Advice on Terms of Reference (ToR) for a Combined EIA/Feasibility Study for Rehabilitation of the Chorokhi River and Batumi Coast in Adjara, Georgia

17 April 2007 / 069 – 033 / ISBN 978-90-421-2103-4

Advice on Terms of Reference (ToR) for a combined
EIA/Feasibility study for Rehabilitation of
the Chorokhi River and Batumi Coast
in Adjara, Georgia

Advice submitted to the Minister of Environment Protection and Natural Resources, by a working group of the Commission for Environmental Assessment in the Netherlands.

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Utrecht, 17 April 2007

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1. INTRODUCTION

1.1 Project setting

Batumi is the administrative centre of the autonomous republic of Adjara and has a population of approximately 130.000 inhabitants. It is one of the most important tourists sites along the Georgian Black Sea coast attracting a growing number of national and international tourists. In March 2007 Batumi international airport will be opened and it is expected that the number of tourists that will visit Adjara will grow up to 1,000,000 visitors in the coming years. At this moment a large number of new hotels and infrastructure is built along the coastline in Batumi and the construction of a large number of new hotels and resorts has been planned.

However, the coastline southwest of Batumi is affected by serious erosion over a length of about five km. Along this section a number of houses and cultivated land has been lost already, see Appendix 1 and 5 for respectively a map and photos of the study area. Seven kilometres south of Batumi the Chorokhi River flows into the Black Sea. Without adequate protection measures coastal erosion will continue at the airport area and at Adlia (village south of Batumi) and might even affect the beaches and the coastline of Batumi. As a consequence the investment climate for tourism development could be influenced.

1.2 Request for advice and objectives

On request of the Minister of Environment of Georgia dd. 10-01-2007, see Appendix 2, this advice is prepared by the Netherlands Commission for Environmental Assessment (hereafter called "the Commission")[1]. This is an advice for Terms of Reference (ToR) for a combined environmental assessment and feasibility study for the rehabilitation of the coast at Batumi in Adjara Autonomous region of Georgia.

The objective of this combined Environmental Impact Assessment (EIA) / feasibility study is twofold:

- to come up with a feasible solution for the long term protection of the coastline of Batumi and;
- establish an emergency preparedness plan for the people living in or near the riverbed of the Chorokhi River for whom flooding risks will change.

[1] The Netherlands Commission for Environmental Assessment is an independent advisory body, has a legal basis and was established in 1985. For more information see the website: www.eia.nl

Therefore a number of alternatives will be studied and compared. Based upon this study the responsible authorities can take a decision to implement one of the alternatives to solve the problem of coastal erosion. And the authorities and people that might be affected by emergency flood situations will be better aware of the risk of flooding and be better prepared for action during such events.

1.3 Justification of the approach

This advice is prepared by a working group of experts of the Commission. The group represents the Commission and comprises expertise in the following disciplines: coastal engineering, river hydraulics and morphology, land use planning and ecology. For the composition of the working group, see Appendix 3. For the preparation of this advice, Georgia was visited from 28 January – 3 February 2007. Adjara and in particular the coast at Batumi and the Chorokhi river, until the Turkish border, were visited during a three day visit. In Appendix 4 the programme of the visit is presented as well as the people that has been met.

Question to Ministry of Environment of Georgia: Will an EIA for this project be mandatory according to the Georgian EIA legislation?

This advice for ToR for a combined EIA/ feasibility study meets the international guidelines for good practice EIA. For the preparation of this advice the Commission made use of the Guidelines for EIA prepared by the World Commission of Dams in 2000 (footnote) and its own international experience. Most likely, an EIA is a condition for international funding of the implementation of the project. It is recommended to prepare one integrated report for the combined EIA / feasibility study.

Starting point for this combined EIA / feasibility study is a pre-feasibility study that has been executed in 2000 by Arcadis and provides already a lot of information. The objectives of the pre-feasibility study were to:

- analyse the existing coastal and river system;
- identify the erosion problems;
- define possible coastal protection alternatives for the entire coastline of the study-area;
- assess the impact of those alternatives by using computer models;
- evaluate the protection alternatives by means of a cost-benefit analysis.

The difference between the pre-feasibility study and the EIA / feasibility study is that the latter study will be performed in more detail, with up-to-date data and participation of the population is recommended as part of the EIA procedure. In addition, better preparation for emergency flood situations will be achieved. In Appendix 5 an overview is presented of available information.

2. PROBLEM DESCRIPTION

2.1 General

The following problems have been identified:
- coastal erosion at Batumi;
- river bed erosion of the Chorokhi and;
- increased risk of flooding due to changes in the natural flood regime of the Chorokhi River.

Due to the available information these problems have been described briefly already in the following sections. In the EIA / feasibility study the causes and the consequences of these problems have to be quantified as much as possible.

2.2 Coastal erosion

The beaches of the coastline of Batumi consist of gravel originating from the Chorokhi River flowing into the Black Sea just south of the city of Batumi (see Appendix 1). During the inspection of the Batumi coastline in February 2007, the Commission could clearly observe the effect of coastal erosion, causing damage to several houses and buildings, especially in the area just north of the airport (village of Adlia).

The coastal erosion in the Batumi area is not a recent phenomenon. In the pre-feasibility study for the coastal erosion problem at Batumi (Arcadis et al, 2000) already a clear overview has been given of the erosion and the related impacts. The following processes or human activities are considered to be the main cause of the erosion of the coastline north of the mouth of the Chorokhi River:

- The large scale autonomous coastline development;
- The construction of dams in the Turkish part of the Chorokhi River;
- The mining of gravel from the Chorokhi River.

2.2.1 Large-scale autonomous coastline development

The beaches of the Adjara coastline consist of gravel originating from the Chorokhi River flowing into the Black Sea just south of the city of Batumi. The Chorokhi River originates in Turkey in the mountainous region of Anatolia. In Georgia the main tributaries are Matschakhela, Adjaristskali and Charnali. Historically the main branch of Chorokhi River reached the Black Sea some 3 to 4 km north of the present river mouth. A smaller southern branch reached the coast approximately 2 km south of the present river mouth. In the 19th century the main northern branch was abandoned and the river mouth shifted towards its present position. The relocation of the delta resulted in a retreat of the former river delta and protrusion of the new delta until it reached the influence area of the submarine canyon in front of the actual river mouth. From 1970 onwards, river training works were constructed to maintain the location of the actual river mouth in front of the submarine canyon. The actual coastline is still adapting to the large-scale movement of the Chorokhi River, which is one of the reasons for coastal erosion.

In order to avoid sedimentation in the port of Batumi a groyne was built in the period 1881 to 1890. This resulted in an accretion of the beach south of the groyne of approximately 200 m. As soon as the coastline reached the tip of the groyne, the gravel was transported into the submarine canyon just north of the groyne. In this way almost all gravel transport is trapped into this canyon.

2.2.2 Construction of dams in the Chorokhi River

The Turkish Ministry of Energy and Natural Resources prepared the Development plan of Chorokhi River Basin and as a result 10 hydro projects in series along the main river in a cascade style on the main course of the Chorokhi River were proposed. The total installed capacity will be 2,536 MW and annual production capacity 8,320 GWh.

Table 1: Chorokhi River development projects

	Project	**Current status**	**Installed capacity (MW)**	**Annual production capacity (GWh)**
Upper	Laleli dam	Approved	99	245
	Ispir dam	Approved	54	327
	Gullubag dam	Approved	84	285
	Aksu dam	Approved	120	344
	Arkun dam	Approved	222	788
Middle	Yusufeli dam	Approved	540	1705
	Artvin dam	Approved	332	1025
Lower	Deriner dam	70% completed (2009)	670	2118
	Borcka dam	90% completed (2007?)	300	1039
	Muratli dam	completed June 2005	115	444
Total			**2536**	**8320**

Source: Republic of Turkey – Ministry of energy and natural resources (Encon environmental consultancy Co.); Environmental Impact Assessment – Yusufeli dam and HEPP project (July, 2006)

Three large reservoirs are going to be constructed at Laleli, Yusufeli and Deriner to regulate the Chorokhi River. The dams in the upper and middle section are approved but construction has not yet started. The completed Muratli dam is located one kilometre from the border with Georgia.

It is expected that all beach forming sediment coming from the Turkish part of Chorokhi River is now captured by the dams. In addition the dams have a significant impact on the flow regime of the Chorokhi River and thus on the transport of sediment. As the discharges in the flood season are reduced by the dams, the capacity of the river to transport the coarse beach forming material to the coast will be reduced. Even the available coarse material in the riverbed will only occasionally be transported towards the Black Sea.

In Arcadis et al (2000) the impact of construction of the cascade of dams in Turkey is estimated. With an analytical approach (see Appendix 4 for starting-points) the direct impact due to a changed flow regime was calculated to be a reduction with 63% after construction of Muratli, Deriner and Borchka dams. An additional 20% reduction is expected after construction of the other dams (in 2015). The effect of interrupted beach forming sediment transport will (with some delay) further reduce the sediment load to the Black Sea with 10%. Based on the analysis it can be concluded that from the original average annual beach forming sediment load of Chorokhi of about 450.000 m^3, only 25.000 – 45.000 m^3 (5-10%) will reach the Black Sea from 2015 onwards.

2.2.3 Mining of gravel from the Chorokhi River

In the Georgian part of Chorokhi River, sediment mining officially started in 1975. The main sediment pit is located in the riverbed 5 to 7 km from the river mouth. According to official statistics, about 500,000 m^3 of coarse sediment was extracted from the river annually. More than 10 million m^3 of alluvial material was officially dredged in the period 1975-1992. According to observations 100,000 m^3/year of alluvium was illegally mined in this period. In addition, approximately 6 million m^3 of gravel and cobbles were dredged at the river mouth in the period 1982-1990. This material was transported by trucks and ships and nourished on various locations along the coast to stop coastal erosion. The nourishment program was stopped in 1991 and not resumed later. The method proved to be effective then, however coastal erosion processes resumed and are causing serious problems at the airport and north of it.

In the period 1992-1997 mining activities were reduced to a minimum. Sediment mining activities for construction purposes slowly resumed since 1997. According to observations the annual volume was about 100,000 m^3 in the period 1997-2000. Licenses for sediment mining in the Chorokhi river have been issued in the last years. In 2006 licenses for about 600.000 m^3 were issued, of which about 250.000 m^3 were connected to construction activities for the new airport. 400.000 m^3 of the allowed sediment volumes were actually extracted. It was decided by the Government of the Autonomous Republic of Adjara that from the beginning of 2007 no new licenses for sediment mining will be issued. However, the Government is still considering to allow for extracting of the remaining 200.000 m^3 because this part of the license could not be used due to discharge conditions on Chorokhi river in 2006.

The Commission recommends to maintain the policy to stop mining until the results of this EIA / feasibility study concerning the sediment loads from Chorokhi river are available. In case the remaining 200,000 m^3 will be extracted it is recommended that part of this material is used for emergency coastline protection (see chapter 8).

With a natural flood regime, mining of gravel from the riverbed influences the beach forming sediment load from Chorokhi River to the Black Sea. In addition the flood regime has changed and sediment loads at the border decreased since the construction of dams. Due to the absence of high floods and the strongly reduced inflow of beach forming material load at the Georgian border the amount of beach forming sediment reaching the Black Sea has decreased.

To what extend is not clear yet. Depending on the amount of sediment extracted from the riverbed, mining of gravel can contribute to a certain extent to coastal erosion. The importance of gravel extraction for coastal erosion has to be studied in more detail.

2.2.4 Riverbed erosion

Besides the coastal erosion also erosion in the Chorokhi riverbed in Georgia is reported since 2000. Most probably this erosion is caused by construction and operation of the dams in Turkey. Ongoing erosion might cause problems for structures in and near the riverbed. In addition water levels will decrease affecting groundwater levels along the river. Furthermore, the natural morphological character (meandering and braided sections) of the river might change due to the ongoing erosion. The river may change from a morphologically dynamic stream with multiple branches and bars, into a morphologically static river, with one incised channel.

2.3 Change of flood regime in Chorokhi River

Since operation of Muratli dam started in June 2005, high daily variations in river discharge, water levels and flow velocities downstream of Muratli dam are observed. Especially during low water seasons these rapid variations often surprise people living near the riverbed. The suddenly upcoming floods can cause rapid flood level rise and high flood velocities being dangerous for people and cattle. Until now no severe accidents have been recorded.

In addition, the dams introduce the risks of extreme floods, for example due to dam breaks or other emergency situations in the upstream part of the Chorokhi River in Turkey. Up to now no emergency plan for such situations is available and in place in Georgia. This causes a feeling of unsafety and hampers adequate emergency actions in Georgia in case extreme floods are released from the Muratli dam.

3. LEGISLATION, POLICIES, PLANS AND PUBLIC PARTICIPATION

In the EIA / feasibility study legislation and existing as well as proposed policies and plans that might have an impact on the area to be studied should be described.
For each of the proposed alternatives it should be described whether they comply with the proposed plans and policies. Furthermore, these policies and plans provide insight in the opportunities and constraints concerning the development of alternatives.

The authorities of Adjara informed the Commission that currently a number of sector development plans are prepared that will be integrated into a Master plan for the development of Batumi. The planning for the development of this Master plan is not clear yet.

The Commission is of the opinion that at least the following sector plans should be included in the EIA / feasibility study:

- Tourism development plan, in particular the planning of tourist sites in areas that might be affected by coastal erosion and or extreme floods;
- Infrastructure development plan;
- Policy for sand and gravel mining in the riverbed. A brief overview of the new quarries for gravel mining in Adjara should be given and the potential impact on the sediment load in the Chorokhi river, in case of land slides;
- Nature development plan in the delta of the Chorokhi river and adjacent marine area. The plan for nature development as elaborated in **(footnote)** might influence the identified alternatives.

In case information on the Master plan is already available during the study, this should be studied as well. Furthermore, the Commission noticed during its field visit that new houses are constructed in the Chorokhi riverbed. Due to the fact that the riverbed is vulnerable for extreme floods this development should also be assessed as part of a land use or Master plan.

The need for EIA should be clear according to Georgian legislation. In case an EIA is not mandatory it is recommended to execute a voluntary EIA because the EIA procedure provides good opportunities for well-informed and transparent decision-making. In addition, international finance institutes or donors will most likely request for an EIA for this project, according to World Bank and European Union screening criteria this project requires an EIA. [2] although according to the EU and WB guidelines it is a so-called category B project.

Public participation

The people living in or adjacent to the Chorokhi riverbed and in the settlements close to the Batumi shoreline are currently directly or indirectly affected by the identified problems. It is therefore recommended that in accordance with international good practice principles, people are informed and consulted in the phase of scoping and reviewing of this EIA / feasibility study. Besides this people other stakeholders should be consulted as well.

4. OBJECTIVES AND DEVELOPMENT OF ALTERNATIVES

4.1 Objectives

The EIA / feasibility study must contain a clear definition of the objectives of the proposed activities to enable identification and formulation of alternatives. The objectives should be specific and if possible quantified.

[2] EU EIA directive: This is an Annexe II project.
World Bank: Category B project.

4.2 Development of alternatives

The Commission recommends to develop and elaborate the following alternatives in the EIA / feasibility study:

- **The reference situation without dams and without mining**
  This alternative concerns a theoretical situation with no dams present in the Chorokhi River and no sediment mining. In fact this alternative is the autonomous development of the coastline to be used as a reference for the other alternatives.

- **The do-nothing alternative(s)**
  In this alternative the coastline development is estimated for the case that no coastal protection measures are taken to slow down the erosion between the Chorokhi River mouth and Batumi. The dams in the Chorokhi river are starting point for this alternative. In fact two do-nothing alternatives have to be considered one with and without sediment mining.

  A comparison between the do-nothing alternative(s) and the reference situation without dam construction provides information on the contribution of the dams and sediment mining to the erosion problem in terms of erosion volumes.

- **River alternatives**
  The following alternatives or a combination of these alternatives influences the beach forming sediment load that is important for coastal protection:
  – River training for protection of structures (e.g. hard sills);
  – Adapted dam operation to influence sediment loads;
  – Alternative sediment mining strategy;
  – Nature development in the river mouth of the Chorokhi river and adjacent marine area .

- **Coastal protection alternative with “soft” measures.**
  In order to mitigate the coastal erosion, gravel or possibly sand can be nourished at various locations along the coastline of Batumi. If executed in a proper way, it might be a good long-term solution, assuming that the nourishment material is available. Circulation of material from Batumi cape to Chorokhi mouth should also be considered.

  Sand nourishment might be a good option since sand is available at the foreshore and sandy beaches are attractive from a recreational point of view. On the other hand such an alternative is not sustainable and may have some problems:
  - Large volumes of material may be required;
  - Mixing of coarse and fine material may occur;
  - The nourishment of fine material may affect the canyon activity;

  These aspects should be analysed in the EIA / feasibility study.

- **Coastal protection alternative with “hard” measures.**
  Another alternative is to construct a series of groynes along the beach or

part of the beach to reduce or stop the alongshore transport and to create relatively stable beach sections. This alternative may also provide the opportunity for sand nourishment because due to the compartimalisation of the beach, nourishment might be possible for separate sections between two groynes. Feasibility of sand nourishment should be studied as part of the proposed alternative or as an option for development in the future. Special attention should be given to the impact of coarse material, originating from the river, on the sandy beach sections.

The alternatives to be presented and compared in the EIA / feasibility consist always of a combination of river alternatives and coastal protection alternatives.

5. MODELS FOR IMPACT ASSESSMENT OF ALTERNATIVES

5.1 General

In order to be able to identify and assess the alternative coastal protection solutions, it is important to understand all relevant coastal and river processes. In the previous study on the protection of the Batumi coastline (Arcadis et al, 2000) a clear description is given of these processes and the relevant sediment transport patterns. Figure 5.1 shows a schematic view of the relevant elements and processes.

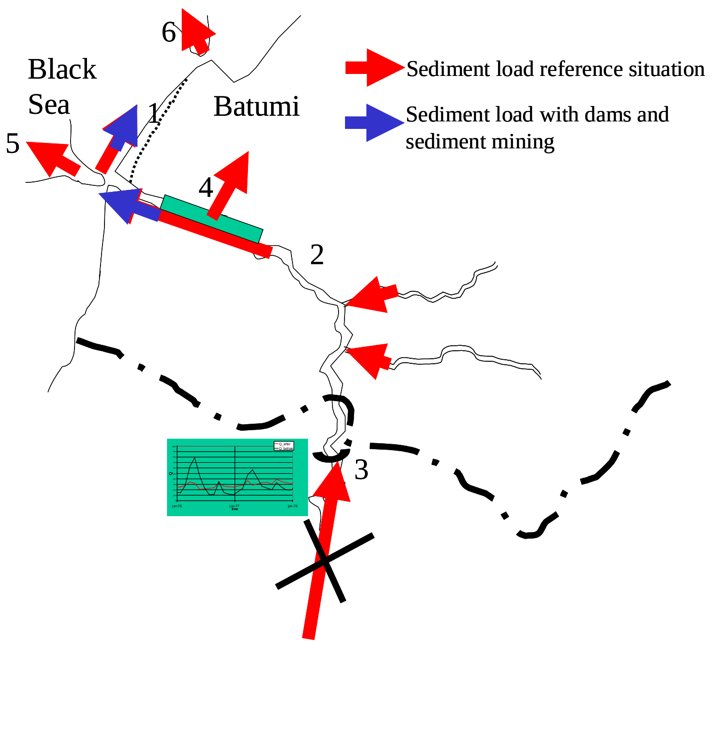

Figure 5.1 Relevant processes and elements (numbers refer to list below)

The relevant elements and processes are:

1. The Batumi coastline, eroding as a result of the autonomous long term coastal retreat;
2. The Chorokhi River and its tributaries, providing beach forming coarse sediments to the coastal system;
3. The construction of the dams in the Turkish part of the Chorokhi River, interrupting the sediment load and changing the flow regime;
4. The sand and gravel mining activities in the bed of the Chorokhi River, reducing the sediment load of the Chorokhi river to the coastal system;
5. The canyon near the mouth of Chorokhi River, in which large part of the sediment load of the Chorokhi River disappears;
6. The canyon near Batumi Cape, in which part of the littoral drift disappears.

In the following sections the approach of the various sub studies is described, taking into account the above-mentioned elements and processes.

The study area is determined by the impacts of the alternatives to be studied. This area is much wider than the project area where the implementation of measures is foreseen. The study area should include the Chorokhi riverbed in Georgia, the tributaries, the Chorokhi river mouth and coastline up to the Turkish border in the south and Batumi harbour in the north. Although a considerable part of the Chorokhi watershed (in Turkey know as the Choruh river) is located in Turkey it is not necessary to include this watershed in the study. However, for adequate modelling of alternatives it is necessary that information as mentioned in section 5.2.2. is provided by Turkey.

In the following sections guidelines are provided for information that is necessary for the recommended modelling of the river system (section 5.2) and the coastal system (section 5.3). Both modelling studies are part of the EIA / feasibility study.

5.2 River system

Objectives of the river studies are to

- assess the impact of dam construction on river morphology and beach forming sediment loads;
- assess the impacts of alternatives.

As indicated in Arcadis et al (2000) and Encon (2006) impact of dam operation is due to interruption of sediment loads and altered river regime. The EIA-report for Yusufeli Dam (Encon, 2006) shows that due to construction of dams in lower Chorokhi (Muratli, Borchka and Deriner) and Yusufeli dam:

- the average flood discharges will reduce;
- the peak discharges will occur slightly later during the year;

- average monthly discharges during low water season will increase.

In Arcadis et al (2000) these impacts were assessed using an analytical approach considered adequate, bearing in mind the information available at that time. As a continuation of the study of Arcadis et al (2000) two approaches can be followed to meet the objectives for the river study; (i) the analytical approach and (ii) the modelling approach.

5.2.1 Analytical approach

In Arcadis et al (2000) the sediment load is calculated. Based on additional information and studies and data gathered since 2000, this analysis can be refined including:

- An assessment of the EIA report for Yusufeli dam (Enron, 2006) resulting in improved boundary conditions for the analysis: more realistic operation rules, sediment loads, upstream discharges;
- Actual information on sediment mining;
- An analytical approach for propagation of erosion caused by sediment trapping and sediment mining (based on morphological time scales).

With this analytical approach the average annual beach forming sediment loads will be estimated for the autonomous development, the do-nothing alternatives and the river alternatives as described in chapter 4. The erosion processes in Chorokhi River will not be visualised.

5.2.2 Modelling approach

As a refinement of the analytical approach, a modelling approach can be adopted having the following advantages:

- More detailed simulation of river hydraulics and morphology (sediment loads and morphological changes) in time and place;
- Calculation of extreme water levels and flood wave propagation;
- Improved impact assessment of alternatives. The simulations will provide more reliable information on developments of sediment loads, bed levels and water levels in time and place.

With the modelling approach the same situations will be considered as described above. The required steps for this modelling approach are:
1. Data collection (discharges, water levels, sediment loads, cross-sections, bed composition, vegetation pattern);
2. Construction of the one-dimensional model;
3. Calibration and verification of the model using: estimates of annual sediment loads, measured sediment loads, estimates of critical discharges (below which no bed material load occurs), measured water levels and bed levels;
4. Simulation of reference situation (e.g. 50 year simulation);
5. Construction of models for all situations and alternatives;
6. Simulation of all situations and alternatives;
7. Optimising the alternatives.

Outcome of the river morphology study will be:

- one dimensional model for the different alternatives do-nothing and river alternatives, but validated for the reference situation;
- long term time series of sediment loads for these situations;
- impact of different activities (dams, sediment mining, river training, etc) on beach forming sediment loads;
- morphological changes in the river for all these alternatives;
- improved understanding of the river system.

Consequence of this approach is that more detailed information will be required. For the river modelling approach the data requirements are (all to be collected by Georgia apart from some data sets under point 2):

1. River cross-sections to build the one-dimensional model. As a minimum one cross-section every kilometre will be required. Especially the typical (wide, narrow) sections need to be measured. When the height contour lines from 2003 prove to be reliable enough this information can be used for the high water parts of the sections. In that case only the wet cross-sections need to be measured;
2. Prolonged time series of discharges, water levels and sediment loads (or bed level) at the upstream location (border or Muratli dam) as well as the (influence of) operation rules of the dams. Discharges and sediment loads at the inflow point of tributaries should be available as boundary conditions for the model. The time series should have sufficient detail (preferable at least daily values).
   The time series at the border (or at Muratli) and operation rules should be requested from the Turkey. Boundary conditions at the tributaries should be available in Georgia;
3. Dimensions of hydraulic structures (e.g. bridges);
4. Information on the vegetation and infrastructure on banks and flood plains. For this available aerial photographs can be used;
5. Bed material sieve curves. It is proposed that additional bed samples for the locations indicated in Appendix 4 (Chorokhi River / bed material) will be collected and sieve curves derived.

It is expected that above mentioned monitoring activities and analyses (points 1, 3, and 5), as well as the data collection (points 2, 3, and 4) can be carried out in a (low water) period of about two months. In order to prevent possible delays it is recommended that within the scope of the joint monitoring programme the request for data available in Turkey should be forwarded to Turkey as soon as possible.

In addition, it is stressed that recovery of the destroyed gauging stations in Chorokhi River at Mirveti and Erge (or a nearby location as the old measuring station seems to be strongly affected) is considered essential. These measuring stations should be robust (resistant to flow conditions and molest) and capable of:

- Automatic registration and data logging of water levels (minimum hourly values)
- Incidental measuring of suspended loads, bed loads, flow velocities (and thus discharges) and cross-sectional profiles.

Information from these stations will be valuable for extending the long-term time series and for analysis of the consequences of dam construction and operation. This will also strengthen the position of Georgian experts in joint activities with Turkish colleagues.
Possibilities for measuring devices for these locations can be obtained from following websites (obtained from an Italian institute installing gauging stations in rivers having identical characteristics as Chorokhi river):

- hydrological instruments: www.cae.it; www.seba.de
- vellocitymeters: www.ott-hydrometry.de
- bed load and suspended load sampling: www.rickly.com; www.wildco.com

For the numerical modelling a one-dimensional software package is proposed. In Arcadis et al (2000) the software package SOBEK was applied for Rioni River. This modelling package was acquired in that project and should be still available in Georgia. Also on-the-job training was provided. This modelling package can also be applied for the feasibility study. At present the modelling software is being extended so as to allow for morphological simulations in steep rivers with graded bed (combination of course and fine) material. The developer expects that the new version of SOBEK will be operational in the summer of 2007.

Recommended approach

The Commission recommends to apply the modelling approach for the feasibility study. However, this approach requires additional data collection (see above). When this data collection forms part of the feasibility study it can be considered to follow the analytical approach parallel to the data collection (of approximately two months). This approach will provide valuable information for selection of alternatives for the more laborious modelling approach.

5.3 Coastal system

The work related to the understanding and modelling of the coastal system performed in the framework of the pre-feasibility study for the coastal erosion problem at Batumi (Arcadis et al, 2000) is a good starting point for the present feasibility study.

The coastline model

In order to better understand the coastal system, the coastal system has been modelled during the pre-feasibility study by means of a one-line coastline model. For the feasibility study the same type of coastline model can be used. The difference is that presently more data is available related to the coastline changes, the sediment characteristics and the sediment discharge from the

Chorokhi River. These data should be used to re-calibrate the model so as to improve its accuracy.

The coastal erosion processes at Adlia seem to be predicted correctly by the existing coastline model. The model predicts an increasing erosion rate (Arcadis et al, 2000) and the erosion rate in reality has indeed been increasing from 4 to 5 m/yr in 2000 to 7 to 9 m/yr in 2006.

The following activities should be performed making use of the new available data:

- update of the near-shore wave climates at several relevant locations along the shoreline by making use of the SWAN wave model which was used in Arcadis et al (2000);
- assessment of the sediment transports (in long-shore as well as in cross-shore direction) by using the UNIBEST-LT model (Arcadis et al, 2000);
- set-up of a coastline model for the existing situation by using the UNIBEST-CL model (Arcadis et al, 2000);
- calibration of the coastline model by simulating the historical observations of the coastline development, especially the recently measured coastline development.

An important input parameter for the coastal system is the sediment load from the Chorokhi River to the coastal system. Sediment mining and the construction of Turkish dams will result in a reduced sediment load, and hence a further retreat of the coastline. The information on reduction of annual load of beach forming material will be obtained from the study of the river system (Section 5.2).

Also the behaviour of the canyons plays an important role. A desk study should be performed based on existing information in order to estimate the impact of the canyon on the coastline development.

The outcome of the coastal modelling study will be a one dimensional coastline model calibrated and validated for the existing situation to be used as a tool to simulate the effectiveness of various coastal protection schemes.

The consequence of this approach is that more detailed information will be required. For the coastal modelling the following additional data are required:

- Recent bathymetry of the coastal area between the Gonio settlement south of the Chorokhi River to the Batumi Cape, including coastal profiles;
- Recent inventory of works done along the Batumi coastline.

As mentioned above, for the numerical modelling a one-dimensional coastline model is proposed. In Arcadis et al (2000) the software package UNIBEST-LT and UNIBEST-CL was applied. This modelling package was acquired in that project and should be still available in Georgia. Also on-the-job training was provided. This modelling package can also be applied for this EIA / feasibility study.
Once the coastline model has been calibrated correctly, the model will be able to predict the coastline development for various coastal protection alterna-

tives as described in chapter 4. The outcome will be used to analyse the effectiveness of the protection measures.

The impact of the various alternatives on the coastal system will be determined by making use of the calibrated coastline model. The outcome of the model will be:

- Coastline changes as function of time;
- Required beach nourishment volumes;
- Required groyne length and distances between the groynes.

Engineering design
Based on this information, engineering designs of the required protection works and nourishment volumes should be made in order to estimate the capital and maintenance cost of each of the alternatives forming the basis for the cost-benefit analysis.

Borrow pits
For some alternatives gravel will need to be extracted from the riverbed or from quarries in the hinterland of Adjara. The impacts of the extraction from quarries on the geological stability should be described briefly. The impacts of gravel extraction from the riverbed should be studies by using river and coastline models. For nourishment of sand as proposed in the "soft" coastal protection alternatives an inventory should be made of the borrow pits for sand and the impacts should be described.

5.4 Gaps in knowledge and information

The study should identify the gaps in knowledge and information. Based on a sensitivity analysis the risks of these gaps for the efficacy of the alternatives should be identified.

6. COMPARATIVE ASSESSMENT OF THE ALTERNATIVES

The evaluation and selection of the preferred alternative will be performed by the Adjara authorities.

For a transparent comparative assessment of the feasible alternatives the following two steps are subsequently recommended to be executed and presented in the EIA / feasibility study:

1. The potential environmental as well as the socio-economic impacts of each alternative should be described and quantified as far as possible. For each impact the following characteristics have to be determined:
    - nature (positive/negative, direct/indirect, reversible/irreversible, cumulative/ synergistic);
    - magnitude;
    - extent/ location (area / volume covered, distribution);
    - timing (during construction, operation, decommissioning, immediate, delayed, rate of change);

- duration (short term, long term, intermittent, continuous);
- likelihood (risk, uncertainty or confidence in the prediction);
- significance (local, regional).

2. Because the alternatives will affect different stakeholder groups the Commission recommends to execute a social cost-benefit analysis to compare the costs of each alternative with the benefits. A social cost benefit analysis allows stakeholders to specific weights to costs and benefits, and also to lost or foregone income opportunities. This means that the identified environmental and socio-economic impacts should be valued in monetary terms. The time horizon for the assessment of alternatives is recommended to be 25 years.

   Besides the analysis of the investment and maintenance costs, specific attention should be given towards:

   - Unit costs for the provision of nourishment materials, such as sand and gravel.
   - The availability of and unit cost of rock for the construction of dams and groynes.

The description of the benefits include assets as well as income. With respect to assets, an analysis is required of the trends in the value of the properties and assets in the affected communities (positive in case of investments, negative in case of the do-nothing alternative). The assessment of a change of income consists of changes in land use, urban developments and tourist / recreational developments.

Finally, potential benefits such as the improvement of the investment climate, the safeguarding of wildlife habitats and the continuity of local communities should be taken into account.

Alternatives should be compared with the reference. The outcome of the cost-benefit analysis will be an assessment of the feasibility of the various alternatives. Subsequently the feasible alternatives will be presented in such a way that the costs and benefits of each alternatives can be compared easily.

7. SET UP OF CHOROKHI FLOOD EMERGENCY PLAN

Dam construction introduces two risks:

1. Daily conditions: rapid changes in water levels and flow velocities due to operation of turbines.
2. Extreme conditions due to emergency situations.

In the current situation Georgia has no flood emergency plan in place and is therefore not prepared for extreme flood conditions due to emergency situations in the Chorokhi river.

Daily conditions

For daily conditions, a warning system is not feasible as such system would issue warnings every day. However, people downstream of the dams should be aware of the dangers of dam operations. In a feasibility study following topics should be addressed:

1. possibilities for clear regulations for operation of the turbines being acceptable for both countries;
2. awareness campaign (people should be informed on the dangers);
3. permanent information at accessible locations along the river. This could be achieved by information panels close to the river bed;
4. flood maps related to the possible operation levels of the turbines of Muratli dam (2 turbines of 180.78 m^3/s, see Arcadis et al, 2000).

Extreme situations

Dam construction introduces additional risks. Examples are dam breaks or uncontrolled releases. In Encon (2006) a separate section is dedicated to dam safety and emergency response. It appears that since 1998 DSI[3] works according to a policy guide "Dam Safety Working Program". In 2005 a Dam Safety Section was established in DSI guaranteeing proper implementation of the guideline which applies to dam projects with a height above 7.5 m and a storage capacity lager than 65,000 m^3. This means the guideline applies to all dams in Turkey in the Chorokhi catchment, which is also stated in Encon (2006): "With this approach, all dams, or other structures, in a basin is integrated in emergency preparedness planning. This will also be the case for Yusufeli and downstream projects".

Emergency preparedness planning includes:

- preparative actions for an emergency (monitoring system, warning system, communication system, procedures for warning and communication (emergency preparedness plan), impact studies, flood hazard mapping, training of staff).
- Operational actions during an emergency (implementation of emergency preparedness plan).
- After-care of an emergency (damage assessment, identification of further actions).

An outline for an emergency preparedness plan for Yusufeli Dam is given in Encon (2006). In the case of Chorokhi the role of Georgia is quite essential, being the downstream party of the cascade of dams. It is therefore clear that Georgian experts should be involved in the design of the emergency preparedness plan and its components. This could be achieved by organising several workshops in which the requirements and possibilities for the emergency preparedness plans are defined.

Up to now restricted experience appears to be available in Georgia with such (transboundary) plans in case of river flooding connected to dam operation. In

[3] General Directorate of State Hydraulics Works

order to prepare Georgian experts for effective discussions with the Turkish experts following activities need to be carried out:

- Assessment of available experiences in Georgia related to flood management in rivers with dams (e.g. Enguri Hydro Power Plant (HPP), Cascade of Vardnili HPPs, Cascade of Vartsikhe HPPs, Lajanuri HPP, Rioni HPP, Cascade of Gumati HPPS, Cascade of Khrami HPPs, Cascade of Shaori - Tkibuli HPPS);
- Identification and description of the (desired) emergency organisation in Georgia;
- Definition of expectations of flood hazard maps downstream of Muratli dam for different flood discharge levels, based on international available examples. For preparing the maps the one-dimensional as described in Section 5.2.2 can be used. Calculated water levels for different flood situations will be combined with a digital terrain model (DTM) to prepare the flood maps;
- Definition of requirements for a flood warning and dissemination system providing maximum reaction time. Also for this international experiences will be valuable and could be assessed in a study-tour to a comparable situation in Europe (e.g. France or Czech Republic). Also from international literature valuable direction for requirements of plans and systems can be obtained (e.g. Mostert, 2000 and van Duivendijk, 2000);
- Drafting of an emergency plan for Chorokhi in Georgia;
- Design of training and exercises for emergency planning.

8. EMERGENCY MEASURES

During the visit of the Commission in February 2007, storm waves attacked the coastline and several houses and buildings were heavily damaged or have been damaged in the past. In order to protect the remaining houses, the local authorities decided to dump construction waste (concrete, stones, etc.) in front of the houses. In this way the coastline retreat is stopped locally. On the other hand, a strong increase of the down-drift erosion of the coastline was observed.

The Commission noticed that this type of emergency measures:
- do not integrate with a sound coastal defence measure;
- have strong negative down-drift effects, both in terms of erosion as in the spread of garbage along the shoreline and beaches.

It is recommended, as an emergency measure for one year, to use coarse bed material from the Chorokhi River and to place that along the eroding beach section. This emergency measure is in fact a small-scale beach nourishment, which is in harmony with the existing beach and is flexible (reversible). The coastal stretch to be immediately protected is located between the airport and 2,000 m north of it. Assuming that the initial height of the beach profile is 7 m and that the erosion rate is approximately 7 m/yr, then a total volume of 100,000 m^3 is required to protect this section for the first year to come. Although structural sediment mining is advised against without further studies, it is considered feasible and not harmful that for the emergency measures this quantity of material should be extracted once-only from the sediment mining area of the Chorokhi River. In order to minimise any adversive effects in the river bed, it is recommended to extract the sediment from relatively high areas in the river bed (bars) not exposed to the highest flow velocities (preferably storage areas). In this way further deepening of the main branches is prevented and the influence on the flow velocities and thus sediment transporting capacity of the Chorokhi River is restricted. In addition it is recommended to extract relatively coarse sediment so as to nourish erosion persistent material. The material should be distributed evenly along the coastline on the dry beach (50 m^3/m^1).

Impacts of these measures

The extraction of this amount of gravel from the Chorokhi river bed as well as the nourishing of this sediment along the coastline do not affect the realization of the coastal protection alternatives that will be elaborated. The measure means a turning back of the erosion process of about one year, providing some time to develop a more sustainable solution. The measure is a flexible one, temporarily restoring the sediment balance along the coast. The effects of the proposed measure are therefore not irreversible.

The Commission recommends to start the environmental assessment / feasibility study at very short notice in order to develop a long-term sustainable coastal protection scheme. During this feasibility study the short-term emergency measures can be updated and refined, including a proper selection of the best location for sediment extraction in Chorokhi River.

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For further information see http://www.dams.org/