Netherlands Commission for Environmental Assessment

Strategic Environmental Assessment for

Hydropower Sector Planning

Guidance Document

National Impact Assessment Programme

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Authors:
David D. Annandale and Hagler Bailly Pakistan (Pvt) Ltd

Technical Support:
Netherlands Commission for Environmental Assessment (NCEA)

Facilitation:
Ahmad Saeed
Arfa Zaheer Azmat

Design:
Hasan Ruvi Zaman

Cover Photograph:
EPA, AJK

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IUCN Pakistan
National Impact Assessment Programme
House No. 2, Street 83
Embassy Road, G-6/4, Islamabad
Tel: +92 (51) 2271027-34
Fax: +92 (51) 2271017
www.niap.pk

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1.1 The Need for Strategic Environmental Assessment Guidance for Hydropower Sector Planning

Regulators around the world are familiar with the approaches used to assess the environmental and social impacts of individual infrastructure projects such as hydropower dams. The techniques associated with environmental impact assessment (EIA) have been refined over the last 40 years. However, EIA is not so easily applied when more than one project is proposed within a river basin. The development of a number of hydropower projects (HPPs) within the same river basin will result in cumulative environmental and social impacts. One large-scale hydropower project of 2,000 MW located in a remote area of one river basin might have fewer negative impacts than the cumulative effect of 400 5 MW hydropower projects in many river basins.[1]

Examining the cumulative impact of many projects requires the application of strategic environmental assessment (SEA) techniques. The OCED's definitive guidance on use of SEA for development cooperation defines SEA as "a family of approaches which use a variety of tools, rather than a single, fixed and prescriptive approach"[2]. One such tool is cumulative impact assessment.

In the context of hydropower development, cumulative impacts can result from (i) multiple actions at a given site associated with a single project, or (ii) can be additive or synergistic[3] in nature when potential impacts of multiple dams are taken into account and are concentrated in time or space, for example, the impacts of a series of small dams constructed on a single stream or on streams within a single river basin.[4] Such impacts may occur when the affected system is being perturbed repeatedly and increasingly by the same local agent with sufficient frequency so that it does not have time to recover between events (time-crowding), or the affected system is being perturbed by several similar activities or different activities having similar effects, in an area too small to assimilate the combined impacts (space-crowding).[5]

This document presents general guidance for undertaking cumulative impact assessment of multiple hydropower projects in Pakistan. Its audience is project proponents, and government regulators at the Federal, Provincial, and State levels. Its main purpose is to assist with hydropower sector planning.

1.2 The SEA Guidance as part of the National Impact Assessment Program

The Government of Pakistan (GoP) and the International Union for Conservation of Nature (IUCN) have jointly implemented the National Impact Assessment Program (NIAP) that aims to contribute to sustainable development in Pakistan through strengthening the Environmental Impact Assessment (EIA) process and introducing Strategic Environmental Assessment (SEA) in national development planning. The Program has four implementation partners: Pakistan Environmental Protection Agency (PakEPA), Environment Wing (EW) of the Ministry of Climate Change (MoCC), Planning Commission of Pakistan (PC), and IUCN Pakistan. Additionally, the Netherlands Commission for Environmental Assessment (NCEA) has an advisory role in the Project and provides technical advice. The total duration of the Program is four and a half years.

To facilitate the SEA activities under NIAP, a SEA Task Force has been established at the Planning Commission to oversee the introduction of SEA in the country, including supervision of SEA pilot studies. In its second and third meetings, the Task Force decided that SEA pilots would be selected from the urban land-use planning and energy sectors, with the latter having a specific focus on power generation.

As a result of the discussions held in the State of Azad Jammu and Kashmir (AJK), the Government of AJK agreed to volunteer its hydropower plan (the 'Plan') for SEA piloting. The SEA of the Plan was completed in early 2014. The work involved the development of a customized methodology for undertaking this kind of SEA. The successful implementation of the methodology in the AJK case implies that there may be useful lessons for other Provinces of Pakistan where there is concern over the possibly rapid development of hydropower projects. This Guidance document draws substantially from the AJK SEA pilot study.

[1] *Egre, D., Milewski, J.C. (2002). The diversity of hydropower projects, Energy Policy, Vol. 30, No. 14, Nov. 2002, pp 1225-1230.*

[2] *OECD (2006), Applying Strategic Environmental Assessment: Good Practice Guidance for Development Cooperation. Paris: OECD Publications.*

[3] *Synergistic or interactive effects are generally the result of interactions between effects of two or more projects that result in combined effects that are greater than the sum of the individual project's effects and typically more complex and difficult to assess than additive effects. Arikan, Esra; Dieterle, Gerhard; Bouzaher, Aziz; Ceribasi, Ibrahim Haluk; Kaya, Dundar Emre; Nishimura, Shinya; Karamullaoglu, Ulker; Kahraman, Bilgen. 2012. Sample guidelines : cumulative environmental impact assessment for hydropower projects in Turkey. Washington DC ; World Bank. http://documents.worldbank.org/curatd/en/2012/12/17671936/sample-guidelines-cumulative-environmental-impact-assessment-hydropower-projects-turkey*

[4] *Rajvanshi, Asha; Roshni Arora; Vinod B. Mathur; K. Sivakumar; S. Sathyakumar; G.S. Rawat; J.A. Johnson; K. Ramesh; NandKishor Dimri and Ajay Maletha (2012) Assessment of Cumulative Impacts of Hydroelectric Projects on Aquatic and Terrestrial Biodiversity in Alaknanda and Bhagirathi Basins, Uttarakhand. Wildlife Institute of India, Technical Report. Pp 203 plus Appendices.*

[5] *Ibid.*

2. Guidelines for the Strategic Environmental Assessment of Hydropower Plans

2.1 Introduction

The Guidelines presented here are meant for use by public sector proponents of Province-wide hydropower plans. These will variously be Planning and Development Departments; Provincial agencies responsible for overseeing the development of energy infrastructure; or Provincial Environmental Protection Authorities. It needs to be stressed that the Guidelines are directed primarily to public sector proponents … rather than private sector project developers, because it is government agencies that are responsible for overall sector planning.

With the gradual introduction of provincial environmental laws post-18th Amendment, statutory requirements for SEA are becoming more prevalent. One of the main purposes of these Guidelines is to assist public sector proponents to meet the requirements of the new laws.
It should also be noted that these SEA Guidelines should be considered as a "companion" to a separate set of EIA guidelines developed by NIAP to assist proponents and regulators when they deal with large, stand-alone hydropower projects.

2.2 Focus on Cumulative Impacts

The purpose of SEA is to examine the environmental and social impacts that may emanate as a result of the introduction of a new policy, plan, or programme. Hydropower plans at the national or regional level may propose many individual projects, of varying sizes. For example, in AJK, the combined plans of the four relevant agencies presented approximately 60 possible new hydropower projects (HPPs) for development in the medium term.

Depending on their size and siting, these projects may not necessarily result in significant adverse impacts when they are assessed individually. However, when looked at as a whole, their cumulative impact could be significant. A method is needed, therefore, that enables a focus on the overall cumulative impacts that may result from implementation of hydropower plans as a whole.

Cumulative impact assessment is a recognized part of the "stable" of SEA approaches. These Guidelines are based on experience with the AJK hydropower plan, but they also draw on the following recent work:

- Arikan, E., et al (2012), Sample Guidelines: Cumulative Environmental Impact Assessment for Hydropower Projects in Turkey. Washington DC, World Bank.

- Egre, D., Milewski, J.C. (2002). The diversity of hydropower projects, Energy Policy, Vol. 30, No. 14, Nov. 2002, pp 1225-1230.

- Hegmann, G., C. Cocklin, R. Creasey, S. Dupuis, A. Kennedy, L. Kingsley, W. Ross, H. Spaling and D. Stalker (1999), Cumulative Effects Assessment Practitioners Guide. Prepared for: Canadian Environmental Assessment Agency. Prepared by: The Cumulative Effects Assessment Working Group and AXYS Environmental Consulting Ltd.

- International Finance Corporation (2013), Good Practice Handbook: Cumulative Impact Assessment and Management. Guidelines for the Private Sector in Emerging Markets.

- Noble, B., and Harriman, J. (2008), Regional Strategic Environmental Assessment (R-SEA): Methodological Guidance and Good Practice.

- Quintero, J. D. and Ledec, G. (2003), Good Dams and Bad Dams: Environmental Criteria for Site Selection of Hydroelectric Projects. LCSES Sustainable Development Working Paper Series: no. 16. Washington D.C.

2.3 Methodological Steps

2.3.1 Introduction to the Approach

As is always the case with any kind of impact assessment work, it helps to have a methodological "map" to guide the study process. Figure 2.1 outlines the methodological approach that should be undertaken when approaching a SEA of a hydropower development plan.

The approach consists of seven distinct steps that should be followed in chronological order. In Section 2.3.2 onwards, these steps are discussed in detail. By way of brief introduction, Step 1 should define and categorize the proposed HPPs as listed in the hydropower plan that is the focus of attention.

Step 2 is used to outline the structural design features of a selection of proposed HPPs of differing generation capacity. This background material allows, in Step 3, for the definition of the generic drivers of potential environmental and social impacts. Categorizing HPPs into different types based on the drivers of impacts helps identify the key issues that are to become the focus of the SEA study and the recommendations that will result from it.

In Step 4 links are investigated between drivers and actual potential impacts by outlining the expected effects from HPPs of different generation capacities. Step 5 extends this analysis to examine the environmental and social risks associated with planned HPP development on specific stretches of rivers and streams. Based on the geographical locations and potential cumulative impacts expected from hydropower development, river and stream sections are delineated into Cumulative Impact Zones. Based on the possible extent and severity of cumulative impacts, these zones are categorized into Moderately Critical, Highly Critical, or Extremely Critical.

With this background analysis in hand, Step 6 involves the careful examination of the environmental and social "baseline" conditions existing along the river and stream stretches that will likely see HPP development taking place. Finally, in Step 7 the Cumulative Impact Zones identified in Step 5 are superimposed on the ecologically and socioeconomically sensitive segments identified in Step 6. This allows the HPPs contained in the hydropower development plan to be ranked according to their overall cumulative impact potential.

The ranking of an HPP will enable the proponents of the project, environmental consultants, and government agencies to identify, at a glance:

- the overall existing ecological and socioeconomic picture of the area where a HPP is being planned for development or currently in the process of being constructed and the regions where more detailed studies need to be prioritized;

- the scale of the impact an HPP will have on the ecology and socioeconomic condition of the area where it will be located;

- the contribution of each HPP to the overall impacts from the development of all the HPPs included in the Plan;

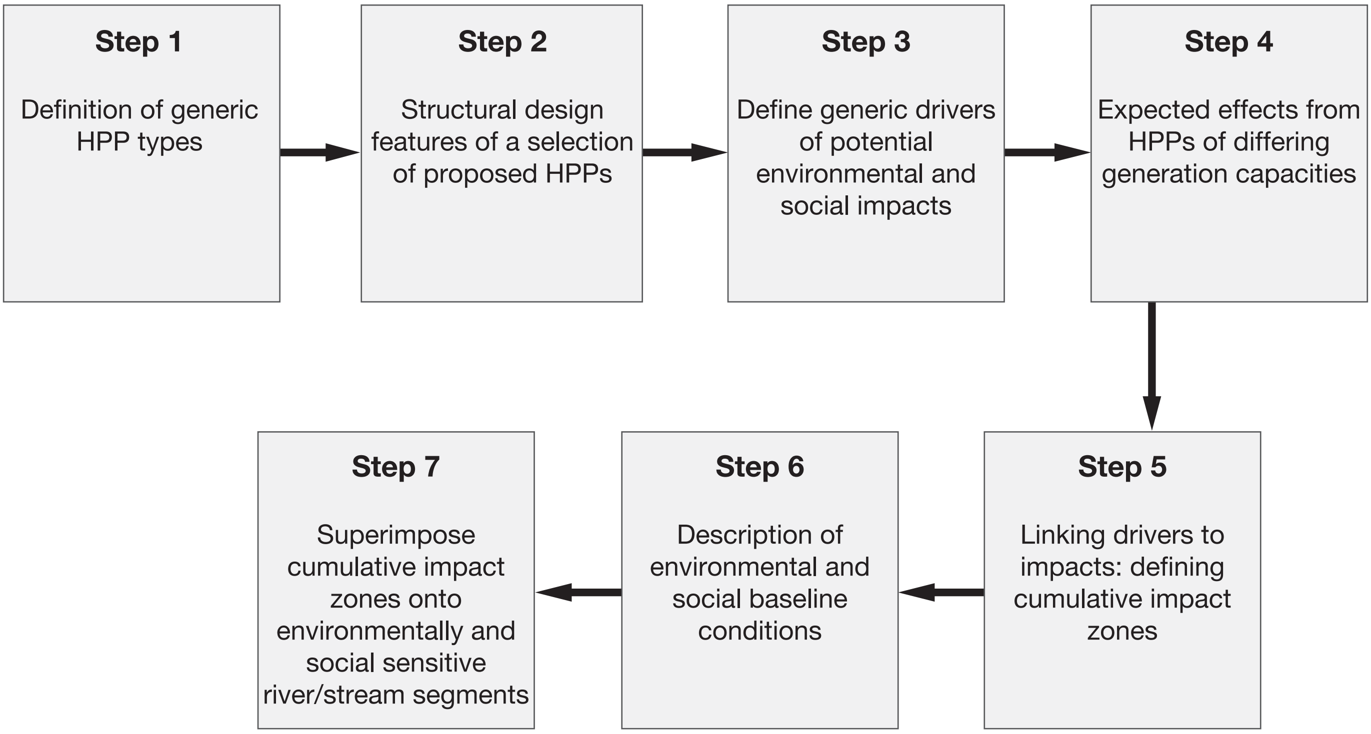
- the potential need for a change of qualifying conditions for either EIA or IEE studies for different HPPs and the level of detail in which the ecological and socioeconomic impact assessment studies need to be conducted for targeted projects;

- the role and significance of coordination between the different government agencies responsible for the development and implementation of the hydropower plan;

- an opportunity for revising the Plan as a whole or revising the type, size, layout and structural components of a HPP to utilize any benefit from other HPPs being built in the vicinity; and,

- specific regions where public awareness campaigns need to be organized by the government to help monitor HPPs during the construction and operation phases.

Figure 2.1:
SEA Study Methodology: Connection between HPP Design, Drivers and Cumulative Impacts



2.3.2
Step 1: Categorizing Proposed HPPs

The first step in undertaking a strategic environmental assessment of a hydropower plan involves describing and categorizing proposed HPPs. If there is more than one government agency responsible for hydropower planning, then the plan proponent will need to extract information from all of them. The information required by Step 1 includes:

- the number of HPPs in different stages of development (i.e "in operation", "under construction", or "in the planning/feasibility stage");

- probable installed capacity available from the Plan (disaggregated according to the three different development stages);

- an illustration of the spread of HPPs in terms of their installed capacities, disaggregating them into the following categories:

- less than 10MW;
- between 10 and 20MW;
- between 20 and 50MW;
- between 50 and 200MW; and,
- greater than 200MW.

This breakdown serves to illustrate the variety of sizes of the HPPs in the Plan.

According to the Constitution of Pakistan, the development of HPPs with an installed capacity greater than 50 MW is the responsibility of federal agencies. Responsibility for the development of HPPs with installed capacities less than 50MW is usually held by Provincial government agencies and/or private sector groups.

It is expected that the federal government, in an effort to overcome the issue of acute power shortage in the country, will prioritize the development of large HPPs (ie greater than 200MW). The scale and extent of environmental and social impacts emanating from large dams can be considerable. This will primarily be due to larger storage and/or diversion structures; greater extent and volume of river water diverted; and, the larger scale of construction activities involved.

Impacts from smaller HPPs, however, should not be underestimated. In AJK, for example, although they may only be responsible for 13 % of the total installed capacity of the hydropower plan, there are currently approximately 52 that are operational or planned. Individually these may be considered to have little environmental and social impacts. A number of them concentrated on the same river systems within a limited geographical spread could, however, result in greater environmental and social impacts.

Most of the dams planned for Pakistan will be run of the river (RoR) projects. These make use of the potential of a natural river course, usually by diverting it from its original path and releasing it back in a section of the same or different river further downstream. Storage dams are different, because they store water to create an artificial head. However, in order to ensure that larger RoR projects run at their design capacities, different degrees of storage or pondage of water for short periods is required to shield the project from the natural daily, weekly and monthly fluctuations of river flow.

This implies a categorization of the environmental and social impacts of different RoRs based on their installed capacities. RoRs with installed capacities close to 100 MW and above tend to have temporary water storage/pondage components and significant flow diversion volumes and extents as compared to smaller RoR projects. This will be discussed further in the next section.

Required Proponent Activity for Step 1

1. List all of the proposed HPPs contained in the hydropower plan. This may involve obtaining project plans from more than one agency.

2. Place them into a table, and define them as being either "in operation", "under construction", or "in the planning/feasibility stage".

3. List each proposed HPP's installed capacity.

2.3.3
Step 2: Generic Design Features of HPPs

The second step in undertaking a strategic environmental assessment of a hydropower plan involves developing and understanding of the generic design features of HPPs. This step is necessary to enable proponents to begin understanding the "drivers" of possible environmental and social impacts. As was previously mentioned, HPPs are based on either the conventional storage of water impounded by a dam; or utilize the potential in coursing rivers by building a diversion facility. Both harness the energy in flowing water to generate electricity. In RoR systems, running water is diverted from a river and guided down a channel, or penstock, which leads to a generating house.

Here, the force of the moving water spins a turbine, which then drives a generator. Used water is fed back into the main river further downstream.

The difference between RoR and large, conventional storage HPPs is usually the absence of a dam or reservoir, and projects tend to be on a smaller scale. RoRs need to be built on a river with a consistent and steady flow. Most of the large RoR facilities do use a dam, or weir, to ensure enough water enters the penstock. Pondage is also used at some facilities to store small amounts of water. RoR plants with pondage tend to be more reliable, as they assuage the effects of daily and seasonal flow infrequencies. The size of the dam and the volume of pondage, however, begin to skew the boundaries between the two project types and thereby complicate the discussion of relative environmental and social impacts.

Figure 2.2 illustrates the main components of a RoR project. The main structural features include[6]:

- Intake weir – constructed to draw water from the river, thereby creating a small 'headpond' of water.

- Penstocks – these pipes deliver water from the headpond to the turbines in the power station downstream. They are normally placed at the bottom of the headpond, in order to maximize the intake of the water flow, and are typically 3-8 km long. Penstocks are made of different materials (from plastic to high quality steel) on different sections of the pipe, depending on the pressure and the economic viability. For example, in the final part of the penstocks where the steepest drop occurs, high quality steel is required because of the high pressure inside the pipe. Penstocks can make up around 50% of a project's cost.

- Powerhouse containing turbines and generators – these turbines and generators are the core of a project. Each turbine and generator is uniquely designed for the site, which is determined by the head[7], flow and volume of water of each site. They also need to be compatible. As technology improves, the turbines associated with RoR hydroelectricity generation are getting better in design and efficiency, leading to a reduction of overall maintenance costs. Turbines and generators will normally take up to around 15% of a project's cost.

- Tailrace – a channel through which the diverted water is returned to its natural flow.

- Access roads – construction may be required depending on the existing infrastructure and remoteness of the project site. This sometimes can have a significant impact on the cost of developing a site.

- Transmission lines – transmission lines from the powerhouse to the local transmission grid can have a significant impact on project costs. A remote site may require significant investment in transmission infrastructure to connect the project to the local grid. However, with strategic planning, this cost can be shared over several projects if several RoR projects are developed in close proximity.

HPPs that rely on the conventional storage of a body of water behind a dam wall to create an artificial head utilize one of three main types of dam design: embankment, gravity and arch dams. The selection of dam type is mainly according to dam-site topography and geology. Earth and rock embankments, which are usually the cheapest to build, make up more than 80% of all large dams in the world. Embankments are generally built across broad valleys near sites where the large amounts of construction material required can be quarried. The Tarbela dam in Pakistan is the world's most voluminous dam containing 106 million cubic meters of earth and rock, more than 40 times the volume of the Great Pyramid.[8]

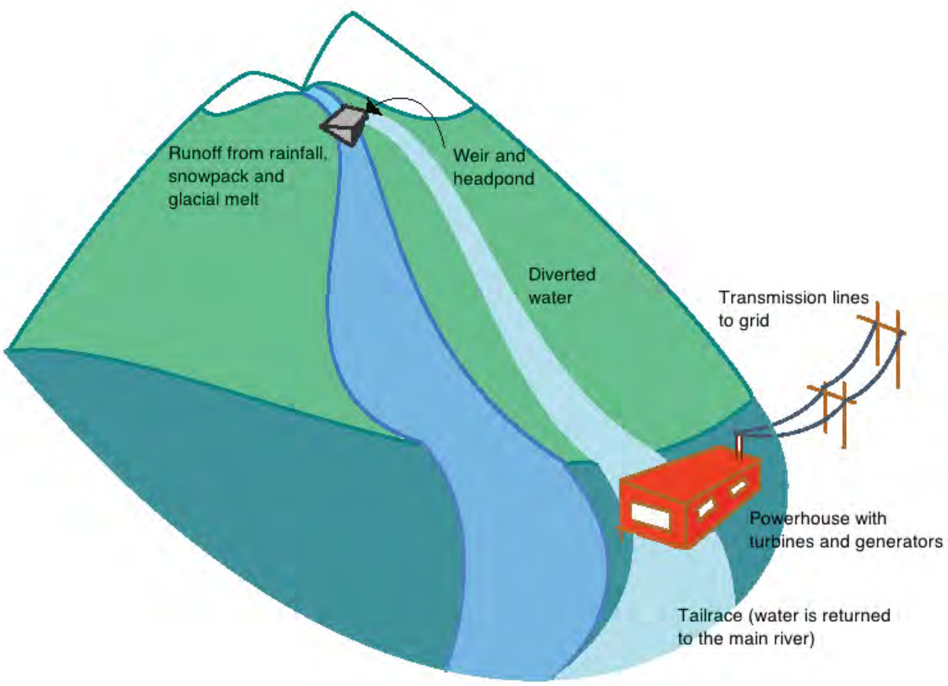
Gravity dams are thick, straight walls of concrete built across relatively narrow valleys with firm bedrock. Arch structures, also made from concrete, are limited to narrow canyons with strong rock walls and make up only around four per cent of large dams in the world. The inherent strength of the shape enables the thin wall of an arch dam to hold back a reservoir with only a fraction of the concrete needed for a gravity dam of similar height. Other than the main wall itself, spillways are used to discharge water from the reservoir. Dams built across broad plains may include long lengths of ancillary dams and dykes as is the case with Mangla dam in Pakistan, which has a reservoir, a main embankment, and an intake embankment.

[6] *Adapted from: www.energybc.ca and Practical Action, www.sswm.info*

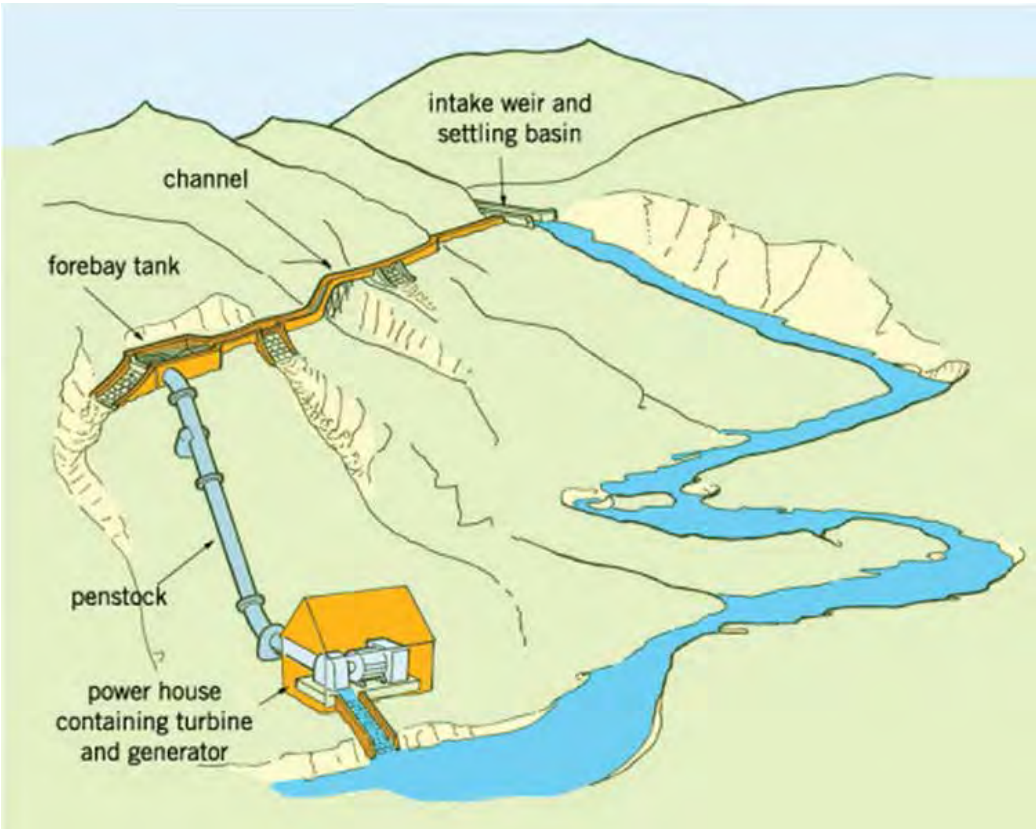
[7] *Head is defined as the difference in the elevation of water at the penstock and the elevation of the turbine inlet located in the powerhouse.*

[8] *McCully, P. (2001). Silenced Rivers: The Ecology and Politics of Large Dams. London: Zed Books.*

Figure 2.2:
The Layout of Run-of-River Projects with the Main Components Illustrated



Typical run-of-river scheme



Components of a run-of-river scheme.

The following general observations can be made about the design features of HPPs:

- The design of RoR projects is strongly defined by the installed power generating capacities of the projects.
- RoRs with lower design capacities are built taking into account the water flows of nullahs while larger RoRs are designed to utilize the larger river flow volumes provided by the main stem of rivers.
- The lower design capacities of smaller RoRs help make use of flow volumes of the nullahs regardless of the seasonal fluctuations. Larger RoRs, however, need to be shielded from daily, weekly, monthly and seasonal fluctuations of river flow in order to operate at design capacities.
- While smaller RoR projects do not store water, larger ones, on the other hand, utilize dam walls to store some volume of water to ensure consistency of flows into the penstock. However, the volumes stored by the larger RoRs do not compete in scale with the volumes stored behind conventional storage dams.
- Smaller RoRs rely only on diversion weirs and inundation canals to divert river water.
- Due to the difference in the types of diversion structures and the extent of diversion of water in terms of distance and volume, smaller RoRs do not have as extensive a construction area as that of larger RoRs.

Required Proponent Activity for Step 2

1. Where possible, describe the components of each of the proposed HPPs that were listed in Step 1. Enter these into the table constructed in Step 1.

2.3.4 Step 3: Defining Generic Drivers of Potential Environmental and Social Impacts

Understanding the design features of different types of hydropower projects allows an initial understanding to be built of the activities that will potential "drive" environmental and social impacts. Step 3 of the SEA process involves listing the range of possible drivers.

Construction activities associated with RoRs tend to be spread from the diversion facility site—such as weirs and dams—to the powerhouse. In some cases, this distance can be quite small. For example, a proposed RoR project in AJK (the 40MW Dowarian) is proposing a 4.7km diversion, whereas the 900MW Neelum-Jhelum dam diversion will likely cover a distance of 30km. For conventional storage dams, the span of areas where construction activities take place is smaller, since all the power production components are located closer together.

Most of the sites where the HPPs are planned are remote locations with little or no existing infrastructure such as roads, residential buildings, markets or hospitals. In general, HPP construction activities will generally include:

- Site preparation activities such as clearing;
- Earthworks (dirt, debris pushing and grading);
- Construction of the intake systems;
- Construction of access roads, channel and pipelines;
- Construction of the powerhouse and installation of the turbine and generator;
- Construction of an electrical substation and transmission lines;
- Preparation and use of material and equipment lay down areas;
- Extraction and haulage of sand and aggregate for concrete ingredients from an appropriate borrow area near the site;
- Storage piles, quarry sites, crushing, concrete batching plants;
- Refueling stations with diesel storage tanks will also likely be used during construction;
- Vehicles, machinery and equipment, and movement of such on unpaved land;
- Combustion of fuel; and,
- Night time construction.

Workforce camps are likely to be established at weir and powerhouse sites which serve as project management staff camps during construction. Pre-construction activities will also include taking over of land and houses; the commencement of construction of the access road to diversion tunnel outlets; diversion tunnel portal excavations; weir and powerhouse access bridges and roads; and preparation of camp sites.

Required Proponent Activity for Step 3

1. List the expected drivers of environmental and social impacts next to each of the proposed HPPs presented in Step 1.

2.3.5 Step 4: Expected Effects from HPPs of Differing Generation Capacities

Step 4 of the SEA procedure focuses on thinking about the relationship between HPP generation capacity and type of impact driver.

The previous two sections pointed to the fact that the type of diversion structure and the extent of diversion of water are major drivers of environmental impacts. The diversion and storage of river water can lead to serious water quality deterioration, destroy riparian ecosystems, reduce sediment and nutrient loads downriver, and flood extensive natural habitats. Livelihoods associated with river resources such as fishing are also affected and, as a result, have an impact on the socioeconomic condition of the people living close to the HPPs and the rivers.

As was shown in Figure 2.2, the construction of an HPP involves many components such as the intake weir, power canal, tunnel, penstock, spillway, powerhouse, tailrace, residential colony and temporary labor camp. The activities associated with construction have their own environmental impacts such as the production of liquid effluents, gaseous emissions, particulate matter, solid wastes, and noise.

In Pakistan, there is a demarcation of HPPs above and below 50 MW based on a very broad and general definition of expected environmental impacts from projects on either side of the dividing line. In 1997 the Pakistan EPA issued the Policy and Procedures for Filing, Review and Approval of Environmental Assessment. HPPs over 50 MW were included in Schedule A, and required the undertaking of full EIA before project approval. Those HPPs with generation capacities less than 50 MW were only required to produce initial environmental examinations (IEE)[9].

According to the policy, projects in Schedule A "are generally major projects and have the potential to affect a large number of people. They also include projects in environmentally sensitive areas. The impact of such projects may be irreversible and could lead to significant changes in land use and the social, physical and biological environment". Projects in Schedule B "include those where the range of environmental issues is comparatively narrow and the issues can be understood and managed through less extensive analysis. These are projects not generally located in environmentally sensitive areas or smaller proposals in sensitive areas".

The environmental and social impacts of an HPP cannot be deduced by size alone, even if increasing the physical size may increase the overall impacts of a specific HPP.[10] Generally, the larger the HPP project in terms of size, the greater the drivers of the impacts. However, because each hydropower plant is uniquely designed to fit the specific characteristics of a given geographical site, the relationship between the magnitude of the drivers and the resulting magnitude of impacts is quite complex.

However, for the purposes of these generic guidelines, the 50MW benchmark will be a sufficient "benchmark hurdle point" to categorize the drivers of environmental and social impacts, based on a number of assumptions.

- It will be assumed that for HPPs less than 50 MW they:
  - have smaller design capacities for power generation and do not require river water stored behind a dam wall;
  - will rely only on diversion weirs and inundation canals which do not store any water;
  - will be built on nullahs and not on major river stems;
  - will divert water from the nullahs into either the same nullah downstream, or the main river; and,
  - will not have an extensive construction area, as the distance between the diversion point and powerhouse will be within 10 km.

- On the other hand, it will be assumed that for HPPs greater than 50 MW they:
  - have large design capacities for power generation and require a certain volume of river water stored behind a dam wall to shield them from seasonal fluctuations;
  - will rely on a dam wall for diversion and pondage of water;
  - will be built on major river stems;

[9] Government of Pakistan. (November, 1997). Policy and Procedures for the Filing, Review and Approval of Environmental Assessment.

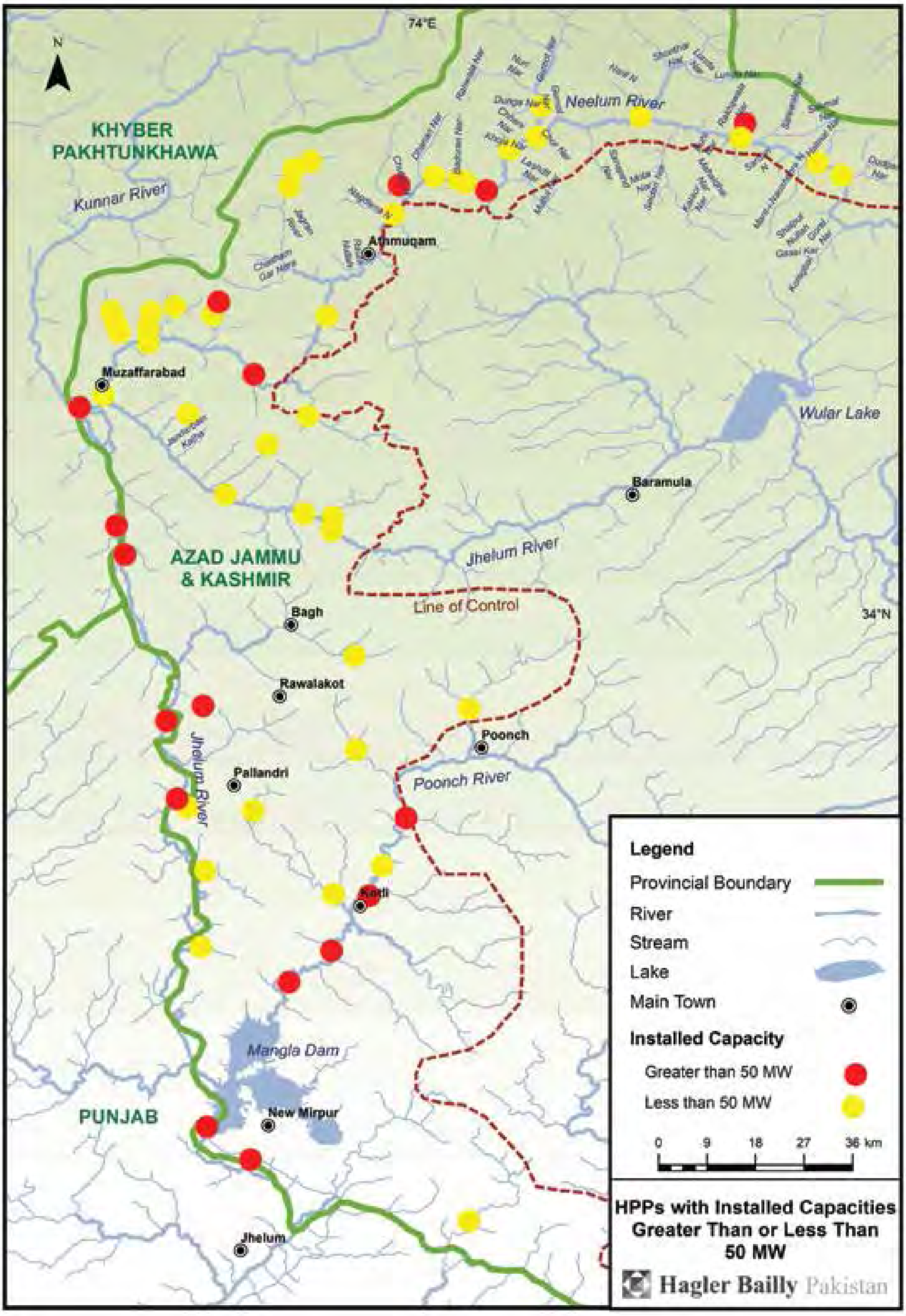
[10] Egre, D., Milewski, J.C. (2002). The diversity of hydropower projects, Energy Policy, Vol. 30, No. 14, Nov. 2002, pp 1225-1230.

- will divert water from the one major river stem into a section of the same river further downstream or into another river; and,
- will have an extensive construction area, as the distance between the diversion point and powerhouse will be greater than 10 km.

Required Proponent Activity for Step 4

The proponent should map the all of the HPPs contained in the hydropower plan on a physical map, using the 50MW benchmark to distinguish between them. Figure 2.3 provides an example taken from the pilot SEA for the AJK hydropower plan.

Figure 2.3: Comparison of Proposed HPPs against Installed Capacity Size of 50MW



2.3.6 Step 5: Linking Drivers to Impacts: Defining Cumulative Impact Zones

Figure 2.3 provides an introduction to the idea that the magnitude of environmental and social impact drivers can be mapped, and that there may be cumulative impacts that should be taken into account when decisions are made about the implementation of the overall hydropower plan.

This section of the SEA Guidelines illustrates how river and stream sections may be identified and ranked according to their susceptibility to cumulative impacts.

Key indicators of Environmental and Social Impacts of HPPs

A Sustainable Development Working Paper[11] published by the Environmentally and Socially Sustainable Development Department of the World Bank in 2003 highlights indicators that can be applied when thinking about the environmental and social impacts of HPPs. This discussion relates to dams as well as RoRs.

Reservoir surface area

The area flooded by the reservoir is a strong proxy variable for many environmental and social impacts. A large reservoir surface area means that there will be loss of more natural habitat and wildlife and displacement of more people. Very big reservoirs are found normally in lowlands with resultant problems such as tropical diseases and aquatic weeds. They also usually impound large rivers putting many aquatic and fish species at risk.

Water Retention Time in Reservoir

Average water retention time in the reservoir during standard operational hours is very useful in estimating the scope of expected water quality problems. The shorter the retention time, the better environmental desirability of the project.

Biomass Flooded

Standard convention for calculating biomass flooded is in tons per hectare based on the percent cover of different vegetation types in the reservoir area. Dams should ideally minimize inundation of the forests which have very high biomass content. Flooding native forests also adds to release of greenhouse gases and threatens biodiversity.

Length of River Impounded

For the conservation of aquatic and riparian biodiversity including riverine forests, hydropower projects should aim to minimize the length of river (main stem plus the tributaries) impounded by the reservoir which is measured during high flow periods.

Length of River Dried Out

This indicator measures the length in kilometers of the river which is left dry (with less than 50% of dry season mean flow) below the dam or diversion weir as a result of water diversion. This value should be minimized due to the loss of fish and other aquatic life, damage to riparian ecosystems, and disruption of human water supplies and agricultural activities.

Number of Downriver Tributaries

This indicator relates to the number of major undammed tributaries downstream of the project site. A higher number of tributaries are desirable for maintaining accessible habitat for migratory fish, the natural flooding regime for riverine ecosystems, and nutrient or sediment inputs needed for the high biological activities of the estuaries.

Likelihood of Reservoir Stratification

Stratification in a reservoir takes place when the upper zone of the lake is thermally segmented from the deeper zone; the latter becoming stagnant and lacking in dissolved oxygen therefore making the region unsuitable for most aquatic life.

Reservoir life

Useful reservoir life is the number of years before the dead storage of a reservoir is completely filled, when further sedimentation decreases the live storage and inhibits power generation. Dead storage refers to the part of the reservoir water beneath the level of the intakes for the dam turbines; and the water above this intake is referred to as live storage. Useful reservoir life depends on dead storage and river borne sediment loads. This indicator is useful in determining relative sustainability of electric power generation. This indicator normally varies from less than ten years before dead storage is filled to potentially thousands of years. Reservoirs which are deep and situated on low-sediment-load rivers have the longest useful reservoir lives.

Access Roads through Forests

Where the risks of induced deforestation are high, project siting should minimize the kilometers of required new or upgraded access roads passing through or near natural forests.

[11] Quintero, Juan David; Ledec, George. 2003. Good dams and bad dams: environmental criteria for site selection of hydroelectric projects. LCSES Sustainable Development working paper series ; no. 16. Washington D.C. - The Worldbank. http://documents.worldbank.org/curated/en/2003/11/5256830/-good-dams-bad-dams-environmental-criteria-site-selection-hydroelectric-projects

Human Resettlement

Hydropower project location should ideally seek to minimize the number of people requiring resettlement from the land area affected by the reservoir and various civil works.

Effect on Critical Natural Habitats

The number of sites and hectares of critical natural habitats that are expected to be lost due to inundation, borrow pits or other components need to be assessed. Critical natural habitats such as officially proposed protected areas, as well as unprotected areas of known high importance for biodiversity conservation need to be taken into account. Some hydroelectric projects imply very important conservation opportunities by providing a strong justification (sediment reduction) and financial resources needed for protecting natural habitats in upper catchment areas.

Fish Species Diversity and Endemism

Fish species diversity is the number of species known from the project area, including the dam and reservoir site, as well as the downstream zone of project influence. Fish species endemism is the number of native species known only from the project area, or the river system where the project is located, and nowhere else on Earth. Dams are environmentally less objectionable if they affect rivers with a naturally low diversity and endemism of native fish species. In general, large, lowland rivers in warm (tropical or subtropical) climates have a high diversity of native fish and other aquatic organisms, while small rivers in cold (tropical highland or temperate) climates have relatively low diversity. Large, lowland rivers are also more likely to have significant seasonal fish migrations, which are effectively blocked by most dams. However, highland rivers and streams often have relatively high endemism in their fish fauna, especially if they are isolated from other rivers by waterfalls or other natural barriers. River segments with threatened fish species found nowhere else should be classified as critical natural habitats and, ideally, would receive permanent protection from dams or other potentially damaging civil works. However, dams and reservoirs in upper tributary rivers and streams need not threaten the survival of any endemic fish (ormollusks, or other aquatic life) if they affect only an insignificant portion of the river area used by these species. They should also be sited so as not to block important fish migrations.

Cultural Property Affected

An indication of the cultural significance of the area to be inundated (or otherwise affected by the project) is the number (by type) of cultural (archaeological, historical, paleontological, or religious) objects or sites.

It is important to note whether each type of cultural property at the project site is salvageable (totally, partially, or not at all).

Applying the Indicators

Not all of the 13 indicators introduced above will be relevant in each case. Nor will it always be possible to find the data necessary to apply the indicators. Before choosing relevant indicators, proponents should assess the criteria and assumptions for categorizing drivers of impacts outlined in Step 4, and should consider the geographic, topographic, hydrological and socioeconomic context of the Province they are working in.

By way of example, the following indicators were considered to be the most relevant in predicting the environmental and social impacts from the development of the AJK hydropower plan:

- length of river dried out;
- number of downriver tributaries;
- construction works and access roads through forests;
- human resettlement;
- fish habitat, effect on critical natural habitats and fish species diversity and endemism; and,
- reservoir size.

Table 2.1 presents a “snapshot” of how two of these indicators (length of river dried, and number of downriver tributaries) were applied in the AJK example, as criteria to compare the environmental and social impacts that might be expected from HPPs that are either below, or above, the 50 MW benchmark.

In Table 2.1, the severity of possible impacts is categorized using a colour scheme. The categorizations are based on the likelihood of the impacts taking place, the magnitude of the effect and the scale of mitigation and monitoring that may be required. The description of the categories is as follows:

- Low (green):
  - Likelihood of impact occurring is low;
  - If it takes place, the severity and magnitude of the impact on riverine ecology is small; and,
  - There are minimal mitigation measures required and no long-term monitoring.

- Medium (yellow):
  - Likelihood of impact occurring is high;
  - The severity and magnitude of the impact on riverine ecology is high; and,
  - It will require some mitigation measures in the design of the HPP but no monitoring required.

- High (red):
- Likelihood of impact occurring is high;
- The severity and magnitude of the impact on riverine ecology and human settlements is high; and,
- Mitigation measures may include compensation and resettlement of locals and regular monitoring of project during its life.

Table 2.1: Snapshot of Environmental and Social Indicator Application for the AJK Hydropower Development

Indicators of Environmental and Social Impacts	Potential Environmental and Social Impacts	Expected difference in Severity of Environmental and Social Impacts in AJK from HPPs with Installed Capacities less than 50 MW and those greater than 50 MW	
		Less than 50MW	Greater than 50MW
I. Length of river dried out	Serious water quality deterioration, due to the reduced oxygenation and dilution of pollutants by relatively stagnant reservoirs (compared to fast-flowing rivers).	HPPs smaller than 50 MW will mostly have diversion weirs in the nullahs with no impoundment of water. Water is expected to continuously flow even when diverted. Water quality deterioration will however be a serious concern in the part of the river downstream of the diversion structure if all the water is diverted, especially in the dry winter season. However, in terms of scale, the length of river expected to be dried out by smaller HPPs is less than that diverted by larger HPPs.	For HPPs greater than 50 MW there may be some form of damming involved with the impoundment of water. This can potentially result in serious water quality deterioration, due to the reduced oxygenation and dilution of pollutants by relatively stagnant reservoirs (compared to fast-flowing rivers), flooding of biomass (especially forests) and resulting underwater decay, and/or reservoir stratification (where deeper lake waters lack oxygen).
II. Number of downriver tributaries	Major downriver hydrological changes can destroy riparian ecosystems dependent on periodic natural flooding, exacerbate water pollution during low flow periods, and increase saltwater intrusion near river mouths. Reduced sediment and nutrient loads downriver of dams can increase river-edge and coastal erosion and damage the biological and economic productivity of rivers and estuaries. Induced desiccation of rivers below dams (when the water is diverted to another portion of the river, or to a different river) kills fish and other fauna and flora dependent on the river; it can also damage agriculture and human water supplies.	HPPs smaller than 50 MW will mostly be located on nullahs. The water from these nullahs will eventually reach the main stem of a river either directly or through other nullahs where flow is diverted. Generally, there are a larger number of downriver tributaries from water diversion points in nullahs than HPPs located in the larger main river stems.	HPPs greater than 50 MW are expected to be built mostly on the main stem of rivers. Therefore, relative to smaller HPPs built on nullahs, they will have less downriver tributaries from the point where water is diverted or temporarily stored. This implies a lack of ecological ecosystem regulation that tributaries provide. Therefore, larger HPPs are expected to harm riparian ecosystems more than HPPs less than 50 MW in size.

Identifying Generic Cumulative Impacts

In previous Steps, both the drivers of the environmental and social impacts, and the impacts themselves have been analyzed, taking into account individual HPPs of different sizes. However, aquatic biodiversity in rivers does not exist in isolation in different stretches of rivers, but as an integrated process across the basin. When the process is disrupted by a diversion structure such as a dam, weir, canal or tunnel, it has basin-wide impacts. The development of a number of HPPs on the same river basin will result in cumulative environmental and social impacts. One large-scale hydropower project of 2,000 MW located in a remote area of one river basin might have fewer negative impacts overall than the cumulative impacts of 400, 5 MW hydropower projects across many river basins.

In the context of hydropower development, cumulative impacts can result from (i) multiple actions at a given site associated with a single project, or (ii) can be additive or synergistic[12] in nature when potential impacts of multiple dams are taken into account and are concentrated in time or space. An example of the latter could be the impacts of a series of small dams constructed on a single stream or on streams within a single river basin.[13] Such impacts may occur when the affected system is being perturbed repeatedly and increasingly by the same local agent with sufficient frequency so that it does not have time to recover between events (time-crowding), or the affected system is being perturbed by several similar activities or different activities having similar effects, in an area too small to assimilate the combined impacts (space-crowding).[14]

A strong correlation exists between stream flow and a river's physico-chemical characteristics such as water temperature and habitat diversity. Changes in flow volume and patterns can adversely impact the structure, distribution and composition of fish communities in the region. Dams, or any construction across rivers, are always a barrier for fish which move from one part of a stream or river to another as part of their life cycle processes. Changes in the sedimentation flows due to dam or barrier construction, especially in Himalayan rivers, are expected to have an adverse impact on fish habitats. Even a few centimeters of sediment layer over the natural substrata is enough to negatively affect foraging and spawning fish. Changes in the abundance of fish species found in rivers and streams may affect income generated by locals from commercial fishing activities and from tourism.

In Step 5, different cumulative impacts should be discussed, based on knowledge of the drivers of impacts of HPPs in the Plan and the nature and magnitude of the impacts. River sections that are most vulnerable to cumulative impacts can be identified as impact zones and should then be superimposed on the environmentally and socially sensitive river sections that will be identified in the baseline analyses to be undertaken in Step 6.

Table 2.2 describes the mechanics of how cumulative impacts from the construction and operation of HPPs may affect different environmental and social components. Potentially affected components include the following:

• Habitats and Wildlife
- Flora and fish species
- Amphibians and Reptiles
- Birds
- Mammals

• Water
- Public water users
- Aquatic environment
- Downstream riverbed

• Sedimentation
- Riverbed substratum
- Foraging and spawning areas for fish species

• Ways of Life, Territorial Organization, Land Use, Protected Areas, Economics
- Closest residential area/receptor
- Terrestrial environment
- Agriculture and Grazing
- Forest
- National parks
- Wildlife preservation and development areas
- Wetlands
- Cultural heritage sites
- Mining
- Fishery
- Tourism

[12]Synergistic or interactive effects are generally the result of interactions between effects of two or more projects that result in combined effects that are greater than the sum of the individual project's effects and typically more complex and difficult to assess than additive effects. Arikan, Esra; Dieterle, Gerhard; Bouzaher, Aziz; Ceribasi, Ibrahim Haluk; Kaya, Dundar Emre; Nishimura, Shinya; Karamullaoglu, Ulker; Kahraman, Bilgen. 2012. Sample guidelines : cumulative environmental impact assessment for hydropower projects in Turkey. Washington DC ; World Bank. http://documents.worldbank.org/curated/en/2012/12/17671936/sample-guidelines-cumulative-environmental-impact-assessment-hydropower-projects-turkey

[13]Rajvanshi, Asha; Roshni Arora; Vinod B. Mathur; K. Sivakumar; S. Sathyakumar; G.S. Rawat; J.A. Johnson; K. Ramesh; NandKishor Dimri and Ajay Maletha (2012) Assessment of Cumulative Impacts of Hydroelectric Projects on Aquatic and Terrestrial Biodiversity in Alaknanda and Bhagirathi Basins, Uttarakhand. Wildlife Institute of India, Technical Report. Pp 203 plus Appendices.

[14]Ibid.

Table 2.2: Mechanics of Cumulative Impacts from Hydropower Projects[15] [16]

Cumulative Impact Sectors	Impact Components	Mechanics of Cumulative Impacts
Habitats and Wildlife	• Flora species • Fish species • Amphibians • Reptiles • Birds • Mammals	• Cumulative impact on aquatic flora and fauna across the basin. • Changes in the hydrological regime. A strong correlation exists between stream flow and a river's physico-chemical characteristics such as water temperature and habitat diversity. Research on the distributional ecology of fishes suggests that fish assemblages form in response to the physico-chemical factors of the environment. • Change in the assemblage structure of stream fishes or species composition is imposed by temporal variation in stream flow, which ultimately affects the entire biodiversity of the river ecosystem. • Changes in the sediment flow. • Changes in the quality of water. • Interruption in the migratory routes. • Interference in strategic biodiversity environment. • HPPs with dams and diversion structures effect the nutrient flow either for longer or for a shorter period depending upon structure. Submerged rivers act as nutrient traps. Changes in the nutrient flow would adversely affect the downstream fishes and other aquatic biodiversity.
		• Cumulative impact on terrestrial flora and fauna across the basin due to multiple projects. • Cumulative impact of deforestation due to various projects. • Loss, fragmentation or isolation of habitats. • Interference or pressure over protected sites. • Pressure over endangered species.
Water	• Public water users • Aquatic environment • Downstream riverbed	• Impact of differential water flow downstream from power house in dry season months, with sudden release of heavy flows during peaking/ power generation hours and no releases during other times. • Opportunity for the multiple uses of water. • Cumulative impact on hydrological flows, at various points within project, at various points within a day, season, year, over the years and cumulatively across the basin and impacts thereof. • This will include impacts on various hydrological elements including springs, tributaries, groundwater aquifers and thus access to drinking water and irrigation.
Sedimentation	• Riverbed substratum • Foraging and spawning areas for fish species • Environmental cues.	• Changes in sedimentation at various points within project, at various points within a day, season, year, over the years and cumulatively across the basin and impacts thereof. • Release of silt free water into the river downstream from the power house and impact thereof on the geomorphology, erosion, stability of structures. • Release of silt laden water into the river channel downstream from the dam, and its accumulation across the dry season.

[15] *Arikan, Esra; Dieterle, Gerhard; Bouzaher, Aziz; Ceribasi, Ibrahim Haluk; Kaya, Dundar Emre; Nishimura, Shinya; Karamullaoglu, Ulker; Kahraman, Bilgen. 2012. Sample guidelines: cumulative environmental impact assessment for hydropower projects in Turkey. Washington DC; World Bank. http://documents.worldbank.org/curated/en/2012/12/17671936/sample-guidelines-cumulative-environmental-impact-assessment-hydropower-projects-turkey*

[16] *Rajvanshi, Asha; Roshni Arora; Vinod B. Mathur; K. Sivakumar; S. Sathyakumar; G.S. Rawat; J.A. Johnson; K. Ramesh; NandKishor Dimri and Ajay Maletha (2012) Assessment of Cumulative Impacts of Hydroelectric Projects on Aquatic and Terrestrial Biodiversity in Alaknanda and Bhagirathi Basins, Uttarakhand. Wildlife Institute of India, Technical Report. Pp 203 plus Appendices.*

Cumulative Impact Sectors	Impact Components	Mechanics of Cumulative Impacts
Ways of Life Territorial Organization Land Use Protected Areas Economics	• Closest residential area/receptor • Terrestrial environment • Agriculture • Grazing • Forest • National parks • Wildlife preservation & development areas • Wetlands • Cultural heritage sites • Mining • Fishery • Tourism	• Cumulative impact of all the project components (dam, tunnels, blasting, power house, muck dumping, mining, road building, township building, deforestation, transmission lines, etc). • Cumulative impact of mining of various materials required for the projects (sand, boulders, coarse and fine granules, etc.). • Cumulative impact of blasting of tunnels on various aspects. • Cumulative impact of muck dumping into rivers. • Road Infrastructure Improvements. • Pressure over the ways of life due to people attracted to the area of the project. • Changes in the way of life of people depending on river-based environmental services. • Epidemiological changes. • Loss of archaeological, historic and cultural patrimony. • Increase of conflicts. • Local Labor Market disruption. • Interference in the territorial organization of local people. • Interference in the flow of people, goods and services. • Loss of municipalities' territory • Pressure over sociocultural relationships • Pressure over ecological conditions of indigenous area. • Loss of areas with economic productivity • Loss of resources (mining, fishery, touristy, agricultural, among others) • Local Government Revenues Increase;

Identifying Cumulative Impact Zones

Having outlined the different possible generic cumulative impacts from the construction and operation of HPPs, and the mechanics with which different environmental and social sectors could be affected, the next component of Step 5 involves relating this general background information to the specific geographical context of the hydropower plan in question. The purpose of this component of Step 5 is to introduce the concept of impact zones.

Based on the geographical locations and potential cumulative impacts expected from hydropower development, river and stream sections across a Province that may be prone to the cumulative impacts of HPP development can be delineated into impact zones. The nature and magnitude of the potential impacts are linked strongly to the rivers and streams themselves. The extent of potential environmental and social impacts, in terms of geographical spread, is also limited to areas close to the rivers/streams. This is due to the topography of the Provinces where HPPs are proposed, where rivers flow through narrow valleys with steep and high slopes on both sides. Therefore, in terms of the lateral extent of impacts, these are not expected to carry the effect of any cumulative environmental or social impact beyond 500 m from the center of the river on both sides.

Therefore, the delineation of impact zones should be centered on the nullahs and the main stems of the rivers where the HPPs will be located. In defining cumulative impact zones, the nullahs and river sections should be split, based on a continuous stretch up to a confluence point where another nullah or river intersects.

For illustrative purposes, the width of the impact zone on each side of the river should be kept at 1.5 km. The lengths of the zones, however, are governed by the effect of RoRs on nullahs and main stems of rivers, not only at the points where diversion structures are located, but also on stretches located downriver. Hence, the longer boundary of the impact zones along the river takes into account the cumulative impacts of the development of a number of HPPs in close proximity on the same river systems.

Based on the predicted extent and severity of the cumulative impacts, the impact zones should be categorized into Moderately Critical Zones, Highly Critical Zones and Extremely Critical Zones.

Methodology for Determining Extent of Cumulative Impact

The extent of cumulative impact can be categorized in terms of a HPP's location on a nullah or the main stem of a river, and the number of other HPPs located on that same section. A scoring system can be used to quantify extent of cumulative impact.

- Nullahs or main-river stems — in terms of the length of river dried out and the number of downstream tributaries available to absorb upstream ecological disturbances, nullahs are considered better locations for HPPs than main river stems. Therefore, if a particular zone is located on a nullah it scores '1', while those on a main river stem score '2'.

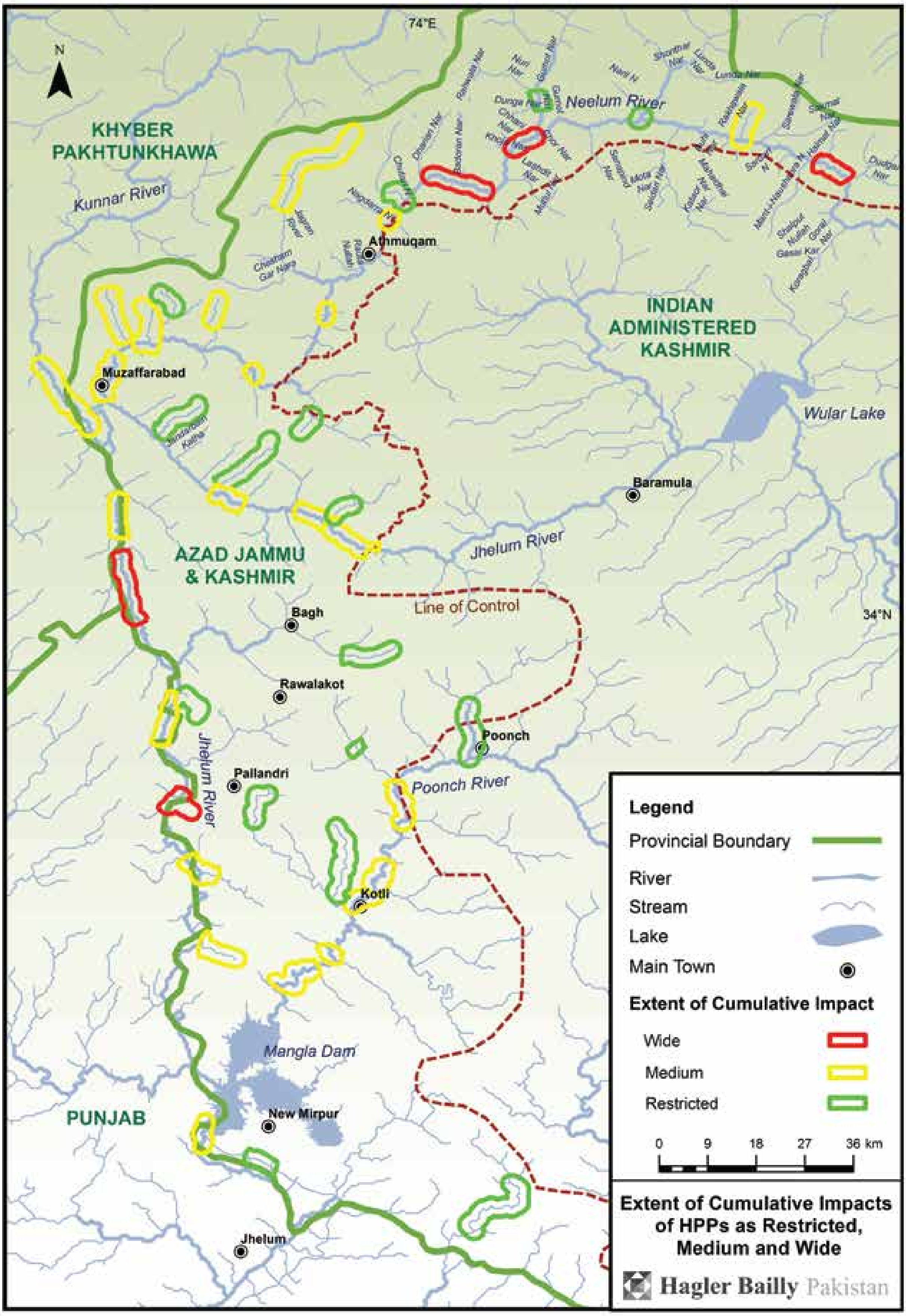
- The number of HPPs - knowing the extent of a river section affected by the diversion of water by specific HPPs - would be the most useful indicator of the extent of cumulative impacts. However, in most hydropower plans the exact locations of the HPPs will not necessarily be evident. The number of HPPs being planned in a particular zone is an adequate substitute to indicate the extent of impact. Zones with one HPP in them score '1', while zones with more than one HPP located in them score '2'.

This scoring system can be used to indicate the extent of cumulative impact. In Table 2.3, the location of an impact zone is designated as being either 'restricted', 'medium' or 'wide'. An example of how this scoring system can be used to graphically express the extent of cumulative impact is shown in Figure 2.4 (using the AJK SEA pilot example).

Table 2.3: Matrix indicating the Extent of Cumulative Impacts as 'Restricted', 'Medium', or 'Wide'

<table>
<tr><th colspan="2" rowspan="2">Extent of Cumulative Impacts (Total Score)</th><th colspan="2">Number of HPPs in a given zone</th></tr>
<tr><th>One (score = 1)</th><th>More than one (score = 2)</th></tr>
<tr><td rowspan="2">Location of impact zone</td><td>Nullah (score = 1)</td><td>Restricted (2)</td><td>Medium (3)</td></tr>
<tr><td>Main stem of river (score = 2)</td><td>Medium (3)</td><td>Wide (4)</td></tr>
</table>

Figure 2.4: Extent of Cumulative Impacts on Nullahs and Main River Stems from HPPs in AJK



Severity of Cumulative Impact

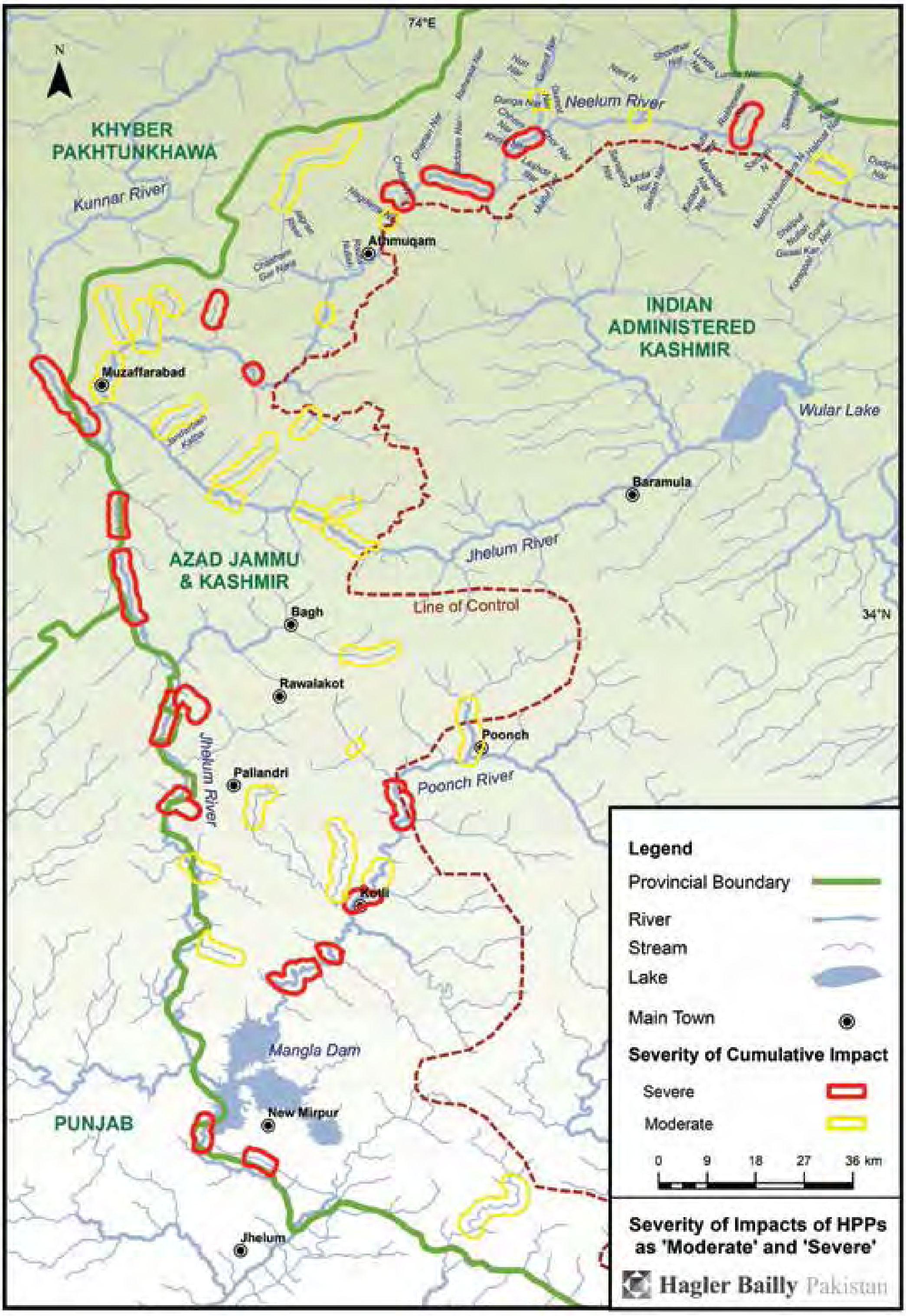
The severity of cumulative impacts in the identified impact zones can be categorized based on whether the proposed HPPs in the zones are less than, or greater than the 50 MW benchmark.

The severity of cumulative impacts can be categorized as:

- Moderate; if all the HPPs in an impact zone are smaller than 50 MW, and,
- Severe: if there are HPPs larger than 50 MW in size, or if there is a mix of both types.

Figure 2.5 from the AJK SEA pilot study illustrates the cumulative impact zones according to severity of impacts.

Figure 2.5: Cumulative Impact Zones in AJK categorized according to the Severity of Impacts



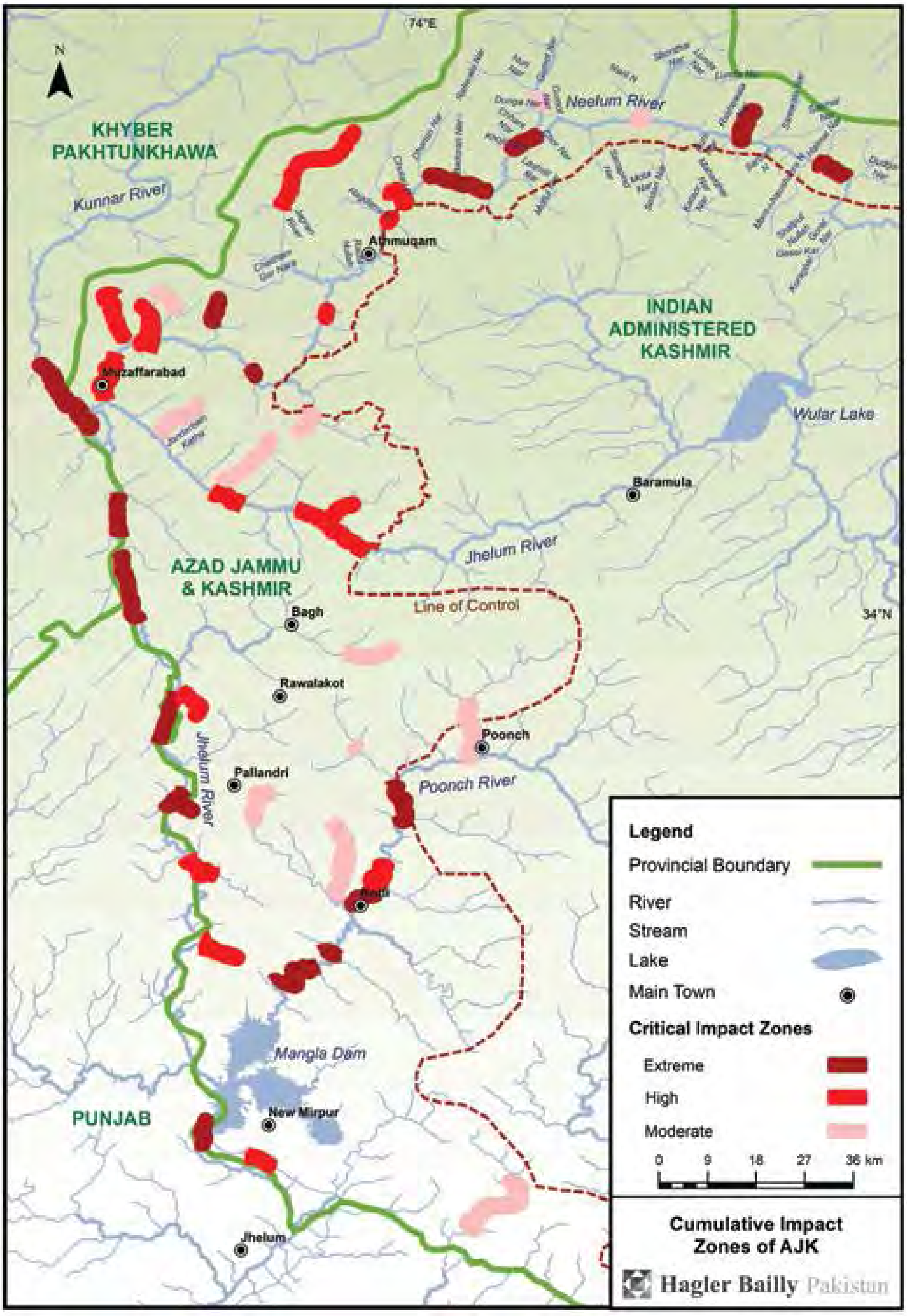
Categorizing Cumulative Impact Zones

Based on the predicted extent and severity of cumulative impacts, the impact zones can be categorized into Moderately Critical Zones, Highly Critical Zones and Extremely Critical Zones according to the categories described in Table 2.4. Figure 2.6 presents these impact zones in mapped format, as determined for the AJK SEA pilot.

Table 2.4: Categorization of Cumulative Impact Zones based on the Extent and Severity of Cumulative Impacts

Categorization of Cumulative Impact Zones		Extent of Impact		
		Restricted	Medium	Wide
Severity of Impact	Moderate	Moderately Critical	Highly Critical	Extremely Critical
	Severe	Highly Critical	Extremely Critical	Extremely Critical

Figure 2.6: Moderately Critical, Highly Critical and Extremely Critical Impact Zones in AJK based on the Extent and Severity of Cumulative Impacts



Concluding Comments for Step 5

Figure 2.6 shows the extent of the river system in AJK that will be affected by the development of HPPs contained in the hydropower plan. All of the main stems of the rivers of AJK are host to Extremely, Highly and Moderately Critical Impact Zones. On the nullahs, the Cumulative Impact Zones are mostly only highly or moderately critical.

It must be remembered that the results of the categorization of the nature of the Cumulative Impact Zones are—to a degree—qualitative. The categorization was based on the severity and extent of the cumulative impacts using qualitative predictive methods as shown in the scoring tables (Table 2.3 and 2.4). In turn, these were based on a brief analysis of the design features of HPPs, and on a limited amount of primary scientific data.

For a fully rigorous study of cumulative impacts, it would be necessary to examine the structural features and components of all the HPPs in the Plan in greater detail. Such a study would look into the exact volumes of water diverted, the remaining downstream flows, the extent of the diversion, the exact volume of planned impoundment of water, the size of the construction works, and the extent and locations of development of new infrastructure associated with each project.

The objective of SEA in this case is to assist hydropower plan proponents to identify the scale, diversity, magnitude and complexity of the potential cumulative environmental and social impacts emanating from the implementation of the plan, and to identify the areas and river sections most sensitive to those impacts. The SEA process also aims to provide the authorities with a guide to help direct the focus of further detailed EIA studies that may need to be undertaken as part of the design of specific projects. The identification of critical impact zones, as shown in the AJK example in Figure 2.6, adequately serves the purpose by providing approximate locations of the areas expected to be affected and the possible severity of impacts.

What remains now is to examine the condition of environmental and social 'baselines' on rivers or nullahs that are likely to be developed. The Cumulative Impact Zones identified in Figure 2.6 can then be superimposed on these baselines, and the areas in the Province most prone to cumulative impacts from the development of the Plan will finally be identified.

Required Proponent Activity for Step 5

1. Decide on relevant indicators of environmental and social impact.

2. Determine the extent of cumulative impact, utilizing a scoring method similar to that displayed in Table 2.3.

3. Map the extent of cumulative impact, using Figure 2.4 as a model.

4. Map the severity of cumulative impact, using Figure 2.5 as a model.

5. Based on the predicted extent and severity of cumulative impacts, categorize the impact zones into Moderately Critical Zones, Highly Critical Zones and Extremely Critical Zones according to the categories described in Table 2.4. Represent these impact zones on a map, using Figure 2.6 as a model.

2.3.7 Step 6: Describing Environmental and Social Baselines

Ecological Baseline and Sensitivity Zoning

The purpose of the second last step in the SEA process is to carefully examine the environmental and social "baseline" conditions existing along the river and stream stretches that will likely see HPP development taking place.

The first part of Step 6 involves designating ecological zones within the region of the Province that will become the focus for hydropower development. The ecological importance of these zones can then be determined by using an indicator such as diversity of fish species. In the case of the AJK example, the following parameters were used:

- Fish Diversity
- Economic Importance of Fish
- Conservation Importance of Fish
- Classification as Protected Area

In addition, the connectivity to upstream and downstream ecosystems was taken into consideration to assess the ecological importance of each zone.

Using this approach, the "sensitivity" of each ecological zone to the construction and operation of HPPs can be placed in three categories: 'highly sensitive', 'moderately sensitive' and 'least sensitive'. These rankings are based on a Total Biodiversity Assessment Score calculated as explained below.

The three fish related indicators i.e. fish diversity, economic importance of fish and conservation importance of fish are given a score of 1, 2 and 3 depending on their rating of low, medium and high respectively. If the entire zone is a protected area it is given a score of 3, if a part of the zone is included in a protected area, it is given a score of 2, and for no protected area present in the zone, a score of 0 is assigned.

The Total Biodiversity Assessment Score for each zone is calculated by adding the scores for each of the four indicators and the following criteria are used to make the final assessment regarding the sensitivity of the zone to hydropower development.

Least Sensitivity Zone – Total Assessment Score of 1 – 4

Moderate Sensitivity Zone – Total Assessment Score of 6 – 8

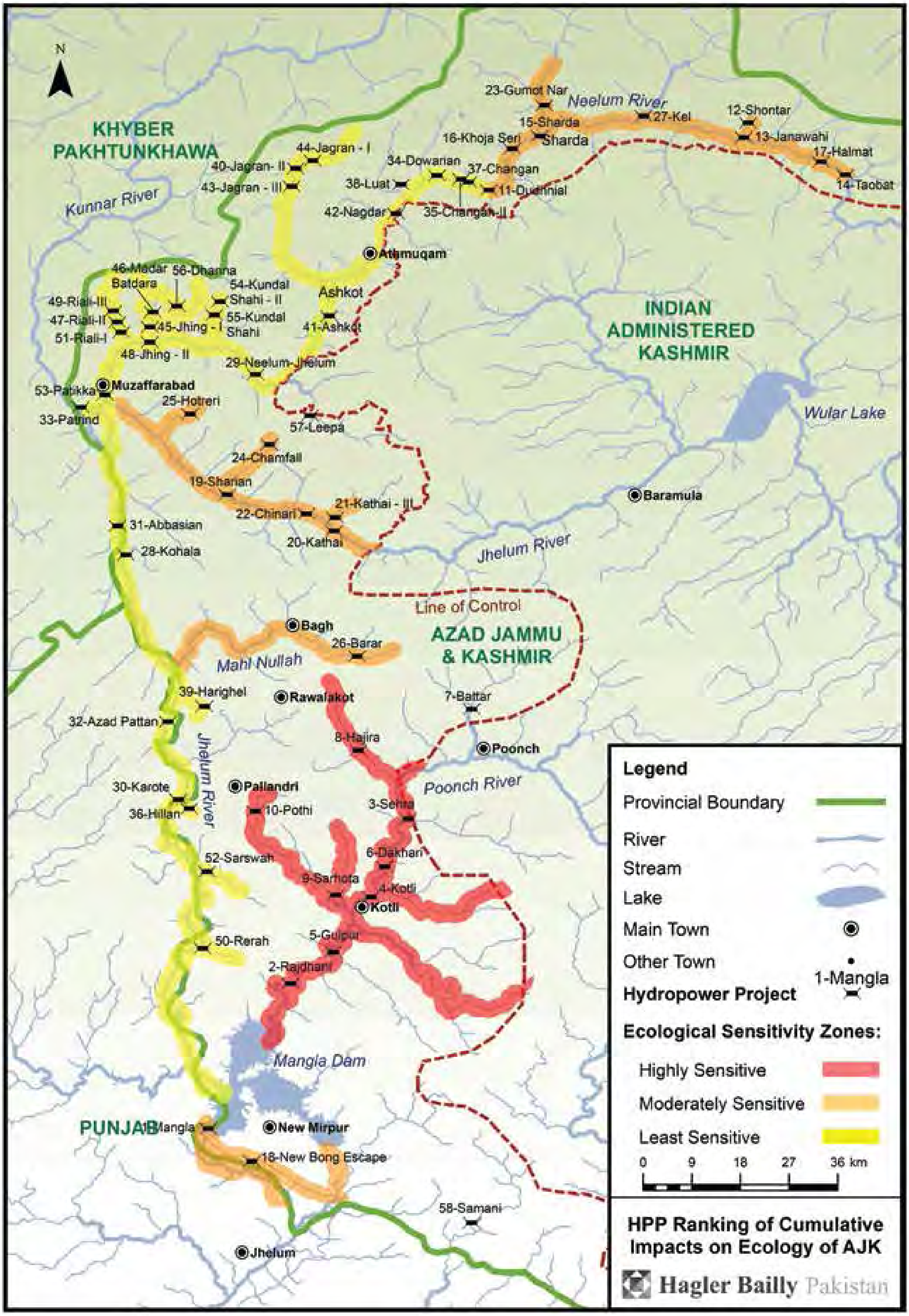
High Sensitivity Zone – Total Assessment Score of 9 – 12

Again, using the AJK example, the sensitivity rating of each designated river zone to hydropower development is shown in Table 2.5, and a map of this sensitivity zoning is shown in Figure 2.7.

Table 2.5: Ecological Sensitivity Zoning for Hydropower Development

Zone Name	Ecological Zone	Fish Diversity	Economic Importance of Fish	Conservation Importance of Fish	Protected Area	Biodiversity Assessment Score	Sensitivity Classification
Zone A	Neelum River from Taobat to Dhudnial	Low	High	Medium	Parts of zone included in Musk Deer National Park	8	Moderately Sensitive
Zone B	Neelum River from Dhudnial to Nauseri	Low	Low	Medium	No	4	Least Sensitive
Zone C	Neelum River from Nauseri to Muzaffarabad	Low	Low	Medium	No	4	Least Sensitive
Zone D	Jhelum River upstream Domel	Medium	Medium	High	No	7	Moderately Sensitive
Zone E	Jhelum River downstream Domel	Medium	Low	Low	No	4	Least Sensitive
Zone F	Mahl Nullah	Medium	Low	High	No	6	Moderately Sensitive
Zone F	Jhelum River at & below the Confluence of Mahl Nullah	Medium	Low	Low	No	4	Least Sensitive
Zone G	Poonch River & Tributaries	High	High	High	Protected Area	12	Highly Sensitive
Zone H	Mangla Reservoir	Very High	High	High	No	8	Not relevant for zoning assessment
Zone I	Downstream of Mangla Reservoir	High	Medium	Low	No	6	Moderately Sensitive

Figure 2.7: Ecological Sensitivity Zones for Hydropower Development



Social Baseline and Sensitivity Zoning

The final component of Step 6 involves repeating the ecological zoning exercise introduced above, but this time focused on social baseline measures.

Again, it is necessary to apportion rivers and streams into social zones. Once this is done, there is a need to determine indicators that will allow for conclusions to be reached about sensitivity of the social zones.

In the AJK case, the following indicators were chosen:
- Fishing (commercial, subsistence, recreational);
- Sand and gravel mining; and
- Tourism Potential.

Using a similar scoring system to the one applied to determine ecological sensitivity, each indicator is "scored" for each of the segments, according to the impact of proposed HPPs.

The outcome of this scoring exercise for the AJK example is presented in Table 2.6. An indicator is given a score of "1" if impacts are likely to be low, "2" if medium, and "3" if high.

The Total Socioeconomic Assessment Score (TSAS) for each segment is then calculated by adding the scores for each of the three indicators. The following system is used to make the final assessment regarding the sensitivity of the each segment to hydropower development:

Least Sensitivity Zone – Total Assessment Score of 1 – 3.

Moderate Sensitivity Zone – Total Assessment Score of 4 – 6.

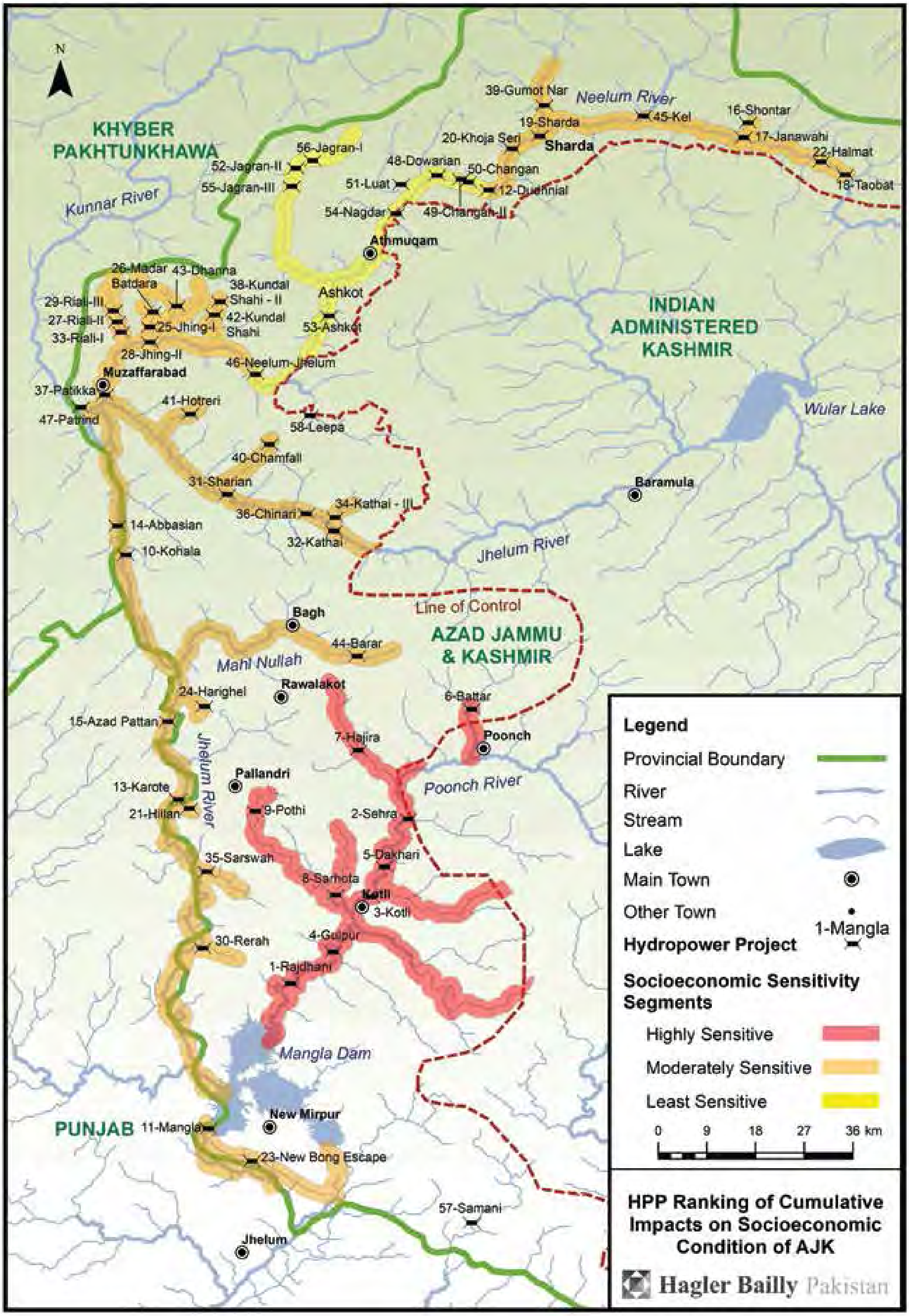
High Sensitivity Zone – Total Assessment Score of 7 – 9.

The socioeconomic sensitivity rating of each segment is shown in Table 2.6, and the mapped sensitivity zones are shown in Figure 2.8.

Table 2.6: Socioeconomic Sensitivity of Segments for Hydropower Development

River	Segment	Socioeconomic Segment	Fishing (commercial, subsistence, recreational)	Sand and Gravel Mining	Tourism Potential	Socioeconomic Assessment Score	Sensitivity Classification
Neelum	Segment A	Taobat to Dhudnial	High	Low	Low	5	Moderately Sensitive
Neelum	Segment B	Dhudnial to Nauseri	Low	Low	Low	3	Least Sensitive
Neelum	Segment C	Nauseri to Muzaffarabad	Low	Medium	Low	4	Moderately Sensitive
Jhelum	Segment D	LoC (Upstream of Jhelum River) to Kohala	Medium	Medium	Low	6	Moderately Sensitive
Jhelum	Segment E	Kohala to Mangla	Medium	Low	Low	4	Moderately Sensitive
Poonch	Segment F	Poonch including Kotli	High	High	High	9	High Sensitive

Figure 2.8: Socioeconomic Sensitivity Segments for Hydropower Development



Required Proponent Activity for Step 6

1. Designate ecological and social “segments” or “zones”.

2. Decide on environmental and social indicators that can be used to measure sensitivity of the segments/zones.

3. Score each segment for sensitivity.

4. Map the ecological and social sensitivity zones, using Figure 2.7 and Figure 2.8 as models.

2.3.8 Step 7: Determination of Overall Sensitivity and Ranking of HPPs

Finally, in Step 7 the Cumulative Impact Zones identified in Step 5 are superimposed on the ecologically and socioeconomically sensitive segments identified in Step 6. This allows the HPPs contained in the hydropower development plan to be ranked according to their overall cumulative impact potential.

The identification and demarcation of the Cumulative Impact Zones did not take into account the existing ecological and socioeconomic baseline conditions existing along the rivers and streams of interest. They were determined on the basis of the drivers of impacts of HPPs of different sizes and the resulting mechanics of cumulative impacts within the context of the topographical, hydrological and social features.

The severity and extent of the environmental and social impacts determined whether the Cumulative Impact Zones were Extremely Critical, Highly Critical or Moderately Critical. Superimposing the Cumulative Impact Zones onto the ecologically and socioeconomically sensitive river/stream segments will also allow the HPPs in the hydropower development plan to be ranked according to their cumulative impact potential.

Figure 2.9 and Figure 2.10 show the final superimposition, and final ranking according to ecological impacts for the AJK case study. Figure 2.11 and Figure 2.12 do the same for socio-economic impacts.

Required Proponent Activity for Step 7

1. Superimpose the cumulative impact zones onto the ecologically and socioeconomically sensitive river/stream segments. Map these outcomes as per the models provided in Figure 2.9 to Figure 2.12.

Figure 2.9: Cumulative Impact Zones Superimposed on the Ecologically Sensitive Areas of AJK

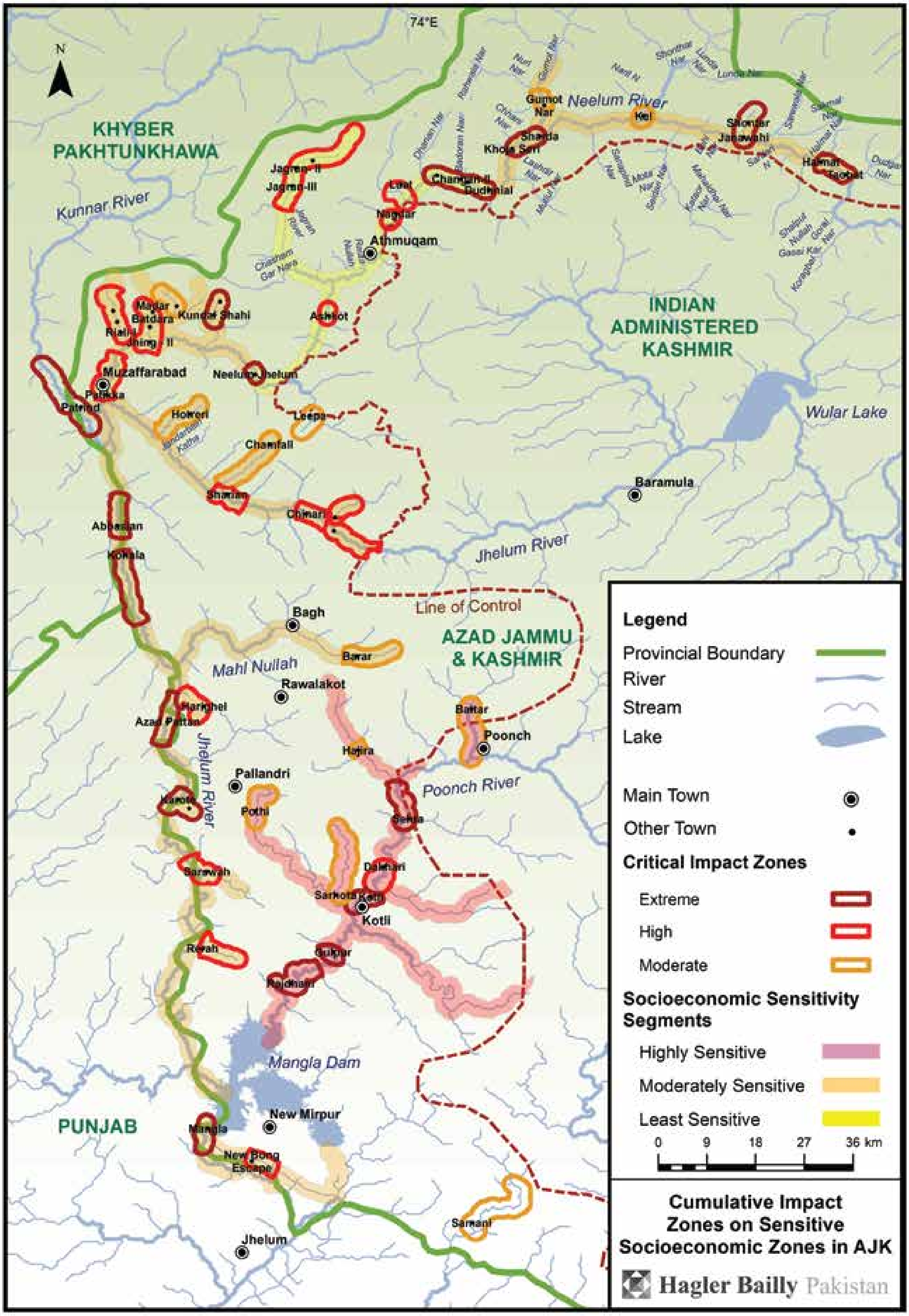


Figure 2.10: A Map of HPPs in the Hydropower Development Plan of AJK and their Ranking based on their Cumulative Ecological Impact

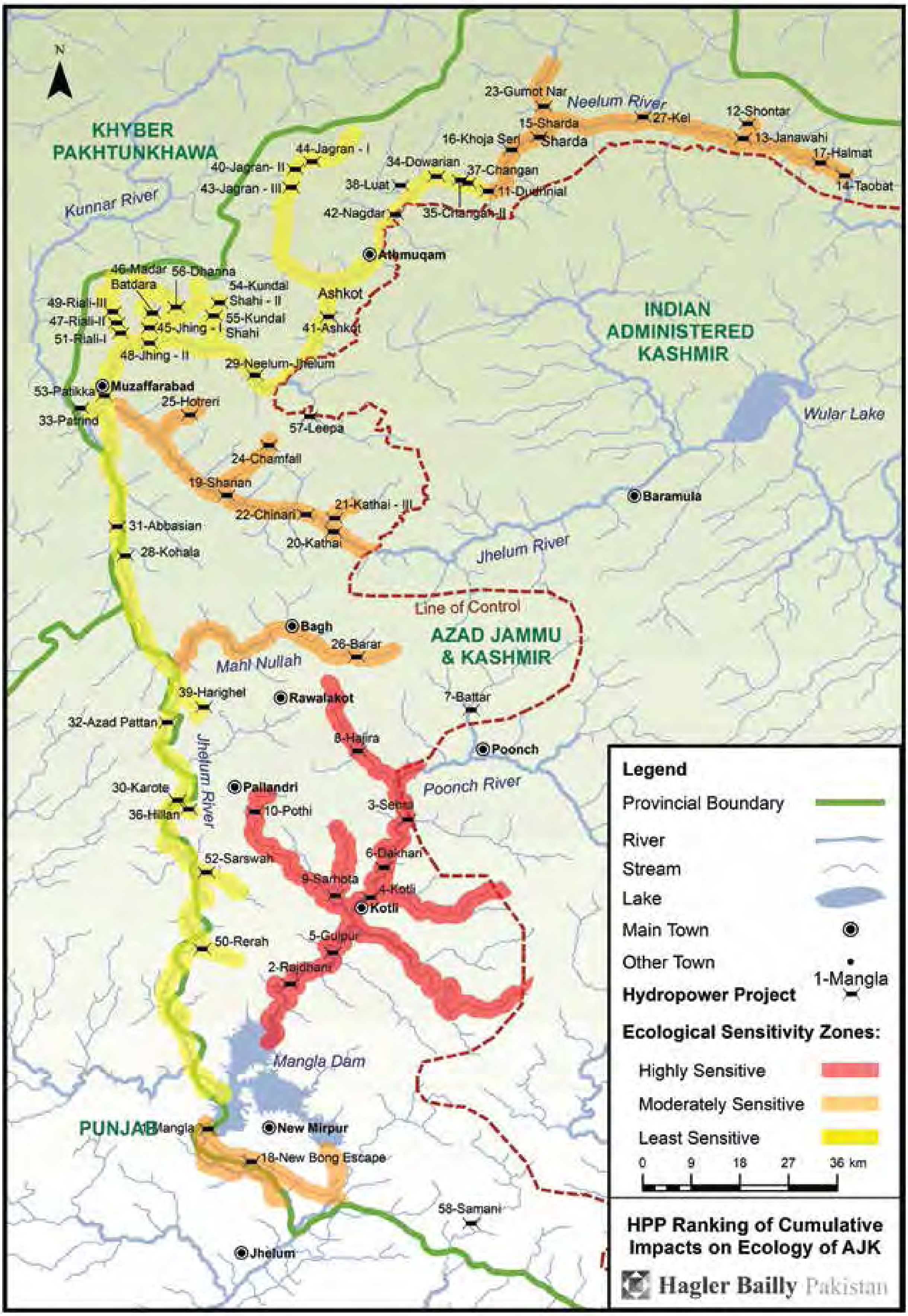


Figure 2.11: Cumulative Impact Zones Superimposed on the Socioeconomically Sensitive Areas of AJK

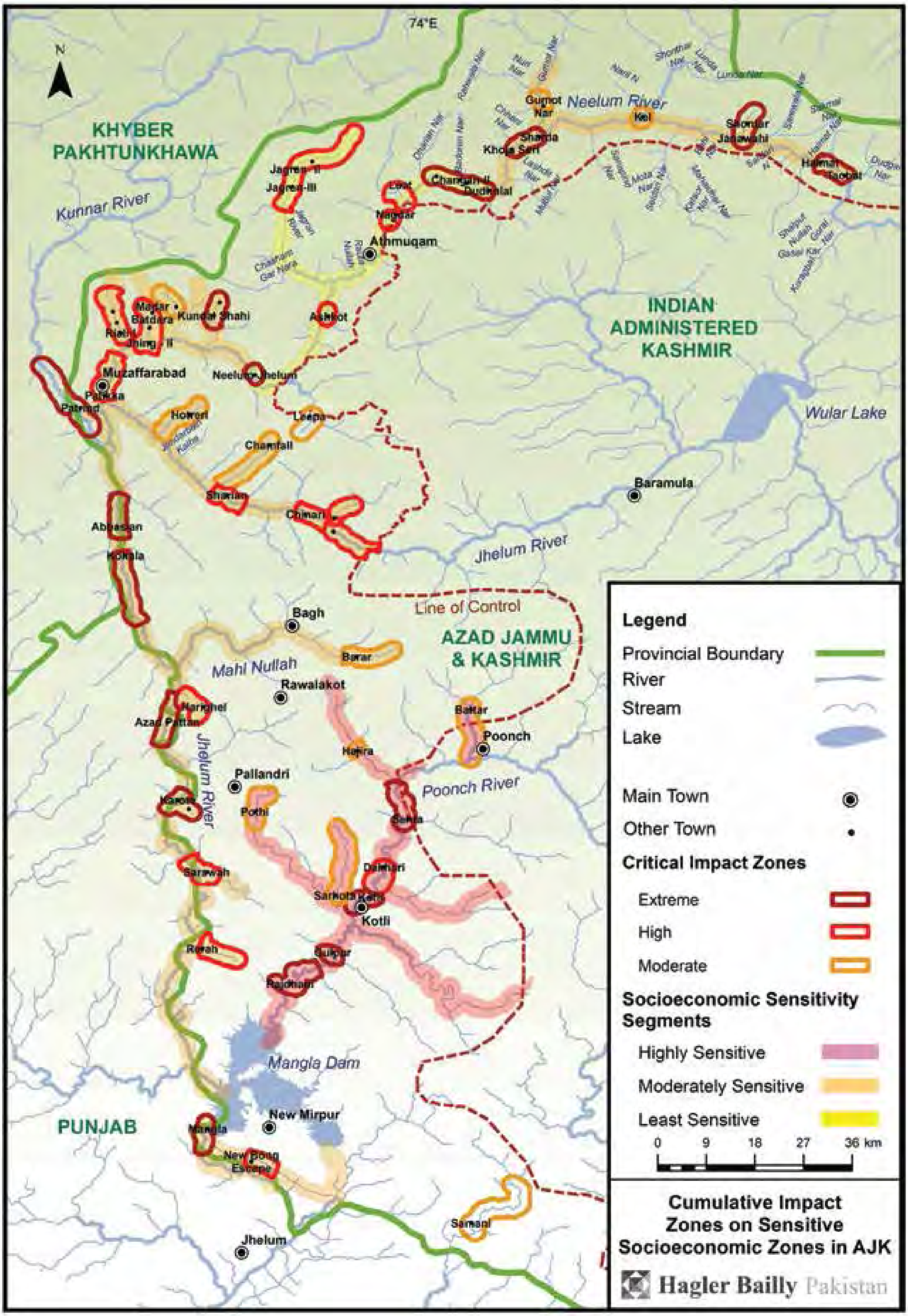
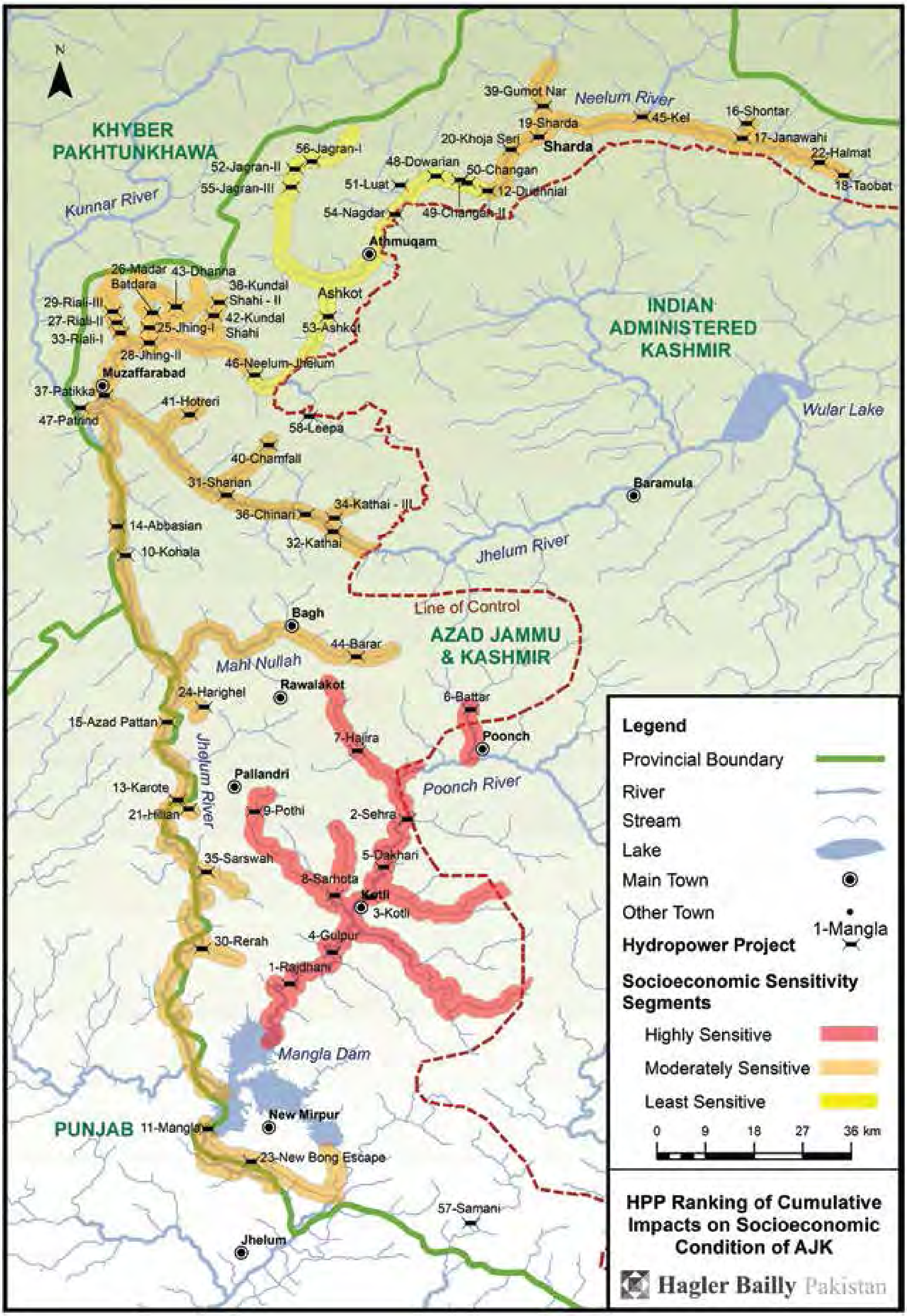


Figure 2.12: A Map of HPPs in the Hydropower Development Plan of AJK and their Ranking based on their Cumulative Socio-Economic Impact



House No. 2, Street 83
Embassy Road, G-6/4, Islamabad
Tel: +92 (51) 2271027-34
Fax: +92 (51) 2271017
Email: niap@iucn.org
Web: www.niap.pk

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