Multi-Purpose Water Infrastructure

Recommendations to maximise economic benefits
Increasingly, water infrastructure is used for more than one purpose hence the term multi-purpose water infrastructure (MPWI) has emerged. Multi-purpose water infrastructure encompasses all constructed water systems, including dams, dykes, reservoirs and associated irrigation canals and water supply networks, which may be used for more than one purpose for economic, social and environmental activities. Worldwide, there are more than 8,000 large MPWI systems by design, plus a significant number of systems that operate as multi-purpose although were designed for single-purpose use.

Globally, the International Commission on Large Dams (ICOLD) registry reveals that 70% of large dams and associated reservoirs (out of almost 28,000 currently in operation) are designed to be single-purpose. Around half of the single-use dams worldwide have been built for irrigation purposes, followed by hydropower generation, water supply and flood control. A single-purpose dam for hydropower is naturally more financially attractive to private investors. However, dams designed as single-purpose often evolve into multi-purpose use over time. This evolution, if not managed, does not allow full realisation of the benefits and synergies of designing infrastructure to be multi-purpose from inception.

While MPWI often generate larger economic benefits for the community than single purpose infrastructure, attracting private investors to finance multi-purpose projects remains difficult. This is due to the inherent complexity of dealing with multiple stakeholders, the need for sustainable business models for both financing, operation and maintenance and the emergence of unforeseen risks and negative externalities. This policy perspective explores the complexity in designing, financing, regulating and managing MPWI projects, with the aim to inform policy and decision making and make MPWI schemes more attractive from inception.

It identifies key issues related to managing MPWI, lessons learned from international experience and possible solutions to the challenges. It examines several principles, approaches and instruments to enhance the sustainability of MPWI, drawing on international experience and an OECD study conducted in Kazakhstan where a computer based hydro-economic model was used to inform decision making.

Knowledge and experience gaps, needs for further research and possible areas of future work are identified.
Introduction

There is great complexity in planning high capital infrastructure objects with an asset life of over 50 and up to 100 years in the context of uncertainties and unforeseen events. Over the long life of dams designed for a single purpose, they often become multi-purpose by practice. This evolution, if unmanaged, does not allow optimum realisation of economic benefits.

Where applicable, infrastructure should be recognised and designed as multi-purpose from inception. This would allow for optimum management of the needs of all concerned stakeholders and water uses and deliver maximum realisation of economic benefits.

To move towards this goal, decision makers and financing bodies need to have confidence in multi-purpose infrastructure projects. This is not currently the case due to the perceived risks of working with multiple stakeholders and competing uses for water. MPWI also has a track record with difficulty in selecting appropriate business models for both financing, operation and maintenance (O&M) and a historic underperformance in meeting financial and performance targets.

Policy makers can improve confidence and performance around MPWI through addressing the areas found in the table below.

MPWI projects provide a number of private goods and services to certain users (they can typically be sold) as well as functions which are often public goods and remain difficult to monetise and capture (WWC & OECD, 2015). For example, flood management, strategic water storage, and water transport with a network of waterways all provide public goods.

Some of them (e.g. navigation) can be used year round or limited to a few months, while the others (e.g. flood management) may only be needed a few weeks or even days in any particular year; therefore large dams and reservoirs used for flood control or strategic water storage virtually always have another purpose, such as power generation or irrigation (Nile Basin Initiative, 2008).

Multi-Purpose Water Infrastructure

<table>
<thead>
<tr>
<th>Application</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Hydropower generation</td>
<td>When combined with a hydropower plant, dams can be used for hydroelectric power generation.</td>
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<tr>
<td>Irrigation for agriculture</td>
<td>Water stored in a reservoir can be used to irrigate agricultural crops, typically through a network of</td>
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<tr>
<td></td>
<td>distribution canals.</td>
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<tr>
<td>Drinking water supply</td>
<td>Reservoir storage capacities and water distribution networks can be used to supply drinking water for</td>
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<tr>
<td></td>
<td>human consumption.</td>
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<tr>
<td>Water supply for industrial</td>
<td>Water storage can also be used for industrial purposes, including power plants for electricity</td>
</tr>
<tr>
<td>needs</td>
<td>generation.</td>
</tr>
<tr>
<td>Transport and navigation</td>
<td>Multi-purpose water systems such as canals and regulation of surface water by dams can provide</td>
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<tr>
<td></td>
<td>navigation and transport services.</td>
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<tr>
<td>Flood control</td>
<td>Dam structures and reservoirs may offer flood protection by regulating water discharge and balancing</td>
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<td></td>
<td>runoff differences.</td>
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<tr>
<td>Strategic water storage</td>
<td>MPWI are also used to mitigate the effects of climate variability and provide a strategic water &quot;buffer&quot;</td>
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<td>which may be used for some of the above purposes.</td>
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Source: ICOLD, 2014
In addition to the benefits derived from their primary purposes, MPWI often generate positive externalities, including:

- **Biodiversity and ecosystem services**: MPWI can be designed to preserve biodiversity and provide environmental benefits by supporting ecosystems. In some cases, the ecosystem services provided can then be turned into a source of income by the local population (e.g., aquaculture), for example, the Nam Theun 2 project in Laos.

- **Recreational use**: lakes created through water storage and water distribution canals can also provide recreational and tourist value, for example, the Canal de Provence in France.

- **Flood control**: through management of reservoir levels when this is not the main purpose of the MPWI e.g., Shardara reservoir in Kazakhstan.

- **Health benefits and accrued productivity of the beneficiary population**: through improved access to water supply for drinking, irrigation, or through additional electricity services.

- **Decreased travel time for affected communities**: thanks to improved transport infrastructure in the area of the MPWI site; and

- **A potential reduction in carbon emissions**: through the use of hydropower over fossil fuels for electricity generation (Liden, 2013).

MPWI are similar to other large water infrastructure schemes in that they may lead to a number of negative externalities. Greenfield MPWIs, particularly those which include large reservoirs, have been found to generate more acute negative social and environmental externalities. Negative externalities may include the following:

- **The relocation of population directly affected by an MPWI project**: ranging from people displaced by new reservoir flooding to properties affected by canal construction.

- **Effects on communities’ socio-economic status and their livelihoods**: for instance through impacts on fisheries downstream of a dam, or waterlogging of soil close to irrigation canals.

- **Public health impacts**: particularly through the increased prevalence of water-related diseases near reservoirs and canals in which vectors may breed.

- **Cultural heritage may be lost**: through reservoir construction and flooding.

- **Biodiversity may be threatened**: including through hindering the migration of aquatic species by damming rivers.

- **Trapping of sediments**: leading to potential erosion downstream of a dam and negative impact on water quality (Kondolf G., 1997).

- **Reservoir siltation**: may decrease storage capacity in the long-term and require sediment management measures; and

- **Ambient environmental quality may be negatively affected**: for example air pollution due to construction, increased traffic, or noise pollution.

The International Commission on Large Dams (ICOLD) notes that capital expenditure for greenfield multi-purpose dams in the developing world is typically partly funded by public authorities, with possible international donor support. Multi-purpose projects are more attractive to international financial assistance, as they may fit well into regional development goals, for example, to improve food production, flood mitigation, water supply or electricity supply in rural areas. Furthermore, they can complement strategies for climate change adaptation, for example, if hydropower generation is combined with increased water storage or flood protection.

Promoting a single purpose dam, especially for hydropower, is typically more financially attractive to private investors as it promises fewer risks and secure financial returns on investment. Attracting private investors to finance multi-purpose projects remains difficult due to the inherent complexity and need for sustainable business models. In particular the conflict of interests among the different uses, e.g. hydropower requiring maximum reservoir storage levels and irrigation causing lower levels, can result in complex and potentially vulnerable contract structures.

Large water sector investments, and MPWI in particular, present a number of challenges that make it difficult to attract private investment. They are capital intensive, prone to high risks and low financial returns over a long time horizon, with some even disputing their value-added for economic development in the long-term (Ansar, 2014). In the case of dams and reservoirs, investment has been limited to small, high reward/low risk projects, and mostly hydropower. Irrigation projects (including reservoirs and distribution networks) have generally continued to receive most of their funding from public resources.

### International trends

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Multi-Purpose Water Infrastructure

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Multi-Purpose Water Infrastructure - 5
Examples of MPWI use

**Regional breakdown of dam’s purpose**

- **North America**
  - 30% Flood Control
  - 24% Irrigation
  - 23% Water Supply
  - 25% Hydropower
  - 19% Other Single Purpose
  - 20% Multipurpose

- **Europe**
  - 31% Flood Control
  - 52% Irrigation
  - 19% Water Supply
  - 14% Hydropower
  - 19% Other Single Purpose
  - 19% Multipurpose

- **Asia**
  - 64% Flood Control
  - 24% Irrigation
  - 20% Water Supply
  - 19% Hydropower
  - 14% Other Single Purpose
  - 19% Multipurpose

- **Africa**
  - 26% Flood Control
  - 25% Irrigation
  - 20% Water Supply
  - 19% Hydropower
  - 19% Other Single Purpose
  - 19% Multipurpose

- **South America**
  - 25% Flood Control
  - 20% Irrigation
  - 23% Water Supply
  - 25% Hydropower
  - 19% Other Single Purpose
  - 19% Multipurpose

- **Australasia**
  - 44% Flood Control
  - 19% Irrigation
  - 19% Water Supply
  - 19% Hydropower
  - 19% Other Single Purpose
  - 19% Multipurpose

**Did you know?**

Externalities may also emerge from regulatory gaps, governance or management failures such as the lack of decommissioning rules. This creates the incentive for MPWI owners to operate the scheme until the net benefits of operation become negative, and then abandon the scheme. Abandoned small dams may cause significant environmental damage, including severe erosion, destruction of aquatic habitat, and loss of fisheries. The cost of removing these small abandoned dams is typically borne by taxpayers (Aylard, 2001).
Policy Perspectives

Tools for improving MPWI management

Taking into account the high capital cost and long life of these assets, there are a number of policies and tools that can be used to attract investment in MPWI. It is through the use of these approaches that the wider benefits of MPWI can be assessed and realised.

Firstly, there are three key areas of decision making associated with the planning and management of MPWI (McCartney, 2007):

1. Strategic planning decisions: should an MPWI be built at all, and for what purposes? What are the guiding legal and regulatory principles and rules for its operation?
2. Day-to-day operations: how should MPWIs be managed in order to balance trade-offs between a range of complex requirements so as to fulfil multiple purposes?
3. An important additional consideration is how to fairly share risks and distribute costs and benefits of an MPWI project between all stakeholders.

Robust planning and cost-benefit analysis

The need to coordinate between multiple sectors during planning and operation adds a layer of complexity, which may pose additional risks to MPWI when compared to single-purpose water infrastructure projects. One of the main challenges with planning MPWI seems to be optimism bias. The World Commission on Dams (2000) reports that MPWI are more prone to not meeting project targets (including project schedule, hydropower and water supply performance) than single-purpose water infrastructure. In particular, MPWI had higher cost overruns than single-purpose projects. Only MPWI projects with irrigation components showed little difference between single and multi-purpose projects in terms of performance. The report concluded that “multi-purpose schemes are inherently more complex, and many experience operational conflicts that contribute to under-performance on financial and targets” (World Commission on Dams, 2000). Planning MPWIs therefore requires thorough research and expertise in order to adequately estimate project targets and schedule, as well as expected costs and benefits and revenue streams.

In addition, risk-based approach and cost-benefit analysis (CBA) can be used to analyse the costs and negative externalities compared to the benefits and positive externalities of large-scale MPWI projects, which can have significant impacts. A cost-benefit analysis should be conducted prior to any design and building of a new project and it should incorporate the social and environmental impacts, often through non-market valuation techniques, which can assist in understanding the full cost and value of MPWI projects. Additional tools are presented in the following table.

MPWI management techniques

<table>
<thead>
<tr>
<th>Tool</th>
<th>Benefits</th>
</tr>
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<tbody>
<tr>
<td>Stakeholder management</td>
<td>Consultation with stakeholders in MPWI projects enhances project sustainability and minimises delays due to conflicts between users regarding water allocation. Stakeholder engagement is critical for success in multipurpose reservoir management in terms of sustainability and efficiency. Policy dialogue at the national or basin level allows cross-ministerial views to be collected.</td>
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<tr>
<td>Participatory tools</td>
<td>Participatory tools including water supply agreements, water allocation rules, and Memoranda of Understanding, can be incorporated to engage key stakeholders and improve management of water with competing uses.</td>
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<tr>
<td>Water allocation rules</td>
<td>Water allocation rules for MPWIs are generally based on hydrological, technical, economic and social factors and rooted in national water policy, laws and regulations. Water allocation for MPWI may differ at the subnational or basin level, based on historical and legal factors, but also on adaptation to the local context.</td>
</tr>
<tr>
<td>Regulation</td>
<td>Economic and technical regulation for MPWI is often focused on addressing negative externalities and safeguarding against various risks and concerns. <strong>Economic regulation</strong>: The economic regulation of MPWI is context-specific and depends on the purposes of the scheme, its ownership and operational rules, legislation as well as any contractual obligations of stakeholders. Nevertheless, key issues around economic regulations for MPWI concern cost recovery and public subsidies. <strong>Technical regulation</strong>: Technical regulation (not least on construction, on dam safety and on routine operations) is key for sustainability of any water system, including MPWI.</td>
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</table>
There is no prescribed “first best” business model for all MPWI projects. Models and solutions are highly country-specific as the technical solutions and affordability for the populations are different. Elements to consider include:

- Clarity on the objective: maximising the project’s value in terms of (i) operator’s profit or (ii) GDP or welfare of the society by fully meeting priority water uses;
- Financing models: dependent on the relationship between different financing options and chosen according to the project’s nature, components, and risk-reward structure; and
- Equity position: sufficient equity to absorb risk and provide a cushion to cope with fluctuations in cash flow.

Figure 1 presents a simplified decision-making tree to determine the financing model for MPWI projects, resulting in three possible options:

- A private project;
- A public-private partnership project; or
- A public sector project.

This decision depends on several factors, including financial arrangements as well as risk allocation. Most MPWI projects are either public projects or public-private-partnerships (PPP) projects. The decision depends on whether it is financially viable on its own, and if not whether a public subsidy is available, the nature of the risks it entails, and the extent to which these risks can be mitigated. Once the decision of implementing the project in the public or the private sector is made, the issue of asset ownership needs to be addressed. Decisions are required on who will own the assets and if they are publicly owned, will the financing come from private or public sources.

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Traditionally, many major MPWI projects were both financed and implemented by government agencies, including the Hoover Dam (USA) as well as more recent major MPWI projects in China (WWC & OECD, 2015). It is sometimes appropriate to implement the project in the public sector, for instance if the project is too large and too complex to attract private investment, if the physical environment means that the site risks are unacceptably high; if the commercial risks cannot be mitigated; or if the appropriate enabling environment is missing.

Public projects can be financed through taxes, tariffs, and transfers (including Official Development Assistance) from the public sector, as well as public or private debt, provided there is a creditworthy and accountable project agency to which the loans can be made. The proposed business model should aim to recover at least the full supply costs of the MPWI (i.e. the capital and O&M costs and the costs of servicing debt).

Establishing a parasatal special-purpose company that operates like a corporate entity can be a potential solution; it may need to be supported by sovereign guarantees to offset country or commercial risks. This may however require substantial institutional and financial support.

Private sector participation includes both entirely private projects (rare for MPWIs, more prevalent for hydropower only schemes), including in the form of public-private-partnership (PPP) projects. The PPP option is often pursued when the MPWI project is economically viable, risk is sufficiently mitigated, the project can have “split ownership” to separate profitable and unprofitable components so private entity can take ownership of the bankable component, and/or public agencies can provide a subsidy for the project.

Private sector participation can take several forms:

1. Existing (brownfield) schemes (dams, reservoirs, and irrigation networks) which could be managed by the private sector can involve concession contracts, management contracts or leases. For instance, a concession arrangement was used in the brownfield Guerdane Irrigation Project in Morocco, as well as for two greenfield projects: the Canal de Provence in France and in the Panir Hydropower project in Tajikistan. They demonstrate the possibility of raising private financing for greenfield and brownfield MPWI projects alike.

2. For schemes where financing for substantial capital investments or rehabilitation is the overriding consideration, the main private sector models in use for MPWI are:
   - BOOT (Build-Own-Operate-Transfer): for instance, a BOOT model was used for the San Roque Multi-Purpose project;
   - BTO/BOT (Build-Transfer-Operate): for instance, a BTO model was used for the Guerdane Irrigation project; and
   - ROM (Rehabilitate-Operate-Maintain).

Single-purpose water infrastructure, such as hydropower, may be more appealing to private investors due to the diminished risks and increased security of financial returns on the energy produced. The San Roque Multipurpose Project in the Philippines originally had difficulty attracting sufficient financing. Though the project was expected to generate strong economic value, the package was financially weak due to the low returns from the irrigation function. The MPWI project split ownership into a public and a private part, with the power complex serving as a commercially separate build-own-operate-transfer (BOOT) project. The power complex was financed through a blend of export credit and commercial lending as a private-led project. This split ownership enhanced the financial viability and provided an appropriate vehicle for private sector engagement.
There are also challenges related to operational costs of MPWI. It is estimated that the cost of operation and maintenance represent around 1 to 3% of total project costs. For irrigation projects, these costs are generally slightly higher due to high maintenance costs of the irrigation network (Beukering, 2014). This is why much more attention is paid to financing capital investments, as the running costs of the MPWI itself are comparatively small and typically well understood. For that reason, it may also not get the attention it deserves and in developing and developed countries alike, MPWIs can run into challenges for financing O&M costs over their lifetime and have to rely on public subsidies. Such costs have also sometimes been passed on to the public sector in the form of negative externalities, such as decommissioning of dams.

The financial sustainability of an MPWI in operation and over its life-time is usually addressed as part of its business plan. However, planning and economic studies for reservoirs are commonly based on a design life of only 50 years, and the business plan itself may become outdated after only a decade, for example due to inflation, changes in the price of energy, or benefits and uses of the dam that are different than originally anticipated. MPWI schemes may have a lifespan of 150 years or longer so the financial sustainability of MPWI needs to be ensured after construction and beyond the 50-years planning horizon.
The Shardara MPWI case study: The contribution of MPWI to the wider economy in Kazakhstan

Maximising the role of MPWI in the wider economy was identified as a high priority by the Kazakhstan government through its National Policy dialogue on water, facilitated by the OECD and UNECE.

The government expects significant water mass balance deficit by 2040, and with significant capital investment planned, wanted to ensure that decision making factored in water and energy security, maximised economic growth and minimised impact upon the public budget. Future supply and demand issues will create a trade-off between building new dams to increase strategic storage or increasing the return from existing MPWI systems complimented by improved water use efficiency. This is particularly acute in the agricultural sector. The Shardara reservoir in Low Syr Darya and accompanying multi-purpose water infrastructure was identified as a pilot area for evaluation of these options. The Shardara reservoir and the whole of the Aral - Syr Darya basin are important for the national and regional economy and the water infrastructure in this area is significant and complex.

The pilot study had the following key objectives:
- To help Kazakh stakeholders identify options for increasing economic and financial returns from a selected MPWI thus reducing demand for extending water infrastructure, the associated capital investment and state support.
- Demonstrate how to maximise the contribution from a MPWI to the national economy and enhanced water, food and energy security so that lessons learnt from the case study may be replicated for other existing or planned MPWI projects in Kazakhstan.

The pilot area, referred to as “Shardara MPWI”, encompassed the Shardara reservoir and also water resources and water infrastructure in the whole Aral-Lower Syr Darya basin, to which approximately 80% of the water flow comes from outside Kazakhstan. Hence, the water flow of the Syr Darya river is determined not only by natural factors of runoff formation, but also changes in water intake, return water and mode of operation of reservoirs and irrigation systems in the upstream neighbouring countries of Kyrgyzstan, Tajikistan and Uzbekistan.

Another key feature is that the water infrastructure in Shardara reservoir and the whole of the Aral-Lower Syr Darya basin has become multi-purpose over the years. Originally, the Shardara reservoir was designed for irrigation, but within a few years of operation it had helped to prevent downstream areas from catastrophic flooding. Since then, the Shardara reservoir has operated as multi-purpose. Today, it offers various services including irrigation and support to livestock, hydropower generation, flood control, potable water supply and commercial fisheries. Recreational activities are planned for the future.

The Shardara MPWI collectively includes:
- Two reservoirs, the Shardara reservoir (irrigation, hydropower, flood protection and fish farming) and Koksaray reservoir (flood protection through storage of excess water and then release for summer irrigation);
- The Shardara Hydro-Electric Station (HES) and a number of smaller hydropower stations in the Kyzylorda region including the Kyzylorda and Kazalinsk hydro units which facilitate operation of irrigation systems;
- River sections and Lakes;
- Irrigated agricultural zones;
- Irrigation canals including main canals and distribution canals in 7 irrigation zones;
- Collector-drainage and return water systems;
- Drinking water supply systems.

To evaluate the role of the Shardara MPWI in maximising its contribution to the economy, three potential actions were assessed reflecting policy questions related to the proposed Kazakhstan investment portfolio.
- Demand side actions: including efficient use of water (through introduction of modern irrigation technologies), physical water loss reduction (through addressing infiltration, leakages, evaporation and commercial losses), metering water use, introduction of an improved irrigation water tariff system combining fixed tariff (per ha) and volumetric tariff (per m³);
- Supply side actions: canal refurbishment focusing on the whole canal or only on the unlined parts of the canal to reduce water losses; investments in collector-drainage systems; and
- Risk management actions: additional flood protection and water storage capacity by increasing the dam height of the Koksaray reservoir, recharge of groundwater reserves with flooding water for use in dry seasons.

Each action may include both capital investment and “soft” measures such as institutional, regulatory or research and development.
A hydro-economic decision support tool for MPWI

Given the wide range of potential actions and scenarios to be considered for the Kazakh case study, the “WHAT-IF” computer model was developed in order to facilitate policy dialogue aimed at prioritising investments and governance actions. WHAT-IF stands for Water, Hydropower, Agriculture Tool for Investments and Financing. In particular, the WHAT-IF model was developed to answer key policy questions associated with the Shardara MPWI:

- How does the costs of improved refurbishment and maintenance of conveyance canals (leading to lower water losses) balance with the increased crop production coming from additionally available water? What are the other impacts?
- How do increased investments in urban water distribution systems (leading to lower losses) balance with the increased crop production coming from additionally available water? What are the other impacts?
- How do increased investments in reservoir capacity (facilitating higher water consumption in dry years and possibly higher energy production) balance with increased crop production in dry years coming from additionally available water? What are the other impacts?
- How do increased flood safety margins in reservoirs impact agricultural production in dry years due to lower dry year water availability? What are the other impacts?
- How does investments in collector-drainage systems improve salinity conditions and agricultural output, and how does this balance with the increased income? Which other impacts?
- What are the other impacts?

The use of the model demonstrated a number of opportunities to increase the role of MPWI in the pilot area.

### Figure 2. Overview of the model

<table>
<thead>
<tr>
<th>Action assessed by model</th>
<th>Findings</th>
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<tbody>
<tr>
<td><strong>Refurbishment of the Kyzylkum canal allowing substantial increase in vegetable cultivation</strong></td>
<td>Investments into refurbishment of Kyzylkum canal does not currently pay off, but might in the future; Current water availability is quite high compared to the amount of available and suitable agricultural land, so the water made available through refurbishment is not particularly productive; Future and severely limited water availability might make the Kyzylkum refurbishment economically attractive, as the saved water will then be useful for avoiding contractions in the cultivated land area; Reclaiming unused irrigated land by reconstructing its water infrastructure might also make the Kyzylkum refurbishment attractive, as the reclaimed land can utilise the water saved by refurbishment.</td>
</tr>
<tr>
<td><strong>Improved drainage in Kyzylorda improving agricultural economic efficiency</strong></td>
<td>Investments into drainage pays off - today; Investments into drainage improves economic productivity of land, as soil salinity is reduced, and agricultural yield increases; Improved crop yields lead to higher profit margins for the farmers whose fields are drained; If the newly drained areas are used for crops consumed domestically, other producers of those crops will face lower prices, as total supply increases. These farmers’ loss is exactly offset by consumers gaining from lower crop prices; In the mid to long term, the increased profitability of irrigated agriculture with drainage will enable farmers to pay for infrastructure costs in improved conveyance, which will be necessary to abate the effects of climate change.</td>
</tr>
<tr>
<td><strong>Increased use of drip irrigation saving water from avoided infiltration and evapoaporation</strong></td>
<td>Investments in increased on-farm water efficiency though drip irrigation does not pay off currently or in the near future; The water saving from drip irrigation is small compared to the investment and operating cost; Increased agricultural efficiency with drip irrigation may make the investment worthwhile.</td>
</tr>
<tr>
<td><strong>Flood protection work</strong></td>
<td>Flood protection investments are of little significance for irrigated agriculture*; Since water is currently abundant and has little economic value, the effects on irrigated agriculture from flood protection investments, such as Koksaray extension and Shardara bypasses are small; This may change with reduced rainfall/runoff due to climate change in the future; The Shardara bypass may have merits in terms of increased income from irrigated agriculture as it provides more water for irrigation; Value created for irrigated agriculture by the Koksaray extension may be limited, as other reservoirs’ storage and environmental flow flexibility offers alternative possibilities for regulating flows for irrigation.</td>
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*Important note: There are other significant benefits of improved flood control that are outside of the agriculture sector. These include protection of lives and economic assets. In this project only benefits associated with irrigated agriculture are discussed.
Findings

The use of WHAT-IF to analyse the Shardara case study delivered the following findings to inform policy and decision making.

First, the limiting factor for profitable agriculture in South Kazakhstan is more often access to suitable land (i.e., with functioning irrigation systems) rather than access to water.

Second, rice is farmed heavily in Kyzylorda, even though fruits and vegetables have the potential to raise economic agricultural productivity, both in relation to land and water use.

Then, when measured in relation to land area used, rice is among the most profitable crops. But measured in relation to water use, this conclusion is reversed, and rice is among the least profitable crops.

Finally, salinity issues, long transport distances and inadequate transport infrastructure may be limiting factors that prevent Kyzylorda to increase its share of high-value crops and favour rice production.

The key recommendation concerns the investment strategy regarding development of Shardara MPWI:

- Focus primarily on improving agricultural productivity, supplemented by water efficiency;
- To increase agricultural productivity by focusing on investments in drainage in the next 15-30 years;
- This strategy will increase incomes and profits of farmers, thereby softening affordability constraints and enabling the Government of Kazakhstan to increase tariffs for irrigation water and lower government subsidies thus helping to address the current financing challenge;
- Gradually, shift the focus on increasing water efficiency through investments in refurbishment and efficient irrigation techniques, for example drip irrigation, after 2030, as impacts of climate change on water availability increase;
- Water efficiency projects may be justified before 2030, before water scarcity occurs, if unused or fallow land exists (or it is reclaimed by refurbishing irrigation canals or investing in conveyance and drainage), and conserved water can be used for cultivating the unused or presently fallow land.

General recommendations on water resources management in Kazakhstan and the wider use of WHAT-IF include:

- Assign priority to improving water productivity and agricultural productivity at the same time;
- In addition to drainage, consider to invest in rural roads, local food processing and storage facilities to facilitate the outreach of new markets for local agri-food produce;
- The need for statistics on agricultural productivity and water efficiency using indicators, for example:
  - Production (in tonnes)/m³ of water, Production/irrigated ha;
  - Profit/1000m³ of water, Profit/irrigated ha (relevant in case of full employment);
  - Gross Value Added/1000m³ of water, Gross Value Added/irrigated ha (relevant in case of unemployment).
- The WHAT-IF model may be used to assess the implications of (i) specific investment projects and (ii) various water allocation rules for normal, dry and super-dry years for each of the agri-food, energy and water sectors. It can also assess the impact upon key actors in each sector and the implications of various financing schemes on the government budget;
- The WHAT-IF model may be used as a pre-feasibility tool, capable of identifying economically sound investments and providing information about prioritization and timing of these.
Further work

MPWI play a significant role in the socio-economic development and the water, food and energy security of many countries, however the lower than expected performance of some MPWIs and of the emergence of unforeseen externalities and risks may signal:

i) the complexity of planning infrastructure objects with an asset life of over 50 and up to 100 years in the context of uncertainties and unforeseen events; and

ii) certain weaknesses in planning and assessing proposed MPWI and the need to think about required improvements in methodology and necessary tools to support decision making and implementation.

Further work is therefore recommended in:
- dedicated case-studies on evolution of business models over the life time of MPWI, and
- development of supporting tools and methodologies for:
  - (i) developing effective mechanisms for fairly sharing the risks, costs and benefits among stakeholders of respective project;
  - (ii) identification and dissemination of best practices in adaptive business models to adjust to evolving socio-economic and regional development priorities;
- development of a comprehensive database on MPWI projects to share the experience with various business models, data on financing and investment trends and best practices.

References

Malerbe, F. (2014). PPP in the water and sanitation sector: the Canal de Provence, UNECE, Switzerland.

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Multi-purpose water infrastructure encompasses all constructed water systems, including dams, dykes, reservoirs and associated irrigation canals and water supply networks, which may be used for more than one purpose for economic, social and environmental activities. This OECD policy perspective, *Multi-Purpose Water Infrastructure: Recommendations to maximise economic benefits*, presents insights for effectively managing MPWIs.

The long life time of an MPWI facility, typically 50 to over 100 years, means there is inherent uncertainty about future developments and risks. This can create local resistance, especially where stakeholders are not appropriately informed or engaged.

Proven instruments including upfront strategic impact assessment plus decision support tools like hydro-economic computer models, stakeholder engagement, sound regulation and social safeguards help to mitigate these risks and enhance the economic, environmental and social sustainability of MPWI projects.

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