identified waste disposal area).

Turbine equipment can often be sold or refurbished for potential reuse. Ancillary elements of a hydropower project may need to be decommissioned, either directly following the construction of the facility or at the end of its lifetime, along with the main hydropower project components.

Analysis of the likely impacts during the decommissioning phase of facilities is equally as important as during the construction phase.



2.4. Alternatives

In accordance with general EIA good practice, an EIA for HPP should consider alternatives. If there are reasonable alternatives to the HPP type, capacity, location, etc., these have to be addressed in the scoping and/or the EIA reports (i.e. described, evaluated and compared). The EIA may also require, for instance in the scoping opinion, that further alternatives be prepared by the project developer and addressed in the EIA.

2.5. Main actors, their roles and responsibilities

- The National Environmental Agency (NEA) plays a key role in the administration of the EIA. It coordinates and supervises the entire procedure, including consultations and public participation. In cases of likely transboundary impacts, it prepares a proposal for initiating a transboundary EIA procedure, submits it to MEPA, and then organizes the implementation of the EIA.
- The developer is a public or private entity who wants to implement an HPP project that falls under Annex I or Annex II of the EAC (i.e. a new project) or modifies an existing one. To obtain permission, a developer must prepare and submit the screening application, the scoping application and report, and the EIA application and report. In the case of a transboundary EIA procedure, the developer has to provide the notarized copies of the respective applications and the attached reports translated into the official language of the country potentially subject to a transboundary impact. After receiving the environmental decision, the developer must implement the project according to the terms and conditions of that decision.

- A consultant can be an individual or a company that is contracted by a developer to prepare a scoping and an EIA report and to provide expert support to an EIA. The consultant must hold the relevant qualifications as well as the scientific, technical and methodological proficiency for preparing an EIA report. Usually, the preparation of the scoping and/or EIA reports involves a team of experts to cover all the relevant environmental and health issues that might be affected by a given project.
- The public is defined as one or more natural or legal persons, as well as other organizational entities (which are not legal persons) according to the legislation of Georgia. The public is entitled to participate in the EIA, including a transboundary EIA procedure. Specifically, the public can submit to the Agency opinions and comments on a screening application, a scoping report and an EIA report in writing, or present these orally during public hearings. The EAC establishes requirements regarding public participation in an EIA; these requirements, however, should be understood as only the minimum scope of public participation and it is highly recommended – in particular in case of large and/or sensitive projects (where HPPs often belong) – to organize public participation beyond the specified legal provisions.
- The public concerned is the public that may have an interest in the HPP or that is likely to be affected by it. The public concerned also includes non-entrepreneurial legal entities registered in accordance with Georgian legislation (i.e. NGOs), whose activity goals relate to promoting environmental protection in the country. It is important to identify the public concerned at the early stages of an EIA – the preliminary identification can be done already at the screening stage and fully developed at the scoping stage.[7]
- An expert commission is established by the Agency for each specific EIA to carry out an expert examination of an EIA report and to issue an expert opinion.
- Other countries should be involved in the EIA process through the participation of the relevant authorities and the public of the country or countries in cases where a certain HPP is likely to have transboundary effects.

Although consultations and public participation are not addressed in the Guidelines, the requirements in this regard stipulated by the EAC have to be considered as only the minimum extent of the consultations and public participation.

HPPs are often sensitive and even controversial projects, where inappropriate communication with the likely affected communities and municipalities may further increase mistrust towards the planned projects and may result in conflict situations at public hearings.

It is therefore recommended that HPP developers proactively approach the public and the public concerned, and the relevant authorities, and organize consultations and public participation in a manner that enables effective consideration of the feedback provided by the stakeholders in the EIA and/or HPP design and/or related permits.

2.6. Preparation of hydropower projects

There are no legally defined steps or approved guidelines for the preparation and permitting process in Georgia. The projects funded by international finance institutions usually follow International Finance Corporation (IFC) guidelines. The scheme set out below, taken from 'Hydroelectric Power – A Guide for Developers and Investors',[8] outlines the general steps of HPP project preparation and permitting process, and construction and links it to the EIA.

7 Not all HPP projects require screening – in such a case, the identification of the public concerned has to be included in the scoping application.

8 Hydroelectric Power – A Guide for Developers and Investors, IFC, 2015.

Figure 1. Typical HPP development steps

BANK PERSPECTIVE	MAIN ACTIVITIES (DEVELOPER)
PHASE 1	**SITE IDENTIFICATION / CONCEPT**
	• Identification of potential site • Funding of project development • Development of rough technical concept
PHASE 2	**PRE-FEASIBILITY STUDY**
	• Assessment of different technical options • Approximate cost/benefits • Permitting needs • Market assessment
PHASE 3	**FEASIBILITY STUDY**
• First contact with project developer	• Technical and financial evaluation of preferred option • Assessment of financing options • Initiation of permitting process
PHASE 4	**FINANCING / CONTRACTS**
• Due diligence • Financing concept	• Permitting • Contracting strategy • Supplier selection and contract negotiation • Financing of project
PHASE 5	**DETAILED DESIGN**
• Loan agreement	• Preparation of detailed design for all relevant lots • Preparation of project implementation schedule • Finalization of permitting process
PHASE 6	**CONSTRUCTION**
• Independent review of construction	• Construction supervision
PHASE 7	**COMMISSIONING**
• Independent review of commissioning	• Performance testing • Preparation of as build design (if required)

Source: Hydroelectric Power – A Guide for Developers and Investors[9]

9 Hydroelectric Power – A Guide for Developers and Investors, IFC, 2015.

3. MAIN ANALYSES TO BE PERFORMED IN THE EIA FOR HPPS

3.1. Identification of relevant environmental and socioeconomic, including health, aspects (scoping)

3.1.1. Introduction

The purpose of scoping is to identify the environmental and health aspects that are likely to be affected and thus should be covered in the EIA report, and also to eliminate those aspects that are of little concern.

3.1.2. Typical environmental and health aspects related to HPP projects

The EAC stipulates (Art. 3) that environmental impact means *'any impact on the environment resulting from the implementation of strategic documents or activities which may include effects on the following: human health and safety, biodiversity and its components, water, air, soil, climate, landscape and protected areas. An environmental impact also includes the impact on cultural heritage or socioeconomic factors resulting from changes to them'*.

HPPs represent a specific type of project with specific environmental and health aspects to be likely affected. Although the scope and significance of the likely impacts largely depend on the specifics of a given project (e.g. type, technical design, location), it is possible to identify the some general environmental and health aspects, which should always be considered in the scoping (and further EIA steps).[10] The following paragraphs describe the rationale for considering the environmental and health issues that may be regarded as the most relevant in the Georgian hydropower context.

3.1.2.1. Climate, greenhouse gas emissions, climate change and related risks

Climate

Social impacts and risks associated with hydropower projects could include disruption of ecosystem services, and those caused by changes in the microclimate, which might affect agricultural productivity.[11] The dams affect vegetation in an indirect way through regulating the microclimate, promoting precipitation and slowing down the rate of temperature rise; and these effects may come from the increase of the upstream water surface area.

10 Adapted from International Finance Corporation (IFC), 2018: Good Practice Note: Environmental, Health, and Safety Approaches for Hydropower Projects. https://www.ifc.org/en/insights-reports/2018/publications-gpn-ehshydropwer

11 https://www.eib.org/attachments/publications/eib_guidelines_on_hydropower_development_en.pdf

Recent studies on the environmental impacts of dams often also address the impacts on both the local and the regional climate. The change of vegetated or bare land into a water body may lead to significant changes in surface albedo and thus can alter the surrounding heat balance. Increased rates of humidity and decreases in temperature amplitudes in the surrounding area of the artificial reservoirs have been reported. An enhanced energy exchange between the reservoir and the neighbouring areas can result in an unstable atmospheric structure, which may lead to a changed precipitation pattern and a changed geographical distribution of precipitation.[12]

Greenhouse gas emissions

Reservoirs emit greenhouse gases (GHGs) as a result of the biochemical processes that take place in organic-rich sediments or the decomposition of vegetation, as well as other organic matter inflows from the catchment basin. Under anoxic hypolimnetic conditions, methane may be produced by the decomposition of impounded organic material in reservoirs and can be emitted through various pathways that mainly include diffusive and bubbling emissions from the reservoir surface and degassing in hydropower dam tailrace and diffusive flux downstream of the dam.

The extent and rates of methane generation and emissions from reservoirs are still the subject of significant scientific debate, ongoing research and criticism. Significant progress has, however, been made in developing qualitative predictive tools to estimate potential GHG emissions from planned reservoirs, as well as in developing methodologies for measuring direct reservoir GHG emissions. The model used in the guidelines prepared by the International Hydropower Association (IHA) can be considered as a standard model.[13]

Climate change and related risks

The hydropower sector is particularly likely to be affected by climate change. Direct and indirect climate-related adverse effects may impact a hydropower project during its life cycle. Increased variability of precipitation as well as changes in the timing and extent of glacier and snow-cover melting are likely to have a substantial impact on hydropower production.

Droughts and extended dry periods can reduce river flows, deplete reservoirs and significantly decrease hydropower output, dramatically reducing national energy supplies and leading to shortages and blackout periods. Competition for water resources, especially in areas under water stress, will further constrain hydropower water supply. These impacts will be more severe when coupled with increased electricity demand and higher peak requirements in summer – when there is peak demand for air conditioning.[14]

Also, more intense and frequent heavy rainfall may put greater stress on dams that were not designed to take account of future climate change and may increase their risk of failure. Current climate trends and future projections show that extreme precipitation has already become more frequent and intense, and is expected to increase in the future, although the magnitude of change is uncertain. Hydropower projects may be more at risk from climate-induced hazards than from changes in water availability. The hydropower facilities may also be at higher risk of being flooded, as there may be increased risk of geo-hazards, where is the risk of landslides, as these have been known to take place in the vicinity of key energy infrastructure[15] blocking and flooding the river upstream and/or blocking road access.

3.1.2.2. Hydrology and hydromorphology

Hydropower plants can substantially affect the water flow (volumes and timing), the morphology of the river channel and floodplains, the hydrologic connections between upstream and downstream and between a river and its floodplains/riverbanks. The issues likely affected include sediment transport and increased erosion potential.

12 https://library.wmo.int/idurl/4/58512

13 GHG Measurement Guidelines for Freshwater Reservoirs, International Hydropower Association, 2010. See https://assets-global.website-files.com/5f749e4b9399c80b5e421384/5fa83e0697a884a4f0e30785_GHG%20Measurement%20Guidelines%20for%20Freshwater%20Reservoirs.pdf

14 ADB (2020b). Key Indicators for Asia and the Pacific 2020. Asian Development Bank: http://dx.doi.org/10.22617/FLS200250-3

15 https://climateknowledgeportal.worldbank.org/sites/default/files/2021-06/15836-WB_Georgia%20Country%20Profile-WEB.pdf

Another serious hydrological issue is flood risk. Whereas on the one hand dams can play an important role in flood risk management, on the other hand their failure can significantly affect the downstream areas (including socioeconomically). Flood risks and management should be taken into consideration in the design of each HPP project.

The hydrological characteristics of the project-related area are typically developed already in a feasibility study, and the EIA can rely on this analysis for estimating the potential impacts of the project on the hydrological regime and related characteristics. It is recommended that at least 30 years of hydrological data for hydropower planning and impact assessment be used.

In Georgia, however, the limited availability of sufficiently long and reliable runoff time series, especially for smaller rivers, can make it difficult to evaluate the impacts. If no data are available, hydrological methods can be used for estimating the hydrology of the project site. The following are some methods that can be applied:

- Hydrological (rainfall-runoff) modelling
- Conversion by the catchment area ratio between gauging station and project site
- Regional empirical formulas
- Use of the correlation between the gauging stations.

However, the suitability of the hydrological analysis method for a given project and site depends greatly on the data available. Therefore the appropriateness of a particular method has to be evaluated at the initial stages of the feasibility study or EIA.

3.1.2.3. Water quality

There are differences in the importance of the likely impacts between HPP projects with and HPP projects without a reservoir. Construction of a reservoir may alter water quality as well as its temperature within and downstream of the reservoir compared with the undisturbed upstream river environment. Such impacts may therefore belong to the most major aspects associated with hydropower projects. A hydropower project without a reservoir (typically a small or medium-sized one) is supposed to have a less significant effect on the water quality. Also, for all HPP projects, water quality can be affected during the construction phase (e.g. through oil leakages, accidents), but these can be relatively well managed by applying specific measures, including an environmental construction plan.

A sufficient baseline must be established to allow for identifying potential risks of negative impacts and for future operational monitoring of the water quality in the project-related area. This should include not only the water quality measurements but also an analysis of existing or potential sources of pollution that could be mobilized or exacerbated in connection with implementing the HP project (e.g. induced changes in land use in the project-related watershed, increased risk of accumulation of hazardous substances in the reservoir).

3.1.2.4. Geology and geological hazards

The general geological features within the area of influence need to be examined to evaluate the vulnerability of the project area to geo-hazards, including subsidence, liquefaction, landslides, flooding and mud or debris flows. Depending on the specifics of a given project, the EIA focuses on identifying risks, examining the assumptions and verifying the adequacy of the analyses carried out by the project design and engineering team related to the dam's structural integrity and break risk.

As Georgia is situated in the seismically active region of the Alpine-Himalayan orogenic collision belt, it is imperative to take seismic hazards into consideration when developing an HPP. In addition, the presence of mountain glaciers in the region poses additional specific hazards such as glacial lake outburst floods (GLOFs), which are notoriously difficult to predict.

3.1.2.5. Sedimentation and erosion

Reduced instream flows in rivers resulting from weir or dam construction may lead to sediment build-up and hindrance to natural sediment movement along the river channel. Sediment retention upstream from the dam or weir may generate sediment-deficient river flow downstream, a phenomenon commonly referred to as a 'hungry river', which can cause significant riparian erosion.

Given the typically high turbidity and high volumes of transported sediment in Georgian rivers, the sedimentation risk and sediment load assessment are of particular importance and the EIA is expected to build on the analyses conducted by the design and engineering team to identify the direct impacts and potential indirect consequences for related environmental components.

3.1.2.6. Land use and land-use change

The development of an HPP can be associated with direct uptake of land and changes in land use (i.e. in connection with reservoir development) but can also trigger land-use changes in a broader area. The newly available water reservoir can, for example, serve as a water resource for irrigation and consequently stimulate the expansion of cultivated land. The electricity generated can attract industrial investment in the region, with an associated expansion of urban areas. These induced land-use changes may trigger further environmental change, often with negative impacts on the natural environment and local communities.

3.1.2.7. Air quality and noise

Even though noise emissions and air pollution are typically not of major concern for a hydropower project, temporary impacts on the ambient environmental quality during the construction phase can be an issue, namely for the construction workers and communities adjacent to the project locality. These impacts relate directly to the construction site, as well as to the transport to/from the site.

Noise will be generated by the turbine(s) during operation of the HPP. The likely impacts on the local population – if the HPP is located close to the inhabited areas – should be considered (although it may be expected that the majority of HPPs will be located far from inhabited areas).

3.1.2.8. Landscape

As HPPs have significant potential for altering the visual landscape characteristics of the locality, the EIA should demonstrate a good understanding of the values associated with the landscape structures and visually prominent features that are likely to be affected by the project. To compensate for the lack of objective criteria for evaluating visual impacts, the decision within the EIA scoping phase as to whether and to what extent a dedicated assessment of the visual impacts should be carried out must be justified and consulted with the relevant stakeholders.

3.1.2.9. Construction materials and waste management

Depending on the size of the project, the HPP can be associated with acquiring and handling of substantial volumes of material (e.g. rock, concrete), which can be obtained in situ as well as transported from elsewhere. The EIA must take into account not only on-site impacts but also impacts associated with extraction, manufacturing (e.g. gravel extraction, concrete production) and transport of key categories of bulk materials and ensure that their production meets applicable environmental standards.

Similarly, environmentally sound handling of large volumes of excavated soil and other material must be ensured, as well as the management of hazardous wastes, in line with the applicable legislation and standards.

The scoping stage must take into account the scale of the project and expected categories and volumes of generated wastes to determine the need for dedicated analyses and preparation of material-specific management plans to minimize the risk of negative environmental impacts.

3.1.2.10. Natural habitats and biodiversity

Hydropower projects are frequently located in the upper parts of the river basins, which are situated in or near protected areas and are to a large extent characterized by intact ecosystems. Also, hydropower projects often have significant impacts on downstream riverine ecosystems and their biodiversity.[16]

Depending on the type and location of the proposed project, habitat degradation and conversion may pose significant threats to aquatic and terrestrial biodiversity. These may occur as a result of reservoir creation and flooding of adjacent territories, changes in hydrologic flow regime, dewatering river reaches, interbasin transfer of water, development of access routes and transportation corridors, construction material extraction, stockpiles and spoils disposal areas[17] or development of transmission line corridors. Habitat conversion may also result from temporary construction-related activities, such as storage/disposal sites and the establishment of temporary work camps and permanent structures. All the above impacts affect biodiversity, which can be further affected for instance by disruption of the river continuum and connectivity and fish migratory routes, by the elimination of propagation sites, and by changes in water quality and temperature.

The construction and operation of HPPs often cause artificial transformation of river beds. This leads to a change in the hydrological regime of the river and affects corresponding habitats and species.[18] Such phenomena as the change in the areas of seasonal flood, a sudden stream of water from the water reservoir/dam to the tail-water or, on the contrary, a sudden decrease of water in the river bed ("hydropeaks") affect freshwater habitats, increase their degradation and lead to the extinction of species.[19] Most affected are the species that are incapable of instant reaction to the sudden change in water regime (e.g. slow or immobile organisms like benthos invertebrates, lithophile fish, plants growing on the riverbanks).

The dams constructed on the rivers also change the chemical and mineral content, acidity and temperature of the water, and reduce the concentration of dissolved oxygen in the water. Frequently, a large mass of nutrients in artificial water reservoirs leads to eutrophication, which, in turn, affects biodiversity.

These impacts are not restricted to HPPs with large reservoirs, but also occur in connection with the development of derivative types of (run-of-river) HPPs, which according to public opinion cause "less damage" to the environment. Unfortunately, a widespread practice is to divert a major portion of waterflow to the artificial ducts (e.g. tunnels, channels, canals) thus leaving the original river bed largely intact. Such sections of the river are, however, often left with only a residual flow not capable of supporting the original river ecosystem. This can lead to extremely negative impacts and a negative cumulative effect higher than the comparative negative impacts caused by a similar HPP with a reservoir.

In the Georgian context, the concern for natural habitats and biodiversity is particularly relevant due to the region´s ecological importance and distinctive natural conditions, with the presence of many rare habitats and species. The HPPs built in Georgia during the Soviet period already inflicted great damage on biodiversity, freshwater habitats and the fishing sector.[20]

In general, the situation is made complicated by the lack of reliable up-to-date biodiversity and habitat baseline data (for both water and terrestrial ecosystems). This, in turn, puts additional emphasis on an EIA baseline analysis to compensate for the information gaps, often through dedicated field research.

Also, the practice in Georgia shows that field surveys are sometimes carried out during inappropriate seasons or times of the year, only for a short period of time, or using incorrect methodology. The collected data cannot therefore serve to evaluate the likely impacts objectively.

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16 Huđek H, Žganec K, Pusch MT, "A Review of Hydropower Dams in Southeast Europe – Distribution, Trends and Availability of Monitoring Data Using the Example of a Multinational Danube Catchment Subarea", *Renewable and Sustainable Energy Reviews*, vol. 117, January 2020.

17 Current legislation in Georgia does not provide for the arrangement of stockpiles on the territory of forests.

18 Beyond the natural flow regime? Broadening the hydro-ecological foundation to meet environmental flows challenges in a non-stationary world. N. LeRoy Poff. *Freshwater Biology*. October 2017. 1011-21. https://onlinelibrary.wiley.com/doi/full/10.1111/fwb.13038

19 Bunn, S., Arthington, A. "Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity". *Environmental Management* 30, 492–507 (2002). https://doi.org/10.1007/s00267-002-2737-0

20 Challenges Related To The Destruction Of Ecosystems Caused By The Impact Of Economic Projects. Essays on Public Policy. Green Alternative. 2016. https://greenalt.org/app/uploads/2021/05/ekosistemebis_ganadgurebasTan_-dakavSirebuli1.pdf

3.1.2.11. Health and safety

During the operation of the HPP, dam safety emergency preparedness and response (including the case of dam and reservoir slope failure) are important health-related issues. Also, static or slow-moving water conditions can promote disease vectors that would otherwise not thrive in faster-flowing unregulated rivers. And the conversion of flowing conditions to static water bodies may exacerbate non-vector-based diseases (such as dysentery and hepatitis A). This, however, applies in particular to HPPs with large reservoirs. Similarly, the regulation of natural seasonal variations in river flows can also promote vectors that thrive in moving water.

The construction phase can also lead to significant impacts on health, depending greatly on the distance of the site from inhabited areas, the extent of earth movement and construction materials extraction activities, as well as construction vehicle movement on access roads. The likely impacts include noise and vibrations (mainly associated with materials extraction activities, excavation, blasting, materials crushing, stockpiling and construction vehicle transit), air pollution (dust from materials extraction and construction activities, other polluting substance from transport) and waste and wastewater management.

3.1.2.12. Socioeconomic issues

The socioeconomic issues to be considered in the EIA report include land and property degradation, resettlement,[21] security risks (dam failure, changes in the flood regime), as well as effects on economic sectors due to changes of the water regime (e.g. on agriculture, fishing) or loss of the natural assets and thus affecting the attractiveness of the area for tourists.

On the other hand, the construction phase can bring about significant employment and business opportunities for local communities, provided that they possess the required skills and capacities. But it is often external contractors and suppliers from the capital city or elsewhere who are employed to carry out most of the project implementation works. Also, local infrastructure (roads, waste management facilities) may be improved as a result of the project.

While HPP development is typically expected to deliver significant net socioeconomic benefits, it is still important to identify potential risks, namely to local communities, vulnerable groups and other stakeholders who may bear disproportionate costs associated with the project.

Similarly, the generated electricity and associated revenues from the HPP operation can be a significant asset for the local communities and the region, provided that the project contains arrangements for fair compensation and benefits-sharing among stakeholders.

Depending on the scale of the HPP, the construction phase can trigger an influx of significant numbers of workers and other professions to commute or move in the communities adjacent to the project site. This can at least temporarily but often significantly alter local demographics (including age and gender balance) with a number of consequences for the communities affected, such as increased pressures on public services, safety and order, increased prices of consumer goods, and conflicting cultural norms.

Some HPP developments may cause population displacement and produce a need for the resettlement of affected communities, with a whole host of related concerns and risks.

Even when no resettlement is necessary, HPP development still can be associated with the loss of various physical assets such as agricultural land or forests, and infrastructure, either because of inundation of the land due to reservoir creation or construction of HPP-related infrastructure. The situation could sometimes be further complicated by the lack of a formal (legal) holding title to a given asset (e.g. customary used land), which would make it difficult for the affected community to claim any compensation.

Through combining expert analysis with a consultative process, the EIA is particularly well positioned to ensure that the HPP design and implementation take into account all the legitimate concerns of potentially affected stakeholders and to put in place reasonable mitigation and compensation measures. This, in turn, minimizes the potential for future conflicts and grievances or risks of costly dispute settlements or litigations.

21 Involuntary resettlement is regulated in Georgia by the Law on the Procedure for Expropriation of Property for Pressing Social Needs, and according to this Law, the expropriation can take place only for the specific projects listed in the Law.

3.1.2.13. Cultural assets

Georgia is very rich in cultural and historic sites, monuments and buildings, which may be destroyed or negatively affected by construction of the HPP and its ancillary elements (e.g. new access roads). The EIA needs not only to consider the legal protection status of individual objects, but also other factors such as the significance of the monuments for the local communities, or whether a given object contributes in an important way to the unique character of a given territory.

Here again, the EIA capacity for combining expertise and stakeholder consultation should ensure that due consideration is given and any unnecessary loss of cultural assets prevented.

3.1.3. Scoping checklist

Table 1 below can serve as a general EIA scoping checklist for the hydropower projects. It should assist in the scoping deliberations with the aim of defining the key environmental and socioeconomic (including health) aspects on which the EIA must focus, as well as what indicators and methodologies must be used for the assessment and what data are available and where additional dedicated surveys need to be carried out.

Table 1. EIA scoping checklist

Issues	Specific aspects to be considered in EIA for HPPs
PHYSICAL ENVIRONMENT	
Climate, climate change and related risks	Local climate
	Local scale climate change projections
	Vulnerability, resilience and adaptation to climate change
	GHG emissions
Hydrology and stream flows	Flows (i.e. velocity, volumes, duration of high and low flows, timing, frequencies, predictability, multi-annual and seasonal variability of flows, etc.)
	River morphology and drainage pattern
	Flood risks
	Changes to environmental flows affecting the physical/chemical, biological, socioeconomic and/or cultural environments
	Impacts due to peaking operations if any
Water quality, water resources	Surface and/or groundwater quality / pollution
	Number, location, seasonal flows and water quality of any aquifers, wells or springs relied on by local communities that could potentially be affected by project-related activities
Geology and geological hazards	Proximity of project components to active faults
	Vulnerability of the project area to geo-hazards including subsidence, liquefaction, landslides, earthquakes, ground movement, GLOFs, and other geological hazards
Sedimentation and erosion	Areas prone to sediment deposition
	Sediment loads and sedimentation rates along the river channel
	Sedimentation risk (sediment load assessment)
	Vulnerability of the project area to soil erosion (with loss of top soil)

Issues	Specific aspects to be considered in EIA for HPPs
Land use and land-use change	Land uses within the area of influence
	Lands within the area of influence declared by the national law as special or critical for various reasons (e.g. ecological, economic or sociocultural)
	Areas that are vulnerable to natural hazards as well as those occupied by local communities
	Sensitive areas such as downstream communities, community forest, relevant social infrastructure (e.g. road and bridges), religious or cult sites, and areas to be inundated
	Deforestation
	New hard surfaces (i.e., covered by concrete, asphalt, etc.) or expansion of already existing ones
	Urbanization
Air quality	Air quality conditions and point sources
Noise	Noise point sources and ambient noise levels at sensitive receptors
Landscape	Landscape values and visual character of the area of influence
	Visually prominent landscape components or values, structures and other existing infrastructures interesting features may include places of worship, tourist destinations, populated areas, or other places of interest
	BIODIVERSITY AND HABITATS
Terrestrial, aquatic and riparian flora and fauna	Terrestrial flora and fauna in the area of influence, with special emphasis on water dependent species
	Aquatic and riparian flora and fauna in the area of influence (Fisheries and aquatic life)
	Species of interest (e.g. important to locals)
	Non-timber forest products (NTFP) and ethnobotany
	Agro-biodiversity
	Migratory species
	Invasive species
	Rare and endangered species and species protected under international conventions and agreements, (e.g. CITES, IUCN, Bern Convention)
	Areas of high biodiversity values or important biodiversity sites
	Existing anthropogenic influences within the area of influence
	Susceptibility to anthropogenic and seasonality influences hunting, poaching and illegal trading
	Forest type and management practices
Natural and critical habitats	National and international designated protected areas and International ecological network sites (e.g. the Emerald Network, RAMSAR sites, UNESCO World Heritage sites)
	Habitats protected under Bern Convention, Birds and Habitats Directives; priority habitats defined by NBSAP identified based on EUNIS classification system
	Loss, degradation, fragmentation of forest
	Biodiversity hotspots, biological corridors and connectivity
	Direct habitat loss
	Critical habitats
Ecosystem services	Provisioning, regulating, supporting and cultural ecosystem services

Issues	Specific aspects to be considered in EIA for HPPs
	SOCIOECONOMIC ENVIRONMENT
Economic and employment opportunities	Opportunities for individuals' employment on the project
	Creation of new jobs and need for skills development
	Opportunities for local/national business to supply goods and services to the project / worker camps / associate industries
	Impacts on industries like tourism that rely on access to natural assets
	Livelihoods
	Local government revenue and service enhancement opportunities
	Benefit (revenue) sharing with affected communities
Population and demographic changes	Increase in population of communities that host project workforce / resettled
	Decrease in population in areas from where communities are displaced
Community values	Community identity, traditions, customary practices, networks and cohesion
	Community stress, conflict and Impact on law / order arising from project related changes/ activities
	Amenity of areas due to presence of construction activities and construction traffic
Involuntary displacement	Community severance and demographic shifts
	Resettlement and rehabilitation of the affected households
Livelihoods and assets	Access to sources of livelihoods
	Homes, farmland, gardens
	Community buildings
	Common property resources (e.g. traditional grazing, common agricultural farms, community resting place)
	Land and productive resources (may lead to loss of livelihood)
	Availability of infrastructure, facilities, services and utilities (roads, water supply, rural electrification, education, health facilities, etc.)
	Use of water for drinking water supply, irrigation, energy generation, water transport, recreational activities, fishing
Health and safety	Emotional and mental stress caused due to resettlement
	Loss or gain in access to medical and healthcare facilities
	Spread of diseases
	Sanitation, hygiene, water and waste management
	Safety risks from construction activities
	Occupational health and safety risks
Gender	Different experiences of men and women of different social groups of various impacts
	Increased female labour force participation
	Ownership and use of compensation amount
	Land titles for women or joint titles for husband and wife
	Changes to gender roles/responsibilities and norms

Issues	Specific aspects to be considered in EIA for HPPs
Vulnerable, marginalized, disadvantaged, and minority groups/ communities	Specific issues of relevance to vulnerable people, groups/communities
	Poor, marginalized, disadvantaged people, groups/communities
	Migrants and internally displaced persons
Social security	Law and order
Cultural assets	Loss of cultural lands, sites and connection to place
	Traditional lifestyles and cultural practices

Source: Adapted from "Good Practice Note: Environmental, Health, and Safety Approaches for Hydropower Projects".[22]

3.1.4. Defining the scope of EIA

In addition to identifying the specific environmental and socioeconomic aspects to be included in the EIA analyses, the scoping phase also serves to define the spatial and temporal scope of the project's likely impacts. Although the definition of the area of impact can vary for different aspects, the main purpose is to establish in a transparent manner a mutual understanding among stakeholders as to where the boundaries for the EIA study are.

The analyses usually include several dedicated studies: for example, regarding seismology; stability of infrastructure, especially of the dam and diversion tunnel, and detailed geotechnical engineering studies; reservoir failure hazards, hydrological analyses including water flow modelling.

There is therefore no need to carry out similar analyses in the EIA, as the EIA report can refer to these studies and draw on their findings. However, the EIA may also require – in case some EIA-relevant important information is missing or incomplete – studies to be updated or additional studies to be prepared.

Table 2 below provides examples of the key considerations to be taken into account when defining the scope of the EIA analyses.

Table 2. Issues to be taken into account when defining the scope of the EIA analyses

Spatial scope	The area over which the project components are to be established and where physical, chemical, biological and socioeconomic impacts are likely to occur. **Areas to be occupied by the hydropower and associated facilities / ancillary elements** Weir/dam, powerhouse, headrace and tailrace (penstock or tunnel), construction and permanent access and haul roads, site and control office, workers' camp, water source, wastewater treatment facility, aggregate quarry site, concrete batching plant, stockpiles and spoils disposal area, switch-yard or substation, transmission towers and lines, reservoir or retention area behind the dam or the weir, curtailed reach downstream of the dam until well below the tailrace. Of particular importance is the consideration of river downstream impacts (which can be both direct and indirect) – the decision as to how far the downstream section of the river shall be included in the EIA scope requires credible justification. **Direct impact areas** The areas to be disturbed as a result of construction and installation activities of the hydropower project components. **Indirect impact areas** Areas not directly affected by project activities and associated facilities / ancillary elements, but which could potentially experience impacts from the project or may raise community expectations/concerns of such impacts.

22 Good Practice Note: Environmental, Health, and Safety Approaches for Hydropower Projects, IFC, 2018

Temporal scope	Consideration of the evolution of activities over the hydropower project lifecycle (pre-construction, construction, operation and decommissioning) and relating to seasonal variations of physical, chemical, biological and social attributes of the existing environment. **Examples include:** Natural migration patterns of aquatic species; precipitation patterns; community / cultural activities along the river.

The defined spatial area of the likely impacts should be described in the scoping report for future reference, ideally with the use of maps or other visuals. For the socioeconomic issues, it is also useful to define the area of impacts in terms of administrative boundaries (e.g. making a list of potentially affected communities, where surveys will be necessary).

3.2. Environmental and socioeconomic baseline

A well-developed baseline analysis is essential for analysing and evaluating the likely impacts of a project. Collecting baseline information is one of the main tasks for the scoping stage and continues into the preparation of the EIA report. If the project requires screening, initial baseline information should be provided already in the screening application.

3.2.1. Baseline components relevant for HPP projects

The following section outlines key baseline components typically analysed within an HPP-related EIA. The EIA scoping stage establishes what specific data, indicators and analytical approaches are available and suitable in the context of the given project:

3.2.1.1. Physical environment

3.2.1.1.1. Climate

If the HPP includes the construction of a large dam or reservoir, the EIA should address the likely impacts on the local climate. A dedicated study on these effects should be prepared, covering the following aspects: microclimate, interaction between the dam/reservoir and weather events at different scales and the reservoir's cumulative climate effects and associated risk assessment.

As climate variability may have multiple natural and anthropogenic causes that manifest themselves over a wide spectrum of spatial and temporal scales, not all regional climate changes can be attributed to an HPP. Such changes must be distinguished from changes attributable to the HPP itself, which are necessarily limited to the local and regional scale. Therefore, a comparison should be made of the pre- and post-collected data from the meteorological stations close to the HPP with the data from meteorological stations located far from the HPP, that is, not exposed to its influence but still within the same regional climatic context.[23]

If insufficient data are available, it is possible to use publicly available data from reliable sources from all available global gridded climate datasets with temporal coverage in the required range, such as WorldClim – a set of global climate layers with a spatial resolution of about 1 km^2, or climate reanalysis, such as ERA5-Land providing hourly high-resolution information of surface variables – produced by the European Centre for Medium-Range Weather Forecasts (ECMWF), or satellite data.

23 https://www.mdpi.com/2073-4433/12/11/1400/htm

Assessment of the likely secondary impacts, for instance on agriculture, might be carried out qualitatively, although some studies use different satellite-based indices, i.e. by analysing the dynamics of the standardized difference vegetation index (NDVI) of the vegetation before and after the construction of the dam, combined with the measured temperature and precipitation data to explore the driving factors of vegetation changes.[24]

3.2.1.1.2. Climate change and related risks

The EIA should describe climate patterns within the proposed project area of influence (in the catchment and adjacent catchments). The climatological parameters to be reported include air temperature, humidity and evapotranspiration, wind speed and direction, rainfall/precipitation. Data will be used for characterizing existing weather and climate patterns within the study areas and for the hydrologic modelling. Additionally, the recorded locality-specific climate pattern should be discussed in the context of available regional climate-change projections so that climate-related risks related to the HPP can be identified.

Information should be obtained from the nearest weather station(s) or using the regional climate data over a 30-year period minimum average, as recommended by the World Meteorological Organization (WMO).[25] The most current period is preferable, but earlier data might be also acceptable. Secondary sources and actual onsite measurements can also be used. Such information should be presented in statistical analyses covering the maximum, minimum and extreme values, as may be applicable in determining the existing climate condition over the project site and within the area of influence.

Hydrometeorological data can be obtained as a paid service from the National Environmental Agency (NEA). Observations on meteorological elements and weather events are conducted at the stations and posts of hydrometeorological networks. In Georgia, most meteorological observations on climatic parameters began in 1846, soil temperature in 1895 and actinometrical measurements in 1904. A paper archive is stored in the Agency's archive. A digital archive contains historical data since 1881. The maximum number of observation points was during the period from 1960 to 1970 (up to 260 observation points in total). The number of observation points has dropped dramatically since the 2006 network optimization. Since 2010, installation of automatic weather stations and posts has started with meteorological elements measured each hour. In total, 120 meteorological stations, 118 posts and 96 precipitation gauges operated in the network during the various periods since the beginning of the observations. Currently active are conventional – five meteorological stations and 31 posts (including eight precipitation gauges) and automatic – 84 points with 40 stations and 44 posts (including 7 rain gauges).[26]

As a member of the WMO, Georgia periodically provides the organization with meteorological observation data for global deployment. Characteristics of the essential climatic variables, including air temperature and atmospheric precipitation, based on the information provided by NEA, for all meteorological stations in Georgia, which are obtained in the Agency's databases and have passed the relevant quality control procedures, are available through the European Climate Assessment and Database Project.[27]

A project needs to be assessed against an evolving environmental baseline. An EIA should demonstrate an understanding of how the changing baseline can affect a project and how the project may respond over time. This task can be approached on several levels of complexity and the required scope of this analysis should be defined during the scoping consultations, while taking into account the size of the project (both in physical and financial terms) and availability of relevant climatic data. Ideally the existing climate-change projections (from experiments performed with General Circulation Models (GCMs) and Regional Climate Models (RCMs)) should be employed. If these are not available for a given territory, the likely future trends of relevant hydro-climatic parameters can be estimated based on the historical data – local observations or global gridded datasets.

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24 https://www.sciencedirect.com/science/article/abs/pii/S0048969722020265

25 https://community.wmo.int/en/world-climate-programme-wcp#:~:text=The%20World%20Climate%20Programme%20(WCP)%20primarily%20aims%20at%20enhancing%20climate,for%20Climate%20Services%20(GFCS)

26 https://nea.gov.ge/

27 https://www.ecad.eu/download/millennium/millennium.php

In order to assess the climate-change signal above observed climatic variability, the characteristics of future climate should be assessed over a period of at least 20 to 30 years (near future) and ideally beyond (far future, i.e. 50 to 70 years from the project construction). It is recommended to incorporate climate-change projections from the Intergovernmental Panel on Climate Change (IPCC), regional and national agencies or organizations, into the assessment of existing climate conditions on site to determine any potential effects throughout the duration of hydropower operations. These could include existing, authoritative and preferably peer-reviewed analyses or reports such as the following:

- IPCC Fifth Assessment Report (IPCC AR5)[28]
- Fourth National Communication of Georgia under the United Nations Framework Convention on Climate Change[29]
- Climate-Change Strategy of Georgia for 2030 and the 2021–2023 action plan[30]
- Georgia's Updated Nationally Determined Contribution (NDC)[31]
- Climate Risk Country Profile: Georgia[32]
- Georgian Road Map on Climate-Change Adaptation.[33]

Also included should be any other relevant adaptation strategies and policies, and academic journals. An initial review at the national level should be followed by a more detailed assessment focusing on the project area.

3.2.1.1.3. Hydrology

The baseline information should include the following:

- Description of the catchment area, its shape and slope
- Delineation of river systems (i.e. major river and tributaries) and its geomorphology (i.e. river cross-section, depth and substrate type)
- Seasonal flows (e.g. velocity, volumes, duration of high and low flows, timing, frequencies, predictability) based on historical measurements or modelling
- Sediment loads and sedimentation rates along the river channel.

Most of the hydrological and sediment data for Georgia are available up to the 1990s. A digital archive of historical data contains data since 1928 (on suspended sediments). However, only data on river water levels and (calculated) discharge data for up to 460 hydrological posts since 1935, as well as current period observation data, are available in digitalized form. There are active 18 non-automatic and 51 automatic hydrological gauges, and 5 manual posts (with long-term streamflow data) measuring water discharge. At the automatic posts, only water levels and temperatures are measured. Streamflow is measured by expeditions, and data for the current period are basically derived from the rating curves.

A significant expansion of the hydrological observing network has recently (2021–2022) been implemented at NEA and this expansion is continuing.

Flow measurements and morphological conditions should be described in representative reaches of the river to be affected by the hydropower project, as well as in important tributaries if any, such as upstream of the tail of the reservoir, at the reservoir site, at the proposed weir location, in the dewatered reaches, and a few sites downstream of the proposed powerhouse and tailrace locations.

Flood risks without the project should also be described particularly downstream of the proposed hydropower facilities (dam or weir and powerhouse). These risks can be established using historical evidence of high flood and lean flow as per experience of local people, flood marks, etc. and using secondary sources, or through flood modelling.

28 https://www.ipcc.ch/assessment-report/ar5/

29 https://unfccc.int/documents/271341

30 https://matsne.gov.ge/ka/document/view/5147380?publication=0

31 https://eiec.gov.ge/Ge/Topics/Documents/10/

32 https://climateknowledgeportal.worldbank.org/sites/default/files/2021-06/15836-WB_Georgia%20Country%20Profile-WEB.pdf

33 http://sd-caucasus.com/en/projects/project_item/202

The hydrology-related analyses in EIA typically rely on hydrological modelling conducted as part of the HPP feasibility studies and other project documentation. The purpose of an EIA is not to replicate such a complex exercise but to verify its key assumptions and acknowledge the potential uncertainties and margins of error associated with predicted changes in the water regime.

In this context, the following outputs/parameters should be examined:

- Spatial and temporal distribution of the upstream water sources that feed river catchment in total and at the project site
- Rivers mean annual flow at project site
- Maximum mean monthly flow at project site
- Mean monthly flow at project site
- Minimum mean monthly flow at project site
- Probable maximum flood at project site
- Headworks/spillway design flood
- Minimum flow of river / minimum flow during low water season.

As future hydrological characteristics may also be affected by the future likely consequences of climate change, it is recommended to analyse the streamflow seasonal distributions based on climate-change scenarios.

3.2.1.1.4. Watershed and erosion

The watershed relevant to the hydropower project should be delineated and drawn in a map, including the subwatersheds. Also, the presence of other relevant projects and activities within the watershed should be indicated. The EIA baseline should also include a description of recent trends and changes in general land cover (e.g. forest to agricultural) and built-up areas and other human activities within the watershed.

The vulnerability of the project area to soil erosion and landslides should be analysed, namely through compiling existing records of erosion trends and hotspots, in combination with identifying areas with steep slopes prone to erosion or landslides on topographic maps, while considering other factors such as the status of vegetation cover.

3.2.1.1.5. Water quality

Baseline information should include an analysis of the water quality in waterbodies within the area of influence. The sampling should include the standard set of parameters such as water temperature, pH, dissolved oxygen, total dissolved gasses, total dissolved solids, total suspended solids, salinity, biological oxygen demand, chemical oxygen demand, total and faecal coliform, alkalinity, hardness and chloride. Based on the scoping analysis, additional parameters can be included to reflect site- or watershed-specific risks (e.g. heavy metals, nutrients, pesticides, oil and grease).

Baseline information on groundwater quality within the area of influence should also be included in the EIA. And if the groundwater is being utilized by the local communities for drinking, baseline conditions should also be compared against applicable national drinking water quality standards.

For springs and/or aquifers located in areas that could be affected by project activities, measurements or estimates of the discharge volumes should be recorded. It is important to acknowledge the presence of any aquifer within the alignment of the proposed tunnelling works, as well as any springs that could potentially be affected by access roads, quarries, heavy vehicle movement, construction camps or any associated infrastructure, ancillary facilities, or other project-related activities.

The location, seasonal flows and water quality of springs and groundwater wells being relied on by local communities for consumption or livelihood support should be described thoroughly in the baseline studies so that unintended or unexpected impacts after project implementation can be identified.

A water-sampling plan should consider the location of the project components that will be installed. It should include both upstream and downstream sections around any discharge point: e.g. construction camps and any other ancillary facility that may generate wastewater; upstream and downstream sections of the tunnel expected to potentially discharge water coming from tunnel boring, blasting or excavations; and other relevant sections of the reservoir, dam, and tailrace and on the upstream and downstream sections of major tributaries and the confluences with the river within the project's area of influence. Sampling frequency should consider monsoon and winter seasons.

In conducting baseline water quality analysis, the implications of seasonality for the observed water regime should also be considered.

3.2.1.1.6. Geology and geological hazards

General geological features within the area of influence should be described in the baseline section, including structure and morphology. Maps showing general geological attributes may be referred to. Special geological features protected by the national government or by customary laws[34] should also be identified in this section.

The vulnerability of the project area to geohazards, including subsidence, liquefaction, landslides, flooding, and mud or debris flow, should be included in the EIA.

Proximity of project components to active faults should be described and indicated in maps. The location of these faults, in relation to the proposed location of the dam and hydropower facilities, should be described.

3.2.1.1.7. Sedimentation

Reduced flows in rivers resulting from weir or dam construction may potentially lead to sediment build up and hindrance to natural sediment movement along the river channel. Baseline studies should establish sediment load at specific sections of the river where key hydropower facilities will be established.

Sediment retention upstream from the dam or weir may generate sediment deficient river flow downstream (the phenomenon known as a 'hungry river'), which may cause significant riparian erosion downstream of the dam or weir. Sedimentation risk and sediment load assessment are key components of engineering studies for an HPP. The EIA baseline analysis should reflect the findings and demonstrate good understanding of the potential significance of the sedimentation issue and its implications for other environmental issues. Additional data could be gathered as part of the EIA process through field observations and photo-documentation, and, if needed, also through an additional sediment sampling at strategic locations along the river stretch where the key components of the hydropower plant will be established.

3.2.1.1.8. Land use and land cover

The EIA should document existing land use as well as describe land-use trends within the area of influence. General trends and changes in land use and cover in the upstream watershed will inform other components of the baseline analysis – related to hydrology, sedimentation and socioeconomic analyses.

The analysis shall include a project georeferenced drawing superimposed over the topographic map indicating potentially sensitive areas such as downstream communities, agricultural land and forests, relevant infrastructure (e.g., roads and bridges) and sites of cultural significance.

3.2.1.1.9. Air quality and noise levels

Existing air quality conditions prior to the development of the project should be determined through air quality monitoring within the direct impact areas, particularly near sensitive receptors (e.g. urban areas, residential areas, natural parks).

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34 According to Blacks's Law Dictionary (2007), which is referred to the UNEP Law and Environment Assistance Platform (UNEP-LEAP) website (see https://leap.unep.org/knowledge/glossary/customary-law), it is the 'Law consisting of customs that are accepted as legal requirements or obligatory rules of conduct; practices and beliefs that are so vital and intrinsic a part of a social and economic system that they are treated as if they were laws'.

Air quality parameters and scope of the monitoring (i.e. number of sampling stations, air quality sampling time and test methods) should be determined during the scoping phase, based on the requirements of national legislation and consultation with the relevant authorities.

Noise-level measurement should be conducted to establish the existing ambient noise levels at nearby sensitive receptors to generate a baseline for assessing any changes in background noise levels that might potentially impact nearby sensitive receptors during the project's construction and operational phases. The location of the measurement points should consider both the HPP site as well as the transport routes (in particular those planned to be used during construction phase).

Noise levels and hourly restrictions

Any existing noise pollution close to or exceeding national standards should be recorded for future reference. Noise levels should not exceed 55 decibels (dB) during the hours 08:00 – 19:00, 50 dB during 19:00–23:00, and 45 dB during 23:00 – 08:00 in areas directly adjacent to multi-storey (>6) residential houses and cultural, educational, administrative and scientific institutions. Noise levels in residential areas with low-rise buildings, medical facilities and children and social-service facilities should not exceed 50 dB during 08:00 – 19:00, 45 dB during 19:00–23:00, and 40 dB during 23:00 – 08:00.[35]

3.2.1.1.10. Landscape

The EIA should demonstrate an understanding of the visual character of existing physical conditions within the area of influence and describe visually prominent landscape components or values, structures and other existing infrastructures likely to be affected by the hydropower project.

The landscape and visual amenity analysis could be equally relevant for major project components, such as of the dam, reservoir and the powerhouse, but also for the associated facilities such as the transmission lines.

3.2.1.2. Biodiversity and habitats

The EIA should describe at the minimum, baseline conditions on habitats and terrestrial flora and fauna present in the project area; aquatic biodiversity values or ecosystem services such as fisheries or fishing resources, tourism (HHPs are often located in the mountainous regions, which are attractive for tourists), endemic or endangered mammal, bird, amphibians, fish, plants or invertebrate aquatic or riparian species present in the project area; and the status of these species and their populations.

Importantly in the Georgian context, also the presence of localities with special protected status (such as the "Emerald Network" or RAMSAR sites) should be acknowledged even if the actual HPP is located outside their borders. And consistently with applicable international standards, a baseline analysis should cover the surrounding environment of the HPP on a catchment/watershed scale, including tributaries not expected to be affected, in order to establish the presence of critical habitats and key ecosystem services.

The biodiversity section of the EIA baseline analysis should present a comprehensive overview of populations of flora and fauna on the project territory, an overview of habitats (based on the EUNIS habitat classification system), and as far as possible describe existing trends (qualitative and quantitative). The findings should be visualized through thematic maps and other means (digital maps, projects, GIS data).

The analysis should be accompanied by a detailed description of sources of information and methodology, explaining the rationale for relying on a given source of information and acknowledging any data gaps and methodology limitations.

Particular attention should be paid to the description of the design and execution of all field surveys (including sampling methods, duration and periods of field research).

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35 Resolution #398 of the Government of Georgia, 15 August 2017, on approval of the technical regulation on acoustic noise norms in residential houses and public/state premises and their surrounding territories.

3.2.1.2.1. Terrestrial and riparian flora and fauna

The baseline analysis should identify species or habitats of interest (e.g. important to project stakeholders) and species or habitats that are sensitive, vulnerable, or protected species protected under international conventions and agreements (e.g. species protected by Bern Convention, Birds and Habitats Directives), and other endemic, relict or endangered species.

In particular, terrestrial and water (including riparian) flora and fauna within the area of influence should be described; placing special emphasis on semi-submerged plants, as well as mammals and birds that are frequently found in riparian zones.

Anthropogenic influences present within the area of influence should be also documented and described in the EIA. Areas of high biodiversity values regardless of habitat type and level of disturbance should be identified and described.

Maps should be prepared to show the context of the project site in relation to the surrounding vegetation, and ecological communities as well as show survey sites and the location of species and habitats of interest. Designs of any surveys and sampling plans should take into account seasonality (i.e. the wet and dry seasons).

The baseline conditions of the ichthyofauna should be described by the diversity of fish species, determination of quantitative indicators and ichthyo-mass per area unit (taking into account seasonal migrations).

3.2.1.2.2. Aquatic flora and fauna

The EIA should describe all types of aquatic habitats in the area of influence and the flora and fauna present in these habitats that could potentially be affected by the proposal project, including priority habitats defined by NBSAP identified on the basis of the EUNIS classification system. Control sites beyond the area of influence should also be established for comparison with existing conditions and for future monitoring of the project's impacts. Details of the scope, timing (survey season/s) and methodology used to obtain information on the aquatic community and/or habitat within the area of influence should be included.

The identification of sampling locations should consider and include different types of habitats along river reaches (e.g. ponds, ripples, waterfalls, meanders, slow-flowing sections). Information on the importance of species and habitats of interest should include the following: utilization (e.g. spawning, foraging, resting, hiding), level of diversity, abundance patterns, conservation significance and population status, location and extent, susceptibility to anthropogenic and seasonality influences.

Qualitative and quantitative information about macroinvertebrates, including crustaceans, molluscs, and aquatic insects, should be included, as well as information on plankton and periphyton. Amphibians and reptiles present within the area of influence should also be identified, and the level of their dependence on unique habitats within the area of influence should also be described.

The information collected as part of the aquatic flora and fauna baseline should be linked to the baseline information collected – preferably at the same sites – as part of the hydro-morphological, surface water quality, sedimentation and sediment flow baseline data. This will allow for a better understanding of the correlation between physical and biological parameters (e.g. species present and their relationship with temperature, dissolved oxygen, water quality, depth, velocity or substrate type), and consequently enable a better assessment to be made of impacts and mitigation options in the subsequent stages of the EIA.

The following box provides examples of approaches to aquatic flora and fauna baseline sampling:[36]

36 Adjusted from IFC InfraVentures Hydropower Aquatic and Riparian and Ecosystem Services Baseline Assessment, draft, 2016.

BOX 2

Examples of approaches to aquatic flora and fauna baseline sampling

- The study reach can be identified and target species determined by:
- Defining the location of reservoir or impounded area
- Delineating the curtailed reach and the area between the powerhouse and the tailrace
- Mapping out important tributaries within the area of influence, particularly fish spawning sites
- Delineating the area upstream of the reservoir, particularly if the presence of long-range migratory fish has been established through secondary sources or interviews
- Identifying a control reach or area not likely to be affected by the project.

Apart from considering the location of the hydropower dam, powerhouse and tailrace, the location of the sampling stations should consider the characteristic of flows at different sections of the river reach. Ecological characteristics and species richness may vary as a function of habitat types such as ponds, ripples, waterfalls, meanders and slow-flowing sections.

It is important to establish sampling stations that characterize these varying habitats.

For hydropower projects expected to cause a long-term impact on aquatic habitats and ecological values, a full season sampling cycle is recommended covering migration, spawning and other key periods of the fish life cycle. Aquatic biodiversity (flora, fauna and fisheries in particular) requires a robust assessment to establish existing conditions of multiple aquatic taxonomic groups, including fish, macroinvertebrates, plankton, vegetation and periphyton.

The methodology of sampling is determined depending on the taxonomic groups present in the river ecosystem. A combination of several techniques could be possible for particularly diverse or difficult-to-sample taxa groups:

- **Macrobenthos**: Macroinvertebrates, including mainly crustaceans, molluscs and aquatic insects, may be sampled with a variety of gear types including Surber samplers, Hess samplers and D-frame kick-nets. Surber samplers and Hess samplers are operated almost similarly, but Hess samplers are more effective at eliminating sampling contamination from upstream and may therefore be the preferred technique in highly turbid or turbulent conditions.

  Both types are effective for quantitative sampling because the frame of the sampler fits over a known area of stream bottom. D-frame nets are the most portable and easiest to use sampling gear and can be used in the widest variety of habitats, but are the most difficult gear type to use quantitatively.
- **Plankton** are sampled using anchored drift net plankton samplers or other equivalent gear type. The sampler is anchored or swept in an upstream direction. All habitats should be sampled in approximate proportion to their abundance in the sample reach. The number of samples will depend on field conditions, but diverse habitats may require deploying multiple samplers. Vegetation is sampled either visually or using hook, rake, grapple, or other device capable of retrieving aquatic vegetation for examination. Snorkelling can also be performed to establish baseline aquatic vegetation through photographic transects. Consultants are encouraged to use 100 m linear transects for aquatic vegetation surveys depending on practicality in implementing field methods.

- **Periphyton** sampling involves removing representative samples of periphyton from a known area of suitable habitat to be analysed. The USEPA Rapid Bioassessment Protocol (RBP) is one of the most commonly applied and cost-efficient protocols available for sampling periphyton. The protocol includes: (a) sampling a single habitat type at each site, used when periphyton biomass is to be used as a measure of primary productivity and (b) multi-habitat sampling of a range of habitat types at each site, used when periphyton diversity has to be calculated.
- **Fish**. A variety of sampling methods are available, including: gill/trammel, seine fyke (or bongo) cast nets, hand nets and specialized research electroshock equipment. Gill and trammel nets are appropriate for slow and moderate currents without significant amounts of floating debris, which can foul and damage the net. Cast nets are useful for almost all types of flows except for fastest currents. They are particularly useful for sampling isolated pools and eddies in otherwise swiftly flowing habitats that would be difficult to sample with other methods.

  For sampling fish in small rivers and their tributaries, a hand net can be used along with a cast net i.e. a small 1 m diameter water-draining tool equipped with side struts, the main purpose of which is to collect fish under stones and boulders in small, inaccessible and obstructed tributaries. For the determination of quantitative indicators of fish and labour input coefficients, which can also be used as a quantitative evaluation criterion, it is possible to use gillnets and cast nets. The most advanced method of assessment of ichthyofauna in relatively small rivers can be considered the carrying out of research fishing with the use of a special research electroshock device, which allows complete extraction of fish, which then can be safely released back into the environment. It needs to be emphasized that carrying out research by use of gillnets and electroshock devices is subject to special permitting. In order to determine the presence and diversity of fish populations in different specific locations, amateur sport fishing tools can be additionally used – a hand-held fishing rod and a trap. However, in all cases, research fishing should be preceded by a desk study, anamnesis collection (interviewing fishermen) and visual identification of habitats to determine the study area and the optimal period (season) of research in advance.

Case example – monitoring for the HPP in Türkiye

Source: Integra Consulting

For a hydropower project in Türkiye, monitoring of fish and other aquatic groups has been carried out to describe the current state of fish populations and species composition, changes in species distribution in the area after construction and surveillance of changes in population structure of IUCN Red List fish species and selected flag fish species. A similar approach has been used for other aquatic groups (macrozoobenthos, phytoplankton, phytobenthos and macrophytes). Two field surveys are conducted every year in the first quarter (April/May) and in the third (September). Surveys and samplings are carried out at 10 localities: at three points from the downstream section, two points from the upstream section and five from the reservoir area.

Fish survey methodology includes electrofishing with two practitioners from streams, or using casting nets in deeper parts and gill nets in impounded (reservoir) sections.

At some sampling sites with riverine characteristics, the fishing effort covers all available microhabitats (e.g. ripple, glide and pools) in a stretch of ~100 m along the stream and up to ~3 m from the terrestrial edge of the riverbank in the wadable parts. Gill nets are 1m x 70m of various mesh size (knot-to-knot 38 to 50 mm). At each sampling site gill nets were kept at least 30 minutes underwater.

Samples of benthic macroinvertebrates are collected along a continuous 100 m long stretch of the river littoral zone with the kicking method (Frost et al. 1971) using a sieve of mesh size 500 µm (25 cm x 25 cm) and by manual picking of individuals from submerged objects. An Ekman grab is used for sampling soft bottom sediment in the reservoir.

Phytoplankton and zooplankton samples are collected by plankton net with 45 µm mesh-size. Benthic algae are collected from sediment, stones and plant specimens. The epilithic and filamentous algae are scraped from the surface of the stones and rocks with a brush. Submerged and emergent aquatic macrophytes on the littoral zone are observed and identified during the field study. In order to make detailed taxonomic analysis, macrophytes are collected by hand or grapnels in addition to visual observation from the banks.

Physical and chemical parameters of the water (temperature, salinity, dissolved oxygen, pH, total dissolved solids and electrical conductivity) are measured in situ by a multiparameter probe. A Secchi disk is used to estimate the transparency of the water in the reservoir. Water samples are collected at surface and 5 m below the water surface of the reservoir with a sampler, stored in 1-litre PE bottles and preserved in these containers at 4°C prior to transportation to a laboratory for analysis of chlorophyll a, a nutrient-level indicator.

The monitoring methodology was amended after the first survey in order to adapt the approach to local conditions.

3.2.1.2.3. Fishery

Baseline information should include the identification of important commercial and recreational fishing areas within the likely affected river sections (it is important to consider both direct impacts i.e. at the HPP location, as well as impacts downstream, e.g. due to changed hydrological parameters). Also, species important for fishery present in the likely affected area should be identified and their ecology described, including e.g. reproductive cycles, behaviours, habitat preferences as well as their conservation status. Also, for any migratory fish species, information on their migratory patterns in time (e.g. timing and potential triggers of upstream and/or downstream migration) and space (e.g. waterways used for migration including the main stream or river and tributaries in the project area) should be included.

The report may also include information on the catch volumes and their trends. Any baseline sampling should consider the high- and low-water season (which also applies to biodiversity surveys in general).

3.2.1.2.4. Natural and critical habitats

Hydropower projects may potentially have significant impacts on natural and/or critical aquatic or terrestrial habitats, including biodiversity hotspots, biological corridors and connectivity. For terrestrial habitats this may be particularly relevant in areas to be inundated or as a result of construction of access roads, either due to direct habitat loss or to blockage of circulation or connectivity of important biological corridors.

Similarly, in the case of aquatic and riparian habitats, impacts can be related to direct habitat loss as a result of impoundments, loss of longitudinal and lateral instream habitat connectivity from weirs or reduced flows, and/or as a consequence of the modification of water and sediment flow patterns. In the case of critical habitats, the focus must be placed on habitats protected under the Bern Convention Birds and Habitats Directives (listed in the Bern Convention Standing Committee resolution #6), and priority habitats defined by NBSAP and identified based on the EUNIS classification system.

As part of the EIA, the baseline study should include in-field surveys that consider seasonal data, and the sampling has to be conducted by competent professionals and external experts as necessary, especially if the project site involves natural and critical habitats. In-field surveys and assessments should make use of recent data acquired within the proposed location of the project facilities, including related and associated facilities, and the project's area of influence. The baseline studies should also be informed by literature reviews and initial desktop analysis.

Following the provisions of the Bern Convention and EU-Georgia Association Agreement, Georgia is obliged to apply the EUNIS37 system of classification of habitats. This system has been developed by EEA and is used throughout Europe (including the Emerald Network) and adapted to Georgian ecosystems.[38] The EIA baseline analysis should therefore present its findings in a manner consistent with this international standard.

3.2.1.3. Socioeconomic conditions

To gain a good understanding of the communities likely to be affected, the EIA should develop a detailed socioeconomic profile for the social area of influence. The social baseline should profile any groups that may be differently impacted or be more vulnerable to the effects of the project due to various factors (e.g. gender, age, socioeconomic status).

For compiling a socioeconomic baseline, the analysis should rely on available published data, ideally complemented by other sources, which may also include direct surveys among likely affected populations. Not only can the surveys provide important data and information, but they can also be considered as part of the consultations within the EIA. As these may be used for informing the local population about the proposed HPP project, it may help to identify the views on the potential impacts and/or mitigation measures. Field surveys should be designed to address the issues identified in the scoping phase and to reflect the nature and scale of a given hydropower project, the target population, and the expected nature and magnitude of socioeconomic impacts.

The sample size for the household survey should reflect the purpose of the analysis. It can range from a full census (i.e. every household) in cases of the population being impacted by involuntary resettlement (such a survey is typically implemented as part of the Land Acquisition, Livelihood Restoration and Involuntary Resettlement Action Plan (RAP). In cases where resettlement is not involved, the sample size for the household survey should be defined during the scoping, combining the following approaches:

- Random sampling – identifies a subset of a statistical population in which each member has an equal probability of being chosen
- Spatial sampling – based on estimating the scope of project impacts, severity of socioeconomic impacts, capturing a representative sample
- Selective sampling – targeted at affected people of special interest (e.g. fishers).

Information to be included in the socioeconomic profile obtained through desk research and field surveys is suggested below and should be specified in the EIA scoping phase.

37 The European Environmental Information Observation Network (EIONET). European Environment Agency (EEA)

38 Habitats of Georgia. NACRES. 2018.

A population profile of all communities located within the social area of influence should be developed to capture information about key demographic characteristics, including the following:

- Total population
- Population growth
- Age distribution
- Gender distribution
- Education levels, access to the educational institutions
- Migration / demographic movement
- Family and household structure and size
- Occupation and income
- Sources of livelihoods
- Land/home ownership, tenure and construction type and material used
- Household assets
- Religious practices
- Ethnicity
- Health conditions including sanitation, drug/alcohol use and other relevant factors.

Although some of this information may be available from secondary data sources, a significant amount of information will need to be collected through community surveys. When compiling baseline data and conducting baseline analysis, the following issues may, depending on the HPP context, deserve particular attention.

3.2.1.3.1. Gender

Ensuring the participation of women in the surveys should be a key consideration. Women participating in the survey can often feel more comfortable when being surveyed by females and it is therefore important that the survey team include women, as well as persons who can also speak the local language. The survey questionnaire should be designed to capture information related to household structure, roles, relations and responsibilities, i.e. to produce sex-disaggregated data.

3.2.1.3.2. Vulnerable groups

The baseline should document and map the location and demographic profile (including population, gender, economic/livelihoods, education, health, cultural aspects) of any likely affected vulnerable groups.

3.2.1.3.3. Health

The baseline should include information about relevant health conditions of the potentially affected population, prevalent diseases, status of any waterborne or airborne diseases, level of health care available and access to health facilities, including distance from communities.

3.2.1.3.4. Economy and livelihoods

The local and regional economic context should be described, including economic sectors particularly dependent on water – such as fishing, agriculture, tourism, navigation – and those related to land loss or access when significant land acquisition and/or physical and economic resettlement is expected. This may include activities funded by the Government, the private sector and international development agencies. In addition, the income status of households and other measures of the economic status of the likely affected population should be described.

3.2.1.3.5. Employment and labour implications

Data on the existing labour force in the likely affected territory should be gathered, including, for example, level of employment, unemployment levels, skills base, current work practices and pay rates for different typical occupations. Information about existing employment opportunities in the region should be described, including an estimate of the proportion available for local communities, along with access to skills development, training, and small business development in local communities. Similarly, possible impacts, both positive and negative, of the project-related labour influx should be considered.

3.2.1.4. Other aspects

The EIA baseline should also collect and map information and data on the broader underlying conditions of the potentially affected region and communities including tangible and non-tangible assets that may be affected by the HPP development.

3.2.1.4.1. Services and facilities

The following information should be collected and mapped:

- Built assets or physical capital, including houses, community buildings, schools, clinics, religious buildings, emergency response facilities, access roads and bridges
- Social and institutional capital in terms of governance and legal structures within the villages, health and educational capacity (e.g. teachers, nurses, doctors), patterns of land ownership, tenure and use
- Water supply and sanitation, including domestic water supply, access to sanitation by household, and irrigation
- Land assets or natural capital, including agricultural fields (irrigated and rainfed), seasonal cropping patterns and yields, forests (community managed and production forests), timber and fruit trees
- Livestock and animal husbandry, including but not limited to the numbers and different types of animals (cattle, buffalos, sheep and goats, pigs and poultry)
- Fisheries and aquaculture resources, including but not limited to the types of fishing, boats and equipment used and seasonal patterns of production and yields
- Other patterns of natural resource use, e.g. mining, ecotourism.

3.2.1.4.2. Land tenure/titles

The baseline should identify and document the status of land use – residential, agriculture, commercial – and land ownership/tenure and titles for individual households as well as for community assets, especially where land acquisition would be required for locating a project's associated facilities/ancillary elements and for the reservoir and at locations where the resettlement would occur. It should also include the status of non-title holders, encroachers and squatters.

3.2.1.4.3. Social conflicts and security

An overview of the issues that could represent a risk of social conflict or relate to the security of the likely affected population, should be identified and described. This includes issues related to land rights/tenure issues, political tensions, tensions between villages and local groups, pressure on existing resources, and loss of traditional practices (e.g. changes to fishing, gardening, hunting, common property resources, community forestry). Historical information should also be included for relevant issues, including the population groups involved, and any past, current or proposed activities (e.g. government interventions) that could reduce social conflict and increase security.

3.2.1.4.4. Cultural assets

A dedicated analysis or survey of the cultural assets (both material and non-material) connected to the area of influence should be identified at the scoping stage. This includes inventorying or mapping historical objects, archaeological areas, and location of religious facilities (e.g. places of worship), as well as identifying important cultural events, activities, norms and values that can be related to the potentially affected area, including the river itself.

3.2.2. Baseline checklist

The following overview of typical baseline indicators and their rationale for EIA can be used as a generic set and/or checklist for preparing an EIA baseline analysis and presenting it in the EIA report. The matrix does not represent any complete or obligatory set of indicators, but rather a model representation of issues and topics. The actual set of baseline parameters needs to be adjusted to fit any specific HPP EIA process.

Table 3. Typical baseline indicators

Environmental issue	Typical parameters	Data sources/ methods of collection	Rationale for EIA
PHYSICAL ENVIRONMENT			
Climate, climate change and related risks	• Temperature • Precipitation • Humidity • Evapotranspiration • Wind direction	Records for nearest weather station(s) regional climate data over a 30-year period[39] Climate-change projections; Climate building codes and construction climatology norms[40]	To establish existing weather and climate patterns within the study area To use in hydrologic modelling To identify climate-related risks
Watershed	• Topography/ geomorphology • River cross section at the project site • Depth and substrate type • Overall description of the catchment area including the shape, slope, size, land use/cover, soil. • Key natural resources • Distinctive topography • Soil erosion potential	Topographic maps Land use maps Field observations Digital elevation model (DEM) Land use-maps Remote-sensing data Aerial photographs Satellite images Literature, surveys Soil loss estimation Measurement of degraded land area as shown on maps Soil erosion potential maps	To describe the catchment area and its key characteristics Terrain features of the catchment serve as basic background information for defining the area of impacts as well as serving as input to all issue-specific analyses To provide input for the hydrological and sedimentation analyses To provide input for the socioeconomic analyses (to identify drivers of land-use change) To identify potential conflicts over resources or encroachment on land use
Reservoir characteristics	• Reservoir area • Reservoir length • Reservoir volume • Reservoir live storage • Reservoir dead storage • Dead storage available for sediments above intake • Reservoir draw-down height • Reservoir boundary and appurtenant structures (e.g. dam/barrage/diversion structure, powerhouse)	HPP project technical documentation including geospatial data (e.g. ESRI shapefiles)	Project description section of the EIA report To provide input for hydrologic and hydraulic modelling, and other issue-specific analyses

39 https://www.ecad.eu/download/millennium/millennium.php

40 Order 1-1/1743, 25 August 2008, of the Minister of Economic Development on approval of construction climatology norms. The norms are available free of charge, while the NEA, except for learning and research purposes, provides climate data as a paid service. (https://matsne.gov.ge/en/document/view/2465275?publication=0). However, it needs to be noted that, although legally valid, the norms are outdated, most of data being the same as in the climate reference books, issued in the period 1965–1970.

Environmental issue	Typical parameters	Data sources/ methods of collection	Rationale for EIA
Geology, geomorphology, soils	• Rock and soil types • Geological formation and structure, lithology, attitudes of beds and discontinuities, etc.	Geological maps, engineering geological maps Aerial photographs Geotechnical investigation information contained in the HPP technical documentation	To establish the baseline information for evaluation of natural hazards and input for the safety engineering design criteria To provide input for the natural hazards assessment (evaluation of the site-specific risks, such as seismic activities, GLOF, slope stability, soil erosion)
Hydrology	• Spatial and temporal distribution of the upstream water sources that feed river catchment in total and at the project site • Rivers mean annual flow at project site • Maximum mean monthly flow at project site • Mean monthly flow at project site • Minimum mean monthly flow at project site • Probable maximum flood at project site • Headworks/spillway design flood • Minimum flow of river • Minimum dry season flow	Project feasibility study typically contains information on streamflow data used for investigating hydropower potential Daily streamflow data (e.g. upstream of the weir or dam, downstream of powerhouse, and midstream of weir/dam of powerhouse) shall be considered If not available, use suitable methods to calculate streamflow (e.g. rainfall-runoff method) Records of historical floods during extreme weather conditions and occurrence of other extreme hydrological events should be included	To describe baseline streamflow characteristics at key relevant sections of the river establishment To provide input for hydrologic and hydraulic modelling of instream flow changes To provide input for analysing aquatic habitats characteristics and water quality data
Sedimentation	• Sediment load analysis at project site	Determine sediment load concentration at selected relevant sections of the river in relation to proposed location of the hydropower facilities (i.e. weir, intake structure, powerhouse, etc.)	To provide input for the hydrologic and hydraulic modelling to characterize river flows and aquatic habitat and future scenarios when hydropower plant becomes operational
Water quality	• Temperature • pH • Dissolved oxygen • Total dissolved gasses • Total dissolved solids • Total suspended solids • Salinity • Biological oxygen demand • Chemical oxygen demand • Total and fecal coliform • Alkalinity • Hardness • Chloride	Records from the water quality monitoring systems (if measuring stations or sampling points are located in the area of influence) Dedicated site-specific water quality sampling. Sampling protocols must be elaborated in accordance with applicable standards.	To set the water quality baseline as a reference point for assessment of HPP impacts To establish water quality of identified source/s of (drinking) water supply in project camps and construction sites

Environmental issue	Typical parameters	Data sources/ methods of collection	Rationale for EIA
	Based on the scoping analysis, additional parameters can be included to reflect site- or watershed- specific risks: • Heavy metals • Nutrients • Pesticides • Oil and grease • Others		
Air quality	• Nitrogen oxides (NOx) • Carbon monoxide (CO) • Sulphur oxides (SOx) • Particulate matter (total suspended particulates, PM10, PM2.5) • Other locally relevant parameters such as volatile organic compounds (VOCs) and benzene	Ambient air monitoring to verify compliance with applicable standards Measurement, analysis with calibrated equipment	To set the baseline for air quality monitoring during the construction to ensure compliance with the ambient air quality limits around construction sites
Noise	• Ambient noise level – equivalent sound level – Leq	Background noise maps if available In situ measurements with calibrated equipment	To establish baseline ambient and equivalent noise levels to assess whether construction and operational activities of hydropower development are likely to impact nearby sensitive receptors
Landscape	• Landscape values and visual character of the area of influence • Visually prominent landscape components or values, structures and other existing infrastructures	Map of landscape / landscape values Visualization of the project including associated infrastructure	The EIA should describe visual character of existing physical conditions within the area of influence and identify any describe visually prominent landscape components or values, structures and other existing infrastructures, which are likely to be affected by the hydropower project (including also the associated facilities such as the transmission lines)
BIODIVERSITY AND HABITATS			
Flora (terrestrial and aquatic)	• Forest type / Forest management type • List of major plant species (protected species including species protected under international conventions and agreements, species protected by Bern Convention, Birds and Habitats Directives listed in standing comity resolution #6 of Bern convention, other endemic, relict or	Field investigation, sampling, inventory and identification Herbarium collection and identification Interview with local community Site visit and observation CITES and IUCN lists	To establish baseline data throughout seasonal variation and using secondary references and identify potential impacts of the hydropower project on flora To examine opportunities for mitigation and offsetting of potential negative impacts

Environmental issue	Typical parameters	Data sources/ methods of collection	Rationale for EIA
	endangered species, non-timber forest products) • Aquatic plants • Invasive species • Agro-biodiversity • Vegetation cover • Medicinal plants		
Habitats	• Habitat types and occurrence • Wildlife corridors • Biodiversity hotspots • Protected areas and ecological network sites (the Emerald Network or RAMSAR site, UNESCO World Heritage Site)	Habitat mapping based on EUNIS classification system	To examine opportunities for avoiding, mitigation and offsetting of potential negative impacts To examine negative impact on the integrity, structure and function of a certain protected area or international ecological network
Fauna (terrestrial)	• Types of wildlife (including mammals, herpetofauna, entomofauna, reptiles, and their migration corridor) • Avifauna (including migration patterns, particularly along/across project sites) • Protected, endemic species	Field investigation using traps/nets, use of pellets, and appropriate techniques Interview with local communities Site walkthrough and observation (e.g. pug marks) Secondary data and CITES and IUCN lists	To establish baseline information on terrestrial fauna To examine opportunities for mitigating and offsetting potential negative impacts
Fisheries and aquatic ecology	• Fish catch and species overview • Fish migration along river and its tributaries • Aquatic habitat status or existing conditions • Macro invertebrates including crustaceans, molluscs, aquatic insects • Plankton and periphyton	Fish sampling Interview with fishermen Secondary data Field observation Meso-habitat survey Surber sampler Plankton net Site-appropriate fishing or netting techniques	To establish baseline data throughout seasonal variation To consider migration patterns in defining project area of influence Input for mitigation measures design (e.g. need for and design of the fish ladder)
Ecosystem services	• Overview of ecosystem services and natural resources	Interviews with communities Field observations Research of water-related ecosystem services, in particular the use of water for various socioeconomic purposes	To identify assets potentially affected by the HPP To describe and quantify the likely impacts on biodiversity and ecosystem services (it is advisable to express the likely loss of biodiversity in financial terms and calculate restoration/compensation expenses)

Environmental issue	Typical parameters	Data sources/ methods of collection	Rationale for EIA
SOCIOECONOMIC CONDITIONS			
Demography	• Population distribution (age, sex, religion, population growth, migration patterns) • Typical family and household size • Ethnic composition, minority groups • Vulnerable and marginalized groups (i.e. migrants, refugees) • Gender (Changes to gender divide/roles, differences in education, occupation, and income, single-headed households)	Census data Municipality profile Household survey Focus group discussion Key informant interviews	To identify stakeholders To provide a baseline for evaluating impacts assessment input for identifying potentially affected people (PAPs) for Resettlement Action Plan, etc. To establish existing conditions and identify opportunities to engage women in project development and enhance benefits to vulnerable groups
Houses and settlements	• Total households • Types of houses and • settlement pattern • Houses status, materials used for construction • House ownership • Average household size	Census data Cadastral data Site visit and observations Focus group discussion Satellite images	To determine location of sensitive receptors, and project-affected households within the project area of influence
Education	• Number and type of educational institutions • Enrolment details • Literacy rate • Educational status (according to level of degree and age)	Census data Municipality profiles Household survey Interview with stakeholder groups School records	To determine level of education of project-affected population and identify potential and capacity to be employed during project development To assess potential benefits project may bring to the region/communities
Health	• General health condition of population • Status of communicable and non-communicable diseases • Key area-specific • Public health determinants • Sources and access to safe drinking water • Sanitary infrastructure (sewage treatment and disposal)	Census data Municipality profiles Consultation with Public health authorities Household survey Interview, site visit, and observations	To establish existing baseline conditions and identify avenues to prevent spread of communicable diseases during project implementation To include input on the assessment of impacts on public health
Waste management	• Existing (solid) waste management and disposal practices (e.g., landfill sites) • Hazardous waste management practices	Municipality profiles Municipal waste management plans Household surveys Interviews, site visit and observations Focus group discussion	To establish existing waste management practices and identify options for properly managing and disposing of wastes during construction and operation phase To identify risks of contamination due to HPP impacts (e.g. contamination due to dumpsite inundation)

Environmental issue	Typical parameters	Data sources/ methods of collection	Rationale for EIA
Physical /community infrastructure	• Status of road and bridges • Existing power sources and facilities • Drinking water supply • Market establishments • Industrial sites • Irrigation infrastructure and water uptake points • Wastewater treatment and discharge	Municipality profiles Information from: water supply and wastewater treatment companies Georgian Amelioration Roads Department Georgian State Electrosystem Interview and conduct of focus group discussion Secondary sources	To establish baseline information to identify potential impacts on physical infrastructure To identify potential for HPP-related compensation and enhancement programmes (and investments) within the area of influence
Economy and livelihood	• Sources of income and livelihood • Employment • Land ownership and tenure • Livestock practices • Poverty status	Municipality profiles Census data Household surveys Interviews, site visit, and observations	To establish existing baseline conditions of project-affected population within the area of influence and identify potential opportunities to improve and support livelihoods, especially of those to be affected (e.g. resettled).
Water use	• Water abstraction and use (agriculture, industry, domestic use, etc.) • Water use rights • Water user groups • Observations on upstream and downstream water uses (e.g. rafting, swimming, household uses)	Municipality profiles Statistical data Household surveys Interview, site visit and observations	To establish river water users/ uses to be able to assess potential impacts on these user groups and opportunities for them to benefit from the project
Culture	• Languages used • Cultural and archaeological sites • Funeral sites and graveyards • Traditional places of worship and rituals • Traditional lifestyles and practices and knowledge • Common property resources (e.g. traditional grazing, hunting, collecting herbs)	National protection monuments database Information from the Ministry of Culture, Sports and Youth Walkthrough Survey Focus Group Discussions	To establish baseline data and assess potential impacts on cultural heritage, vulnerable groups, their lifestyle and determine opportunities to preserve or enhance cultural assets

Source: Based on Hydropower Environmental Impact Assessment Manual.[41]

41 *Hydropower Environmental Impact Assessment Manual*. Ministry of Forests and Environment, Nepal, 2018. https://lib.icimod.org/record/35838

3.3. Assessment of impacts

In these EIA steps, the likely impacts of the specific HPP projects on the key environmental and health issues, identified in scoping, are analysed. The impacts are assessed by dedicated specialists (i.e. EIA consultants) through estimating the likely effects of project-related activities (both individually and in combination) on the previously established environmental baseline. The impact analysis should consider all the phases of the project – pre-construction, construction, operation (and maintenance) and decommissioning.

Where possible, the likely impacts should be quantified. If this is difficult or impossible, methods that allow systematic estimates and comparison of the likely impacts should be used (this may include, for example, rating techniques). For each likely impact identified, the following typical parameters should be described:

- Nature (positive, negative, direct, indirect, cumulative)
- Magnitude (significant, moderate, low)
- Scope/extent (area/volume affected, spatial distribution, local, regional, national)
- Timing (i.e. at which stages of the project the impacts will occur)
- Duration (short-term, long-term, intermittent, continuous, temporary, permanent)
- Reversibility (reversible, irreversible)
- Likelihood (probable/improbable, certain/uncertain).

The experts carrying out EIA can use numerical evaluation of the above parameters (e.g. from +2 to -2), which should be accompanied by a verbal description and explanation.

The following sections provide an overview of typical HPP-related impacts, which can serve as a benchmark or checklist for developing the EIA.

3.3.1. Pre-construction phase

The main source of impacts during the preparatory phase is land acquisition (both permanent and temporary) and site preparation. Also, the pre-construction phase may include the preparation/signing of the lease agreement with landowners where temporary facilities will be established (e.g. laydown areas, campsites, water/ wastewater treatment plants, temporary storage areas for used oils or waste). The likely impacts will be mainly on socioeconomic and cultural issues.

Table 4. Impacts during the pre-construction phase

Issues	Potential impact	Assessment approach
Social	Physical and economic displacement Community conflicts induced by the project Influx of workers	Semi-quantitative: inventory of potentially affected people and assets, estimation of direct and indirect costs, identification of non-financial impacts
Health	Public health and well-being effects of psychological stress from the project	
Economic	Loss of land and related livelihoods, Short and long-term employment opportunities. Impacts on housing and accommodation	
Cultural	Loss of cultural heritage	Semi-quantitative: inventory of cultural heritage objects and non-material aspects, which may be affected, estimation of direct and indirect costs, identification of non-financial impacts

The pre-construction phase is typically not associated with a physical impact on the natural environment (with the possible exception of activities such as geological surveys). However, effects on the social and economic environment and related well-being of local communities can be potentially significant.

The assessment of these impacts typically involves combining quantitative and qualitative analyses of likely changes in the baseline triggered by the HPP implementation. Directly measurable impacts such as loss of agricultural or forest land, loss of buildings and infrastructure due to reservoir area inundation and other project-related developments must always be expressed quantitatively. At the same time, however, all such results must be accompanied by a clear judgement of their significance (e.g. information on what proportion of the total community agriculture land will be lost, how large a part from the total settlement area will have to be relocated).

Where relevant, impacts in terms of assets lost should also be expressed in financial terms to provide a basis for the future implementation of mitigation and compensation measures. It is therefore important to account for both permanent as well as temporary loss of assets and livelihoods (i.e. due to land occupation by the construction camp, provisional access roads and other temporary facilities). The financial evaluation of the affected assets (e.g. building to be removed, agriculture land to be inundated, assets to be lost in case of dam failure)[42] should reflect the usual market values in a given location and region. However, the financial compensations should also consider the replacement costs, should the resettlement be necessary.[43]

IFC Guidance Note 5 on "Land Acquisition and Involuntary Resettlement" (2012)[44] defines the replacement costs as follows:[45]

- Agricultural or pasture land: land of equal productive use or potential, located in the vicinity of the affected land or the new housing site (for resettled population), plus the cost of preparation to levels similar to or better than those of the affected land, and transaction costs such as registration and transfer taxes or customary fees. In situations where blocks of replacement land are identified in areas not immediately adjacent to affected land, the difference between present and potential land use should be established to ensure that replacement land is of equivalent potential. Typically, this requires an independent assessment of land capacity and/or carrying capacity (e.g. soil surveys, agronomic capability mapping). Compensation for affected land with land of less productive potential may prevent the restoration of livelihoods and require a higher cost of inputs than prior to displacement. Land-based compensation strategies are the preferred form of compensation for agriculturally based households.
- Fallow land: market value of land of equal productive value in the vicinity of the affected land. Where value cannot be determined or land for land compensation is not feasible, in-kind communal compensation is recommended.
- Land in urban areas: the market value of land of equivalent area and use, with similar or improved infrastructure and services preferably located in the vicinity of the affected land, plus transaction costs such as registration and transfer taxes.
- Houses and other structures (including public structures such as schools, clinics and religious buildings): the cost of purchasing or building a replacement structure, with an area and quality similar to or better than those of the affected structure, or of repairing a partially affected structure, including labour, contractors' fees and transaction costs such as registration, transfer taxes, and moving costs.
- Loss of access to natural resources: The market value of the natural resources which may include wild medicinal plants, firewood, and other non-timber forest products, meat or fish. However, cash compensation is seldom an effective way of compensating for lost access to natural resources and every effort should be made to provide or facilitate access to similar resources elsewhere, thereby avoiding or minimizing the need for cash compensation.

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42 The IFC Performance Standards (https://www.ifc.org/content/dam/ifc/doc/2010/2012-ifc-performance-standards-en.pdf) and related Guidance Note (https://www.ifc.org/content/dam/ifc/doc/2010/2012-ifc-performance-standards-guidance-note-en.pdf).

43 Resettlement is not just for physically displaced households but also for those that are economically displaced, i.e. have lost assets that contribute to their livelihoods, e.g. land or access to the means of production (EIA Guidance for Large-Scale Hydropower in Pakistan, IUCN Pakistan, 2014).

44 https://commdev.org/wp-content/uploads/pdf/publications/IFC-Guidance-Note-5-Land-Acquisition-and-Involuntary-Resettlement.pdf

45 Text slightly adapted.

The role of an EIA is mainly to identify the likely directly and indirectly affected assets and stakeholders. It may also indicate the relevant costs, while a detailed financial evaluation usually follows the standardized mechanisms, which considers – as mentioned above – the usual market values in a given locality and/or the region. In practice, the issue of compensations often requires long-term negotiations between the affected people, investor and political representation. To ensure the transparency of this process, it has to be described in the EIA (in the EIA report, the Environmental and Social Management Plan, and/or in the Resettlement Action Plan) including the details on the methodology of the financial evaluation, and be a subject of stakeholder consultations.

BOX 3

Case example: Raising the Mangla Dam (Pakistan) – compensations for resettlement[46]

The Mangla Dam was completed in 1967 on the Jhelum River with a total installed capacity of 1,150 MW. The original dam was 138 m high and over 3 km long, with a reservoir of 251 km2 and storage capacity of 5,560 m^3. Over 280 villages and the towns of Mirpur and Dadyal were submerged and over 110,000 people were displaced from the area.

The Mangla Dam Raising Project was started in 2004 and the main dam, spillway and its allied works were completed in 2009. This project raised the dam height by 9.15 m to 147 m, thereby affecting about 44,000 people, 6,388 hectares of land, with the inundation of 8,000 houses, as well as affecting economic values and livestock.

These impacts were mitigated through a Resettlement Action Plan, which included a highly attractive and unprecedented compensation package. The main benefits included land/house compensation at market value and allotment of land for rebuilding houses in a new city and four towns, which were being developed with modern infrastructure and basic amenities.

The resettlement cost was approximately US$ 578 million, which was about 60% of the total cost of the project.

For less tangible impacts, such as the generation of employment opportunities or effects related to social cohesion or public health, the assessment typically focuses on the identification of risks, while relying on the expert opinion(s) informed by EIA-facilitated stakeholder consultations.

3.3.1.1. Consideration of climate change

In addition to addressing potential environmental impacts the EIA shall also review key relevant assumptions made by the HPP planners regarding the future effects of the climate change on the project and its broader context. Such considerations shall be ideally made already as a part of the feasibility study along with hydrological modelling and other essential analyses. However, it is for the EIA to verify its adequacy and to compensate for its shortcomings, if necessary. Key features of such analysis are outlined below:

Assessment approaches and methods

For each vulnerable project component requiring further climate-change analysis, the EIA should assess how climate change and its impacts may affect the project component, and the potential consequences of these effects for related environmental components. Each estimate should be accompanied by a characterization of uncertainty and level of confidence in the estimate.

46 Adapted from the EIA Guidance for Large-Scale Hydropower in Pakistan, IUCN Pakistan, 2014.

Baseline information on weather and climate will be used in hydrological flow modelling to assess impacts on changes in stream flows, as well, in extreme events to calculate the design floods for a hydropower project. Design floods and safety check floods are usually derived from flood frequency analyses and/or from Probable Maximum Flood (PMF) assessments.

It is recommended that the climate-change vulnerability assessment include the development of a representative hydrological model of the catchment. The model should be run for a suitable range of future climate scenarios to estimate changes in the net runoff from the catchment based upon input climate data and physical catchment characteristics.

For hydrologic, hydraulic and most other modelling efforts, overlap in temporal coverage is needed in all available datasets of precipitation, temperature, streamflow, land use, etc. For Georgia, the period of streamflow record will be the limiting factor for modelling efforts. The last 30 years of data is available only for few sites, however, as it is a common practice, design of hydropower projects might be based on data for the period 1961–1990, since for this period data of reasonable quality is typically available.

Also, for the same period, mean annual runoff map determined using results from a spatially distributed hydrological model that simulates the water balance for the entire land surface of Georgia and upstream areas in neighbour countries is available through the project 'Institutional Cooperation between Ministry of Energy and the National Environmental Agency of Georgia, and the Norwegian Water Resources and Energy Directorate (NVE).[47]

Flood frequency analyses are statistical methods that allow assessment of the magnitude of floods of a given return interval based on analyses of observed (or simulated) samples of flood events. In order to assess the impact of climate change on flood frequencies, a flow series of at least 30 years needs to be simulated by a continuous hydrological model. PMF estimates are based on a deterministic concept where the Probable Maximum Precipitation (PMP) is determined and then transformed into the PMF by a precipitation-runoff model. To account for future climate conditions, the PMP calculation requires a meteorological approach (e.g. as described by WMO, 2009[48]) which allows for varied meteorological parameters that might be affected by climate change.

If low resolution in hydro-meteorological data which does not allow the creation of a continuous hydrological model in at least daily time steps and/or larger ensembles of RCM projections is not available, then a simplified approach with a monthly step hydrological model and/or a limited number of scenarios should be selected. If limitations in the data set make it impossible to set up and calibrate a hydrological model, regression models and historical climate analogies can be applied.

In addition, it is recommended to use appropriate tools to carry out climate risk screening, including information on the following:

- Evaporation and evapotranspiration. (Since 2015 to 2020 hourly reference evapotranspiration data from 19 AWS of National Food Agency (NFA) network calculated based on the Penman-Monteith equation, exists at NEA database).
- Sedimentation (if available) – suspended sediment discharge data from 100 hydrological posts of various lengths exist at NEA from 1928 to 1980. There is no electric archive. Currently no longer measured.
- Glaciology/permafrost (where applicable) – records, trends and historical events related to glaciers and glacial hazards or permafrost in the catchment and adjacent catchments (relevant studies and documentation from the recent past for the region, country, river basin or at site level).
- Natural hazards – Is the site downstream, exposed to or close to any natural hazards (e.g. geological hazards, earthquakes, avalanches, debris flows, landslides)? Information on hydrometeorological hazardous events (e.g. avalanches, strong winds, snowstorms, heavy rains, thunderstorms, hail, drought, flash-floods, mudflows) occurrence (location, time, duration) and impacts for the last 60-years period is collected and available at NEA, annual statistics are published by the National Statistics Office of Georgia.[49]

47 https://www.nve.no/international-cooperation/georgia-institutional-cooperation-between-georgia-and-norway/

48 https://library.wmo.int/index.php?lvl=notice_display&id=1302#.YOxdO-gzaUk

49 https://www.geostat.ge/en/single-categories/109/environment

The resulting estimates should be presented in a way that is relevant and understandable to stakeholders and decision-makers. Where there is quantitative information, the following types of summaries should be presented, where possible:

- Mean values and variances or spreads on the estimates
- Confidence intervals of the estimates
- Ranges of the estimated values noting possible extreme values in particular
- Full probability distributions of the estimated impacts.

Where the estimates and uncertainties are measured qualitatively, they can only be described and presented with considerably less precision, and the following types of summary descriptions should be provided:

- Description of the central tendency of the baseline condition, together with any possible variation away from the central tendency
- Ranges of the estimate, such as "low to medium" (when imprecise, qualitative terms and descriptors such as "low", "high", or "significant" are used, the basis underlying their particular application and the meaning of the term needs to be clearly explained).[50]

Tips for practice

For each environmental component that could be moderately to highly affected by climate change in each phase of the project, the EIA should project the future baseline condition of the component as it may be affected by climate change, to the extent possible, using quantitative approaches to assess the effects of climate change on priority project components. Each estimate should be accompanied by a characterization of uncertainty and level of confidence in the estimate.

(a) It is recommended to identify worst cases to consider, based on observed climate trends, plausible climate-change scenarios. Review climate-change projections of relevant variables, such as the annual averages, seasonal variability, or changes in monthly maximum and minimum values of precipitation and temperature. As mentioned in the section (2), as a minimum, use at least two different Representative Concentration Pathways (RCPs) (e.g. 4.5 and 8.5) and a minimum of two future 30-year time periods (most relevant to the project and asset lifetime), considering the 10th, 50th and 90th percentile change values (e.g. a reduction in precipitation) from the full range of the latest models.

(b) Communicate climate-change results with uncertainty range. In climate projections, main sources of uncertainties are (i) the internal variability, (ii) the scenario uncertainty and (iii) the model uncertainty. The IPCC uses a likelihood scale based on a probabilistic assessment of some well-defined outcome that may have occurred in the past or may occur in the future.[51] The use of return periods and of changes in return periods aims to attach probabilities or changes in probabilities to extreme weather events.

There exist a number of methods inferring probabilities for different conditions related to climate change. One of them involves counting the number of climate and impact models in which the event occurs and constructing a probability distribution based on the frequency of occurrence. Another approach to estimate probabilities at the project level is the Monte Carlo-type simulation based on climate scenarios, climate sensitivity and local change projections. This method can be used to produce probability distributions for changes in temperature and precipitation based on climate-change projection scenarios. The climate data generated through Monte Carlo simulations[52] can then be used for impact assessment models, such as rainfall-runoff models, to generate probability distributions of climate-change impacts.

Considerable progress has been made in the area of climate change and infrastructure vulnerability and risk assessment. The 'Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment' aims to help improve the way in which climate change and biodiversity are integrated in EIAs.

50 https://climateriskinstitute.ca/wp-content/uploads/2019/09/BestPracticesForConsiderationOfEffectsOfClimateChangeInProjectEAs2017.pdf

51 https://www.ipcc.ch/site/assets/uploads/2017/08/AR5_Uncertainty_Guidance_Note.pdf

52 See New and Hulme (2000) and New et al. (2007) for more details.

'Environmental, Climate and Social Guidelines on Hydropower Development' by the European Investment Bank summarizes best practice recommendations for integrating social, biodiversity, natural resource management and climate considerations into hydropower projects. The 'Hydropower Sector Climate Resilience Guide' by the International Hydropower Association (IHA) has been developed to help hydropower practitioners manage the risks of climate change.

Construction phase

During the construction phase, the most direct physical impacts occur in connection with activities such as:

- Site preparation including removal of topsoil, drilling and blasting in foundation areas
- Establishment and operation of ancillary and associated facilities (access road, construction power supply line, camp site, storage yard, quarry site, crusher plant, batching plant, etc.)
- Construction of the dam or weir, intake structure, tunnelling, trenching for pipeline, powerhouse, etc.
- Quarrying of construction materials, processing, storage, and transport of these materials to the construction area
- Earthworks at various sites for ongoing construction
- Generation of spoils or excess excavated materials
- Regular heavy equipment movement
- Installation of electromechanical equipment.

Such project activities will likely have a vast array of potential impacts on the physical and chemical environment, as well as on biodiversity and socioeconomic conditions. The assessment of these impacts relies predominantly on the project documentation for the localization and quantification of construction operations, which are confronted with the environmental baseline for identification risks of direct or indirect negative impacts.

In addition to the potentially significant in situ impacts, the EIA should also take into account project-induced impacts occurring outside of the defined area of impact. This can include, for instance, impacts related to sourcing of the construction materials (e.g. impacts from off-situ rock quarries, emissions related to the production of cement and construction steel, transportation).

3.3.1.2. Physical and chemical factors

Table 5. Impact assessment approaches during the construction phase – physical and chemical factors

Potential impact	Assessment approach
Changes in site geomorphology as a result of dam or weir construction, including access roads	Qualitative description of key changes, visualization
Hydrological changes (diversion during construction, filling the reservoir)	Throughout description of envisaged flow changes including time-schedule
Land use change resulting from conversion of, for instance, agricultural lands	GIS analysis and impact quantification and visualization
Soil pollution and degradation (contamination by used chemicals and spills)	Identification of site- and activity-specific risks and hazards
Inducement of soil erosion and sedimentation due to removal of top soil, excavation of trenches, opening of access roads, quarrying activities, foundation preparation, and other construction activities	Identification of vulnerable locations

Potential impact	Assessment approach
Dust generation and vehicle emissions and increased traffic affecting air quality (e.g., dust particulate matter, NOx, SOx)	Estimation of changes compared to baseline measurements. Identification of vulnerable localities, comparison with the applicable air quality standards (a need for a full air pollution dispersion study is established during the scoping stage)
Water pollution and contamination (both surface and groundwater) due to spills, deposition of wastes, spoils handling, wastewater, siltation and construction site drainage discharge, etc.	Identification and localization of risks of accidental spills, drainage discharge points, sensitive recipients. Spatial localization. Description shall include spatial information (i.e. map) as far as practicable Potential effects of seasonal changes in hydrological conditions shall be taken into consideration as relevant for the risk identification
Impacts on aquifer, springs, or general hydrogeological conditions due to excavations and other terrain modifications (e.g., tunnel and access road constructions)	Description of risks and likely effects. Quantification of impacts on water resources capacity as far as possible
Slope destabilization due to site preparation activities, during access road construction, weir or dam construction, and establishment of powerhouse	Mapping vulnerable locations, estimation of scale and risks of potential slope slides or other movements
Generation of excavated materials and spoils	Estimation of volumes of relevant categories of materials, description of handling and temporary in situ deposition
Noise and vibrations from heavy equipment movement and blasting and drilling	Estimation of changes in ambient noise levels compared to baseline measurements. Identification of vulnerable localities, comparison with the applicable noise standards (a need for a full noise study is established during the scoping stage)

3.3.1.3. Biodiversity and ecosystems

Table 6. Impact assessment approaches during construction phase – biodiversity and ecosystems

Potential impact	Assessment approach
Aquatic habitat disturbance due to water diversion and works in the natural river channel	Description of scope of impacts, quantification of area of affected habitats. Description of risks and implications. Indication of reversibility and timescale of recovery, if relevant
Effect on aquatic ecology resulting from changes in water quality during construction activities (increased turbidity and siltation, and contamination due to accidental spill and wastewater discharges)	Description of risks and potential impacts, identification vulnerable species, identification of critical thresholds or time periods particularly sensitive to potential impacts (e.g. times of high temperature/low oxygen levels in river, low-flow/high flow period, spawning season, etc.)
Clearing and removal of vegetation **Disturbance and removal of riparian vegetation**	Description, quantification and localization of vegetation projected for removal
Habitat fragmentation as a result of construction of access roads, weir or dam, powerhouse, above-ground pipeline and associated hydropower facilities	Spatial analysis (GIS) – identification of risks and assessment of impact on key affected habitats in terms of their capacity to retain its ecosystem functionality

Potential impact	Assessment approach
Loss of critical habitats, protected areas, wetlands etc.	Spatial analysis (GIS) – Quantification of loss for critical habitats, identification of risks and assessment of impact on key affected habitats in terms of their capacity to retain its ecosystem functionality
Reduction in biodiversity due to changes in terrestrial and aquatic ecology (e.g. due to reduction of environmental flow)	Description of impacts on key ecosystems and biotopes and likely effects to biodiversity
Impact on endangered, threatened species and their habitats	Description of likely impacts and risks to ecology and populations of relevant species
Poaching, illegal fishing, unauthorized harvesting of wood and other forest products and other illegal encroachment by the project workers or due to project-related improvement of access to the project area	Identification of risks and vulnerable assets
Forest fire due to negligence or unsafe manipulation with flammable materials	Identification of vulnerable localities, assessment of risks as relevant

According to the Bern Convention and the EU-Georgia Association Agreement, Georgia is obliged to apply the EUNIS system of classification of habitats. Established by the EEA[53], this system is used throughout Europe (including the Emerald Network) and has been adopted to Georgian ecosystems.[54]

The EUNIS system enables identification of the habitats and species to be protected (including those to be protected under international obligations) using a unified and internationally recognized approach and assessment of the scale of potential impact on habitats and species.

The EIA report should include detailed information on the species and habitats (based on the EUNIS habitat classification system), as well as describe the likely impacts in qualitative and quantitative terms, using corresponding maps (digital maps, projects, GIS data), including evaluation of the impacts on the "Favourable Conservation Status" of protected habitats, including the so-called biogeographic regions on the national level.

Description of the direct and indirect impacts on the Emerald network sites should include biodiversity (in particular, the species of the EU Birds and Habitats Directives, especially the species protected by Annex IV of the Habitats Directive and Annex I of the Birds Directive and their populations, the relevant habitats for the species protected by Annexes I and II of the Bern Convention according to the EUNIS classification system) and the description of the correspondence of the planned activity with the status of the Emerald Network sites.

3.3.1.4. Socioeconomic environment

Table 7. Impact assessment approaches during construction phase – socioeconomic environment

Potential impact	Assessment approach
Demographic changes to the area and communities (influx of project workers)	Estimation of incoming vs. local workforce, Indication of numbers of project personnel and time scale of their presence
Impacts on housing and accommodation facilities in the project area and adjacent communities	Description of housing condition for the project personnel estimation of capacities required for accommodation and how they will be ensured. Estimation of risks (such as emergence of informal camps and unauthorised settlements)

53 European Environment Agency.

54 Habitats of Georgia. NACRES. 2018.

Potential impact	Assessment approach
Increased demand for social infrastructure and services such medical care, leisure, transportation, in the areas hosting workers	Identification of missing capacities, needs for temporary or permanent infrastructure upgrades
Increased traffic on access roads due to shipment of construction materials and equipment	Estimation of HPP-related and induced transport volumes, Identification of affected roads and estimation of the changes in traffic intensities. Identification of bottlenecks and congestions risks as well as communities and localities particularly affected by the traffic-related impacts (noise, air pollution, time-loss due to congestions, etc.)
Employment and business opportunities local contractors and labour	Estimation of realistic capacity of local labour and businesses to participate in the construction works and to provide support services
Public health risks due to project-related human migration, sanitary conditions on the construction site and accommodation facilities, risk of water borne diseases, and risks associated with contamination. Workplace safety	Estimation of public health risks and availability appropriate mitigation capacities (hospital beds available, emergency system functionality). Identification of vulnerable and sensitive groups
Impacts on community values and civil conflicts between residents and incoming workers, or between interest groups within the affected community. Impacts on public safety	Identification of potential conflicts, vulnerable groups specifically at risk (e.g. women)

3.3.2. Operation phase

The operation phase is typically associated with a host of long-term effects associated with permanent modification of the environment (built new infrastructure such as a dam and reservoir), but also with modifications often radically altering the hydrological regime of the area, including the river flow. From this stem not only changes in the physical and chemical parameters of the downstream river but often far-reaching ecosystem changes and socioeconomic effects. Furthermore, the nature and scope of at least some of these impacts depend on the adopted dam operational practices, which can be changed in response to different natural conditions, or to needs and preferences of the operator.

3.3.2.1. Physical and chemical factors

Table 8. Impact assessment approaches during the operation phase – physical and chemical factors

Potential impact	Assessment approach
Changes in hydrological flow regime such as fluctuation in flow rate and water level upstream and downstream of the dam/weir, downstream of powerhouse depending on the purpose of dam/ operational rule	Hydrological modelling, establishment of the environmental flow
Flood risks	Risk assessment, identification of potentially affected area in extreme flows, or dam failure
Changes in downstream river and upstream (reservoir) water quality	Estimation of impacts on key parameters such as turbidly level, dissolved oxygen, total suspended solids, temperature

Potential impact	Assessment approach
Sediment build-up at the reservoir upstream of the weir or dam. Downstream impacts of sediment flushing, and/or sediment loss	Sediment modelling, quantitative estimates of the sediment load
Soil erosion along areas to be inundated, such as upstream of the dam or weir	Identification of vulnerable areas (GIS, geomorphological surveys)
Impacts on aquifer and water bodies hydrologically connected with the project location	Hydrological modelling, identification of risks and vulnerable water resources, hydrogeological surveys commissioned by the project developer
Generation of greenhouse gas from decomposition of biomass from inundated vegetation at dam or weir reservoir	Depending on the HPP scale (relevant only for large reservoirs) – estimation of volume of inundated biomass and GHG emissions

From the above-listed typical HPP-related impacts on the physical and chemical components of the environment, the modification of the river hydrology including flow-pattern changes is the crucial factor determining many of the other direct as well as indirect environmental impacts (including impacts on biodiversity and ecosystems, and socioeconomic effects). The following section therefore provides a summary of the considerations for preparing the analysis of impacts on the flow regime and sediment load.

As mentioned above, the impacts on hydrological and sediment transport regimes vary and depend to a large extent on the type of dam operation. The main features to consider in this regard are summarized in the table below:

Table 9. Hydrological impacts of HPP by operation type

Type of dam operation	Operational practice	Changes in hydrology
Storage reservoir	Stores water in high flow season, discharges higher than normal flows in the low flow season. Filling and discharge follow operational rule curve	Peaks in high flows tend to be reduced Flows in low flow season increased
Run-of-river	Passes the flow of water down the river, with little storage – from a few days to one month storage depending on flow. Most plants have several turbines and can vary the flow to these depending on the flow in the river, thus fewer turbines will be in operation in times of low flow	Little seasonal change in downstream flows
Daily peaking	Plant operated to meet daily peaks in demand for electricity – maybe 8 or 16 hours per day. Flow through turbines may be ramped up and turned down at the start and end of the peak period over a relatively short time (20–30 minutes)	Flow downstream of powerhouse will vary over 24 hours, with minimum flow being released during the night when demand is low, and increasing by an order of magnitude during the day
Base load operation	Plant is operated continuously without daily changes in turbine operation.	No daily variations of flow

Currently, the majority of the EIA reports in Georgia include the criteria table of potential impacts on surface hydrology which is divided into five categories – very low, low, medium, high and very high. Also, the implications during the construction and operation phase are provided in separate sub-sections.

Only a few projects use hydraulic models for water level, velocity, depth and duration changes assessment with different scenarios and operation regimes between the dam and powerhouse (when the powerhouse is not directly downstream of the dam) as well as downstream.

Sediment transport and morphodynamic models have not been applied for the impact assessment downstream of the project site. Such modelling can be recommended for future EIAs. However, if such an exercise cannot be performed (due to time or financial reasons), an indication of expected changes of these parameters has to be provided in the EIA report, together with an explanation of the rationale for the conclusions about the likely impacts.

Regardless of the level of detail and employed methodology for establishing the future flow regime, the obligatory component of any project documentation (reflected in EIA) must be the definition of the environmental flow (e-flow). Currently, there are no national legislative requirements or approved standards concerning e-flow estimation.

Globally, more than 200 e-flow assessment methodologies exist. They are classified into four main categories: hydrological, hydraulic rating, habitat simulation and holistic.

With the support of USAID, the methodology for assessing the environmental flows of the rivers and streams of Georgia was developed[55] in 2017. The methodology provides detailed guiding principles and steps for determining the e-flow. Also, it states that e-flow cannot be defined only on hydrological information and must incorporate morphological, physio-chemical, social and ecological aspects.

The methodology also underlines that the e-flow assessment should be carried out by a multidisciplinary team consisting of experts at least in the following areas: hydrology, morphology, habitat hydraulics, river ecology and the social sciences. Currently, this methodology is not being used in Georgia. Its adoption is envisaged to be introduced once the already prepared draft water law is approved, which is harmonized with EU Water Framework Directive.[56]

International practice shows that the methods and tools for e-flow estimation vary by country. The table below highlights the methods commonly used in different countries in the world.

BOX 4

Environmental flow

Different environmental flow estimation methodologies

Method category	Resolution level	Ecosystem	Time	Cost
Hydrologic	Very low/low	River	Short	Less
Hydraulic rating	Low	River	Short/long	Less/medium
Habitat simulation	Medium/high	River	Medium/long	Medium/high
Holistic	High	Wetland, floodplains	Long	High

55 https://geo.org.ge/wp-content/uploads/2019/02/THE-ASSESSMENT-OF-ENVIRONMENTAL-FLOWS-FOR-THE-RIVERS-AND-STREAMS-OF-GEORGIA-1.pdf

56 Consideration of environmental flow is required by the new draft Law on Water Resources Management that was endorsed by the Government and submitted to Parliament for adoption at the time of finalizing the guidance (spring 2022). According to the draft Law, the methodology for calculating the environmental flow (to be approved by a ministerial order) has to be adopted before the end of 2023.

Commonly used methods/methodologies for e-flow assessment in selected countries/regions[57]

Country/ region	Available guidance/ legislation	Most commonly applied methods/ methodologies	Notes
Australia	Yes	Holistic	Monitoring and adaptive management based on holistic methodologies are commonly used
Canada	Yes	Hydrological/ holistic	An e-flow protocol is determined on a case-by-case basis, along with a public participation decision-making process
China	No	Hydrological	Most applied methods refer to minimum flow estimation
European Union	Yes	Hydrological/ hydraulic-habitat/ holistic	Hydrological approaches are the most commonly applied methods; not all Member States have national legislation on e-flows
India	No	Hydrological	Proposed recommendations for a longer-term e-flow research programme only are available
Japan	Yes	Holistic	Environmental minimum flow is assessed to maintain river functions, which meets maintenance flow for ecological processes and water uses by humans
Latin America	No	Hydrological	E-flow assessment is still referred to as a methodological proposition
New Zealand	Yes	Hydrological	Minimum flows based on proportions of the mean annual seven-day low flow (7-day MALF)
South Africa	Yes	Holistic	The BBM framework can be resource intensive and time-consuming (1–2 years), but a simplified BBM can be applied in situations where considerable data on the river system already exist
Türkiye	Yes	Hydrological	Some 10% of the annual average flow is determined as e-flows to be released from existing and new water abstractions
United Republic of Tanzania	Yes	Hydrological/ holistic	This country can be seen as a leading example for e-flow implementation in Central Africa
United States	Yes	Hydrological/ hydraulic-habitat/ holistic	Hydrological methods are largely applied; the ELOHA framework (Poff et al., 2010) has already been endorsed or applied in several States

The best method for a specific project depends on the amount of resources, data availability and the level of details required. Therefore, the most appropriate methods for the individual project must be decided by the experts involved in the EIA.

57 *Guidance on Environmental Flows – Integrating E-Flow Science with Fluvial Geomorphology to Maintain Ecosystem Services*. World Meteorological Organization. 2019. https://library.wmo.int/doc_num.php?explnum_id=9808

Another important hydrological issue of an EIA for an HPP is a flood hazard and risk estimation for the downstream area of the dam. While dams play an important role in flood risk management, their failure can cause significant economic damage and social impact on neighbouring and downstream areas.

Therefore, dam-break risk analysis must be carried out in accordance with international standards and practices. Inundation and risk maps should then be used as a basis for effective early warning/alarm system and emergency management plan development. Currently, few EIA reports cover these aspects and often dam-break analysis is not included in EIA reports.

There are several methods that are widely used for the assessment of dam breach potential failure mechanisms, including breach parameters and discharge hydrographs, which then can be applied as an input for hydraulic modelling to produce maps of downstream flooding characteristics and inundation areas.

Underestimation of the reservoir sedimentation rate may cause a serious impact on the safety of dams and reduce energy production, storage, discharge capacity and flood attenuation capabilities as well as the lifespan of the dam. On the other hand, the reduction of sediment transport downstream of the dam can lead to river bank and bed erosion, as well as significant channel and adjacent floodplain modification.

The EIA document should refer to sediment studies carried out during the feasibility study phase to provide quantitative estimates of the sediment load transported in the river downstream and trapped by the dam. It should also provide information about the estimated lifetime of the reservoir. Also, the downstream effects and cumulative impacts resulting from the sediment transport pattern changes should be reviewed.

Climate change may have an impact on sediment transport. This is predominantly important for the projects located in the glacier-fed basins, where increasing temperature and glacier retreat may tend to raise the erosion rate, sediment load and accumulation rate. These analyses can be undertaken through a combined climate-hydrological-hydraulic-sediment transport modelling approach.

3.3.2.2. Biodiversity and ecosystems

Table 10. Impact assessment approaches during the operation phase – biodiversity and ecosystems

Potential impact	Assessment approach
Impacts on aquatic ecosystems resulting from altered (reduced) downstream flow	Assessment of changes in flow fluctuation on aquatic and riparian habitats, flora and fauna species. Identification of vulnerable species
Impacts of altered water quality on the ecosystems	Identification of ecosystems and fauna and flora species sensitive to the projected alteration of key water quality parameters (e.g. temperature, dissolved oxygen levels)
Impacts of changes in downstream sediment load and sedimentation and erosion patterns	Estimation of the impacts of modelled changes in the river hydrology and sedimentation patterns on downstream aquatic and riparian ecosystems, estimation of area of lost or severely altered habitats
Creation of new habitats in inundated reservoir	Identification of risks for invasive species
Fragmentation of river continuum, disturbance of wildlife migration patterns	Identification of vulnerable species and likely effects on their populations
Impacts on aquatic fauna and flora populations	Identification of potential risks and vulnerable species
Effects on terrestrial wildlife and avifauna	Identification of potential risks and vulnerable species, including consideration of impacts of supporting infrastructure (e.g. power-lines, roads)

Potential impact	Assessment approach
Disturbance of wildlife due to increased human presence and noise from power generation machinery and other activities	Identification of vulnerable species and likely effects on their populations
Contamination from waste, oils and other chemicals used in the operations and maintenance of the HPP	Identification of pollution sources and risks

The above list of typical potential impacts is by no means exhaustive; however, it points out several key considerations necessary for any EIA to capture adequately the HPP impacts. Namely, the EIA should describe the likely impacts on the biodiversity hotspots, and natural and critical terrestrial, aquatic and riparian habitats, including any potential barrier effect on identified ecological corridors.

Also, it should as far as possible quantify any envisaged vegetation removal and other habitat loss, in terms of its proportion to the remaining extent of the corresponding habitats in the affected area. The transparent description of the scale of impacts then can provide a basis for assessing the significance of the described impacts for a given ecosystem and its ability to continue supporting the associated biodiversity.

The assessment of the potential impacts on fish species diversity and abundance has to take into account the situation on both upstream and downstream reaches. It has to address issues such as obstruction to fish movements and migration caused by the project structures and/or by the alteration of the river flow regime, loss of suitable species-specific habitats such as gravel beds and in-channel wetland areas, and loss of access to suitable spawning sites. Similarly, the modification of the river flow regime may affect the natural cues (e.g. flow, velocity, temperature) for upstream and downstream migration.

The biodiversity assessment component of the EIA ought in particular to evaluate the impacts on species considered protected under national legislation and/or registered as threatened (IUCN Red list: Endangered (EN) or Critically Endangered (CE)). The EIA should include an assessment of their population within the area of influence and describe how they will be impacted by the various components of the project, and whether this may cause a significant reduction of the local population or even trigger a change in the overall conservation status of the species.

3.3.2.3. Socioeconomic conditions

Table 11. Impact assessment approaches during operation phase – socioeconomic conditions

Potential impact	Assessment approach
Demographic changes due to HPP-related developments	Estimation of long-term effects on migration, economic opportunities, urban development and other relevant factors – to establish if HPP may trigger a major demographic change in adjacent communities or not
Impacts on livelihoods of downstream communities that rely on the water resources tapped by the project	Survey in downstream communities to identify water resources potentially affected and their role in livelihoods of the users
Impacts on fisheries	Estimation of economic impact due to expected changes in populations of relevant species to both subsistence and commercial fishing (if any). Establish baseline for future monitoring of long-term impacts (e.g. volume of catch for key species)
Changes in the volume of water released may impact the safety of downstream communities that may use the water course	Identification of downstream safety risks due to water level fluctuation (e.g. for the local navigation, swimming, river-crossing). Mapping high-risk areas or locations

Potential impact	Assessment approach
Impacts on recreational use and on tourism	Description of expected changes and identification of risks and opportunities for tourism
Changes in property values	Estimation of expected changes with help of expert opinion (e.g. property market analyst) and examples from similar context
Impacts on irrigation and other water use	Describe and quantify impacts on supply-demand of irrigation water and other water diversion and extraction demands (current and projected). Verify its consistency with maintaining of reliable e-flow
Dam safety and flood risks	Modelling of flooded areas for different high flow scenarios (including overspill and partial or complete dam failure) and identify vulnerable areas (e.g. urban areas, sensitive infrastructure)

In terms of socioeconomic impacts, the EIA for an HPP usually focuses on several distinctive groups of issues. Its key responsibility is to correctly identify all potentially affected people and evaluate their assets to be lost or affected in the course of the HPP implementation.

Secondly, the assessment should provide an estimation of broader socioeconomic costs and benefits for the communities and businesses in the project area in order to adjust the project as far as possible to minimize risks and maximize benefits for all stakeholders. Such analysis can entail, for example, an estimation of effects on the local labour market, energy system, tourism sector and housing market.

Thirdly, the EIA should take stock of risks related to the facility's operational safety and identify any inadequacies or missing arrangements to address any significant emergency related to dam failure and flooding.

3.4. Addressing the likely impacts and monitoring

The role of EIA – besides identifying and describing the likely impacts – is to propose how these impacts should be addressed i.e. what measures should be applied to avoid, mitigate or compensate the likely impacts, and how the impacts should be monitored during the implementation of the project (including all its phases).

From the procedural point of view, the requirements regarding the measures to avoid, mitigate or compensate the likely impacts, and monitoring should be included in the environmental decision, and its implementation should be supervised by the Environmental Supervision Agency.

3.4.1. Measures to avoid, mitigate, or compensate for likely impacts

Following the assessment of likely environmental and social impacts, the EIA presents adequate measures to control and manage all identified impacts. In general, managing impacts consists of benefit enhancement/augmentation and adverse impact mitigation measures. At the broadest level, site selection is the single largest determinant of environmental impacts. Careful site selection thus can be understood as the most effective measure to minimize negative impacts. Conversely, if the chosen site is unsuitable, it is unlikely that other subsequent mitigation measures can fully address generated negative impacts. The second important factor is then the size and type of the HPP. In general, a distinction can be made between the reservoir/storage dams and run-of-river schemes. While the second type may avoid some of the typical impacts associated with the creation of large river reservoirs, it is by no means certain and the environmental costs and benefits of any given design should be judged only in the context of the HPP-specific location. Also, a number of the impacts during the operation of the HPP can be effectively avoided or mitigated by an appropriate operation plan / operating conditions (in particular impacts associated with a change of the water regime).

In practice, however, the EIA study is often carried out when the decisions about the location and key design features of the project have been already taken. Unless the EIA analyses reveals some critical but up to that point disregarded circumstances (such as the presence of an unknown population of a critically endangered species) the possibility to mitigate identified environmental impacts through changing the HPP location or radically altering its design is typically not available (the Strategic Environmental Assessment – SEA, ideally conducted earlier on, in the phase of sectoral or watershed planning, would be much better positioned to make recommendations in this regard).

3.4.2. Typical mitigation measures

Measures employed to prevent, mitigate, or compensate negative environmental impacts are tailor-made in response to the findings of the previous EIA analyses. The following table provide a generic overview, which can be useful to start with when considering available mitigation options for any given project.

Table 12. General overview of mitigation measures

Impacts	Mitigation measures
Involuntary displacement	Resettlement of displaced, including provision of new housing, replacement lands, and other material assistance. Consultation and participatory decision making on the part of the resettled and host populations is necessary.
Loss of livelihoods	Loss of income or other livelihoods derived from fisheries, agricultural or grazing lands, or other resources should be mitigated through providing as far as possible adequate similar resources, and other income restoration assistance (e.g. employment, job training, productive assets).
Loss of cultural heritage	Where feasible, tangible objects of cultural value should be salvaged following a scientific inventory and documentation in order to be preserved in museums or other facilities. However, large structures, as well as unique or sacred sites with religious or ceremonial significance to local people usually cannot be replaced.
Loss of natural habitats	Vegetation rehabilitation, restoration of the original habitat type, offsetting lost habitats.[58] Compensatory protected areas can be established and managed under the project to offset the loss of natural habitats due to reservoir creation or other reasons. The offset area protected under the project should be of comparable or greater size and ecological quality to the natural area lost.
Loss of terrestrial wildlife	Wildlife relocation efforts rarely succeed, and can be justified only in exceptional circumstances (suitable protected habitat available, high conservation value of concerned species). Development of compensatory protected areas offsetting the lost habitats is more effective.
Deterioration of water quality	Water pollution control measures (such as sewage treatment plants or enforcement of industrial regulations in the broader reservoir watershed) may be needed to maintain/improve reservoir water quality. Reservoir pre-inundation clean-up, include selective vegetation removal within the impoundment area should be completed before reservoir filling.

58 Georgian legislation includes regulations concerning felling of individual trees or forest stands which stipulate monetary compensation for extracted trees. In addition, compensatory tree planting has been required in some cases, e.g. with the ratio of 1:3 (that is, planting three trees for each one extracted) for non-protected species and the ratio of 1:10 for species included in Georgia's Red List. However, it is not recommended to apply this approach for the critical habitats – planting trees in a new area will at best help maintain the balance of total forested area in general terms, but by no means should it be considered as an adequate mitigation for the loss of natural habitats. Even with the best planning it will take years before the newly planted forest will start functioning as a forest ecosystem and wildlife habitat.

Impacts	Mitigation measures
Downstream hydrological regime changes	Managed water releases Water release management shall be designed to ensure balance between: (a) adequate downstream flow to maintain viable conditions for riparian ecosystems, (b) reservoir and downstream water levels sufficient for fish survival, (c) maintaining reservoir and downstream water quality, (d) needs for irrigation and other human uses of water, (e) flood protection, (f) recreation (e.g. boat operation) and (g) power generation. The water-release pattern shall as far as possible reflect the natural flooding regime to minimize ecological disruption. The established minimum e-flow parameters shall be respected by the dam operation management plan.
Fish and other aquatic life	Managed water releases consistent with maintenance conditions for the survival of concerned fish species in and below the reservoir. HPP infrastructure can create a significant barrier to fish movements and can also selectively injure or kill fish as they pass. Fish passage (fish ladders, elevators, or trap-and-truck operations) and diversion facilities, allowing migratory fish move upriver past the dam, may mitigate the negative effects on fish population caused by construction of dams and other infrastructure. Many types of fish passes have been developed over the last few decades to allow fish to move upstream past a dam. The selection of the appropriate restoration and mitigation measures depends on a number of site-specific considerations and often have to be decided on a case-by-case basis. It should be also mentioned that the effectiveness of such measures is often limited to only a few species and is further complicated due to lack of safe downstream passage for many adult fish and fry. Many studies show that only a small proportion of fish populations can benefit from such supportive structures, and some species can disappear completely as a result of the HPP construction in spite of mitigation efforts, which may include significant investments in fish passes and hatcheries.[59,60,61,62] Accordingly, modern approaches used in the European Union and other countries such as the United States or Canada prefer measures to avoid, and, if possible, remedy significant adverse effects rather than take mitigation measures.[63] Since only the use of fish passes and fish diversion is not efficient enough, it is also necessary to plan and implement compensatory measures. In order to maintain populations of natural species, fish hatcheries and fish-stocking programmes can be applied. For these purposes, fish species are reproduced in hatcheries, where the necessary conditions for spawning and the development of fry are ensured by maintaining appropriate environmental conditions (e.g. water temperature, oxygen concentration in water), an adequate supply of fish food and protection from predators. Fish hatcheries and fish-stocking programmes can conserve declining natural populations, increase fisheries opportunities and provide ecological and economic benefits. The hatcheries can be useful for maintaining populations of native species that can survive but not successfully reproduce within the reservoir, an option often used for economically important species. The introduction of non-native species on economic grounds must be avoided. Fish-stocking measures should be implemented according to the fish-stocking plan that should be prepared on the basis of the assessment of the scale of the negative impact of the HPP on ichthyofauna as a result of ichthyological and hydrobiological studies, taking into account the conservation status and bioecological value of fish species. Introduction/adjustment of fishing regulations might be important to maintain viable populations of commercially valuable species (e.g. to prevent net fishing immediately below a dam where migratory fish species concentrate in high numbers and are therefore easy to catch).

59 Brown, J. J., Limburg, K. E., Waldman, J. R., Stephenson, K., Glenn, E. P., Juanes, F. and Jordaan, A. (2013b) Fish and hydropower on the U.S. Atlantic coast: failed fisheries policies from half-way technologies. Conservation Letters 6: 280-286.

60 Larinier M. & Travade F. (2002). The design of fishways for shad. *Bull. Francais de la Peche et de la Piscicult*. 364, 135-146.

61 Oldani N.O. & Baigun C.R.M. (2002). Performance of a fishway system in a major South American dam on the Parana River (Argentina-Paraguay). *River Res. Appl*. 18, 171-183.

62 Mallen-Cooper M. & Brand D. (2007). Non-salmonids in a salmonid fishway: what do 50 years of data tell us about past and future fish passage? *Fish. Manage. Ecol*. 14, 319-332

63 Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment (Article 5) and Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Article 2 and Article 6).

Impacts	Mitigation measures
Reservoir sedimentation	Watershed management can limit sedimentation and extend the reservoir's lifespan (controlling land-use and specific activities such as mining, agriculture and forestry in the upper catchment area to reduce erosion and subsequent sediment flows into reservoir). Installation of sediment management structures (barriers and sediment traps and protecting dam outlets) as well as active removal of sediment deposits through flushing or mechanically are further mitigation options.
Greenhouse gas emissions	Relevant only in HPP with large reservoirs. Avoiding inundation of forest and other areas with high volumes of biomass and a proper pre-inundation reservoir clearing reduce the volume of GHG emissions.
Impacts of associated infrastructure	New access roads and power lines sited in corridors to minimize environmental and social impacts. Forests and other environmentally sensitive areas along the road corridor may receive legal and physical protection. Road design to ensure drainage to protect waterways and minimize erosion. Power lines shall minimize cutting through unfragmented forest areas, and bird-friendly tower design and proper spacing of conducting wires shall be ensured to minimize impacts on large birds. Quarries and borrow pits should be sited within the future inundation zone. Where this is not feasible, pits should be rehabilitated (e.g. for conservation purposes such as wetland habitats).
Off-site impacts by contractors	Environmental rules for contractors (including penalties for noncompliance) should cover construction camp siting, gravel extraction, waste disposal, water pollution, workers´ behaviour (e.g. no hunting, no open fire), compliance with project-related road and traffic management plan, and other good practices for construction.
Induced development	Follow-up developments shall be taken into account as far as possible when evaluating potential cumulative impacts within the EIA, namely where a plausible link between the HPP and other envisaged developments can be established (e.g. irrigation projects utilizing water from the reservoir, planned industrial facility utilizing the HPP electricity).

Source: "Hydroelectric Power – A Guide for Developers and Investors".[64]

3.4.3. Environmental and Social Management Plan

The proposed measures are typically assembled in a logical system – Environmental (and Social) Management Plan (ESMP), which is a detailed plan of actions to be undertaken throughout the project development process to ensure sound environmental performance.

Each proposed mitigation measure must be described in a manner allowing for its practical implementation. Certain mitigation measures constitute a complex arrangement consisting of a number of actions and requiring the participation of numerous actors.

Such mitigation measures should be set out in the form of issue-specific management plans, e.g. Waste-management Plan, Reservoir Clearance Plan, and Drainage and Erosion Control Plan. These management plans form autonomous sections of the ESMP, but can be used as self-standing documents to be followed by the relevant actors during the project execution.

If the actual technical details for an individual mitigation measure cannot be yet specified during the EIA, the ESMP should clearly indicated when and how the missing information will be completed.

Possible structure of the ESMP with a dedicated section for each project development phase:

A. Brief description of the HPP

B. Anticipated Environmental and Social Impacts

64 Hydroelectric Power – A Guide for Developers and Investors, by Fichtner Management Consulting AG, IFC, 2015.

C. Mitigation Measures

1. Pre-construction phase
   - Preparing a land acquisition process and community development programs for compensation of affected communities and individuals
   - Adjustments of the project design to minimize negative impacts (e.g., Powerhouse structure should be designed to avoid excessive noise with regard to the nearby sensitive receptors such as terrestrial fauna and households)
2. Construction phase
   - Confinement of construction and concreting works within designated areas of key project components to avoid downstream river contamination
   - Reservoir clearance (vegetation removal, clean-up of potential contamination sources)
   - Implementation of specific management plans for construction related environmental issues, such as:
     - Disposal of wastes (construction wastes, hazardous and contaminated wastes, etc.)
     - Dust and noise generation control
     - Erosion prevention and control plan
     - Workers and community safety protocols
     - Transport and traffic management (including vehicle speed limits, road signages installation, etc.)
   - Installation of appropriate fish migration-aiding measures (for the locally identified migratory fish species)
   - Workforce management (workforce accommodation, code of conduct and safety training)
   - Community liaison (to maintain a relationship with the community and address complaints)
   - Emergency response plan for the project
3. Commissioning/operation phase
   - Rehabilitation of the construction site
   - Slopes stabilization with appropriate technique/methods
   - Restoration of community livelihoods of downstream communities affected due to the changes in the water resources
   - Implementation of the community development programs (verification of effectiveness after the initiation of the operations phase, benefit sharing arrangements, etc.)
   - Safety and warning systems for the dam and in the downstream areas
   - Operation of fish migration system
   - Watershed conservation measures (e.g. establishment of forest nursery for reforestation, conservation programmes for affected species)
   - Implementation of environmental flow releases to support identified ecological values of in-stream river ecosystem
   - Environmental monitoring

D. ESMP Implementation Matrix

E. Appendices

- Self-standing issue-specific management plans

The individual mitigation measures must be clearly linked to environmental and social impacts identified in the assessment stage of the EIA. In order to facilitate their implementation (i.e. their adoption by the responsible managers, contractors, subcontractors, or public authorities), it is useful to present them assembled into a coherent Environmental (and Social) Management Plan Implementation Matrix that clearly indicates actions, costs and responsibilities. The Implementation Matrix also serves as a transparent checklist for progress in the implementation and as a basis for ESMP-related reporting.

Table 13. ESMP Implementation Matrix

Impact (identified in EIA)	Enhancement /mitigation measure	Location specification	Timing/ duration	Estimated cost	Responsible for implementation	Notes/other information

3.4.4. Environmental monitoring

The environmental monitoring system should be designed to capture relevant aspects of the environmental change across three key dimensions:

- Baseline conditions (to document evolution of key baseline indicators, to identify any unforeseen effects)
- Compliance (to document effective implementation of all mitigation measures and their sound functioning)
- Impact (to verify EIA predictions, expected nature and scale of impacts).

For each of the dimensions, a set of indicators representing all relevant environmental issues should be assembled, including an indication of practical aspects related to data collection, evaluation and application of the monitoring results in the project management.

Table 14. Environmental monitoring

Environmental issue	Indicator	Method of acquiring data	Frequency	Estimated cost	Responsible for implementation	Notes/other information
Baseline						
1.						
2.						
Compliance						
1.						
2.						
Impacts						
1.						

Annex
RELEVANT GUIDANCE DOCUMENTS

Guidance documents under the Espoo Convention

UNECE, 2006. Guidance on the practical application of the Espoo Convention. New York, Geneva: UNECE. https://unece.org/environment-policy/publications/guidance-practical-application-espoo-convention

UNECE, 2006. Guidance on public participation in environmental impact assessment in a transboundary context. New York, Geneva: UNECE. https://unece.org/guidance-public-participation

UNECE, 2009. Guidance on notification according to the Espoo Convention. New York, Geneva: UNECE. https://unece.org/info/publications/pub/21588

Guidance documents under the UNECE Protocol on SEA

UNECE, 2023. Assessing Health Impacts in Strategic Environmental Assessment. https://unece.org/sites/default/files/2023-10/ece_mp.eia_sea_2023_10_e.pdf

UNECE, 2016. Good Practice Recommendations on Public Participation in Strategic Environmental Assessment. https://www.unece.org/index.php?id=42234

UNECE, 2011. Resource Manual to Support Application of the UNECE Protocol on Strategic Environmental Assessment. https://www.unece.org/index.php?id=27379

Other guidance documents

European Bank for Reconstruction and Development, 2019. Environmental and Social Good Practice Note for Small Hydropower Projects. https://www.ebrd.com/documents/environment/environmental-and-social-guidance-note-for-small-hydropower-projects.pdf?blobnocache=true

Energy Community Secretariat, 2020. Policy Guidelines on Small Hydropower Projects in the Energy Community. https://energy-community.org/dam/jcr:91af0fb3-54e6-4755-8607-0c1c6e400917/HPP_PG_02-2020.pdf

European Commission, 2018. Guidance on the requirements for hydropower in relation to Natura 2000. https://ec.europa.eu/environment/nature/natura2000/management/docs/Hydro%20final%20May%202018.final.pdf

International Finance Corporation, 2015. Hydroelectric Power – A Guide for Developers and Investors. https://openknowledge.worldbank.org/bitstream/handle/10986/22788/Hydroelectric00lopers0and0investors.pdf?sequence=1&isAllowed=y

International Finance Corporation, 2018. Good Practice Note: Environmental, Health, and Safety Approaches for Hydropower Projects. www.ifc.org/EHSHydropower

International Hydropower Association, 2010. Hydropower Sustainability Assessment Protocol. https://www.hydrosustainability.org/assessment-protocol

International Hydropower Association, 2018. Hydropower Sustainability Guidelines on Good International Industry Practice. https://assets-global.website-files.com/5f749e4b9399c80b5e421384/604b7d2381cf9d101f68472c_hydropower_sustainability_guidelines_feb_2021.pdf

International Commission for the Protection of the Danube River, 2013. Guiding Principles on Sustainable Hydropower Development in the Danube Basin. https://www.icpdr.org/sites/default/files/nodes/documents/icpdr_hydropower_final.pdf

Netherlands Commission for Environmental Assessment, 2018. ESIA and SEA for Sustainable Hydropower Development. https://www.eia.nl/documenten/00000361.pdf

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