# Policy Brief

## Performance and Resilience of Small and Medium Irrigation

### Rationale

Agriculture is a mainstay of the economy of Nepal, providing about 30% of the GDP and supporting livelihoods for most of the population. It is very vulnerable due to the monsoon climate as well as to topography. Population growth and land fragmentation have made individual holdings so small that they are insufficient even for subsistence needs for most people. Off-farm employment and rural-urban migration are increasingly important, but agriculture remains a key part of livelihoods. There is a need both to improve agriculture and to make it more resilient to climate uncertainty and to change in general.

Three-quarters of agricultural land benefit from some form of irrigation. This is mostly long-established and is essential for ensuring a good crop. However, despite a long history of irrigation in the country, it is widely recognised that the sector is still not performing as well as it could and that climate change will only make the situation worse. Recent floods (such as in the Babai river in 2014) and droughts have raised concerns that climate is changing rapidly and that existing arrangements for irrigation design and management may no longer be appropriate.

Irrigation is a high priority and it is critical that investments are made wisely, taking appropriate account of climate change and other developments. However, existing policies and procedures for irrigation do not fully consider climate change. Climate change may also offer an opportunity for facilitating transformational change to a more equitable and productive rural economy.

This study aimed to help understand the impacts of climate change and to develop a framework for improving the resilience and effectiveness of small- and medium-scale irrigation systems – both existing and potential. It focuses on small and medium irrigation as this accounts for about 75% of the total irrigated area, and directly benefits about 40% of the total arable land area. Whilst the small number of about 20 large and major systems can be studied and planned individually, this is not possible for the vast number of medium and small schemes (probably more than 15,000, averaging less than 100ha in size).

There needs to be a good understanding and consistent approach across the sector, both for management of systems already in operation and those in the pipeline.

The objectives of the study were to improve the approach and methodology for planning, delivery, and management of efficient, effective, equitable and climate-resilient irrigation; to assess processes, institutions and policy; and to prepare a framework to increase the climate resilience and effectiveness of small- and medium-scale irrigation systems, and to ensure that it is understood by relevant stakeholders.

## Methodology

The study has been conducted in close coordination with the Department of Irrigation, with participation by other relevant stakeholders at national and sub-national levels. It began with a review of existing policies, strategies, policies programmes and studies. This formed a basis for a national overview of the irrigation sector in Nepal, covering infrastructure type, agriculture, socio-economy, governance and management arrangements.

The impact of climate change was assessed through analysis of existing climate data and literature, and projections of climate change for alternative emission scenarios and timescales from the Intergovernmental Panel on Climate Change (IPCC) and the Coupled Model Inter-comparison Project (CMIP5).

The study included a reconnaissance of 17 systems in various geographical and agro-ecological zones in 2015, and more detailed studies in two river basins in 2016. These studies included:

- Climate data collection and analysis (temperature and rainfall, including frequency and intensity of rainfall events),
- Observations and consultations on irrigation infrastructure and management arrangements, including historical trend analysis,
- Consultations on inter-relationship between adjacent irrigation systems and water users within a single river basin catchment,
- Measurements and data collection on irrigation performance (canal flows and agriculture),
- Focus group discussions and questionnaires with farmers and other stakeholders covering perceptions, performance, needs and constraints in relation to irrigation.

## Results

**Climate:** There is a sparse database for historical climate, making it difficult to identify many changes which may already have occurred – despite a local strong albeit inconsistent perception of change reported in household surveys and focus group discussions. Some warming trends in temperature can be seen and recent years have been relatively dry. The recent decline (since 2000) in annual rainfall may be a short-term phenomenon and it contrasts with the anticipated impacts of climate change which include increased total rainfall. Other observed changes include the timing and duration of the monsoon, number of days with very light or very intense rainfall, and the numbers of warm and cold days. All of these changes vary across the country but can be expected to influence crop choice and productivity in the future.

**Impact of Climate on Irrigation:** Irrigated agriculture is very dependent on rainfall and only provides partial protection against drought: any changes to rainfall patterns will affect both supply and demand for irrigation water. There are few irrigation systems which have access to a reliable and adequate supply of water for the entire command area even under the present climate, so any change in climate can be expected to have a direct impact.

Climate change potentially has four important effects for irrigated agriculture:

- Reduced runoff in rivers, due to changing rainfall patterns in the catchment,
- Increased flood flows due to more intense rainfall,

- Increased demand for water due to higher temperatures and more erratic rainfall, and
- Changes in crop suitability due to temperature changes.

**Other concurrent changes.** Climate changes must be reviewed in the context of other changes which are affecting both supply and demand for irrigation water, and also influencing the importance of agriculture and its place in livelihoods and the economy. These include:

- Increasing water use upstream due to increasing population and the changing socio-economic situation, which greatly exceeds the impact of climate change,
- Degradation or changing management of watershed, including mining of riverbed materials,
- Declining interest in agriculture,
- Urbanisation and migration,
- Improvement in rural access,
- Globalisation of agricultural markets.

This study has shown that these other changes are more important in the short term for most small and medium irrigation, with the possible exception of the impact of increased rainfall intensity on flood risk. In the longer term, climate impacts will become much greater than they are at present, but there will also be uncertainty in the magnitude of the other changes mentioned above.

**Performance of Irrigation.** Measurements, observations and consultations in the Girwari *khola* in Nawalparasi and Banganga *nadi* in Kapilvastu reveal several strengths and weaknesses of irrigation performance which highlight its vulnerability to changes in climate:

- Water is inadequate: demand is almost always greater than supply even allowing for rainfall and even in many parts of well-supplied systems. The situation deteriorates towards the tail of most systems, although return flows can result in excess water at a late stage.
- There have been substantial reductions (measured) in river and canal flows in the dry season over the past 20 years, and reported increases in flood flows (anecdotal but supported by water level observations). These are believed to be mainly a consequence of changes in land and water use in the upper catchments which affect runoff.
- Canal flows follow rainfall: flows increase in response to rainfall, i.e. they match supply in the river rather than crop water requirements; abstractions are not reduced at time of high rainfall, except in the case of extreme events and then sometimes because of flood damage rather than deliberate operation.
- Permanent weirs and intake structures prevent many problems with abstraction of water from the river and, combined with better control structures, can significantly improve water management within individual systems. However, this can influence downstream farmers/systems – particularly those reliant on direct return flows via drains, but also downstream systems taking water from the same river.
- Equitable management is very challenging, usually with pronounced head-tail variations in access to water, sometimes enshrined in water rights. Surface storage is only possible on a very small scale, and few people have access to tube wells. Large-scale conjunctive management of surface and groundwater would be needed to improve this situation.
- In many cases command areas are declining, partly due to shortage of water. Loss of agricultural land as a result of urban development and decreasing interest in subsistence agriculture in marginal areas appear to be more immediate reasons for the changes.

Despite these observations which might appear to indicate *ad hoc* and weak management, the systems are operated effectively given their current objectives and development history. The field studies indicate that irrigation performs well if the institutions are strong, water users involved effectively, and the infrastructure is appropriate.

Irrigation systems have responded partly to the profound changes in requirements in recent decades, but further attempts to optimise water use and productivity need to be planned with extreme sensitivity in the context of local livelihoods. Otherwise, they will risk destroying long-established institutional arrangements.

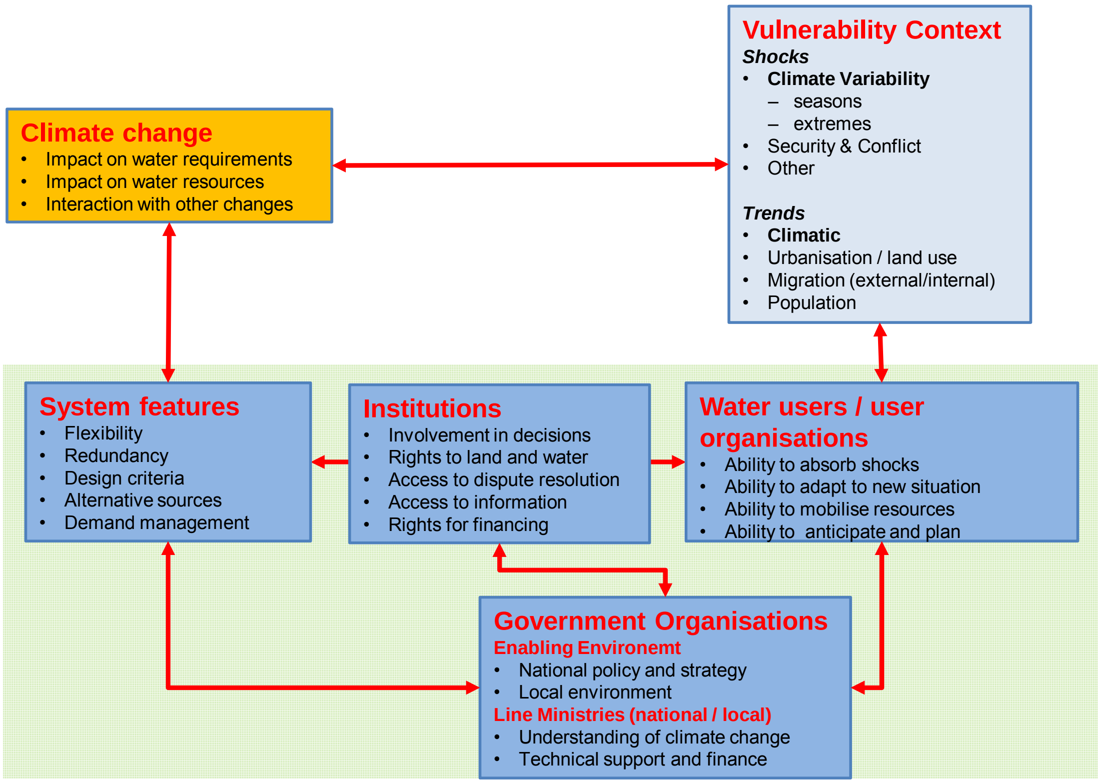
There is some evidence that improving physical infrastructure to improve water control or to reduce losses has had a detrimental impact on downstream farmers. It is important to evaluate all interventions in a river basin context: irrigation is widely reported to be inefficient, but most ‘lost’ water is reused immediately downstream. The greater uncertainty that will come as climate change becomes more severe will require greater sensitivity in management and, in particular, more coordinated operation of systems within a single catchment. High tech ‘water-saving’ irrigation is unlikely to reduce consumption of water and may reduce water availability for others further downstream.

## Framework for Resilience

Climate resilience is a new and unfamiliar concept to many local practitioners and planners, and it brings with it a new language and terminology, and new stakeholders - but the underlying issues are familiar. Good practice for promoting irrigation performance will address many of the issues, as well as the additional and growing risks caused by climate change.

The IPCC definition of resilience is ‘*the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity of self-organization, and the capacity to adapt to stress and change*’ (IPCC, 2014). Resilience also includes the ability to anticipate shocks, and to develop into a stronger state.

**Figure 1: Framework for Resilience**



The framework set out above may appear complex, but it is an attempt to put many issues which are individually well understood into a logical structure. It aims to help understand how to build resilience and improve performance in response to all changes.

The first part of the framework covers the overall vulnerability, and the second part relates to the key features of resilience. Following the Drivers of Change framework, this considers three components:

- Systems (infrastructure and river basins)
- Institutions (rules)
- Agents (actors/individuals/organisations).

Examples of actions in relation to these three main components are given in the table below. All three elements of the framework should be addressed together, and the responses should be designed on the basis of a good understanding of the vulnerability context (including climate extremes and trends as well as other facets of vulnerability). Infrastructure is part of the solution, but it is only of value if it is designed and operated well and fits with the local situation and requirements of the users and other stakeholders.

**Table 1: Examples of Actions to Promote Resilience**

| Systems (infrastructure) | Institutions (rules) | Agents (individuals, organisations) |
|---|---|---|
| Modified design criteria, particularly flood and dry season flood estimates.<br>Design of structures and systems to be adaptable as the need changes.<br>Flood capacity – exclusion of peak floods, safe escape structures and fuse plugs, protection of vulnerable canal reaches.<br>Control of water at low flows; impact of improved control on other users.<br>Development of new sources, with conjunctive management. | Arrangements for cooperative management of natural resources, including river bed materials as well as water.<br>Water rights, across the river basin - to avoid causing adverse impacts, and taking account of traditional rights as well as new policy provisions.<br>Mechanisms for preventing /resolving conflicts.<br>Enhanced ability to raise finance.<br>Markets and subsidies for crops, and support systems for agricultural development. | Farmer ability to absorb, adapt, anticipate change, in response to climate uncertainty and other non-climatic changes.<br>Access to knowledge, willingness and resources to adapt or diversify agriculture and livelihoods more widely. |

## Recommendations for Climate-Resilient Development

Climate is changing and this will get worse. Water is already scarce: river basins are stressed and need to be better managed to ensure that water is, overall, used in the best way possible. The smaller the basin the more sensitive it is to change, and most irrigation is dependent on small catchments. Adaptive management is essential – irrigation can be developed gradually as the situation changes. Climate finance also provides new opportunities for facilitating transformational change of agriculture and enabling a more resilient and prosperous society.

Irrigation is highly sensitive to climate, and actions to reduce this sensitivity are likely to be complex in terms of both infrastructure and institutions. Actions in one area may have negative impacts in other areas, so it is recommended that any changes are carefully monitored and introduced incrementally as they are needed. Sensitivity tests can be done to analyse and mitigate the risk of catastrophic damage in the short term. It is recommended that:

**Systems:**

- Climate stations are improved, at least for key parameters (min and max temperature, and daily rainfall), with river flow monitoring introduced in representative small basins.
- More reliable methods are derived for flood and low flow forecasting in ungauged catchments, and estimation of effective rainfall.
- Research is undertaken on the impact of soil and water conservation in upper catchments, including small-scale water harvesting as this can reduce availability further downstream.
- Risk-based approach to design is introduced, with improved procedures for:
  - Design of diversions and intakes, particularly in flashy Siwalik rivers
  - Flood and sediment control at permanent intakes
  - Consideration of lift irrigation to reduce the need for long vulnerable canals in the hills
  - Management of low flows, diversified cropping, crop water requirements and delivery mechanisms for winter and spring cropping
- Evaluation of new approaches to infrastructure, including
  - Lift irrigation in hills and on river terraces (*tar*)
  - Provision and use of small-scale and on-farm storage.
  - Tube wells integrated into surface systems.

**Institutions:**

- Water management is improved (at system level and on-farm), with development and use of appropriate operating rules.
- There is a value chain approach to agricultural development, linking producers to markets and addressing constraints at all levels.
- Support is provided for deep and shallow development to supplement surface irrigation, and for conjunctive management of surface and groundwater (covering arrangements for both development and management of tube wells).
- Institutional arrangements for river basin management are developed and strengthened (considering all water users, and actions in the river), with better understanding of the trade-offs between different users and optimal sharing of benefits.

**Agents:**

- Actions are taken to promote understanding of climatic and other changes, their impacts, and coping mechanisms in the context of irrigated agriculture.
- Make better use of short term and seasonal forecasts on water availability and floods, and adapt crop and water management decisions accordingly.

**Water Control Structures**