Gender equality, disability and social inclusion in water modelling: A practitioners' toolkit

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Foreword

Climate change is significantly impacting the availability of fresh water and sustainability of water sources in most geographies. As this challenge unfolds, its social and economic impacts will be felt most acutely by low-income households, women, socially and politically marginalised communities, and people with disabilities. While we have developed a robust understanding of the bio-physical processes that underpin the changes, more work is required to understand and respond to the socio-economic processes that follow, threatening the most vulnerable among us. This toolkit goes some way to fill that gap.

The toolkit has been developed to help hydrologists, water resources engineers, water managers, and policymakers to integrate Gender Equality, Disability and Social Inclusion (GEDSI) considerations into water modelling. We know that there are differential impacts of water stress and water-induced disasters on different segments of society. These play out along gender lines, across age groups, across income groups and across communities with different levels of access to resources. It is important that we accurately reflect this reality in our assessments, models, response strategies, and resource allocations. Although there will be operational challenges in obtaining disaggregated data, managing complexities and fine-tuning practices, this toolkit will help to start that learning process in earnest.

This toolkit is a product of the partnership among DFAT, CSIRO, and ICIMOD. We hope it will contribute to our on-going basin planning assistance to Government of Nepal's Water and Energy Commission. I congratulate CSIRO and ICIMOD for developing this toolkit, which will be a valuable resource for government agencies, universities, development partners and other stakeholders in the water sector.

Her Excellency Ms Felicity Volk
Australian Ambassador to Nepal

Foreword – ICIMOD

Without the critical components of Gender Equality, Disability, and Social Inclusion (GEDSI), any discussions and interventions around water will be incomplete and solutions ineffective. They play a significant role in shaping access, usage, and management of water resources. I am delighted to present the "Gender Equality, Disability, and Social Inclusion in Water Modelling: A Practitioners' Toolkit," which for the first time brings the focus on GEDSI in water modelling, a scientific research process. This toolkit is the result of our collaboration with the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia and represents a significant milestone in our collective journey towards promoting inclusive and sustainable water management practices. As we celebrate the outcome of this collaboration, our gratitude extends to the steadfast support of the Department of Foreign Affairs and Trade (DFAT), whose unwavering trust in both the cause and the team has been truly invaluable.

For the region that is home to 10 major river systems, the Hindu Kush Himalaya (HKH) region is facing increasing challenges from climate change impact on water resources, poor water management practices and the growing demands. We now live in the times of unique phenomenon of "Too Much Too Little" water, increase in frequency and intensity of multi-hazard disaster events and growing inequality. Sustainable management of this precious resource is, therefore, critical issue for the region.

Water-related challenges are particularly pronounced on vulnerable communities, and the prevalent water resource management approaches in the region remain largely traditional. While having some system in place is a step forward, these conventional approaches tend to overlook the needs and contributions of different genders, diverse communities, and people with disabilities. Water modelling provides critical information to support decision making in investments related to water resource development, hence, integrating GEDSI components in water modelling is a critical step towards achieving more equitable and resilient water management outcomes. Recognising the unique needs and roles of different genders, diverse communities, and people with disabilities is paramount in designing effective and contextually relevant solutions.

This toolkit is fit for the purpose of meeting the needs of the region. It will empower hydrologists, water resources engineers, water managers, and policymakers with the necessary knowledge and skills to embrace GEDSI-aware modelling practices. By doing so, we can unlock the wealth of benefits, including enhanced community engagement, better-informed decision-making, and the promotion of social justice.

The toolkit's structure and content are designed to support water modelling processes, projects, or initiatives while facilitating both self-learning and group training. From understanding the advantages of GEDSI-aware modelling to developing proficiency in data collection and scenario modelling, this toolkit covers a wide spectrum of topics.

I am confident that this toolkit will inspire water professionals and stakeholders to embrace a more inclusive and sustainable approach to water management. Together, we can create positive and lasting impacts on the lives of millions who depend on water resources for their well-being and livelihoods. As we continue our journey towards equitable and resilient water management, this toolkit serves as a powerful resource, guiding us towards a more just and sustainable future.

Pema Gyamtsho
Director General, ICIMOD

Foreword – CSIRO

Water is essential to life, underpinning our health, wellbeing and wealth. Change driven by climate, shifting populations, new technologies and industry all impact water. Analytical models are essential tools for understanding changes to water supply and quality, and they assist in more informed water allocation and usage decisions. As a society that promotes sustainable, fair and equitable decisions, it is critical to consider ethnicity, religion, gender, disability, and social inclusion in models that aim to deliver water security for all. Typically, issues of gender, disability, and social inclusion are not part of the design of water models. There are also limited guidance notes, books, or examples to follow on how to do this. By not addressing these gaps, reaching Sustainable Development Goals will continue to be challenging.

At CSIRO, we undertake research to improve water security for all, regardless of ethnicity, religion, gender, disability, and social status. Recently, we brought Gender, Equality, Disability, and Social Inclusion (GEDSI) and modelling experts together to identify entry points to integrate GEDSI into the modelling workflow. They identified several critical approaches to recognise and address the differential needs of women, disabled and marginalised people and their underrepresentation in the planning, implementation, and evaluation stages of water modelling projects.

This toolkit offers guidance, examples, tips, and training material to help consider GEDSI in modelling decision-making and practice. By doing so, we check that our modelling practices are more inclusive and considerate of the needs of all individuals.

Everyone has a role in promoting GEDSI in water and building a more equitable and just society. With this toolkit, we aim to positively impact the water modelling industry and contribute towards making water resources accessible, sustainable, and fair for all.

Dr. Carmel A. Pollino
Research Director, Water Security, CSIRO

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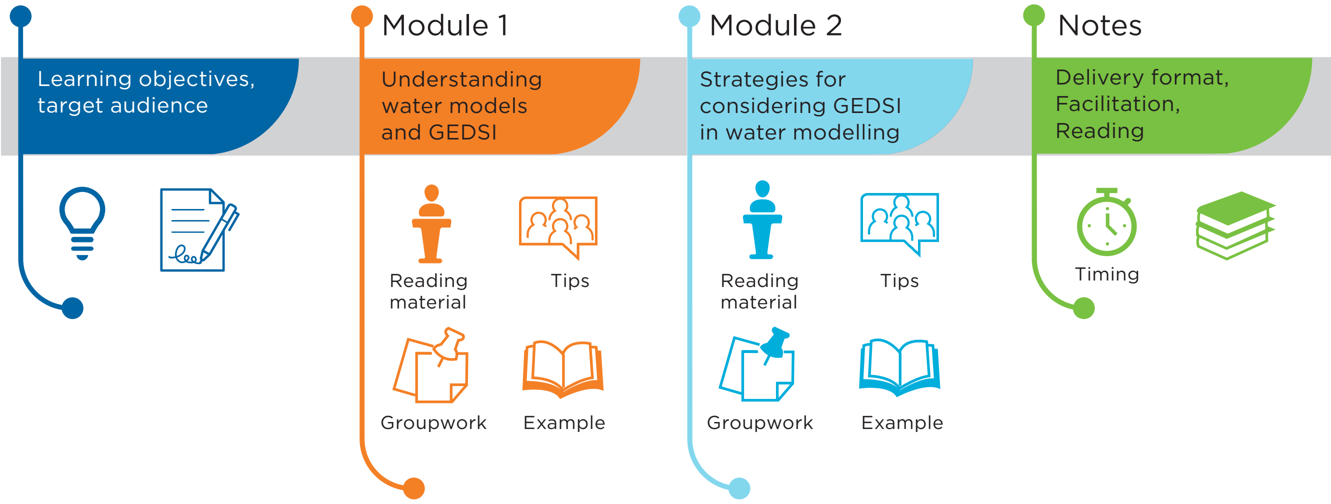
The toolkit at a glance



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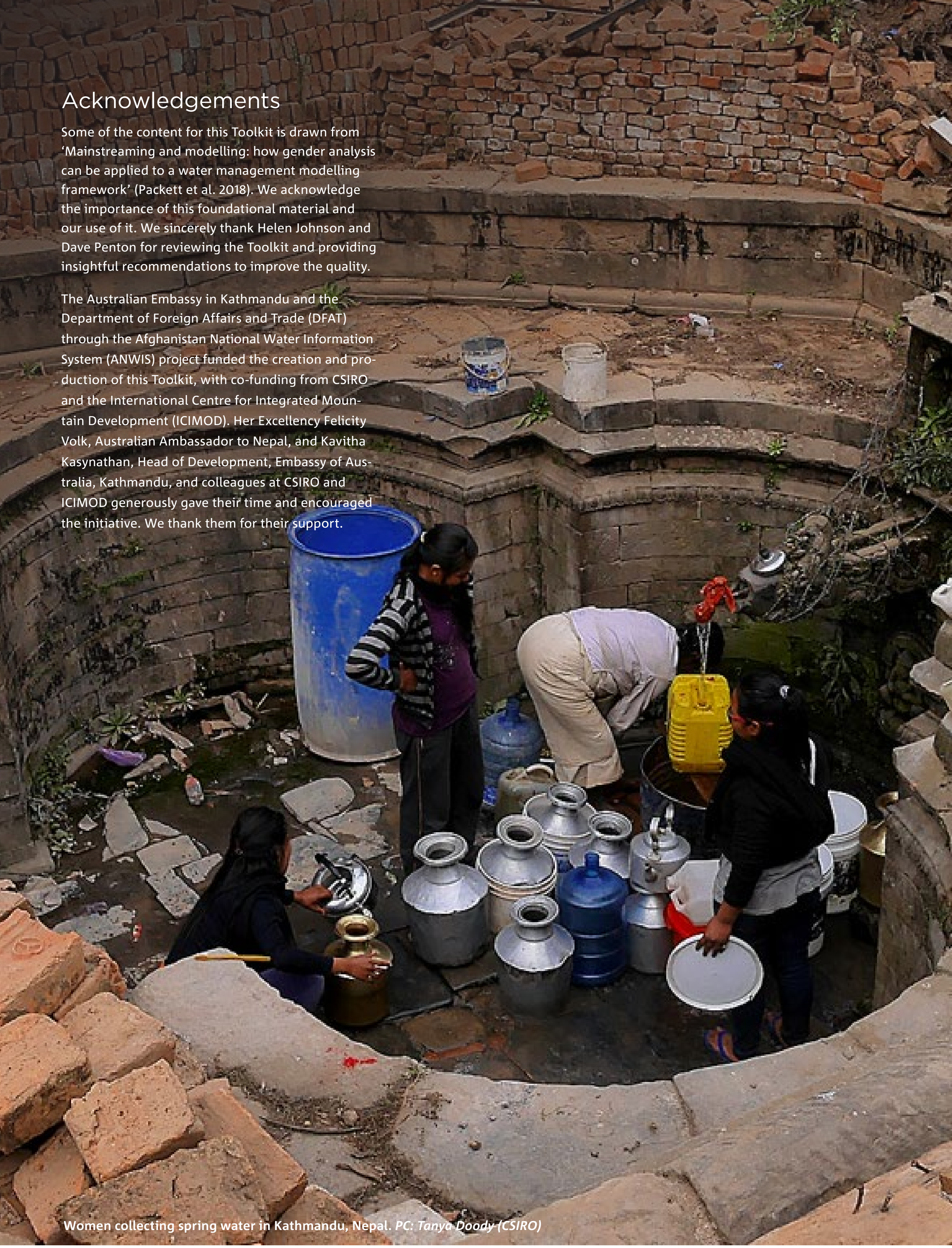
Acknowledgements

Some of the content for this Toolkit is drawn from 'Mainstreaming and modelling: how gender analysis can be applied to a water management modelling framework' (Packett et al. 2018). We acknowledge the importance of this foundational material and our use of it. We sincerely thank Helen Johnson and Dave Penton for reviewing the Toolkit and providing insightful recommendations to improve the quality.

The Australian Embassy in Kathmandu and the Department of Foreign Affairs and Trade (DFAT) through the Afghanistan National Water Information System (ANWIS) project funded the creation and production of this Toolkit, with co-funding from CSIRO and the International Centre for Integrated Mountain Development (ICIMOD). Her Excellency Felicity Volk, Australian Ambassador to Nepal, and Kavitha Kasynathan, Head of Development, Embassy of Australia, Kathmandu, and colleagues at CSIRO and ICIMOD generously gave their time and encouraged the initiative. We thank them for their support.



Women collecting spring water in Kathmandu, Nepal. ***PC: Tanya Doody (CSIRO)***

Overview

What will the toolkit help you with?

1. Gain insight into the advantages of integrating Gender Equality, Disability and Social Inclusion (GEDSI) into your modelling approach, recognising the added value and relevance of GEDSI-aware modelling in addressing complex water management challenges.
2. Develop an understanding of the potential negative impacts of GEDSI-blind modelling on communities and researchers, including the perpetuation of disparities and biases in water management outcomes.
3. Build confidence in incorporating GEDSI considerations into your modelling practice, acquiring the necessary skills and knowledge to integrate GEDSI into your modelling workflows effectively.
4. Acquire the ability to identify strategic GEDSI entry points in the water modelling process, such as data collection, analysis, interpretation, model development, and scenario modelling.
5. Develop proficiency in gathering and analysing GEDSI-disaggregated data and learn to use GEDSI-aware modelling techniques to capture and analyse water systems effectively.
6. Acquire the skills to develop and model scenarios to identify and explore pathways and interventions that promote GEDSI and evaluate their potential impacts.

Who is the target audience for this toolkit?

Hydrologists, water resources engineers, water managers, and policymakers who use modelling extensively are the toolkit's primary audience.

Other stakeholders, such as those working in GEDSI, social science, community representation, agriculture, and disaster risk management, may also find the toolkit helpful.

What does the toolkit consist of?

There are two modules in this toolkit. You can use the modules to guide your modelling practice or you can use it for delivering training. Recommendations for training delivery, format, suggested duration and breaks are provided at the end of the toolkit.

How do I use the toolkit?

The toolkit is organised to support a typical water modelling process, project, or initiative. It contains practical guides, tips for further learning and professional development and examples to help individuals or organisations achieve gender equality, disability and social inclusion in water modelling. There is one practice exercise for each module. They can be used for practice or group work during training.

Introduction

Population expansion, climate change, urbanisation, and industrialisation have put immense pressure on our planet's freshwater sources. Discrimination, social exclusion, and infrastructural deficits worsen water challenges in many underdeveloped and developing nations, prolonging poverty and inequality. Sustainable water management can benefit from Gender Equality, Disability and Social Inclusion (GEDSI) concepts. GEDSI promotes resource fairness, engagement of marginalised communities and people with disability, and diverse viewpoints and needs.

Integrating Gender Equality, Disability and Social Inclusion (GEDSI) into water management can improve access to water regardless of race, ethnicity, religion, disability or social status. Equitable access to water empowers women, girls, marginalised and people with disabilities, allows access to education and jobs, and breaks the poverty cycle. Involving everyone in decision-making ensures multiple perspectives and acknowledgement of the needs of all in society. Diverse viewpoints and knowledge systems enable innovative solutions considering local context, cultural practices, and environmental sustainability. GEDSI empowers communities to adapt to climate change and build resilience.

Globally, water professionals use water models to develop a shared understanding of water problems, interventions and policies between scientists, planners, decision-makers and stakeholders to ensure clarity and consensus. Although they recognise the cultural and political spaces of water management (Zwarteveen 1997), the water models for decision-making are often inadequate to address GEDSI issues. Water models are usually constructed at the macro level and set the boundary for what people can and cannot do at the micro level (Packett et al. 2018). If we ignore social norms and practices, model outputs will reproduce inequality and lack inclusion, with one group accorded more power, privilege, and opportunities than the other (Shrestha & Clement 2019) and some members of socially disadvantaged and disabled groups ignored altogether.

In the last decade, several researchers (Escobar et al. (2017), Packett et al. (2018), Resurrección & Johnson (2015) and Baker et al. (2015)) worked to mainstream gender within hydrological modelling, water programs and policies. However, there is a general lack of GEDSI awareness among water modellers and toolkits to fill the knowledge gap.

This practitioners' toolkit explicitly targets water modellers to consider technical and social contexts simultaneously, integrate gender-disaggregated data, and place GEDSI at the core of decision-making. The toolkit recognises that not everyone in the community faces the same privilege or discrimination. Some may face discrimination based on gender, ethnicity and disability, historically or economically. Some older adults may lack formal education and live in remote, rural communities. We hope you, the reader, can use the toolkit to gain new skills and knowledge and improve modelling practice, leading to improved GEDSI outcomes.

Module 1: Understanding water models, gender equality, disability and social inclusion

Models represent various social and biophysical systems and processes using different inputs and modellers' world views. Water professionals use models to collate information and make decisions.

Models allow decision-makers to investigate systems and analyse how different interventions may interact and develop pathways to solve real-world water challenges. This module introduces you to contemporary modelling thinking and practice – specifically, how gender can be included in the models that traditionally underpin Integrated Water Resources Management (IWRM). This approach helps create inclusive and diverse models, which can lead to more equitable and socially inclusive outcomes.

A woman is washing clothes near her house in Nepal. ***PC: Tanya Doody (CSIRO)***

Water models

Water models are used to mathematically simulate, predict, and analyse the behaviour of water systems, such as rivers, lakes, oceans, groundwater, and atmospheric water. The process involves developing mathematical models representing the physical processes governing water flow and transport in these systems, such as fluid dynamics, hydrology, and water chemistry.

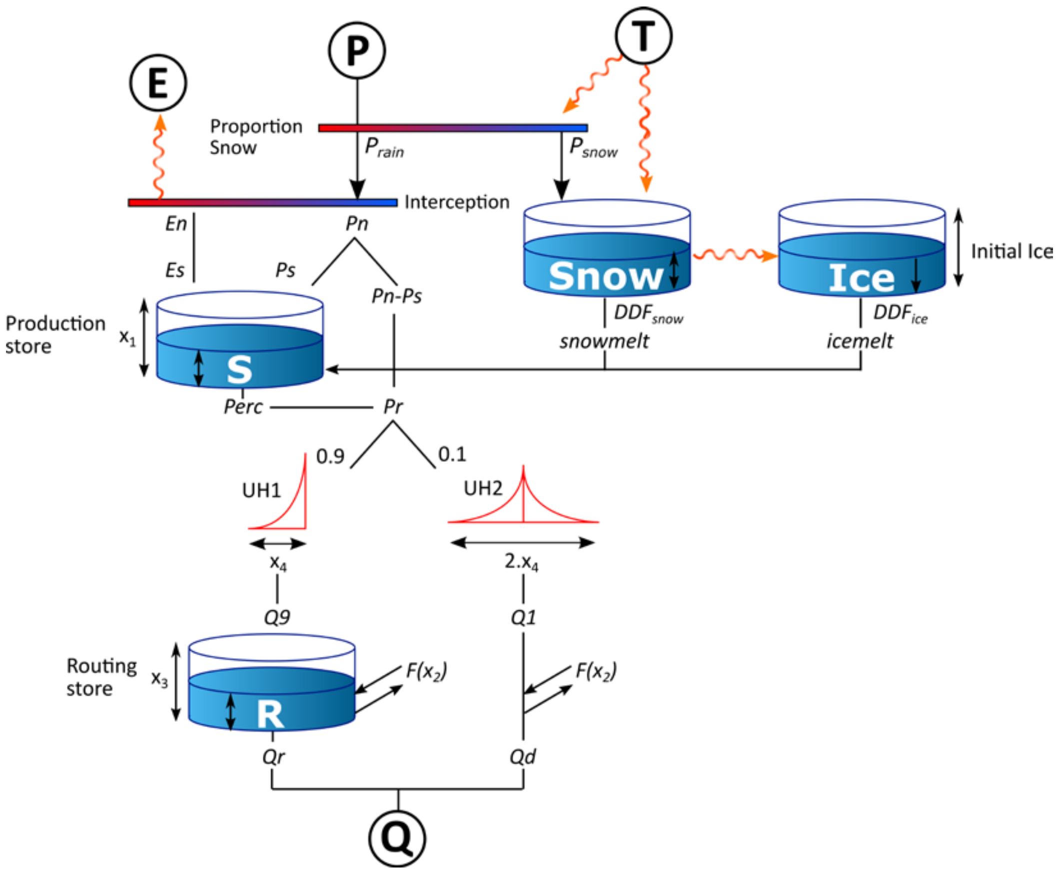
Water models are used to study many water-related issues, including water availability and distribution, flood forecasting, erosion and sedimentation, water quality management, and environmental impact assessment. They are essential for decision-makers in various fields, including water resources management, urban planning, agriculture, and environmental protection. As such, water models are often integrated or work with social and ecological processes or models to support more comprehensive decision-making. Here, we summarise some water models widely used to address different processes and issues.

1. **Rainfall-runoff models** simulate rainfall transforming into runoff, which is the water that flows over the land surface and into rivers and streams. They help estimate the amount and timing of runoff generated from a particular catchment or watershed, which is crucial for flood forecasting, water supply management, and ecosystem studies.
2. **Water balance models** simulate the water balance of a particular area, considering inputs such as precipitation, outputs such as evapotranspiration, and other processes such as infiltration and runoff. They help assess water availability, estimate water yield, and understand the interactions between hydrological cycle components.
3. **Groundwater flow models** simulate the movement of water through the subsurface, including the flow of water in aquifers and the interaction between surface water and groundwater. They help assess groundwater availability, predict changes in groundwater levels, and evaluate the impacts of groundwater pumping on water resources and ecosystems.
4. **Flood models** simulate the occurrence and propagation of floods in rivers and streams. They help estimate flood risks, assess flood impacts, and support flood forecasting and early warning systems. Flood models can be used to analyse floodplain management, floodplain mapping, and flood risk reduction strategies.
5. **Water quality models** simulate the transport and fate of waterborne contaminants, such as pollutants and pathogens, in water supply and sanitation systems. They help assess water quality risks, identify potential sources of contamination, and evaluate the effectiveness of water treatment processes. Water quality models can support decision-making regarding water treatment, disinfection, and source water protection.
6. **Sediment transport models** simulate sediment movement in rivers, including sand, silt, and clay. They help assess sediment erosion, transport, and deposition processes, which are crucial for understanding river morphology, sedimentation patterns, and riverbed changes. Sediment transport models are used in river engineering projects, sediment management, and environmental impact assessments.
7. **Ecological models** simulate the interactions between biotic and abiotic factors in rivers, such as fish habitat, aquatic vegetation, and nutrient cycling. They help assess the impacts of human activities, such as dam operations, river channelisation, and pollution, on river ecosystems. Ecological models are used in river restoration, ecosystem management, and biodiversity conservation.
8. **Hydraulic models** simulate water movement in pipes, channels, and other conveyance structures. They help analyse water flow in distribution networks, sewer systems, and stormwater management systems. Hydraulic models consider factors such as pipe diameter, elevation, pressure and flow rates to optimise the design and operation of water supply and sanitation systems.
9. **Hydrodynamic models** simulate and predict the behaviour of fluids in complex systems, such as rivers, estuaries, coastal areas, and oceans. They are often used for coastal and oceanographic studies, flood prediction, and environmental impact assessments.
10. **Demand forecasting models** estimate future water demand based on population growth, economic development, and water consumption patterns. They help plan for water supply infrastructure, determine appropriate storage capacities, and optimise water allocation strategies. Demand forecasting models are essential for long-term planning and sustainable management of water resources.
11. **Asset management models** help optimise maintaining and replacing water supply and sanitation infrastructure. They use data on asset condition, age and performance to predict maintenance needs, prioritise investments and extend the lifespan of water infrastructure. Asset management models assist in making cost-effective decisions about asset replacement, rehabilitation, and repair.

12. **Integrated hydrological models** integrate multiple processes into a comprehensive framework, such as rainfall-runoff, groundwater flow, and water balance. They provide a holistic understanding of the hydrological system and support integrated water resources management, considering the interactions between surface water and groundwater, land use and climate change.
13. **Integrated river system models** integrate multiple aspects of rivers, such as water flow, sediment transport, water quality and ecological processes, into a comprehensive framework. They provide a holistic understanding of river dynamics and support integrated river basin management, which considers the interactions between different components of the river system and their impacts on water resources, ecosystems, and human activities.
14. **Decision support models** integrate multiple aspects of water supply and sanitation systems to support decision-making at various levels, from strategic planning to operational management. They provide a holistic view of the system's performance and help evaluate the impacts of different management strategies, policies, and investment options. Decision support models enable stakeholders to make informed decisions about water supply and sanitation system development, management, and policy formulation.

Example of a conceptual rainfall-runoff model

GR4JSG is a conceptual model which uses functional units to define catchment units. It is a spatially lumped model and models the precipitation to runoff relationships using 4 water stores. This diagram is a conceptual layout of the model. The Nepal et al. (2016) paper compares the performance of this conceptual model in the Tamor catchment of Nepal against streamflow and MODIS snow extent.



Box 1 Example of conceptualisation of a rainfall-runoff model. In this case, the model is to be used in a situation where inflows come from both snowmelt and ice melt, so they are included in the conceptualisation of the water cycle (Figure 4 in Nepal et al. 2016)

Challenges to considering GEDSI in water modelling

Traditionally, water modelling starts with defining the problem, scoping what the model needs to test and conceptualising the system to be modelled. Modellers decide how the model will represent the system, and select appropriate inputs based on their worldview and knowledge. Decisions made by modellers at this stage – such as metrics and algorithms for reporting, sensitivity or uncertainty of the analysis – affect the model's output. Modellers rarely consider issues of gender, disability or social disadvantage. Gender-disaggregated data are often collected from statistics agencies – e.g. the number of people in the district who are male/female, which is not enough to be helpful. A lack of gender analysis and a broad range of social input data may make model outputs 'gender-blind' and ignore people with a disability. Decisions made from such models ignore the social diversity in all societies. They will fail to ensure equitable and inclusive outcomes for the people and the socially disadvantaged within each society.

There are various factors for GEDSI blindness in the traditional water modelling workflow. Firstly, most water modellers come from a mathematics or engineering background. Their background training in the past did not include a strong purpose for including gender, disability and social inclusion issues, and often they fail to perceive that considering GEDSI may change the representation of the purely biophysical processes in their models.

Water modelling exercises are often time- and resource-constrained. A typical team may consist of engineers, spatial analysts, data wranglers, environmental scientists, natural resource managers, river managers, basin planners, and software engineers and typically would not include human geographers, anthropologists, knowledge brokers and social scientists. With such a team composition, a typical modelling workflow would not consider, and certainly would not prioritise, gender, disability and social inclusion issues (Escobar et al. 2017).

Furthermore, up-front model specifications (including assumptions) are sometimes unclear, resulting in many revisions to the model, adding complexity and reducing transparency. More time is spent on data collection than planned. Little time is given to managing the multi-disciplinary nature of the social and cultural context.

Finally, there is a general lack of GEDSI disaggregated data. Modellers often overlook the importance of creating user profiles tailored to different livelihood types, including agricultural, forest-based, and industrial livelihoods, age and ability-related subsistence and livelihood activities, and household water use. This oversight results in the inadequate estimation of water use across various livelihood and subsistence types and insufficient quantification of the number of users within each profile in different catchments and demand sites within the basin. The model outputs do not show the gender and disability-differentiated and socially disadvantaged impacts of various supply and demand strategies.

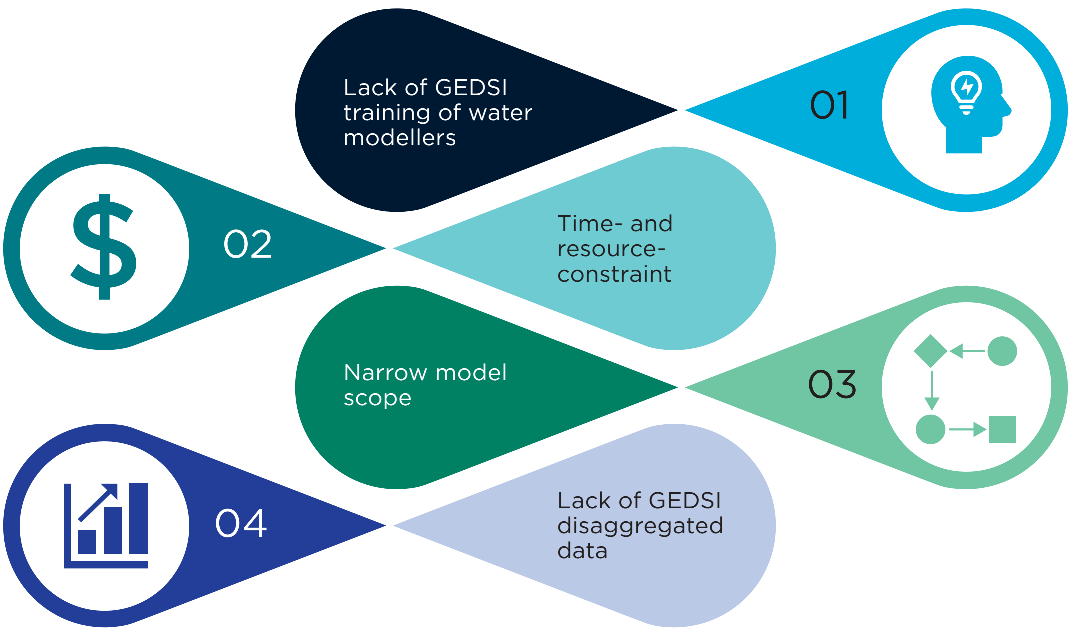


Figure 1 Challenges to considering GEDSI in water modelling

GEDSI-responsible water modelling workflow

A typical modelling project is delivered in several steps:

1. Problem identification, objectives, and scope
2. Conceptualisation, data collection, model selection and setup
3. Model calibration and validation
4. Scenario development and solution identification.

Each step can be an entry point for GEDSI consideration in water modelling.

First, the GEDSI-responsible water modelling workflow starts with defining the problem, objectives and modelling scope considering gender, disability and social inclusion. GEDSI analysis reveals contextual social relations, uncovers the specific needs of people with a disability and members of socially disadvantaged groups, and conceptualises the system to be modelled. Inclusive stakeholder engagement helps identify particular needs, such as those of people with a disability and inspires and empowers people during problem identification, objective setting and scoping.

Second, based on the problem definition and available data, societies' relationships with water are quantified or qualified using a GEDSI lens to conceptualise the system, select a modelling approach and setup the model. Various types of water models, such as hydrological, hydraulic, water quality, and integrated models, combine multiple components. The selection of the appropriate model depends on the specific system being modelled and the objectives of the modelling exercise (e.g. Kelly et al. 2013). The model setup typically involves defining the model parameters, specifying the boundary conditions, and setting up the model domain. GEDSI-responsible model development should use gender, disability and socially disaggregated data, when possible, to reveal insights and social relationships of power which may ignore the needs of women, people with a disability and the socially disadvantaged and the options that aggregated data may mask.

Third, once the model is setup, it is calibrated and validated to ensure it accurately represents the real-world system. The process involves adjusting the model's parameters or settings based on observed data, such as streamflow measurements, water quality samples, or other relevant field data. The aim is to optimise the model's performance by minimising the difference between model predictions and observed data. Water models are sometimes not calibrated due to a lack of data, a need for a quick assessment (e.g. in emergency response scenarios), or when models are used for sensitivity analysis (understanding the relative changes in model outputs rather than achieving accurate predictions). GEDSI objectives (such as considering the part of the hydrograph that has more impact on women, disabled and socially disadvantaged groups) are used to inform the appropriate choice of calibration and validation objectives and procedures. Model performance metrics, such as accuracy, precision, and error statistics, are used to assess the reliability and validity of the model results.

Fourth, gender, disability and social inclusion goals are included as criteria for success and designing relevant reporting metrics. Scenarios can be developed to target gendered power structures or analysis for a gender effect. Modellers account for missing GEDSI-specific knowledge by identifying any risks the outputs present and assessing implications for confidence in the modelling results.

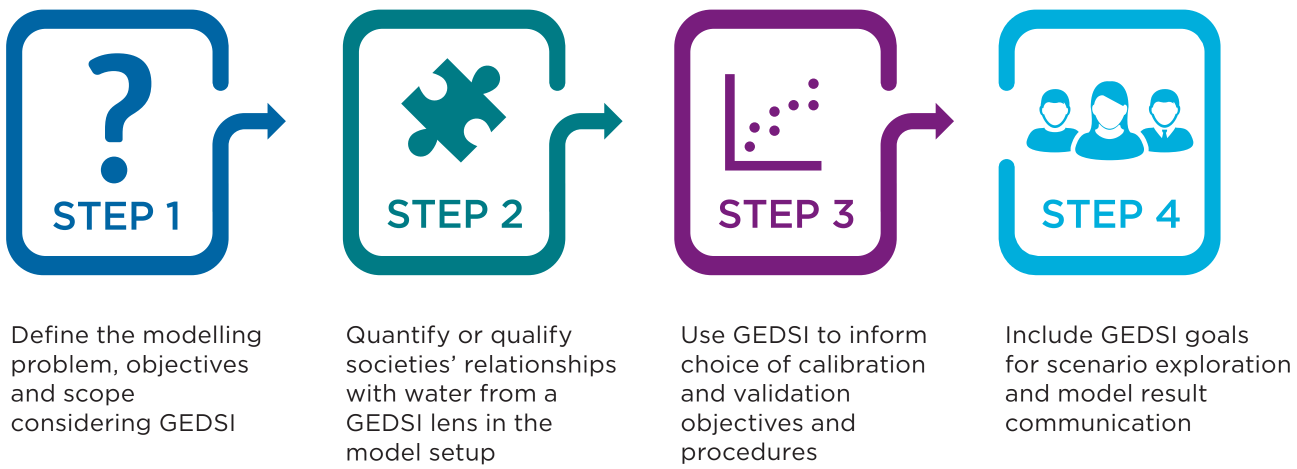


Figure 2 GEDSI-responsible water modelling workflow

GEDSI terms and concepts

Gender refers to socially constructed identities, roles, and qualities that society ascribes to each sex. At the same time, sex is the biological difference between females and males. Gender roles are a deeply rooted social construct, varying by culture and changing over time. In all, gender determines power relations between females and males.

Gender division of labour refers to the allocation of work/type of work between women and men, usually driven by culture, tradition, and customs. Goodrich et al. (2019) categorised the division of labour into three main groups:

1. Reproductive roles involve caregiving and childbearing within households, such as cooking, fetching water, washing, cleaning, and other unpaid or low-valued activities. Women and children typically carry out these responsibilities.
2. Productive roles involve activities that generate goods and services for consumption, trade, or subsistence needs. Both women and men perform these tasks, but women's activities are often less visible than men's.
3. Community roles include activities related to caring for the community or participating in social events, and are often seen as an extension of reproductive roles for women. At the same time, men tend to participate more in political affairs, such as institutions and committees.

Gender equality and gender equity are crucial factors contributing to improved gender relations. Achieving gender equality does not mean that women and men become the same, but that their opportunities and rights are not governed by their gender. All genders should be free to develop their abilities and make choices not limited by stereotypes, prejudices, or rigid gender roles. Gender equality and equity aim for equal decision-making power, access to and control over resources, and equal opportunities for education, employment and livelihood.

Gender equity means respecting all people without discrimination, regardless of their gender. Although gender equity is often used interchangeably with gender equality, gender equity recognises the historical and social disadvantages that prevent women and men from having a level playing field. It entails treatment that is different but considered equivalent concerning rights, benefits, obligations, and opportunities through which it recognises the uneven power relations between women and men and various measures to be used to counter the imbalances to achieve gender equality.

Access to and control over resources In productive resources, 'access to' implies rights and opportunities, 'control over' refers to rights and power. For an individual, access means one has the right to use specific resources (financial, natural, social, political) and control over resources, including the right and power to decide how to use the resources. Such as control over land means the individual can access or use the land, own it, and decide whether to sell or rent the land (Goodrich et al. 2019). However, access to and control over resources are shaped by socio-cultural, political, economic, and religious institutions and their associated values.

Practical Gender Needs (PGNs) and Strategic Gender Needs (SGNs) PGNs arise from the actual condition that women and men experience because of their responsibilities and tasks associated with traditional gender roles. If these practical needs are unmet, it leads to inequalities such as in water, health care, employment, and other sectors. It does not challenge gender roles and women's subordination; it only brings improvement in the lives of women (or men).

The SGNs are needs required to overcome the subordinate position of women to men in society and are related to women's empowerment. The strategic gender needs and interests are contextual and may include legal rights, domestic violence, equal wages, and women's control over their bodies. Addressing SGNs can transform or fundamentally change one or more aspects of women's lives. It can involve women or enable them to be agents of change or improve their position in society.

Condition and positions Condition refers to the state in which women and men live, relating to their responsibilities and work (Goodrich et al. 2019), such as the provision of water services, credit facilities, food and nutritional requirements or increased women in training programs or community development activities. Conditions can be changed by fulfilling practical needs.

Position refers to women's social and economic standing relative to men and is linked to the opportunities to make decisions and gain authority and power (Goodrich et al. 2019). It also refers to the disparities in wages, employment opportunities, unequal representation in institutions, unequal ownership of land/property and vulnerability to violence. Addressing strategic gender interests can positively change women's position (UNDP 2001).

Gender intersectionality refers to different facets of a person's identity that overlap and interact with one another, moulding experiences and determining access to opportunities, resources, and power in complex manners (Green 2017). For example, a transgender woman from a socially disadvantaged community may encounter discrimination and prejudice not only because of her gender identification but also because of her race and ethnicity. Similarly, a disabled gender nonconforming individual may experience discrimination because of their gender identity and disability status.

The concept highlights that gender identity alone does not determine a person's experiences but that other social identities and oppressive systems interact with gender to influence individuals' lived experiences. Intersectionality also acknowledges that oppression systems are interrelated and mutually reinforcing and that individuals may experience numerous forms of privilege and oppression simultaneously based on their various social identities.

Stereotypes and implicit bias Gender stereotypes are over-generalisations about the characteristics of an entire group based on ethnicity, nationality, culture, race, and gender, among others. In this manner, women and men are presented in a stereotypical way that reflects and sustains socially endorsed views of gender. For example, farming is done by men, and women care for the family. Often, stereotyping results in implicit biases against specific gender or social groups.

Implicit bias occurs when someone consciously rejects stereotypes and supports anti-discrimination efforts but also unconsciously holds negative associations in their mind. Implicit bias can affect people's decisions and their behaviour towards people of other social groups. This type of decision and behaviour results in exclusion and inhibits the decision-making of women, the poor and disadvantaged groups.

Sex-disaggregated data are collected and analysed separately for males and females. The data reflect the realities of women's and men's lives and policy issues relating to gender. The data allow for measuring differences and inequalities between women and men on social and economic dimensions and are required to obtain gender statistics. Gender statistics are more than data disaggregated by sex; they provide visibility into how programming targets and impacts women and girls.

Gender indicators are essential for assessing and measuring women's empowerment and progress towards gender equality. These indicators provide crucial information about the status of men and women, as well as gender roles and relationships, in a broad spectrum of life, including social, economic, cultural, and political domains. Gender indicators assist in monitoring progress towards gender equality goals by tracking changes over time. As a result, these indicators are handy for GEDSI-responsible water modelling. They are an excellent starting point for considering gender-disaggregated data in modelling processes.

There are several valuable pieces of literature on gender indicators. Hunt (2013) discussed gender equality outcomes and water supply and sanitation infrastructure indicators. The gender equality outcome is measured by reducing time burdens for women and girls in collecting water and caring for the sick due to demand-driven water supply and sanitation infrastructure that responds to both women's and men's needs and priorities. The measured GEDSI dimensions include human capital, economic empowerment, voice and rights, and gender capacity building.

Water modelling can highlight the GEDSI-specific challenges and opportunities associated with water resources management. It can also assist in identifying gender disparities, vulnerabilities, and gaps in access to and control of water resources. This data can help inform the development of gender-responsive policies and interventions and advance gender equality and women's empowerment in the water sector.

Disability-inclusive development ensures that people with disabilities are fully included in growth and benefit from development programs. It involves recognising the rights and dignity of people with disabilities and actively working to remove barriers and promote equal opportunities for their participation in all aspects of life (CBM Australia 2021).

Further information on GEDSI terms, Analysis framework and tools can be found in the Additional Resources section of this toolkit.

Gender mainstreaming and analytical tools and techniques

To reflect GEDSI issues and concerns, it is necessary that gender mainstreaming is adapted to GEDSI and integrated within the modelling approach and strategy. This means the modelling tools consider the concerns and experiences of different groups of women and men, people with a disability and members of socially disadvantaged groups in designing, implementing, monitoring and evaluating policies and programs (Packett et al. 2020).

The gender mainstreaming strategy is generally based on the principles of ensuring equal access to and control over the use and management of services, meaningful participation of women in all decision-making bodies/ positions, and the use of gender-specific data or sex-disaggregated data for statistical analysis to reveal the gendered dimension of policy impacts on different groups of women and men (Hamdy et al. 2004; Panda 2007). This also involves providing the necessary gender sensitivity training, tools for gender analysis and establishing linkages among multiple stakeholders engaged in managing water resources.

However, when conducting gender analysis, ensure the concept of 'intersectionality' is understood and an intersectionality approach to how women and men contribute to, participate in, and perpetuate unequal gender relations is used (Thompson 2016). These differences are addressed when designing, implementing and evaluating projects. Gender analysis can be conducted at multiple stages of policy and programs to highlight gender differences and inequalities. It is also a move from understanding 'women' to bringing in the men's perspectives (among those affected by the strict gender norms) (Lau et al. 2021; Regmi 2020).

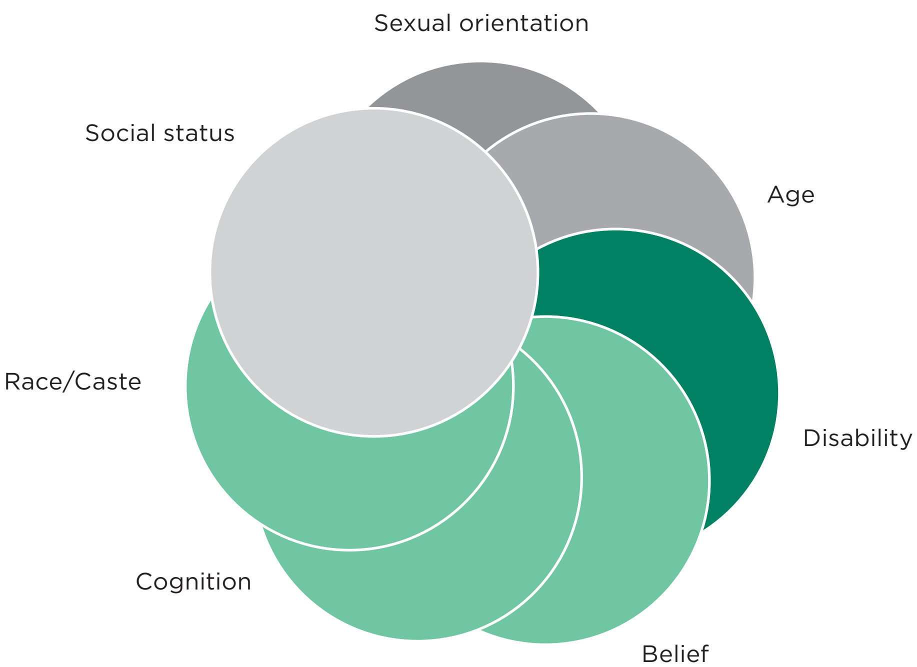


Figure 3 Intersectional approaches to gender analysis

In practice, gender mainstreaming occurs at multiple levels, and the approach differs. Table 1 summarises the broad approaches to gender mainstreaming work to achieve gender equality and more effective GEDSI-transformative development outcomes.

For water professionals and modellers, the gender integration continuum can be used to understand how to adapt it to GEDSI and to move along the continuum – from gender/GEDSI sensitive to gender/GEDSI-responsive to implementing a GEDSI-transformative approach and actions. In addition, this integration continuum will help the modellers assess how well their modelling exercises, such as the problem formulation and conceptualisation, have identified, examined and addressed gender/GEDSI considerations. In this context, it is important to emphasise that modelling exercises should always aim to be gender/GEDSI sensitive and move towards GEDSI-transformative change. It is also important to understand that modelling exercises may not fall neatly into one type of approach and may include both approaches; for example, they may have elements from the gender/GEDSI-sensitive and gender/GEDSI-responsive approaches.

Table 1 Approach to gender/GEDSI mainstreaming

Gender blind	The gender-blind (negative) approach does not consider gender in policies and programs. It ignores gender norms, political roles, rights, entitlements, power dynamics biases, and stereotypes reinforcing gender inequalities.
Gender neutral	The approach does understand gender differences but does not consider these differences as relevant to development outcomes. As a result, it neither worsens nor improves gender norms, roles and relations. It maintains the status quo.
Gender-sensitive	This approach acknowledges the differences between women and men and the inequalities but does not address the inequity. Gender is considered a means to reach development goals. Thus, it addresses gender norms, roles and access to resources but only to achieve the project goals.
Gender-responsive	In this approach, gender consideration is central to achieving development outcomes and, as a result, it acknowledges gender norms and differences and considers women's and men's specific needs. The project outcomes consider changing gender norms, roles and access to resources.
Gender transformative	The approach seeks to transform gender relations to promote gender equality and achieve development outcomes in projects and programs. It changes unequal gender relations to promote shared power, control of resources, and decision-making. It strengthens or creates systems that support gender equality, including changing gender-discriminatory norms and practices and establishing an enabling environment for women's empowerment.

Source: WHO (2011)

Practice exercise: Looking at basin-scale modelling differently

The photo shows a group of women washing clothes at an irrigation canal near their village. They are also looking after their children. ***PC: Auro Almeida (CSIRO).***

Imagine that the irrigation canal is part of the model you commission (or build) in a basin planning exercise. It is essential to reflect on the different water uses by different genders, people with a disability and social groups, based on livelihood practices, such as farmers, fisherfolk, pottery makers, and jute workers and subsistence practices such as gathering river plants and crustaceans, fishing and hunting. This reflection will enhance gender, disability, and social awareness among the water modellers because women often engage in different livelihood and subsistence activities than men. The modellers can quantify the water needs and manage water equitably based on water access and usage.

Please reflect on the different water uses by women, men, disadvantaged and disabled, and answer the following:

1. Who uses water, and for what purposes? Which socially disadvantaged groups are likely to be excluded? What are the specific needs of people with disability?
2. What are the water management and distribution practices? Who is involved in formal and informal institutions, and for what reasons?
3. Now based on the above information, how do you incorporate the GEDSI information in water modelling?

Answers to the questions are suggested in the **Answers to practice exercise questions** section. If you use the practice exercise for training, suggestions for group work are available in the **Notes for Training** section at the back of this toolkit.

Module 2: Strategies for considering GEDSI in water modelling

GEDSI in water modelling is more than ensuring equal women and men's participation in modelling activities. It does not mean treating women and men the same – the goal is to develop models that consider GEDSI when analysing and planning water use and adding social equity and sustainability as outcomes.

Considering GEDSI in modelling requires methods beyond our standard toolkits as technical modellers. We may need to seek input from gender and disability experts during different stages of any modelling exercise. Sharing or training gender and disability experts in modelling approaches can help fully integrate GEDSI. In this module, we learn about considering GEDSI in various modelling steps.

1. Defining the modelling problem, objectives, and scope
2. Conceptualising, setting up the model and collecting data
3. Calibrating and validating the model
4. Developing scenarios and identifying solutions.

Problem definition, objectives, and scope

To effectively model water, it is crucial to have a comprehensive understanding of the river basin or water system, including societal values, norms, politics, structures, and ecological systems and their role in supporting livelihoods and subsistence activities. This holistic understanding can be achieved through primary and secondary research, such as surveys, key informant interviews, focus group discussions, literature reviews, and engaging with various organisations' stakeholders, experts, representatives and members of local communities. Given the technical nature of these processes, it is essential to consider gender, disability and social inclusion, and other related issues during the problem definition stage to ensure appropriate objective setting and selection of suitable modelling tools.

To properly define problems and setup objectives and scope, it is crucial to conduct a gender analysis to understand how any proposed action, such as legislation, policy, or programs, will affect women, men, people with a disability and different societal groups. By examining gender, disability and social relations, this analysis can reveal how development challenges are interconnected with GEDSI issues. It involves identifying and analysing the various roles and activities performed by women, men, elders and children, people with a disability and members of socially disadvantaged groups and examining the relationships among these groups in the context of development policy and implementation. Furthermore, it investigates how people in general and men and women in particular access and control resources differently.

Several gender analytical frameworks are available to aid in understanding social and economic conditions and identifying gender gaps and inequalities that affect both women and men (March et al. 1999). For water modellers, utilising these gender frameworks can help collect data on gender disparities or gender-specific issues and challenges to aid in developing an accurate and credible model. Adapting gender frameworks to include all the social categories denoted by GEDSI adds valuable accuracy and necessary complexity to water models.

Several commonly applied gender analytical frameworks (March et al. 1999) are listed here.

- **Harvard Analytical Framework** gives practical guidance in identifying the gender division of labour and their needs and exploring the division of labour between women and men. It can be helpful in disaster preparedness to understand who does what, when and where, and who has access and control over resources and the factors that shape differences between women and men.
- **Moser's Triple Roles Gender Analysis Framework** (Moser 1993) helps explore the division of labour between women and men, practical gender needs (PGNs) and strategic gender needs (SGNs).
- **Gender Analysis Matrix** (GAM) is helpful in monitoring, evaluating, and exploring the gender impact of Disaster Risk Management (DRM) programs at the community level.
- **Capacities and Vulnerabilities Assessment Framework** (CVA) is used in humanitarian disaster preparedness issues; capacities – existing strategies and strengths; vulnerabilities – existing weaknesses or the ability to cope with issues and problems (Birks et al. 2017)
- **Longwe's Women's Empowerment Framework** (Longwe 1995) is helpful in monitoring and evaluation; assess the contribution of interventions in all sectors to women's empowerment.
- **Levy's Web of Institutionalisation Framework** (Levy 1996) explores gender mainstreaming in institutions.
- **Social Relations Framework** (SRF) explores gender aspects of sustainable development and institutional change – goals of development as human well-being; the concept of social relations (about resources); institutional analysis (State, Market, Community, Family/Kinship).
- **Washington Group Short Set on Functioning** (WG-SS) Disability is a dynamic, complex process that must be understood and 'unravelled' to create a measurement tool of international relevance and produce cross-nationally comparable data. The WG Short Set of six questions on disability functioning for use in surveys was developed using the World Health Organization's International Classification of Functioning, Disability, and Health (ICF) as a conceptual framework. The ICF presents a bio-psychosocial model that locates disability at the interaction between a person's capabilities (limitation in functioning) and environmental barriers (physical, social, cultural or legislative) that may limit their participation in society.

While applying these frameworks, it is essential to know that no single framework is complete; the researcher or the practitioner may customise these tools depending on the gender scenario. Furthermore, we can combine the frameworks and tools to draw in-depth analysis. Geographic Information System (GIS) can integrate and support improved decisions on environment management, disaster risk management, and resilience to climate change. In this regard, multiple gender tools and frameworks can be combined to gather GEDSI-related information (more information in the **Additional Resources** section).

Disability data can inform inclusive development practices and improve results, and CBM Australia (2021) provides a helpful framework. They discuss the need to gather data that consider people with disabilities and how data can be utilised to improve disability inclusion across the whole lifecycle of a project or programme. When persons with disabilities are included in the data collection procedures that affect them, the results will likely be more accurate, considerate, and valuable. These practices can act as a springboard for broader disability inclusion measures, increase their ability to participate in community decision-making processes, offer good role models, and combat harmful stereotypes.

Example 1 Framing Australia's drought modelling

Australia frequently experiences drought, and models are used to analyse and prepare for droughts and allocate water during scarcity. As time progressed, water modellers became aware that during periods of severe drought, where farming fails to generate adequate income for agricultural families, women tend to seek off-farm employment to supplement their income and keep their families in agriculture. Often these actions resulted in women travelling long distances to urban areas, leading to social isolation and mental health issues for both men and women. Upon recognising this problem, modellers were able to incorporate gender differences in the impacts of water allocation into their models and investigate how such trends as worsening water scarcity might affect men and women in different ways. This understanding allowed modellers to propose measures to mitigate the impacts of temporary female out-migration during droughts.

Source: Alston (2009a, 2009b)

A dried riverbed in Nepal. ***PC: Jitendra Bajracharya (ICIMOD)***

Conceptualisation, data collection, model selection and setup

Conceptualising a water model considering GEDSI involves developing a conceptual framework or representation of a water system's physical, biological, and social components. This process involves identifying and characterising the vital elements of the system, such as sources of water, storage, distribution, and usage, and the interactions between these elements. The conceptual model should reflect the relationships among the various components of the water system and should follow the definition of the problem, objectives and scope in the previous modelling step, scientific data, theories, and expert knowledge. It serves as the basis for mathematically setting up the model to simulate and predict the behaviour of different water system components under different scenarios and conditions.

Participatory modelling is a contemporary technique to represent a water system's physical, biological, and social components (Jonsson et al. 2007). The modelling process involves stakeholders, such as local communities, indigenous groups, representatives of disability organisations, NGOs, and government agencies, in developing and implementing water models. The participatory approach recognises the importance of local knowledge, social and cultural norms, and values in understanding water-related issues and developing practical solutions that are sustainable and equitable. It creates a platform for stakeholders to share their views and concerns, contributes to setting up the models, and participate in the decision-making process. The approach uses dialogue and collaboration leading to increased stakeholder engagement, empowerment, and ownership of the water models and their outcomes. Participatory modelling has been increasingly used in water modelling to combine supply- and demand-side stories.

A typical watershed in Nepal. ***PC: Arun Shrestha (ICIMOD)***

For example, when allocating water to competing demands, a market-based system may prioritise diverting water to industries or large irrigation schemes, potentially leaving disadvantaged populations without access to water. It is essential to consider disadvantaged groups' presence, size, and location and ensure the effective participation of these groups during the model conceptualising and data collection phase. By doing so, we can ensure that water allocation decisions do not disproportionately affect these groups. To incorporate this consideration into our modelling, we may need to identify water demand nodes and prioritise supply in a way that addresses the water needs of disadvantaged communities and considers gender-based water demands. These may include domestic potable water, irrigation of crops valued by women smallholders, ecological flows for natural resource preservation, and other cultural needs.

Thus, instead of selecting pre-existing software (e.g. Figure 4), a modeller relies on input from stakeholders to identify various processes that must be considered when setting up a model. By adopting this approach, the modeller can examine the system from a GEDSI perspective, which helps identify any overlooked parameters and enhances the relevance of the model outcomes. Two examples (Example 2 and Example 3) are provided in the boxes to highlight model conceptualisation and setup considering GEDSI.

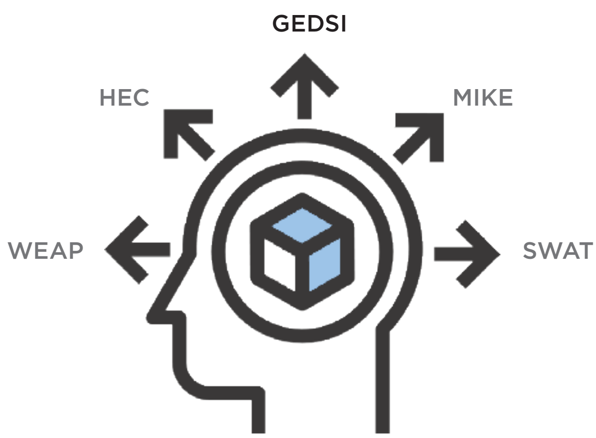


Figure 4 GEDSI should be considered when selecting modelling tool or software

Example 2 Men and women view and conserve watersheds differently

In many regions, the primary source of municipal water supply is from upstream watersheds. However, anthropogenic activities such as urbanisation and agricultural practices can lead to the degradation of the quality and quantity of water in the watershed, posing a threat to downstream water users. Therefore, it is crucial to conserve watersheds to ensure a sustainable water supply.

Watershed conservation approaches may include reducing water usage, minimising water pollution, and restoring natural vegetation in the watershed. One example of a conservation approach is the implementation of a riparian buffer zone. This vegetated area protects the water source by intercepting and filtering contaminants from runoff and providing habitat for wildlife.

Research has shown that different sections of the communities have different views, needs and responsibilities in watershed conservation. Many older women grow water-based plant gardens on riverbanks and sell the produce. Children play in or near rivers. Druschke and Secchi (2014) found that women had lower knowledge about best management practices but more positive attitudes towards conservation and collaboration than men. Yang et al. (2018) found that women better-perceived water quality and erosion control, soil formation, habitat conservation, and sustaining biodiversity. Men had more knowledge of fuel and timber and extreme event mitigation services. Men are more likely to see conservation benefits as financial, while women are more like to see them as social (Westerman 2021). Miller and Buys (2008) reported that men are more supportive of building dams, and women are more likely to save water. Asteria and Herdiansyah (2020) found that women's leadership in conservation is more sustainable.

Modelling studies should be able to acknowledge and identify which households are more likely to conserve and how they are benefiting from conservation measures, which is crucial for the sustainable management of water resources in the watershed.

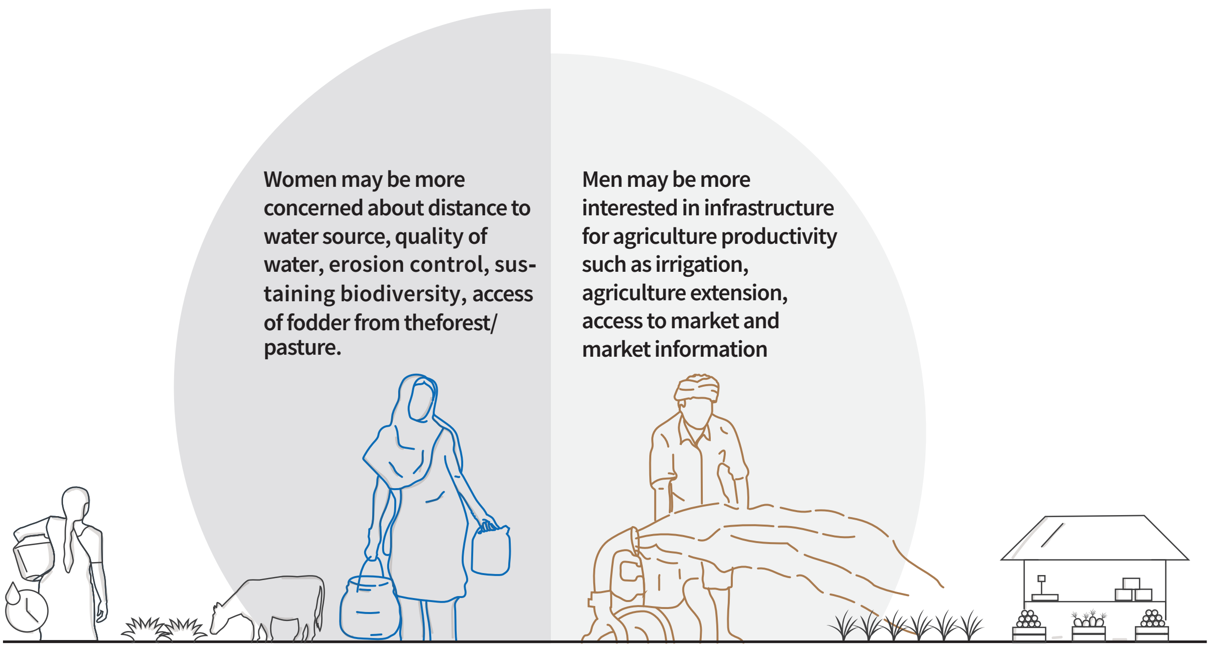


Figure 5 Men and women view and conserve watersheds differently

Example 3 Modelling groundwater use in Bangladesh

Groundwater is a crucial resource for ensuring food security in Bangladesh, a country heavily reliant on agriculture for its economy. Traditionally, water management models in Bangladesh have focused primarily on maximising groundwater extraction for agricultural purposes and used various factors such as safe yield and improved pumping technology, specifically the use of deep tube wells, as planning tools. While these models can be helpful, they often overlook the significant role that hand pumps play in rural women's access to domestic water supply for cooking, cleaning, and other household tasks. Women's access to safe and reliable groundwater is critical for their well-being and the health and nutrition of their families.

Therefore, contemporary groundwater modelling in Bangladesh needs to assess the impact of allocation or use on women, men, and people with difficulties walking, seeing, and with multiple disabilities. The outcomes will allow water management planners to identify and address potential disparities in water access and usage and ensure that water management plans benefit all community members regardless of gender, disability and social groups.

Source: Rahman et al. (2021)

A woman using a hand pump for domestic water in Nepal.
PC: Jitendra Bajracharya (ICIMOD)

Accurate data are essential to setup, calibrate and validate water models. The quality and quantity of data available for water modelling significantly impact the accuracy and reliability of model outputs. Therefore, collecting and analysing reliable and comprehensive data to develop robust water models is crucial. For a modelling project to consider GEDSI explicitly, one needs to gather data on the following (Figure 6):

1. **Disaggregated water users** Gender, social status, caste, ethnicity, religion, economic condition, disability, etc., to understand diverse water needs and the varied impacts on decision-making
2. **Gender roles** Roles of women, men, people with a disability and other groups in water management
3. **Access to water and sanitation** Access to safe and hygienic sanitation, clean drinking water, time spent on collection and storage, use of irrigation water by farm size/crop type
4. **Social network and power structures** Key actors and decision-makers in water management and their relationships
5. **Cultural practices and beliefs** Cultural and spiritual practices related to water use, management, and conservation.

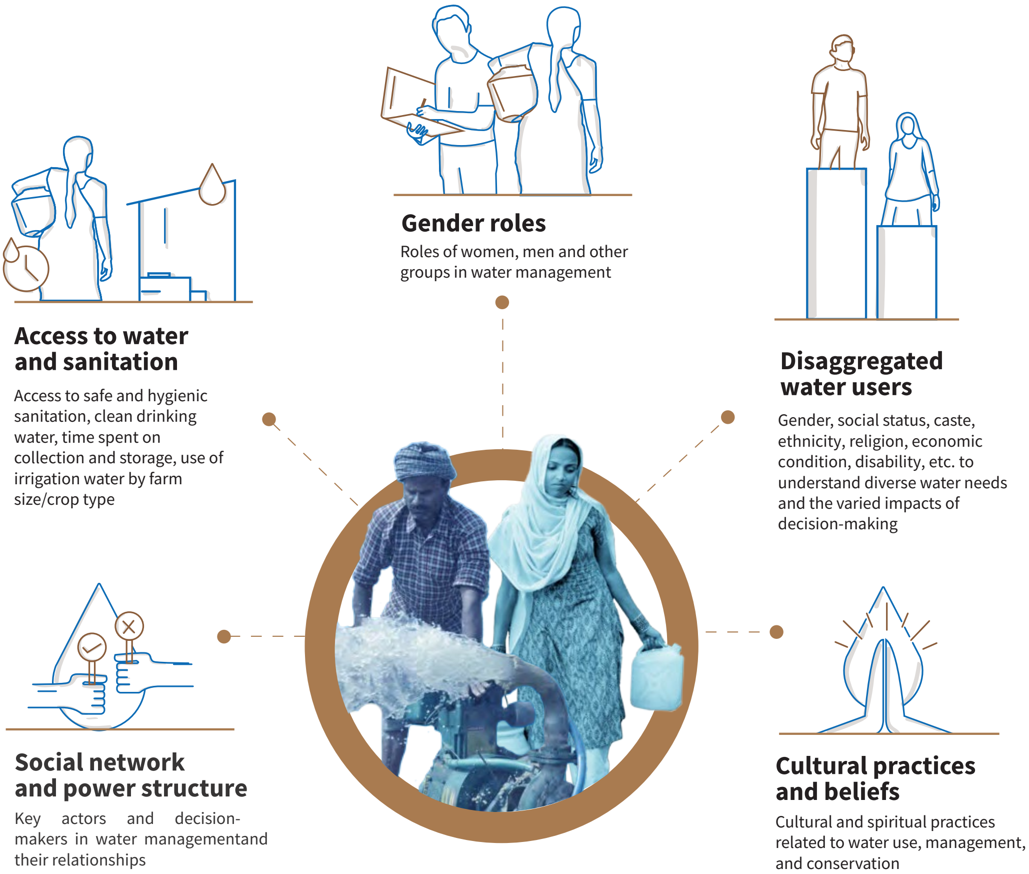


Figure 6 GEDSI data for water modelling

Finding gender, disability and socially disaggregated data for modelling can be problematic. Often, such data do not exist. Additional time and funding must be given to gather data that consider GEDSI. Data can come from various sources, but gaps should be filled without changing statistics inappropriately. Where data are available, the following must be regarded by modellers.

1. Often, gender, disability and socially disaggregated data are incomplete, inconsistent, or outdated, making it difficult to comprehensively understand the social dynamics and gender relations within a given population. Poor data can lead to inaccurate model conceptualisation and setup, which do not reflect the complex realities on the ground. See unesco.org (2020) for an example questionaire for collecting sex-disaggreagated water data.
2. Gender, disability and social processes are complex and can be subject to interpretation. Even GEDSI experts may have different definitions of gender, disability or social categories, leading to data collection and analysis inconsistencies. Modellers must identify and include all social groups and avoid reinforcing existing stereotypes and biases or perpetuating discrimination against gender, disability or social groups.
3. Gender, disability and socially disaggregated data can be sensitive. Water modellers must ensure that they obtain informed consent and ethics approval and protect the privacy and confidentiality related to the use of GEDSI disaggregated data.
4. Typically, gender data are disaggregated by households which can be misleading (Hart 1992). For instance, data collected on household water demand or willingness to pay for water may not accurately reflect the views of all household members, including women and girls, and may overlook their specific needs. Despite sharing similar goals, women and men in farming families may differ in their priorities and opinions on how best to meet them.
5. Quantitative data may need to be integrated with qualitative data to identify GEDSI issues in water management. The mixed method and Subject Matter Experts (SME) approaches are two standard methods. In a mixed-method approach, qualitative information obtained from surveys is quantified by ranking it using metrics (Teferra et al. 2014). For instance, during an open-ended group survey, women can be asked about the changes in their lives resulting from water management. Responses can be classified and

compared to enable meaningful analysis. The Subject Matter Experts (SME) method is a powerful tool for creating models integrating behavioural patterns into computer simulations. The approach requires flexibility and multi-disciplinary expertise and can yield valuable insights that would not be possible through a single-discipline approach. However, it is essential to use verification and a triangulating process, incorporating other SMEs and sources, to ensure the accuracy and completeness of data.

6. Another issue with model data is the level of data aggregation or model depth. For example, attempting to model the demands of each household is neither practical nor desirable. Instead, it is more efficient to aggregate household water demands into groups that can capture GEDSI issues. Modellers must be able to represent an adequate number of processes and interactions within the system to replicate system dynamics accurately. They can create water user profiles to estimate the number of 'winners and losers' for water management decisions. This approach ensures that GEDSI issues are appropriately accounted for in decision-making. Overall, this technique effectively ensures that the model reflects the needs of diverse users and can help identify potential areas of bias or inequality.

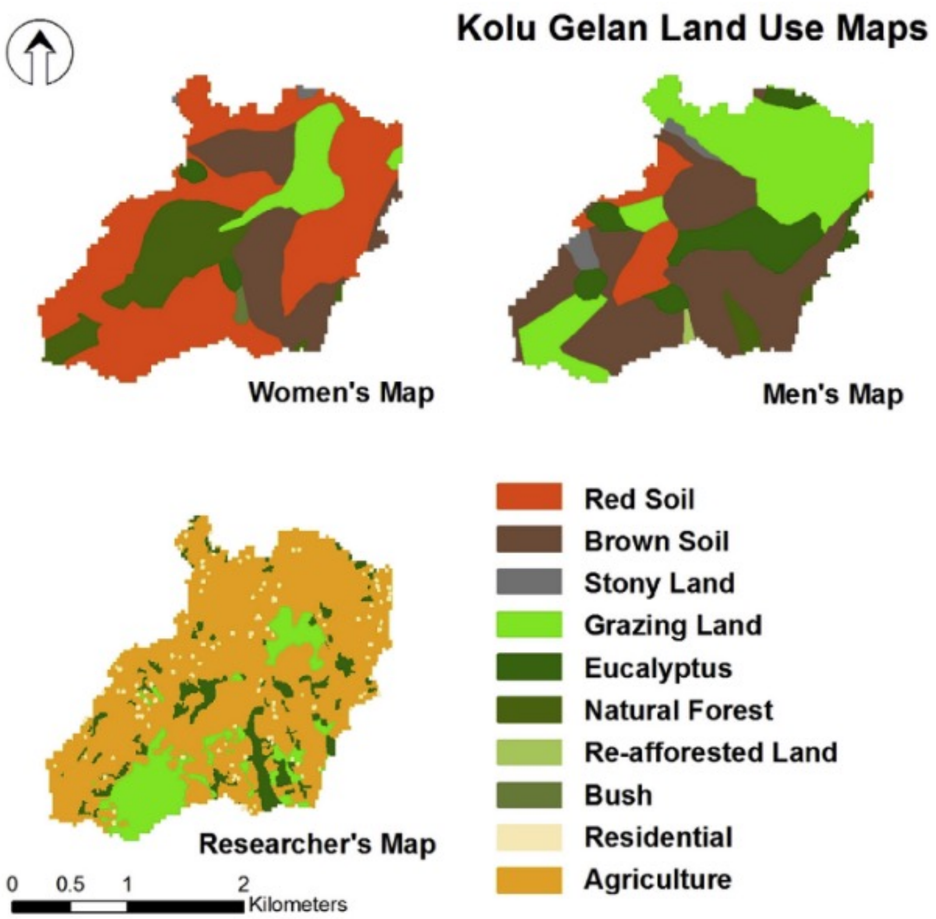
TIP 1 – Model conceptualisation must reflect the voices and needs of all social groups

Communities are increasingly involved in conceptualising a water model to promote a participatory and bottom-up approach. Community participation often relies on membership in various groups tied to official land titles or labour participation. In many circumstances, men hold land titles more than women or specific social groups, resulting in gendered exclusion from decision-making (Ray 2007). When a membership is tied to labour participation, women's contributions may be deemed unofficial or illegitimate (Meinzen-Dick & Zwarteveen 1998). Women with young children may also face barriers to involvement if financial or time contributions are required, as they may not have the resources to meet these expectations (Meinzen-Dick & Zwarteveen 1998). These exclusionary membership rights or household biases can show how men see the world and what they think is essential. During the conceptualisation of a model, those who study water must ensure that all social voices and needs are considered.

A meeting of a water users group in Nepal. ***PC: Jitendra Bajracharya (ICIMOD)***

Example 4 Women and men view the landscape differently, depending on how they use it

Baker et al. (2015) characterised gendered differences and differences between researchers and community members in mapping landscape features in a sub-catchment in Ethiopia. When creating input layers for their Soil and Water Assessment Tool (SWAT) model, researchers classified modelled areas within the catchment based on land use and crop type. In contrast, women classified areas based on soil type, proxies for productivity and land degradation. Conversely, men classified larger land areas as grazing, reflecting their role in stewarding livestock. These differential views meant that land that would have been assigned crop or soil type (by the women) was depicted as grazing on men's maps. This study showed how differing perspectives could influence judgements of relevant data when conceptualising modelling issues. Similarly, the values system of the researcher can influence outcomes, especially given it is often the researcher who selects the input data.



Map reproduced from Baker et al (2015) under Creative Commons CC-BY-NC-ND license. The map shows how differently the local women and men, and the researchers undertaking the study, viewed the system to be modelled when parameterising a soil and water assessment model (the SWAT model).

Example 5 Scaling Up Disability Inclusion in Water Projects: Case Study of PAMSIMAS

PAMSIMAS is a rural Water Supply and Sanitation development platform that has improved water supply and sanitation facilities for millions of low-income rural and peri-urban populations in Indonesia. PAMSIMAS introduced a disability-inclusive approach in various villages. They identified disabled people's organisations and encouraged them to participate in the project process, including providing labour and checking facilities for accessibility. They made villagers aware of disability inclusion (Koyama 2020).

A web-based management information system (MIS) collected and monitored project data. The system contains information on the number of persons with disabilities in a village and the number of participants with disabilities in community meetings and training. This data is collected by community facilitators at the village level and sent to district coordinators. The facilitators work at the village level to collect data and support the community. District coordinators are responsible for managing the data and supporting the community facilitators. Provincial and regional level operators monitor the data and help the district coordinators if necessary. The data collection and management efforts are most valuable to include the unique needs of persons with disabilities in water modelling and ensure that persons with disabilities are included in the development process.

CBM Australia, Plan International Australia and the Nossal Institute of the University of Melbourne have developed a Practice Note on how disability information can be used at all stages of the project and program cycle and methods and tools that can be used to gather data (CBM Australia 2021).

Model calibration and validation

Calibration and validation are essential steps in developing water models and involve adjusting the model's parameters so that outputs match the observed behaviour of the modelled real-world system. Calibration aims to achieve the closest possible match between model predictions and the actual observations to increase the model's accuracy and reliability. Model validation uses the same model setup (including parameters) to test the model performance, usually with a different range of years than the model run. The process confirms that the model can mimic the real world when using data that have not been used during the calibration of the model.

Water modellers should consider the following GEDSI-related issues during the model calibration and validation.

1. **Calibration objectives should consider GEDSI**. For example, assume you are tasked to model a flood embankment project. While calibrating the model, your target is to match the high-flow events – i.e. floods. In this circumstance, a modeller often does not try calibrating low-flow conditions. Modelling high and low flows (multiple sections of the hydrograph) in the same model setup may be time-consuming and challenging. Now imagine that the basin contains essential wetlands serving women's livelihoods. The wetland needs water in low-flow periods. Since you have not calibrated the model for low flows, your modelled recommendation may negatively impact the wetland, inadvertently affecting women's livelihoods.
2. **Calibration must reflect all gender, disability and social groups' priorities**. Women and men may differ in their perspectives of water availability and use. For example, in a study of the Chhattis Mauja irrigation system in Nepal, women and men worked together as co-farmers but had differing priorities regarding water flow conditions (Zwarteveen & Neupane 2014). While both genders require a consistent water supply for their crops, men prioritise irrigation water supply at the beginning of the season. At the same time, women were more concerned with maintaining water throughout the season. This divergence was due to the gender-assigned roles within the region, with men responsible for land preparation and women responsible for weeding. Notably, the pond depth in the field affected women's time to weed, as water could impede weed growth. The situation demonstrates that different water flow characteristics may have distinct values other than the dominant groups, even in the same context. If the knowledge was only sourced from a single group, this distinction would be lost, and the model calibration would reflect only one group's priorities.
3. **The social and environmental situation in the model setup used during calibration may change in the validation period**. This type of change can be problematic, and the modeller should report such a situation in the validation report.

Scenario development

Potential solutions to problems, and the status of socioeconomic or environmental changes, are explored through developing scenarios in water models. Scenarios are useful to explore and inform decision-making and reflect the actors' knowledge systems. They can be different between men and women, rich and poor, large landholders and smallholders etc. and are typically informed by social norms, power structures, culture, ethnicity, socioeconomic status, and more.

The following steps should be undertaken to consider GEDSI in scenario development.

1. **Identify the stakeholders**. Start by identifying the stakeholders who the scenario may impact. This effort can include people of different genders, ages, races, cultures, castes, disabilities, and socioeconomic backgrounds. Consider how the scenario might affect these groups differently.
2. **Analyse gender roles and stereotypes**. Consider how gender roles and stereotypes might impact the scenario. The process can include examining how different genders are portrayed in the scenario and whether these portrayals are accurate and fair.
3. **Consider the impact on gender equality, disability and social inclusion**. Consider how the scenario might impact GEDSI. Actions can include analysing whether the scenario perpetuates or challenges gender-based discrimination and inequality and answering questions on 'who pays', 'who works', 'whose decisions', 'who are affected', 'whose resources', 'who enjoys', and 'why is one person much more water-secure than another?'. For instance, in a river system model, you can introduce specific water supply requirements (model constraints) to recognise cultural water needs for women, indigenous peoples or disadvantaged communities.
4. **Incorporate diverse perspectives**. Consult with people from different genders, disability and social backgrounds to ensure the scenario is inclusive and representative. The process will allow the reflection of diverse perspectives in the developed scenarios.
5. **Incorporate access to and control over water as a constraint**. A GEDSI-targeted scenario could observe gender differences in rights and access to water and build them into the model as constraints. For example, in many communities, women collect water, which can be time-consuming and physically demanding. Fetching water can limit their ability to engage in other activities, such as education or income-generating activities (UN Women 2015).

   In a Pacific community, young single mothers lived together in one part of the village so they could help each other raise their children. They were at the tail-end of the village irrigation system and got water every two days. They frequently ran out of water for their children and were worried about what that would do to their health. When the young mums' plight was brought to the attention of the male village chief, the decision was made to prioritise their access to water whenever the channels were opened.

   By recognising this GEDSI-specific constraint, a scenario could be developed that simulates the removal of this constraint and observes the effect on water management activities, such as agriculture. This approach is consistent with Srinivasan et al.'s (2016) notion of modelling a values scenario where specific behaviours could be mapped, and the system's probable trajectory could be simulated.
6. **Use GEDSI-sensitive language**. Use GEDSI-sensitive language throughout the scenario development process. This action means avoiding language that reinforces gender stereotypes and ensuring that language is inclusive and respectful to all genders. For example, we often say, "Water scarcity mainly affects poor communities." A GEDSI-sensitive language to communicate the same would be "Water scarcity disproportionately impacts socially disadvantaged communities, including those living in low-income areas." In this example, GEDSI-sensitive language recognises that the impact of water scarcity is not evenly distributed and often disproportionately affects disadvantaged communities such as those living in low-income areas. Thus, we can avoid stigmatising language like "poor communities" and instead use a more inclusive and neutral term, e.g. disadvantaged communities, to promote social inclusion.

A reservoir in Nepal. ***PC: Arun Shrestha (ICIMOD)***

In short, GEDSI-targeted scenario development can contribute to planning that works backwards in a theory of change to elucidate 'which sets of actions by which actor' allow the system to reach a specific point. For example, suppose a scenario simulates the removal of constraints on women's access to water. In that case, planning could work backwards to identify which actions by which actors (e.g., policymakers, community leaders, households) would need to occur to achieve this outcome. GEDSI-targeted scenario development can inform more effective policy and planning interventions by understanding the required actions.

It is important to note that male engineers and modellers traditionally dominate water departments in many developing countries. The project needs to consider how masculinity (e.g. implicit biases towards and against specific options) might affect the development of scenarios and the financing of outputs as solutions.

Example 6 Hydraulic missions and socially inclusive development

Most of the basin development processes are 'hydraulic missions' involving the construction of physical infrastructure such as dams and water transfer schemes. They emphasise construct, command, and control. They can have positive and negative effects on gender equality, disability and social inclusion, depending on how they are implemented and the broader social and political context in which they occur. Molle et al. (2009) note that large-scale water resources development projects have often become an end in themselves, fuelling rent-seeking and symbolising state power rather than a means to an end. Aleixo et al. (2019) found that constructing a water supply system in a rural community in Brazil's semi-arid region was insufficient to eliminate inequalities in access to water as certain families continued to use contaminated water. Sekhri (2014) found that access to groundwater can increase poverty and conflict in rural India, as disputes over irrigation water rise around the groundwater table cut-off depth. Scenarios must be developed to include socially disadvantaged groups' concerns and knowledge systems and account for the potential disproportionate influence of more powerful actors.

Solution identification

Once the scenarios of different potential futures or management options are simulated within a model, water modellers must identify preferred solution pathways. This step is critical as it requires water modellers to consider the objectives, preferences, and constraints of various actors or stakeholders, weigh competing objectives and compare different options (Black et al. 2011).

Water modellers use multi-criteria analysis or decision-making processes to identify desired solutions or the 'best' option from the modelled scenario outputs. The following general steps should be considered to ensure GEDSI during solution identification.

1. **Developing criteria and indicators**. Criteria and indicators should be developed that consider GEDSI in the decision objectives. The criteria should be measurable and can be qualitative or quantitative. Indicators are the specific measures used to assess and monitor the extent to which gender equality and social inclusion are achieved in various contexts. They can be economical (e.g. participation in irrigation development, such as labour force), education (e.g. literacy rates, gender parity index), health (e.g. access to healthcare as a result of a water project), social (e.g. social insurance), political (e.g. representation in elected bodies, participation in public life, and access to decision-making positions), discrimination (e.g. discrimination based on race, ethnicity, religion, disability, sexual orientation, and other forms of discrimination). For example, if evaluating an irrigation project, a different criterion could be added to determine how the project will impact different genders. This criterion could consider factors such as access to and control over water, safety, and convenience.
2. **Developing and scoping options**. Develop a range of feasible alternatives to meet the objectives and address the decision problem. Score each alternative against each criterion using the indicators. The scoring can be done using different techniques, such as assigning weights to each criterion or using a pairwise comparison. Modellers must remember that scoring alternatives are a 'value-ridden process' (Paneque Salgado et al. 2009). The scores should consider GEDSI according to their relative importance (Hajkowicz & Collins 2006). For example, using an index to measure how an option would affect women on the ground. An index of 0–1 could identify the difference in outcomes between genders. Closer to 0 would indicate that the option has equal outcomes for both men and women, not entrenching disadvantage for either gender. Comparatively, 1 would represent that all the benefits or costs of an option were being gained or lost by one gender.
3. **Adjusting the weighting of criteria, if needed, to reflect GEDSI considerations**. The adjustment can be done by assigning higher weights to criteria more critical for certain genders or socially disadvantaged groups. For example, if assessing the impact of a new irrigation development model, women's access and rights could be given a higher weight to reflect its importance for women.
4. **Evaluating trade-offs and making a decision**. GEDSI is an important consideration when evaluating trade-offs or developing compromise outcomes, as it can affect how individuals experience and prioritise different criteria. For example, a trade-off prioritising economic development over environmental protection may disproportionately affect women, who may rely more on natural resources for their livelihoods and subsistence activities. Water modellers should consider the differential impact of trade-offs on different genders or social groups while making a decision.

Example 7 Women's underrepresentation in South Asian water agencies can perpetuate gender biases in modelling

In South Asia, government water agencies have traditionally been male-dominated, with women accounting for only a small percentage of engineering staff (Best and Taganova 2021; Kulkarni et al. 2011). Women engineers in such contexts often find themselves in a challenging position, trying to navigate and reconcile the deeply ingrained male bias in institutional values while maintaining traditional female traits to avoid negative assumptions (Liebrand & Udas 2017).

The lack of women's representation in water agencies is not only a gender equity issue but also a missed opportunity for improving water governance outcomes. Recognising and addressing the gendered implications of institutional values in water modelling is crucial. We must acknowledge and challenge the underlying assumptions and biases that shape decision-making processes in water agencies. Adopting a GEDSI-sensitive approach to water modelling can help identify and address the specific water-related needs and priorities of women, people with a disability and other socially disadvantaged groups.

Example 8 Institutionalising gender equality and social inclusion (GESI) in Nepal's water sector

In Nepal, the legislative frameworks have adopted GESI at the heart of development planning. Several efforts are taken to institutionalise GESI mainstreaming across the development sector: developing GESI operational guidelines, providing budgets for GESI, GESI reporting, and appointing gender focal persons etc., within the ministry and its line departments (Shrestha & Clement 2019). Nepal's new constitution (2015) has a strong commitment to gender equality and social inclusion (GESI) and guided GESI in the water sector's project cycle, and provided a budget for GESI auditing of programs.

There are Gender Focal Persons (GFPs) appointed in these ministries/departments responsible for implementing gender plans and activities supported by the Ministry of Women, Children and Senior Citizens. However, most GFPs lack a formal gender background and are challenged with limited budgetary provision, lack of authority in decision-making, frequent transfers and inadequate training on emerging gender nuances (Goodrich et al. 2021). Across the water institutions, there are more male engineers/staffs and the few females appointed are in junior administrative posts. Unlike other sectors, the Ministry of Water Resources and Irrigation does not have a GESI policy, strategy or guidelines. When international donor-supported projects are implemented in the water sector, gender is integral to project planning, activities, monitoring and evaluation. Unfortunately, gender mainstreaming practices continue only during the project period. The water sector needs more institutional commitments towards GESI mainstreaming. Therefore, women's participation in the water user associations (WUAs) must enable meaningful inclusion of women's interests in decision-making processes (Shrestha & Clement 2019).

Sources: Shrestha & Clement (2019), Goodrich et al. (2021)

Practice exercise: GEDSI-responsible modelling

The government has initiated a new project to build several reservoirs to address flooding and drought. You are tasked to develop a water model to help decision-making on flood management, dam operation, mainstream climate change adaptation in water planning, etc. While collecting background information, you learned that most of the basin's houses do not have piped water, and women rely on river water for washing clothes.

Please discuss and answer the following questions in groups.

1. How will you ensure women's gender-specific needs and the basic water access requirements of people with a disability are considered in the model setup, including accessibility, safety, and cultural norms for washing clothes in the river and accessing drinking water?
2. When collecting data for modelling, how will you ensure that you have data on gender-disaggregated water use patterns, challenges faced by disadvantaged groups, and access to water and sanitation facilities for disabled people in the community?
3. What type of scenarios would you like to test the model, and how to ensure a consistent water supply to the river from upstream and maintain sufficient flow in the river throughout the year?

Answers to the questions are suggested in the **Answers to practice exercise questions** section. If you use the practice exercises for training, suggestions for group work are available in the **Notes for Training** section at the back of this toolkit.

TIP 2 – Communicating and presenting model results

The water modelling process is often influenced by subjectivity and values systems. They can induce uncertainty in modelled outcomes. Water modellers should explicitly communicate the assumptions and uncertainties to support decision-making (Mockler 2016). Moreover, it is essential to acknowledge that the presentation of modelled options can substantially influence decision-making. Black et al. (2011) highlighted that the presentation of modelled outcomes could affect the decision-making process, and how the results are presented can significantly impact the decision-maker's preferences.

For example, suppose the modelled outcomes show that the costs and benefits of different options are not equitably shared across genders, people with a disability and socially disadvantaged groups. In that case, modellers must find additional information from other sources to identify the preferred option. They can engage with affected communities, consult relevant stakeholders, and incorporate feedback from diverse groups. The efforts will ensure equitable and inclusive decision-making based on the model results.

Additional resources

Glossary of terms and concepts

Gender relations	Gender relations are the social relationship between women and men concerned with power. It intersects with social factors such as age, caste, class, ethnicity, race, education, and other factors to determine the position and identity of people in a social group. It creates and reproduces systemic differences between women's and men's roles in society. Gender relations are socially created and can be changed (Goodrich et al. 2019).
Gender bias	It is a form or tendency of preferring one gender over another, which most often results in favouring men or boys over women and girls (Rothchild 2014).
Gender gap	It is the systemic difference between women and men, boys and girls, in achieving development goals, access to resources or the level of participation. The gender gap indicates gender inequalities (Goldin 2008, Goodrich et al. 2019).
Gender norm	It is a subset of social norms that govern the behaviour, attitude, and characteristics of males and females in a society at a particular time. These gender norms are ideas on how women and men should be and act to what is appropriate. Gender norms are neither static nor universal and change over time.
Gender disparities	They are statistical differences between women and men regarding their access to resources, status and well-being, which usually favour men and are often institutionalised through policies, laws and social norms (Goodrich et al. 2019).
Gender parity	It is a numerical concept concerning relative equality regarding numbers and proportion of women and men, girls, and boys. Gender parity is calculated as ratio of female-to-male for a given indicator (Goodrich et al. 2019).
Gender planning	It is an approach that recognises the differential needs, priorities and roles of women and men in the planning and designing of the implementation phase of policies, programs, and projects.
Gender-based violence	It is violence directed towards a person because of their gender. It includes sexual, physical, mental, and economic harm inflicted in public or private. This phenomenon is deeply rooted in gender inequality; most victims are women and girls.
Patriarchy	Patriarchy refers to a social system in which men primarily hold dominance and privileges. Men control the allocation of resources and decision-making. The masculine characteristics have higher values compared to feminine characters. It operates through inequalities in law, state policies and programs, and home and workplace. Powerful cultural norms supported by tradition, education and religion uphold a patriarchal mindset that fails to recognise women's subordination and needs.
Masculinity	It is a set of behaviour, attitude, and roles associated with boys and men, often socially constructed, and vary in a different context and even between other men. Cultural and biological factors influence these representations. Masculinity is centred around authority, physical toughness and strength, heterosexuality and paid work (Connell & Messerschmidt 2005). The ideology legitimises women's subordination and promotes dominance and authority even among men to maintain the hierarchy, knowledge and power (Zwarteveen 2008).
Empowerment	Empowerment is both a process and an outcome for women and men in taking control over their lives, setting their agendas, gaining skills, building self-confidence, solving problems and developing self-reliance. It is about expanding people's ability to make strategic life choices in a context where this ability was previously denied to them (Kabeer 1999). Through this process, gender norms shape unequal relations and practices, replacing equitable relationships between women and men for gender transformative changes.
Gender transformative change	Gender transformative change is fundamental as it challenges the unequal gender relations of power and discriminatory norms and practices, which typically favour men. It addresses gender strategic interests. It is committed to rigorous gender analysis, organisational change, capacity and institutional strengthening, and ensuring gender-positive impact through meaningful participation of women and men in leadership, policy and decision-making processes and institutions.
Social inclusion	It refers to removing institutional barriers and enhancing incentives to increase access by diverse individuals and groups to development opportunities. It is about recognising the ability, opportunity, and dignity of those disadvantaged based on their identity. This requires changes in policies, rules, and social practices and shifts in people's perspectives and behaviour toward excluded groups (ADB 2010).
Disadvantaged/ excluded groups	Disadvantaged/excluded groups (in Nepal) refer to women, Dalit, indigenous nationalities (Janajatis), Madhesi, Muslim, persons with disabilities, elderly people and people living in remote areas who have been systematically excluded over a long time due to economic, caste, ethnicity, gender, disability, and geographic reasons and include sexual and gender minorities (ADB 2010).

Gender Analysis Frameworks – additional reading

Table 2 Gender tools and frameworks used for gathering gender-related information

Category	Variables and Indicators	Tools that can be applied
Gender-disaggregated data – households, workplace on labour, decision-making with use of resource	Productive work Reproductive work Community roles	Harvard Analytical Framework, Moser Framework, Social Relations Framework
Entitlements – access to and degree of control over resources	Land entitlements (ownership, stewardship, use rights) Credit and financial resources Support networks	Almost all the tools mentioned in Module 2
Gender-differentiated impacts of changing environment	Impacts on health, education, assets and livelihood Declining sources of water and its impact on women's time for collecting water	Gender Analysis Matrix, Capacities and Vulnerabilities Assessment Framework, Equality and Empowerment Framework
Resources utilised for livelihood	Private resources Non-private and communal resources	Levy Framework, Social Relations Framework

The gender-related indicators and the tools listed in Table 2 are not exhaustive, but examples for each category and indicator in which tentative tools can be applied.

Still, gender-related information, especially about access to and control over resources, the effects of changing environments on people's lives and ways of making a living, gender roles and responsibilities, gender-based land use patterns, travel time, and workload, among other things, can be used for wider spatial and scalar visualisation to put people on the map and make gender-responsive policy agendas possible.

Similarly, Escobar et al. (2017) suggest that to gender mainstream models that would challenge the norm, gender-disaggregated data can be used to highlight potential 'winners and losers' for different management options. This could be achieved by developing gender-specific user profiles based on the types of livelihoods, estimating water use in every kind of livelihood (agricultural, forest-based, industrial) and in households, and quantifying the numbers of users fitting each profile. This profiling can be carried out using different or a combination of gender tools and frameworks. Such profiles can show the gender-differentiated impact of various supply and demand strategies. Although obtaining this data can create additional work, it can raise awareness of previously unnoticed issues.

Answers to practice exercise questions

Practice exercise: Looking at basin-scale modelling differently

Who uses water and for what purposes? Which socially disadvantaged groups are likely to be excluded? What are the specific needs of people with a disability?

The focus here is to understand that all women and men are not the same; they have different water needs based on their gender, class, ethnicity, disability, and other social structures. It is essential to understand that the uses, needs, and access of water needs can be gendered and socially disaggregated. Therefore, the gender and intersectionality lens have to be applied to address the differential water needs and priorities.

Reflect on how within households (across different types of households) the water needs of women and men are different, where women biologically need more water as compared to men, in addition given the domestic roles to be fulfilled by women, these roles demand more water as compared to men who are not engaged in household responsibilities. Similarly, water needs for different groups of women and men differ in the agriculture sector. Reflect on Female-Headed Households and households with male outmigration. Women take account of meeting water needs and are also not recognised as farmers in the local decision-making institutions.

Similarly, think about the water needs, such as domestic use, livestock, forestry, and economic use by different women and men.

What are the water management and distribution practices, who is involved in formal and informal institutions and for what reasons?

This question focuses on understanding women's and men's participation in water institutions. Little attention is paid to knowledge of whether women and men from different social groups meaningfully participate in the decision-making user groups. Therefore, we collect information on the number of women and men from different social groups engaged in the user groups and holding decision-making positions. However, we ignore whether women and the disadvantaged raise their voice, their concerns and if they are met, and how decisions are made. We need to qualitatively reflect if their needs and priorities are considered in the decision-making, who makes the decision and for whom.

Please note who is the most influential in decision-making and for what reasons they participate.

How do you incorporate the GEDSI information in the water modelling?

This focus of this question is to ensure that we have identified information on who uses water and for what purposes, who has access and who controls decision-making. This exercise supports the gathering of gender, disability and socially disadvantaged disaggregated information because, if we miss understanding the 'who', then we miss opportunities to effectively integrate women, people with disability and the socially disadvantaged within decision-making tools.

Final note

GEDSI integration is about bringing or moving towards a more equitable society i.e., breaking the existing status quo. Therefore, just integrating gender into modelling and decision-making often may not be enough. It is also necessary to think and plan to integrate GEDSI in a way that challenges the on-going discriminatory gendered and social norms and practices that would lead towards true equality – gender and social.

Practice exercise: GEDSI-responsible modelling

How will you ensure women's gender-specific needs and the basic water access requirements of people with a disability are considered in the model setup, including accessibility, safety, and cultural norms for washing clothes in the river and accessing drinking water?

For your basin and reservoir modelling job, you may or may not include the small river (stream order 1 or 2 in the hydrological model) depending on their flow contribution. This omission is because your assigned focus was not a lack of water in the river. Therefore, you must do the following.

1. Ensure you include the river used for washing in the model setup.
2. Pay special attention to calibrating dry season flow so the women have water to wash clothes throughout the year.

When collecting data for modelling, how will you ensure that you have data on gender-disaggregated water use patterns, challenges faced by disadvantaged groups, and access to water and sanitation facilities for disabled people in the community?

Your focus is on more significant basin-level water dynamics, e.g. how much water is available in the basin and how much water can be stored in the reservoir. A basin hydrology model (e.g. U.S. Army Corps of Engineers Hydrologic Engineering Centre - Hydrologic Modelling System, HEC-HMS[1]) and a reservoir system model (e.g. U.S. Army Corps of Engineers Hydrologic Engineering Centre - Reservoir System Simulation, HEC-ResSim[2]) will allow you to answer the questions. Therefore, you will collect data to set up and calibrate HEC-HMS and HEC-ResSIM models. If you limit yourselves to collecting only these forms of data, you will not know about the needs of women or the disadvantaged groups in society.

Therefore, data need to be collected on the special water needs of the basin (e.g. gender-disaggregated water use patterns, water access by disadvantaged groups), the social and economic background of the water users (e.g. to determine if there is an alternative to washing clothes in the river), households' access to piped water etc. If you have other special water uses (e.g. water needed for wetlands), you may need to do additional water models for water allocation (e.g. Water Evaluation And Planning, WEAP model[3]). Note that the WEAP model has a gender plug-in[4].

What type of scenarios would you like to test the model, and how to ensure a consistent water supply to the river from upstream and maintain sufficient flow in the river throughout the year?

You can take several modelling approaches to ensure adequate water in the river.

1. You can model the construction of water storage infrastructure, such as dams, reservoirs, and weirs, to regulate and manage water flow from upstream to ensure a consistent water supply to the river downstream. You can set up your reservoir model (e.g. HEC-ResSim) such that the dam is operated to ensure water in the river throughout the year.
2. You can model watershed conservation processes such as afforestation, soil conservation, and sustainable agricultural practices in the upstream areas to reduce erosion and sedimentation and improve water retention.

You can model different water allocation policies, such as prioritising environmental flows, setting minimum water requirements for downstream river health, and considering the needs of other user groups, including women, people with a disability, the elderly and children, and other socially disadvantaged groups. Using a water allocation model like WEAP might introduce a constraint to meet particular water needs like washing clothes in the river.

1 https://www.hec.usace.army.mil/software/hec-hms/
2 https://www.hec.usace.army.mil/software/hec-ressim/
3 https://www.weap21.org
4 https://www.weap21.org/downloads/WEAP_Tutorial_Gender_Equality.pdf

Notes for training

Suggestion for training delivery

We recommend delivering the training over two days to allow participants time to absorb and process the novel concepts and processes. Our recommended approach to the session format is:

Day	Session	Topic
1	**Morning 1**	Opening, Introduction, Overview
	Morning 2	Water models, Challenges to considering GEDSI in water modelling
	Afternoon 1	Gender terms and concepts
	Afternoon 2	Group work 1: Looking at basin-scale modelling differently, reflection and feedback
2	**Morning 1**	Defining the modelling problem, objectives, and scope Conceptualising, setting up the model and collecting data
	Morning 2	Calibrating and validating the model
	Afternoon 1	Developing scenarios Identifying solutions
	Afternoon 2	Group work 2: Setting up a GEDSI-aware model, reflection and feedback

Suggestion for group work

The two Practice Exercises can be used for training group work. You may divide the trainees into 3-4 member groups. Number the groups from 1 through the number of the last group. Each group needs to identify a scribe. Group members will present their ideas in response to the question on their sheet of paper, e.g., Question 1 to Group 1, Question 2 to Group 2 etc. Multiple groups could work through the same questions if there are more groups than questions. The scribe will write the group's ideas on a sheet (or sheets).

After 5 minutes, the participants will give their sheet to another group that has not answered the question. Ensure that all groups have a chance to write answers on sheets.

Return each sheet of paper to the original group that started with it. Ask each group to number their top 3 priorities and explain their reasoning.

References

ADB (Asian Development Bank) (2010) Overview of Gender Equality and Social Inclusion in Nepal. www.adb.org

Aleixo B, JL Pena, L Heller, S Rezende (2019) Infrastructure is a necessary but insufficient condition to eliminate inequalities in access to water: Research of a rural community intervention in Northeast Brazil. Science of the Total Environment, 652, 1445–1455. https://doi.org/10.1016/J.SCITOTENV.2018.10.202

Alston M (2009a) Drought policy in Australia: gender mainstreaming or gender blindness? Gender, Place & Culture 16(2), 139–154

Alston M (2009b) Gender, Place & Culture A Journal of Feminist Geography Drought policy in Australia: gender mainstreaming or gender blindness? https://doi.org/10.1080/09663690902795738

Asteria D, H Herdiansyah (2020) Analysis sustainability of women's leadership for watershed conservation in the urban area. International Journal of Social Ecology and Sustainable Development, 11(2), 38–50. https://doi.org/10.4018/IJSESD.2020040103

Baker T, B Cullen, L Debevec, Y Abebe (2015) A socio-hydrological approach for incorporating gender into biophysical models and implications for water resources research. Applied Geography 62, 325–33

Best J, J Taganova (2021) The Role of Gender in Water Conflicts. In Resolving Water Conflicts Workbook (pp. 123-148). CRC Press

Birks L, C Powell, J Hatfield (2017) Adapting the capacities and vulnerabilities approach: a gender analysis tool. Health Promotion International, 32(6), 930–941

Black D, P Wallbrink, P Jordan, D Waters, C Carroll, J Blackmore (2011) Guidelines for water management modelling, Towards best-practice model application. eWater Cooperative Research Centre. CSIRO, Australia. http://hdl.handle.net/102.100.100/103180?index=1

CBM Australia (2021) Collecting and using data on disability to inform inclusive development. CBM Australia. [online] Available at: https://www.cbm.org.au/resource/collecting-and-using-data-on-disability-to-inform-inclusive-development [accessed 13 Apr 2023]

Connell RW, JW Messerschmidt (2005) Hegemonic Masculinity: Rethinking the Concept. Gender and Society, 19(6), 829–859. http://www.jstor.org/stable/27640853

Druschke CG, S Secchi (2014) The impact of gender on agricultural conservation knowledge and attitudes in an Iowa watershed. Journal of Soil and Water Conservation, 69(2). https://doi.org/10.2489/jswc.69.2.95

Escobar M, L Forni, E Ghosh, M Davis (2017) Guidance Materials for Mainstreaming Gender Perspectives into Model-based Policy Analysis. Stockholm Environment Institute – U.S. Center. https://www.sei.org/mediamanager/documents/Publications/SEI-2017-Gender-guidance-for-modelling-studies.pdf [accessed 20 Mar 2023]

Goldin C (2008) Gender gap. The Concise Encyclopedia of Economics. Availbable at: https://www.econlib.org/library/Enc/GenderGap.html, 27–46

Goodrich CG, DD Gurung, A Bastola (2021) State of gender equality and climate change in Nepal. International Centre for Integrated Mountain Development (ICIMOD)

Goodrich CG, PB Udas, H Larrington-Spencer (2019) Conceptualising gendered vulnerability to climate change in the Hindu Kush Himalaya: Contextual conditions and drivers of change. https://doi.org/10.1016/j.envdev.2018.11.003

Green MA (2017) Can intersectionality theory enrich population health research. Social Science & Medicine, 178, 214–216. https://doi.org/10.1016/J.SOCSCIMED.2017.02.029

Hamdy A, R Quagliariello, G Trisorio-Liuzzi (2004) Mainstreaming gender in integrated water resources management: major issues and challenges. Integration of gender dimension in water management in the Mediterranean region: INGEDI Project, 33–40

Hajkowicz S, K Collins (2007) A review of multiple criteria analysis for water resource planning and management. Water Resources Management, 21(9), 1553–1566. https://doi.org/10.1007/S11269-006-9112-5/METRICS

Hart K (1992) Household heads and gendered identities, In The Gendered New World Order (pp. 98-119) Routledge

Hunt J (2013) Tool Kit on Gender Equality Results and Indicators. Philippines: Asian Development Bank

Jonsson A, L Andersson, J Alkan-Olsson, B Arheimer (2007) How participatory can participatory modeling be? Degrees of influence of stakeholder and expert perspectives in six dimensions of participatory modeling. Water Science & Technology 56(1), p 207

Kabeer N (1999) Resources, Agency, Achievements: Reflections on the Measurement of Women's Empowerment. Development and Change, 30(3), 435–464. https://doi.org/10.1111/1467-7660.00125

Kelly (Letcher) RA, AJ Jakeman, O Barreteau, ME Borsuk, S ElSawah, SH Hamilton, HJ Henriksen, S Kuikka, HR Maier, AE Rizzoli, H van Delden, AA Voinov (2013) Selecting among five common modelling approaches for integrated environmental assessment and management. Environ. Model. Software 47, 159–181. https://doi.org/10.1016/j.envsoft.2013.05.005

Koyama A (2020) Scaling Up Disability Inclusion in Water Projects: Case Study of PAMSIMAS. [online] World Bank, Washington, DC. doi:https://doi.org/10.1596/34429

Kulkarni S, S Bhat, S Majumdar, CG Goodrich (2011) Situational analysis of women water professionals in South Asia. SaciWATERs

Lau JD, D Kleiber, S Lawless, PJ Cohen (2021) Gender equality in climate policy and practice hindered by assumptions. Nature climate change, 11(3), 186–192

Levy C (1996) The Process of Institutionalising Gender in Policy and Planning: the web of institutionalisation. DPU Working Paper No 74, Development Planning Unit, University College, London

Liebrand J, PB Udas (2017) Becoming an Engineer or a Lady Engineer: Exploring Professional Performance and Masculinity in Nepal's Department of Irrigation. Engineering Studies, 9(2), 120–139. https://doi.org/10.1080/19378629.2017.1345915

Longwe S (1995) Gender Awareness: The Missing Element in the Third World Development Program in Candida M, T Wallace, Changing perception: new writings on gender and development. Oxford: Oxfam

March C, I Smyth, M Mukhopadhyay (1999) A Guide to Gender-Analysis Frameworks. https://oxfamilibrary.openrepository.com/handle/10546/115397

Meinzen-Dick R, M Zwarteveen (1998) Gendered participation in water management: Issues and illustrations from water users' associations in South Asia, Agriculture and Human Values, 15(4), 337–345

Miller E, L Buys (2008) Water-recycling in South-East Queensland, Australia: What do men and women think? Rural Society Journal, 18(3)

Mockler EM (2016) Assessing the relative importance of parameter and forcing uncertainty and their interactions in conceptual hydrological model simulations. Advances in Water Resources, 97, 299–313. https://doi.org/10.1016/J.ADVWATRES.2016.10.008

Molle F, P Mollinga, P Wester (2009) Hydraulic Bureaucracies and the Hydraulic Mission: Flows of Water, Flows of Power. Water Alternatives

Moser C (1993) Gender roles, the family and the household. In Gender planning and development: Theory, practice and training. Routledge. https://www.routledge.com/Gender-Planning-and-Development-Theory-Practice-and-Training/Moser/p/book/9780415056212

Nepal S, J Chen, DJ Penton, LE Neumann, H Zheng, S Wahid (2016) Spatial GR4J conceptualization of the Tamor glaciated alpine catchment in Eastern Nepal: evaluation of GR4JSG against streamflow and MODIS snow extent.Hydrological Processes 31, 51–68. https://doi.org/10.1002/hyp.10962

Packett E, J Wu, N Grigg (2018) Mainstreaming and modelling: how gender analysis can be applied to a water management modelling framework. CSIRO Land and Water. https://doi.org/10.25919/5bB0fb725fac

Packett E, NJ Grigg, J Wu, SM Cuddy, PJ Wallbrink, AJ Jakeman (2020) Mainstreaming gender into water management modelling processes. Environmental Modelling and Software 127 (2020) 104683. https://doi.org/10.1016/j.envsoft.2020.104683

Panda SM (2007) Mainstreaming gender in water management: a critical view. Gender, technology and development, 11(3), 321–338

Paneque Salgado P, S Corral Quintana, Â Guimarães Pereira, L del Moral Ituarte, B Pedregal Mateos (2009) Participative multi-criteria analysis for the evaluation of water governance alternatives. A case in the Costa del Sol (Málaga) Ecological Economics 68(4), 990–1005

Rahman MW, J Hasneen, MS Palash, S Jalilov, M Mainuddin, S Wahid (2021) Sustaining groundwater irrigation for food security in the northwest region of Bangladesh: socioeconomics, livelihood and gender aspect. CSIRO, Canberra. https://doi.org/10.25919/68h1-pg41

Ray R (2007) Culture, participation and sustainability in rural water systems: A case study from Maharashtra, Economic and Political Weekly, 42(13), 1188–1195

Regmi SC (2020) Gender mainstreaming in the water sector in Nepal: a real commitment or a token?. In Gender, Water and Development 95–113. Routledge

Resurrección B, K Johnson (2015) Gender and GIS. Guidance Notes. Bangkok: SERVIR-Mekong. https://servir.adpc.net/publications/gender-and-gis-guidance-notes [accessed 23 Mar 2023)

Rothchild J (2014) Gender Bias. The Blackwell Encyclopedia of Sociology. https://doi.org/10.1002/9781405165518.WBEOSG011.PUB2

Sekhri S (2014) Wells, Water, and Welfare: The Impact of Access to Groundwater on Rural Poverty and Conflict. American Economic Journal: Applied Economics, 6(3), 76–102. https://doi.org/10.1257/APP.6.3.76

Shrestha G, F Clement (2019) Unravelling gendered practices in the public water sector in Nepal. Water Policy 21 (5), 1017–1033. https://doi.org/10.2166/wp.2019.238

Srinivasan V, M Sanderson, M Garcia, M Knoar, G Blöschl, M Sivapalan (2016) Prediction in a socio-hydrological world. Hydrological sciences Journal 62(3), 1–8

Stockholm Environment Institute. (2019). Water Evaluation And Planning System Incorporating Gender Aspects. https://doi.org/10.1371/journal.pone.0155981

Thompson JA (2016) Intersectionality and water: How social relations intersect with ecological difference. Gender, Place & Culture, 23(9), 1286–1301

Teferra K, MD Shields, A Hapij, RP Daddazio (2014) Mapping model validation metrics to subject matter expert scores for model adequacy assessment. Reliability Engineering and System Safety, 132, 9–19. https://doi.org/10.1016/J.RESS.2014.07.010

UN Women (2015) Women's access to water, sanitation and hygiene (WASH). https://www.unwater.org/water-facts/wash-water-sanitation-and-hygiene

UNDP (United National Development Program) (2001) Nepal's Human Development Report, 2001. Kathmandu, Nepal: UNDP

Unesco.org (2020) Questionnaire for collecting sex-disaggregated water data [online]. https://unesdoc.unesco.org/ark:/48223/pf0000234514 [accessed 8 Sep 2020]

Westerman K (2021) Unpacking the perceived benefits and costs of integrating gender into conservation projects: voices of conservation field practitioners. Oryx. https://doi.org/10.1017/S0030605320001295

WHO (2011) Gender mainstreaming for health managers: a practical approach. World Health Organization. 87pp. Available at https://apps.who.int/iris/bitstream/handle/10665/44516/9789241501064_eng.pdf?sequence=2 [accessed 23 Mar 2023]

Yang YCE, S Passarelli, RJ Lovell, C Ringler, C (2018) Gendered perspectives of ecosystem services: A systematic review. Ecosystem Services, 31, 58–67. https://doi.org/10.1016/J.ECOSER.2018.03.015

Zwarteveen MZ (1997) Water: From basic need to commodity: A discussion on gender and water rights in the context of irrigation. World Development 25 (8), 1335–1349

Zwarteveen M (2008) Men, masculinities and water powers in irrigation. Water Alternatives, 1(1), 111–130. www.water-alternatives.org

Zwarteveen MZ, N Neupane (2014) Gender aspects of irrigation management: The Chhattis Mauja Irrigation System in Nepal

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