# Integrated Solutions for Water, Energy and Land

## Progress Report 1

Period (1 November 2016- 28 February 2017)

## UNIDO Project No. 140312

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# Contents

# 1. Introduction

## 1.1 Rationale

Integrated Solutions for Water, Energy and Land (ISWEL) is a three-year project (2016-2019) lead through a GEF-IIASA-UNIDO partnership. It officially started the 1 November 2016 and its first phase will run until the end of November 2019. The overall goal of ISWEL is to lay the foundations for developing integrated approaches to identify evidence-based policy and investment strategies that will inform decision making across the water, energy, and land-use sectors. Specifically, ISWEL will explore the challenges and opportunities different regions of the world face to jointly meet water, land and energy demands under different development pathways and provide a portfolio of cost-effective solutions. This assessment will be carried out at the global level and include regional case studies consisting of selected transboundary basins, which are facing multiple development and environmental challenges: the Zambezi and the Indus basins.

The rationale for ISWEL is very much supported by the growing evidence that a "business as usual approach" has proven to be eroding as millions of people still have not achieved basic living standards yet whilst at the same time our system is already approaching and even exceeding some physical planetary boundaries. From a development perspective, the world has accomplished important development goals in the course of the last decades (e.g. since 1990 1 billion people have been lifted out of extreme poverty, 2.6 billion people have gained access to an improved water source and 1.9 have gained access to an improved sanitation facility), but important challenges remain since these benefits are not shared evenly across the global population, and the poorest regions of the world are still a long way from having decent living conditions.

Bridging this inequality is a top priority, but also doing so along more sustainable pathways is becoming an imperative. Much of the socioeconomic development humanity has achieved in these decades has come at a high environmental and societal cost. Climate change impacts, growing water scarcity conflicts, land degradation, and biodiversity loss are clear expressions of this intensive transformation and exploitation of our natural environment, and are likely to exacerbate if we continue doing the same. ISWEL aims to provide insights into how contrasting development pathways (e.g. BAU versus sustainability scenarios) might influence water, energy and land (WEL) demands globally and regionally, to inform decision makers about risks and opportunities for attaining WEL-related Sustainable Development Goals (SDGs).

A second argument that supports the need for projects like ISWEL is the growing interlinkages or "nexus" that exists between water, food and energy and the need to seek integrated solutions to avoid unexpected outcomes and costs. Improving access to water and sanitation requires energy, in the same way that energy provision requires large quantities of water. The linkages or nexus between food and water are also quite relevant since improvements in food security largely rely in the development of irrigation (which in turn creates an energy requirement), and careful planning is required to ensure resource availability and sustainable use. The growing interconnectedness of regions, sectors and economic systems experienced during the past couple of decades increases the regional linkages and the nexus management challenge, but it also offers some opportunities (e.g. trade as a mean to alleviate local resource scarcity).

Addressing the growing resource demand, interconnectedness of sectors and regions and tackle the increasing environmental degradation requires new approaches and new ways of thinking "out of the box". This involves the development of new tools as well as institutional arrangements. In relation to tools, current challenges require that traditionally separated resource management models of water, energy, and land use merge into a new generation of integrated systems analysis framework. Yet, and although there has been some success in linking sectoral models, the development of integrated assessment frameworks has been limited and there is substantial scope for improvement both at the global and regional level. To address this gap, ISWEL will develop a systems analysis platform that is scalable and regionally-transferable. It will be capable of simulating WEL interactions by taking into account resource constraints, as well as the role of distribution infrastructure in alleviating resource allocation challenges (e.g. how energy development goals can be met given the actual and future water availability and variability and vice versa). The goal of ISWEL is also to improve the representation of nexus impacts on the environment (e.g. impacts on water quality and availability or land use requirements). The development of this systems analysis framework will allow rigorous analysis of potential interactions, synergies and trade-offs between resource management options at the global and regional level.

Last but not least the complexity of the challenges we are facing requires strengthening cooperation between the different stakeholders, including local and global scientists, decision makers and implementation organizations. Science and technology alone cannot hope to provide an adequate diagnosis of the problem or design adequate solutions that are effective in all economic and sociopolitical settings. Moreover, engagement with different parties fosters the acceptance, reliability and credibility of alternatives. ISWEL will allocate significant efforts on engaging with relevant stakeholders at the regional level to identify priority challenges in relation to WEL, and explore best solutions under different development pathways and associated uncertainties. Building the stakeholder network in each of the two case studies will also create a good opportunity to build and enhance capacities in relation to nexus thinking and assessment tools in local research institutions and implementation organizations.

## 1.2 Objectives

The specific goals of ISWEL are:

1. Development of an integrated assessment tool capable of jointly modelling water, energy and land demands and cross sectorial impacts at the global and regional level.
2. Identify global water, energy and land hotspots and explore a portfolio of cost-effective solutions under a range of alternative development pathways
3. Explore cost-effective solutions for water, energy and land management in the Indus and the Zambezi basins taking into account different regional development pathways
4. Engage with decision makers, investors and implementing organizations to better understand and assess trade-offs and synergies relating to water, energy and land
5. Build the foundation for a knowledge and capacity network on nexus decision support in the global south

## 1.3 Outcomes and outputs

ISWEL is structured around 4 components or work packages. Table 1 summarizes the outcomes and outputs for each of the components included in the approved project proposal.

Table 1. Expected outcomes and outputs of ISWEL

| Component 1. Development of a systems analysis framework for assessing solutions to nexus challenges | | | | |
|---|---|---|---|---|
| *Outcome 1.1. Development of scenarios describing uncertainties in future trends and drivers* | | | | |
| | Indicators | Targets | Means of verification | Assumptions |
| **Output 1.1.1 Stakeholder-informed scenario co-design for capturing uncertainties in future trends and drivers** | Number of stakeholder-informed regional change pathways<br>Number of stakeholder informed 'solution' and 'policy' scenarios<br>Number of stakeholder consultations | At least two stakeholder-informed regional change pathways per case study<br>At least eight stakeholder informed 'solution' and 'policy' scenarios<br>One stakeholder consultation in each case study | Document summarizing the stakeholder-informed regional change pathways<br>Document summarizing the stakeholder-informed 'solution' and 'policy' scenarios<br>Agenda, minutes, and presentations from stakeholder consultation posted to project website | Good attendance at stakeholder consultations and interest in the development of regional change pathways<br>Interest in regional stakeholder meetings from different sectors to discuss scenario design and nexus challenges |

*Outcome 1.2 Method and tool development*

| | Indicators | Targets | Means of verification | Assumptions |
|---|---|---|---|---|
| **Output 1.2.1 Nexus modeling tool developed and presented with preliminary results: Tool will illuminate trade-offs among sectors and explore solutions for achieving multiple development and environmental objectives** | Nexus modeling tool developed (yes/no)<br>Number of presentations of nexus modelling tool and preliminary results | A completed nexus modelling tool<br>Two presentations of the nexus modelling tool and preliminary assumptions and results (one in each region) | Preliminary results based on model runs presented at stakeholder meetings (ppt)<br>Minutes from regional stakeholder meetings and demonstration (ppt) available on project website | Model development is not delayed by unforeseen technical challenges; required data are available and accessible |
| **Component 2. Exploring nexus solutions at global and regional scales** | | | | |

*Outcome 2.1 Regional assessment of nexus challenges and solutions. Understanding of sectorial trade-offs, synergies, and solutions for meeting nexus challenges improved among regional stakeholders*

| | Indicators | Targets | Means of verification | Assumptions |
|---|---|---|---|---|
| Output 2.1.1 Tangible strategies for improving regional decision-making across sectors and borders identified for two selected regions | Identification and documentation of key regional insights (yes/no) | Joint GEF-IIASA-UNIDO Summary for Policymakers (SPM) | SPM available on project website | Regional model development is successful and yields clear insights regarding trade-offs, synergies, and solutions for regional nexus challenges |

*Outcome 2.2 Global nexus hotspots and transformation pathways: multi-sectorial vulnerability hotspots under different socioeconomic and hydro-climatic scenarios identified*

| | Indicators | Targets | Means of verification | Assumptions |
|---|---|---|---|---|
| Output 2.2.1 Global assessment of multi-sectorial hotspots and transformation pathways | Global assessment of multi-sectorial hotspots and transformation pathways (yes/no)<br>Identification and documentation of knowledge and data gaps (yes/no) | Documentation and communication of key insights from global assessment in publications and SPM<br>Inclusion of knowledge and data gaps in SPM | Scientific publications and white papers completed;<br>SPM available on project website | Global model development is successful and yields clear insights into global nexus hotspots and sustainable transformation pathways<br>Global and regional model development is successful and yields insights regarding knowledge and data gaps |

## Component 3. Capacity Building and Knowledge Management: Building the foundation for a knowledge and capacity network on nexus decision support

*Outcome 3.1 A foundation of a regional and global knowledge and capacity network established*

| | Indicators | Targets | Means of verification | Assumptions |
|---|---|---|---|---|
| Output 3.1.1 Establishment of connections and interactions among stakeholders from a wide array of institutions, sectors and countries; including expert advisory meetings | Number of stakeholder meetings per case study region<br>Expert advisory meetings (yes/no) | Three total stakeholder meetings in each case study region (includes consultation on study design) (~one per year)<br>Number of informal expert advisory meetings conducted | Minutes and participant lists from stakeholder meetings<br>Summary from advisory meeting | Interest in regional stakeholder meetings from a wide array of institutions and sectors; willingness of stakeholders to interact; progress on project to enable stakeholder feedback |

*Outcome 3.2 Capacity building: Regional capacity for nexus assessment and solution identification improved*

| | Indicators | Targets | Means of verification | Assumptions |
|---|---|---|---|---|
| Output 3.2.1.a Two capacity building workshops per case study region, held concurrently with stakeholder meetings | Number of capacity building workshops | Two capacity building workshops per case study region | Minutes and presentations from capacity building workshops posted on project website | Interest and engagement from regional scientists and practitioners |
| Output 3.2.1.b Exchange of scientists/experts with partner academic institutions, ministries and/or multilateral organizations | Number of scientists/experts exchanged | At least one scientist/expert per case study region | Report by exchange scientist on their research and contribution to the project | Interest from regional and IIASA scientists; sufficient quality of scientists |

*Outcome 3.3 Knowledge dissemination: Infrastructure established to disseminate findings of the project*

| | Indicators | Targets | Means of verification | Assumptions |
|---|---|---|---|---|
| Output 3.3.1.a Participation in high-level panels, conferences, and events | Number of presentations at high level events | Presentations at a minimum of three high level events per year | Links to event agendas and/or presentations posted on project website | External interest in project, model, and insights |
| Output 3.3.1.b Online database for sharing of scenario results | Development of online database (yes/no) | Online database accessible and populated with scenario results | Link to online database on project website | Successful implementation of models scenario results |
| Output 3.3.1.c Two experience notes shared via IW:Learn | Number of experience notes shared | One experience note per case study completed | Link to experience notes on IW:Learn website | Material available for drafting of experience notes |

| | | | | |
|---|---|---|---|---|
| **Output 3.3.1.d Joint GEF-IIASA-UNIDO Summary for policymakers describing project insights and outcomes** | Development of a Joint GEF-IIASA-UNIDO Summary for Policymakers (SPM) (yes/no) | Joint GEF-IIASA-UNIDO Summary for Policymakers (SPM) | SPM available on project website | All components of model development are successful and yield valuable insights for inclusion in the SPM |
| **Output 3.3.1.e Scientific publications and white papers** | Number of publications | At least eight scientific publications and/or white papers submitted over the life of the project | Links to scientific publications and white papers on project website | All model development yield worthy of scientific publication |

## 2. Main outputs for the period

Table 2 provides an overview of the initiated activities and relevant milestones achieved.

| | Activities in execution | Important milestones accomplished |
|---|---|---|
| **Component 1: Development of a systems analysis framework** | | |
| 1.1 Assessment of future trends and drivers | ✓ | System boundaries established and preliminary (zero level) downscaled socio-economic and climate input data ready |
| 1.2 Method and tool development | ✓ | |
| **Component 2: Exploring nexus solutions at global and regional scales** | | |
| 2.1 Regional assessment of nexus challenges and solutions | | |
| 2.2 Global nexus hotspots and transformation pathways | | |
| **Component 3: Capacity building and knowledge management** | | |
| 3.1 Knowledge and capacity network | ✓ | 1 Meeting with ZAMCOM |
| 3.2 Capacity building for system analysis and nexus decisions | | |
| 3.3 Dissemination and outreach | ✓ | Participation and co-organization of 3 High level panels/Conference<br>1 Peer review paper submitted January 2017 |
| **Component 4: Project Monitoring and Evaluation** | | |
| 4.1 UNIDO reporting | ✓ | |
| 4.2 Meetings with the Project Steering Committee (SPC) | ✓ | First introductory meeting 12 December 2016 |

## 3. News for the period

- Since the kick off (November 2016) four new full time staff members have been hired. Three researchers to support the research activities within the Water, Ecosystem Services and Management and Transitions to New Technologies programs related to ISWEL, and a project officer. The PO was hired in January 2017 will take charge of the project management activities as well as supporting some of the stakeholder activities in the two case study areas.

- First contacts have been established with stakeholders from Indus and Zambezi basins. Following through from the seminar at Stockholm Water Week 2016, ISWEL has initiated an exchange of communication with ZAMCOM (The Zambezi Watercourse Commission) through its Secretariat. A presentation on the project and request for involvement in co-design of the scenarios both of the component riparian countries and the basin as a whole was discussed at a meeting of the technical committee (Zamtec) in Tete, Mozambique in February 2017. There was significant interest in the work, request for more information and for an agreement to develop a plan for a stakeholder process which might feed into the ZAMCOM strategic plan. Contact with a few stakeholders in the Indus have been made as well. Originally it was suggested the best entry point might be the Indus Forum and there next meeting was to have been in March 2017. In February we learnt this has been delayed until June. Alternative entry points are now be explored.

- Internal arrangements have been made to start planning the first stakeholder meeting at the Zambezi. To this end a stakeholder process document is being developed internally, to clarify the specific goals of the meeting, the work flow and the composition of the IIASA team that will be in charge of this process. Also, discussions are been held to identify the stakeholders which could benefit and be interested in our study based on (but not limited to) the list included in the approved proposal (Annex H).

- ISWEL team has established contact with the leaders of the European Horizon 2020 project DAFNE (https://dafne.ethz.ch/). This project is led by ETH Zurich and it will also look at the nexus issues in transboundary basins of Africa, the Zambezi being one of the case study areas. Both research teams have agreed to collaborate and try to establish an alliance that will benefit both projects. A face-to-face meeting will take place before the summer 2017 with the two teams to explore synergies regarding the stakeholder process and ways to avoid repetition and overlap.

- In terms of communication, several products are underway. The ISWEL team is working to have the project website launched as soon as possible (currently a short briefing holding web page is in place outlining the project). It was agreed to develop the project website within the IIASA web, to benefit from the wider audience and make possible an easy link to the different IIASA web contents on model and programs. A brochure describing the vision and goals of ISWEL has also been prepared to facilitate the communication and outreach of the project when attending meetings.

- As can be seen in section 5 the timeline of the working plan has been updated and details are provided regarding the deliverables.

# 4. Activities executed (November 2016-February 2017)

This section describes the activities that have been started since November 2016, reporting on the main achievements and milestones accomplished by February 2017. All initiated activities correspond to components 1, 3 and 4. Tasks related to component 2 will start in April 2017.

## Component 1 Development of a system analysis framework

### 1.1 Development of scenarios describing uncertainties in future trends and drivers

Task description: Working within the systems analysis framework requires a preliminary assessment of the future trends and drivers of the systems. Scenarios of future trends and drivers are being developed both for the global and the regional scale. These regional and global change pathways will be co-designed with regional stakeholders to capture uncertainties about future drivers and developments in relation to demographic, socioeconomic, behavioral, technological, and climatic trends.

IIASA has extensive experience in this area at the global scale, for example, having played a key role in the development of the SSP and RCP pathways for the IPCC, as well as hosting these databases used for climate change impact, mitigation and adaptation research and policy all around the world.

Using stakeholder consultations, a set of scenarios for future water, energy and land demands will be developed for each of the two regional case studies taking into account future global and regional drivers and associated uncertainties. For each case study, at least two regional change pathways will be defined, and whilst intended to fit within the broader global scenarios (e.g. Shared Socio-economic Pathways-SSPs), will be tailored according to local challenges and stakeholder needs. At the global level, stakeholder consultations will take place to identify the number and type of development pathways to be included in the scenario analysis.

Technical progress: A key aspect of this work has been first defining the system boundary conditions that will be represented in each modeling and assessment tool, with specific focus on the water-energy-land (WEL) nexus interactions. This has included defining the geopolitical boundaries for all models, delineation of the spatial units and identifiers across the WEL sectors, and the downscaling of the available socio-economic and climate data sets. Accordingly, the following decisions have been agreed:

- The definition of the geopolitical borders are based on Global Administrative Unit Layers (GAUL2015) implemented by FAO.
- Watershed boundaries and sub-basin delineations at a global scale are based on the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP) (https://www.isimip.org/) delineation and Hydrobasin (http://www.hydrosheds.org).
- For downscaled climate datasets, the climate forcing from the ISI-MIP project data are being used, obtained from five leading global climate models (GCMs) that have already been bias-corrected for future projections. The data is widely used within various research communities and is available for four emissions pathways (RCP2.6, RCP4.5, RCP6.0 and RCP8.5) at 0.5°x0.5° grid resolution (I.e., 50 km by 50 km).
- New downscaled socioeconomic datasets have also been produced at 0.125°x0.125° grid resolution, combining projections of population growth, GDP and urbanization, urban income, and rural income for the SSP scenarios.

With the system boundary conditions commonly defined across the modelling teams, development and modelling of subsequent (preliminary) projections for future WEL demands and water availability are also well under way. Ongoing tasks include:

- Downscaled and gridded future projections for water, energy, land and ecosystem demands. For example, analysis of energy demands has also begun to understand how heating/cooling demands change with time: both due to a growing and increasingly wealthy populations (more people using more energy - SSP projections) and also due to the climate change impacts (warmer winters, hotter summers). Current and future water demands for the municipal and manufacturing sector have been estimated for three SSPs and using three state-of-the-art hydrological models. New country-specific data on land cover and agricultural production are collected for Malawi from various sources, and will be used as input for GLOBIOM.
- Downscaled and gridded future projections for water availability (I.e., water supply) and variability, consistent with the projected water demand estimates (above). A stakeholder informed, scenario-based assessment of water resources (and water demand), employing ensembles of socio-economic, hydrological and hydro-economic models is in progress (Wada et al., 2016). The result will be a consistent and comprehensive projection for global possible water futures reflecting regional information and not limited global available data sets.
- Estimates of crop productivity, and associated irrigation water requirements, for different crop intensification levels at a global scale using the global Environmental Policy Integrated Climate (EPIC) model. Combinations of irrigation and nitrogen fertilizer scenarios produce the future yield intensification pathways. Besides water requirements, major ecological constraints to global crop production are also being investigated.

With the fast-track analysis and scenario definition well underway, next steps will involve stakeholder consultations for a first phase refinement of the scenarios at the global and regional scales.

Tasks related to output: D 1.1.1

Product(s) coming out of this task:

- Database input to all models containing harmonized geopolitical boundaries, basin borders, and global climate forcing data.
- Scripts and procedures for post-processing the scenario data.
- Gridded climate and hydrological datasets, based on the ISIMIP data, which have been post-processed according to the project needs.
- Global data set of municipal and manufacturing water demand has been produced at $0.5^{o}$x$0.5^{o}$ gridded (I.e., 50 km by 50 km) and country scale.
- Gridded datasets of changing energy demand (heating & cooling), according to different projections of population, wealth and climate change
- Downscaled land cover and land use information for case-study regions that can be used in GLOBIOM.
- Gridded water supply information including river discharge, groundwater recharge, soil moisture, and hydrological variability that will be used for the inputs to the other nexus models including GLOBIOM and MESSAGE.
- Database input to GLOBIOM (crop productivity and irrigation requirement database). An initial version is expected to be completed at the end of March 2017.

Technical documentation linked this task:

- van Dijk, Michiel. Technical Report on Downscaling Water scenarios at GLOBIOM SimU level
- Burek P, Satoh Y, Fischer G, Kahil MT, Scherzer A, Tramberend S, Nava LF, Wada Y, et al. (2016). Water Futures and Solution - Fast Track Initiative (Final Report). IIASA Working Paper. IIASA, Laxenburg, Austria: WP-16-006.
- Wada, Y., Flörke, M., Hanasaki, N., Eisner, S., Fischer, G., Tramberend, S., Satoh, Y., van Vliet, M. T. H., Yillia, P., Ringler, C., Burek, P., and Wiberg, D.: Modeling global water use for the 21st century:

the Water Futures and Solutions (WFaS) initiative and its approaches, Geosci. Model Dev., 9, 175-222, doi:10.5194/gmd-9-175-2016, 2016.

Issues or problems faced with the task execution and recommendations on how they will be solved: No

## 1.2 Method and tool development

Task description: In order to build a systems analysis framework, within this task, respective WEL integrated assessment models have been developed (at a global level) and will be further improved (both at global level but importantly downscaled for use at the regional level). Task 1.1 is providing system boundary conditions and associated inputs for each model in order to examine potential feedback among the water, energy and land sectors. Within the system analysis framework future scenarios provided by Task 1.1 will be eventually used to evaluate possible integrated solutions for water, energy and land, considering potential trade-offs, synergies and co-benefits at the global and the regional scales (i.e., Indus and Zambezi). Integrated scenario and solution assessments will highlight hidden trade-offs, that may cause undesirable impacts on one sector. For example, increased demands for low-carbon biofuels may lead to higher water demands and land competition for food production, subsequently increasing water scarcity and reducing water availability for ecosystems.

IIASA already has extensive experience in modeling system analysis and scenario analysis. The long-established energy-economic model (MESSAGE) and the agro-economic system model (GLOBIOM) have both contributed to IPCC assessments. These two models are being upgraded in order to contribute to the integrated nexus modeling framework developed for the project. Similarly, a new global and regional scale hydrological model (Community Water Model) has been developed to provide water system boundaries. One important innovative aspect within this task is to provide a global and regional scale hydro-economic model (GLOBECHO) that represents water resource systems, infrastructure, management options and associated economic values in an integrated manner. GLOBECHO includes an economic-hydrologic optimization procedure that aims to balance water demand and supply at the level of large-scale river basins worldwide, suited specifically for regional nexus assessment. After model development and improvement, all model will contribute to build the integrated system analysis framework.

Technical progress:
The following model improvement and development has been achieved within the different WEL nexus models after 4 months from the ISWEL project inception:

- Improvement of the global energy-economic model (MESSAGE): In order for the model to be used to consider constraints on water availability for energy supply occurring at the basin-scale, initial work has focused on basin-level representation of constraints. Technical results include mapping existing electric power generation infrastructure (mainly hydro and thermal) at the global scale, including identifying the associated cooling technologies for thermal power plants, which represent the majority of energy-related water use. Moreover, the cost and performance of alternative cooling technology options (e.g., air cooling) have been incorporated in the MESSAGE modeling framework, and will enable identification of least-cost adaptation pathways in the energy sector in response to water constraints. Maps of technical potentials, including for solar and wind power, are also in development. Preliminary analysis has also been conducted to test changes in impacts of droughts, floods and air temperatures (e.g. heatwaves) on spatial datasets of energy infrastructure (e.g. power plants) and also aggregated representations at decision-making scales (basins).

- Improvement of the agro-economic system (GLOBIOM): For this model to be used at the river basin scale it will be necessary to consider the energy requirements of agricultural production and the physical and economic constraints of the supply of water for irrigation including biophysical suitability of irrigations systems and competing demands for water from other sectors. Technical results achieved to date include downscaled and improved modeling infrastructure to incorporate water demand projections for the SSPs to be used for basin-level analysis. This considers the interactions between water demand from other sectors (e.g., energy) and water demand for agriculture (for irrigation) at a high spatial resolution, with on-going efforts to aggregate these to the basin level. Efforts to incorporate the economic constraints of water available for irrigation from the hydro-economic model are in the scoping and development phase. The integrated framework for linking developments in energy sector and impacts on land use, at the global scale, preceded activities in this task. Integrating the energy system and land use systems at the basin level are currently building upon the existing global integration and are in the development phase.

- Development of the Community Water Model (CWatM): A basic version of the scalable Community Water Model (CWatM) that can calculate water balance including water availability over river network with hydrological routing has been developed at the global scale. In order to yield realistic water supply, a calibration technique has been developed using the Budyko framework. Preliminary results of regional water supply, water demands and environmental needs have been produced and being tested against available observations. The model is open source and community-driven to promote our work amongst the wider water community worldwide and is flexible enough linking to further planned developments such as water quality and the hydro-economic model. Effective integration manner of CWatM with MESSAGE and GLOBIOM has been explored and investigated.

- Development of the global hydro-economic model (GLOBECHO): A basic version of the hydro-economic model for Africa has been developed. The model already includes the optimization scheme to minimize total costs of meeting water demands from agricultural, energy, manufacturing and municipal sectors, subject to various technical and resource constraints. The optimization includes capacity expansion and is solved over a multi-decadal horizon. Seasonal variability has been incorporated at a monthly time-scale. The model can be used to simulate a variety of basin management decisions including resource extractions, inter-basin transfers, reservoir operation regimes, and water infrastructure investment. Various cost data have been gathered to yield realistic cost estimates. Integration with CWatM, MESSAGE, and GLOBIOM is being explored in order to achieve the WEL nexus scenario assessment. Currently, the model is able to interact with MESSAGE and CWatM through water demands and water availability linkage.

- The ixModeling Platform (IXMP): In addition to individual model advances, progresses has also been made in relation to the development of IXMP. This is intended for integrated and cross-cutting analysis of the WLE nexus and aims to facilitate the highest level of openness and transparency both for researchers at IIASA and for a wider audience.  The platform and all data can be accessed either through a web-based user interface for model/scenario management including intuitive 'drag-and-drop' visualization tools, or through an 'application programming interface‘(API). This feature will be of particular importance in the ISWEL project for an effective integration of models, since results from one model can easily be used by another group as input data or exogenous assumptions via the standardized data handling routines provided by the iXMP.

These improvements and developments of respective WEL nexus models are well underway. How to establish effective linkage among the WEL nexus models will be key activity for coming quarters.

Tasks related to output: D 1.2.1

Product(s) coming out of this task:

- Database input to MESSAGE (energy resource potentials, existing infrastructure and technology performance database).
- Database input to MESSAGE (river discharge, supply cost of water, variability/risk of water scarcity/flood).
- Database input to GLOBIOM (river discharge, groundwater recharge, soil moisture, variability/risk of water scarcity/flood).
- Regional dataset for Africa on water supply, demand, infrastructure capacity, and investment and operation costs of several water management options by basin has been prepared to be used as input data to the hydro-economic model.
- Internal technical report on increasing the temporal and spatial resolution of the water supply constraint (economic and physical) for irrigation in GLOBIOM
- Review of water/food security of study area using spatially explicit water constraints in GLOBIOM, Draft conference paper to be submitted March 2017

Technical documentation linked this task: Guidelines on the elaboration of the global power plants database (Annex I)

Issues or problems faced with the task execution and recommendations on how they will be solved: No

## Component 3: Capacity building and knowledge management: Building the foundation for a knowledge and capacity network on nexus decision support

### 3.1 Stakeholder engagement in the design, development, and communication of regional case studies

Task description: High stakes and deep uncertainties about the future suggest that there are mutual benefits for scientists and decision makers to work together applying model-based scenarios in order to develop solutions resilient with respect to a wide range of future threats and opportunities. However, many big challenge remain concerning how to address the specific needs of diverse stakeholder groups.

Building on the extensive experience some ISWEL team members have in participatory approaches and scenario planning, the goal of this task is to develop and implement a process to enable the water, energy, and agricultural sectors at the regional level (Indus and Zambezi) to better understand the synergies and trade-offs among WEL sectors under a range of contrasting development pathways, and to provide strategic advice on nexus interactions, infrastructure investments, and opportunities for transboundary cooperation.

This stakeholder process should provide added value to all parties i.e. contribute to fulfill ISWEL project goals but equally important, generate new knowledge that can support decision making in the Indus and Zambezi. Desirably, the stakeholder process designed in ISWEL will:

- Inform ISWEL team about specific nexus challenges and considered solutions at the river basin and national scale
- Inform stakeholders about modeling and scenario tools available to address these challenges and analyze solutions pathways
- Jointly frame the most pressing nexus problems, that require system analysis
- Provide data by stakeholders for calibrating models and shaping future scenarios
- Provide the results of the systems analysis to stakeholders including trade-offs and synergies between solutions
- Enrich modeling frameworks based on insights provided by stakeholders
- Build capacity for using models and systems analysis for policy support

Technical progress:

- The first step in the setup of the stakeholder process is the creation of the networks in the two case study areas. <u>Preliminary contacts and a meeting with the Zambezi Water course Commission</u> (ZAMCOM) has taken place. Exploratory discussions with the Indus Forum and contacts with Pakistan and India have been initiated.
- Several <u>internal discussions and meetings</u> have taken place to agree on the expectations and needs for this stakeholder process. The design of the stakeholder process has been initiated and a draft of the process will be ready by mid-March 2017.
- The <u>first regional stakeholder meeting</u> is planned for September 2017 and will take place in the Zambezi. Current efforts are being placed in developing a work flow towards this first meeting, targeting and approaching key stakeholders for this first meeting.

Tasks related to outputs: D1.1.1, D 3.1.1 and D 3.1.2

Product(s) coming out of this task:

- A database of stakeholders that will be consulted and invited to take part in the participatory process of ISWEL is well advanced. The database contains, for the two case study areas, a preliminary classification of what role different organizations would play in the process. For example based on their interest and influence whether they can support the scenario development, or they could be data providers, or targeted actors for capacity development activities). This product is still in draft.
- A stakeholder strategy document is being developed but is yet not completed. This document should be the basis for guiding the stakeholder process as a whole and also for later reporting on the outcomes (D 3.1.2)

Technical document that describes the activity: Preliminary draft of the stakeholder process (see Annex II)

Issues or problems faced with the task execution and recommendations on how they will be solved: The ongoing political conflicts in the Indus basin and the fact that IIASA has only limited contacts in the region, limits the capacity of the ISWEL team in the establishment of contacts with local stakeholders. The strategy as with the Zambezi is to approach the River Commission. For the Indus the initial entry point has to been to explore the Indus Forum. However, the next meeting is scheduled for June 2017. One of the Project Steering Committee Members (Dr. Srivastava) is based in India and has volunteered to introduce ISWEL team to the Secretary of Water Resources of India in order to establish initial contacts with government representatives. The Water Program within IIASA has also some governmental contacts in Pakistan. Communication will be established in the coming weeks. In the absence of positive progress we will propose a contingency plan which could include an alternative basin such as the Mekong.

## 3.3 Knowledge dissemination: Infrastructure established to disseminate findings of the project

Main purpose of this task: The aim of this task is to facilitate the outreach of ISWEL and its results. To this end, several actions have been proposal: 1) Participation of ISWEL members in high level panels, nexus related workshops and conferences; 2) Ensure dissemination of project results within the scientific community through the elaboration of high impact peer review publications; development of a project website; 4) make project results publicly available by sharing the databases coming out of the project; 5) elaborate a joint policy brief with UNIDO and GEF for each of the two case study areas; and 6) Contribute with two experience notes via IW:learn.

Progress:

Since August 2016 various ISWEL team members have been participating in several high level panels and nexus workshops, discussing key challenges and introducing ISWEL. Worth mentioning is the participation of Dr. Simon Langan in:

- Presentation and co-organization of a session on "Operationalizing the water-energy-food nexus" at the Stockholm World Water Week 2016. The presentation was taught by Dr. Langan and dealt with mechanisms to address nexus dimensions across sectors and boundaries. Link to the Program: http://www.worldwaterweek.org/wp-content/uploads/2016/08/2016-WWW-Programme-web.pdf
- Participation in High-Level Seminar: "Accelerating Sustainable Energy for All in Landlocked Developing Countries through Innovative Partnerships" co-organized by UNIDO and SE4ALL. Dr. Langan participated as invited panelist in the session: "Nexus Session: Integrated Solutions for Water, Energy, and Land" Link to the Panel Website: http://unohrlls.org/event/high-level-seminar-accelerating-sustainable-energy-landlocked-developing-countries-innovative-partnerships/
- Participation in the workshop "The Water-Energy-Food Nexus and its linkages to the implementation of the SDGs" co-organized by the Future Earth Water-Energy-Food Cluster study, the South African Water Research Commission, and the University of KwaZulu-Natal by the Future. Dr. Langan participated as an invited panelist in the session "International cooperation in the area of water to assist in the implementation of the W-E-F Nexus and the SDGs for international and national basins". Link to the meeting and agenda: http://www.futureearth.org/events/water-energy-food-nexus-and-its-linkages-sdgs

Regarding the elaboration of scientific publications, a peer review paper based on the output of the scoping study has been submitted to Frontiers in Ecology in January 2017 and is currently under review.

Progress has also been made in relation to the development of the project website. There has been some internal discussions on the whether ISWEL website should be included within the IIASA website or as a separate project website since both options have advantages and disadvantages. Nevertheless, a proposal of website contents and structure is being produced, but the final product will depend on the selection of the platform that we choose to host ISWEL. Furthermore, initial discussions with IW:Learn facilitated with GEF have been undertaken about inclusion of the work on their website, together with joint development of other dissemination tools.

Product(s) coming out of this task:

- Presentations or proceedings from conferences and participation in workshops.
- Published scientific peer review papers.
- A website describing ISWEL vision and goals, working packages contents, team members and roles, updates about activities and progresses, and links to other related projects or organizations.

Technical document that describes the activity: No

Issues or problems faced with the task execution and recommendations on how they will be solved: No

## 5. Project management

The project management structure developed for ISWEL is summarized in Figure 1. Staff from the four participating IIASA Programs (Energy (ENE), Ecosystems Services and Management (ESM), Transitions to New technologies (TNT), Water (WAT)) are implementing the project and will conduct the research including both global and regional perspectives as well as the two case studies. This work is governed by an internal Executive Committee (EC) at IIASA, consisting of representatives of the four programs and supported by a Project Officer. The EC is in charge of liaising and work with both the IIASA Directorate and the Project Steering Committee (PSC). The PSC consists of the representatives of the three partner organizations (GEF, IIASA, UNIDO) and three well known experts have a role in commenting on the policy relevance, budgetary and scientific content.

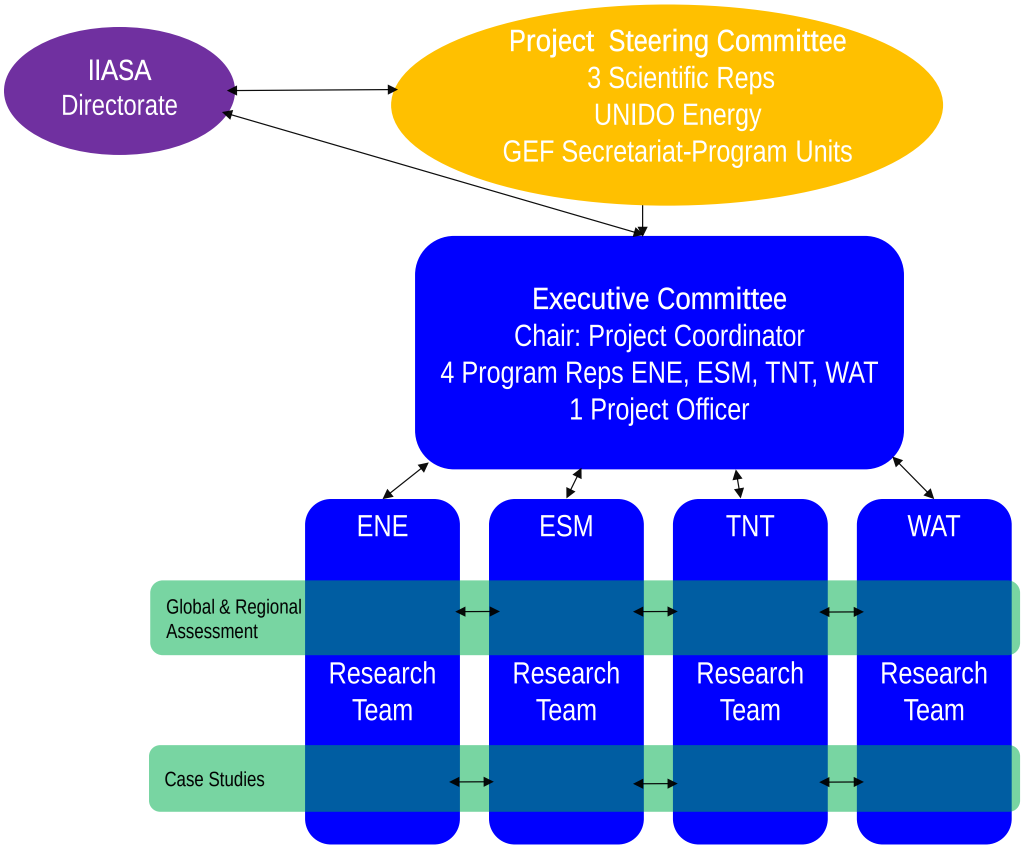



Figure 1. *Project Management organization*

During the reporting period (November 2016-February 2017) the following management progress can be reported:

1) A project Officer (Dr. Barbara Willaarts) has been hired and stared in January 2017 to coordinate IIASA progress work and report to the Executive Committee.
2) The Project Steering Committee (PSC) was officially formalized in the first weeks of November 2016. The committee is composed by three world scientific experts (Prof. David Grey, Prof. Youba Sokona and Dr. Leena Srivastava, the Director of the Energy Department at UNIDO and Dr. Astrid Hillers as a representative from the GEF secretariat.
3) The composition of the Scientific Steering Committee has changed with respect the one included in the proposal. Dr. Leena Srivastava has been appointed instead of Dr. Rosina Bierbaum. A full BIOS of the three scientific members of the Project Steering Committee is included in Annex III.
4) The first introductory meeting (conference call) with the Project Steering Committee took place on the 12 December 2016. During the meeting the IIASA executive team presented the project, main outcomes and work plan. Feedback on the contents as well as the work plan was provided to ensure overall scientific consistency. The next meeting will take place in April /May 2017 and will be face to face.
5) Given that UNIDO staffing has changed over this reporting period we have started to develop communication with the new (acting) Director of the Energy Department (Mr. Phillippe Scholtès). A meeting is planned for March to provide an overview of ISWEL and its progress and discuss UNIDO expectations and views on ISWEL.
6) IIASA project officer has also established initial contact with the UNIDO project manager Mr. Takeshi Nagasawa

## 6. Evaluation of consultants and contractors

During the executing period no services have been sub-contracted by IIASA

## 7. Next steps

Figure 2 describes the work plan for ISWEL with the adjusted timeline to match the contract duration. Deliverables have also been included in the work plan. A description of the deliverable contents is included in box 1.

| |
|---|
| <u>BOX 1. Planned Deliverables ISWEL</u><br><br>D 1.1.1 Report describing the stakeholder-informed regional scenarios for exploring nexus challenges, drivers and solutions (*December 2017)*<br>D 1.2.1 Report/Paper describing the model development and integration into system assessment platform (*July 2019*)<br>D 2.1.1 One Summary for Policy Makers (SPM) for each case study on tangible strategies for improving regional decision-making across sectors and borders identified (*July 2019*)<br>D 2.2.1 Summary for Policy Makers (SPM) on Global assessment of multi-sectorial hotspots and transformation pathways (*July 2019*)<br>D 3.1.1 Database with stakeholder contacts for the global consultation and the two case study areas (*June 2017*)<br>D.3.1.2 Report describing the stakeholder process and the outcomes of the regional workshops (*September 2019*)<br>D 3.2.1 Presentations and report of the capacity building workshops uploaded into the project website (*September 2019*)<br>D 3.2.2 Report describing the results of the scientific exchange program and their contribution to ISWEL (*September 2019*)<br>D 3.3.1 Project Website (*April 2017)*<br>D.3.3.2 Report summarizing the participation in high level panels, workshops and conferences related to ISWEL project (*October 2019*)<br>D 3.3.3 Open access web tool and platform to share scenario results and related databases for investors and stakeholders (*October 2019*)<br>D 3.34 Two shared experiences available online for the IW:learn (*October 2019*)<br>D 3.3.5 Three edited Summary for Policy Makers (SPM) (global and for the two case studies) available online (*July 2019*)<br>D 3.3.6 At least six scientific peer publications related to ISWEL outcomes submitted (*October 2019*) |

No deviations with respect to the planned activities have occurred between November 2016 and February 2017. However, we foresee the need to re-plan one activity for the next reporting period that we will like to anticipate. This rescheduling concerns the stakeholder consultations, and in particular the occurrence of the first in-depth regional stakeholder meetings. The two regional workshops where initially planned in the project proposal for period February-April 2017 (region a) and May-July (region b). Given the efforts that require establishing the contacts with the stakeholders in the two regions, and the need to carefully plan the stakeholder process as a whole, we have decided to allocate more time for the preparation of these first meetings. As shown in the updated work plan (Figure 2), the first regional stakeholder meeting (Zambezi) is now planned for September 2017 and the Indus for November 2017. Due to this delay, Deliverable 1.1.1 (Report describing the stakeholder-informed regional scenarios for exploring nexus challenges, drivers and solutions) won't be ready until December 2017, one month later than initially planned. Such delay won't alter the planning of any other activities and the second phase of the stakeholder process (subsequent meetings).

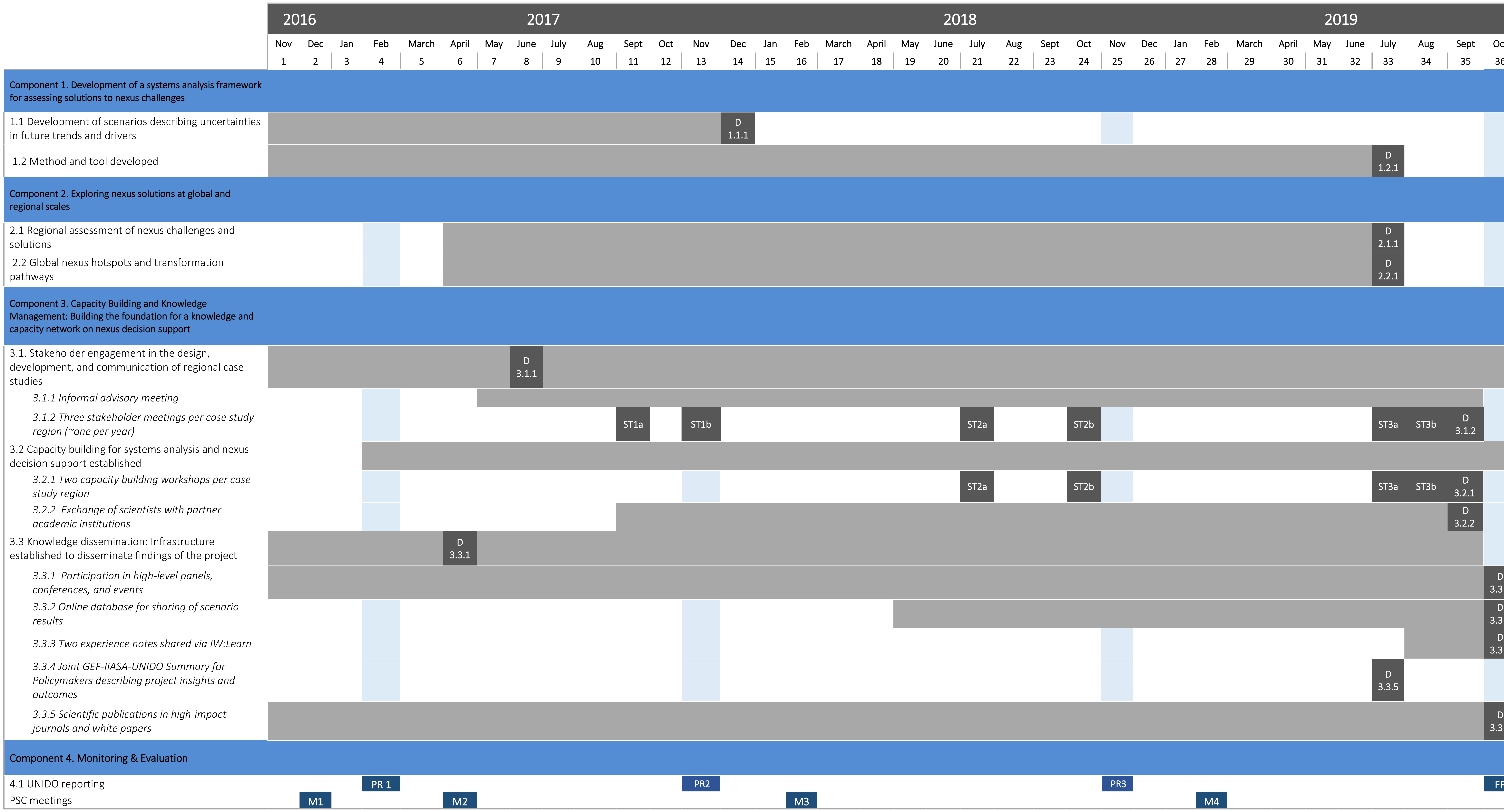
In regards to the risk mitigation strategy, the approved proposal identified two medium size risks: 1) Technical and coordination problems emerging from the potential insecurity in the case studies areas

and the lack of data; and 2) institutional risks related with the difficulties of stakeholders to buy-in the project.
The actions undertaken to mitigate the technical and coordination risks in the two study areas consisted of:

1. A preliminary desktop assessment of data requirements and yet accessible data sources in the two case studies, including a review on available data sources, project documentations or publications.
2. Contact established with organizations working on the ground on topics and/or with stakeholders relevant for ISWEL. In the case of the Zambezi, a first meeting was hold with the Zambezi River Commission to introduce the project and obtain their endorsement. In the Indus, contact has also been established with the Indus Forum. PSC member Dr. Srivastava is in parallel facilitating the introduction of the management board of ISWEL project to the Director of the Secretary of Water Resources of India.
3. Identify other ongoing activities or projects in the case study areas dealing with nexus issues to foster as much as possible cross-project cooperation and avoid stakeholder confusion and fatigue.

In regards to the risk of not being able to achieve buy-in by the stakeholders in the process and having a low degree of engagement, the most important action is a careful planning of the whole stakeholder process. The participation process will be successful as long as it generates added value to both parties. For this reason, ISWEL researchers will have to ensure that the whole process contributes to match stakeholder needs and expectations with the technical capabilities of IIASA staff and models for providing adequate solutions and products. This requires the design of a stakeholder process, which provides the vision of what the process should be, what outcomes should deliver and how we can reach those outcomes. To this end, internal discussions with team members involved in previous projects dealing with stakeholder process have been held over the last two months to collect views on what worked and what didn't. The stakeholder strategy is now being drafted and will be ready by mid-March 2017. This document will provide the route map for guiding the process internally and will be revised and updated as the process develops.

**Figure 2 ISWEL Work Plan**




ST = Stakeholder Meeting (region a/b), D = Report/Deliverable/Publication, M= meeting, PR= Progress Report, FR=Final Report

# 8. Annex

## Annex I: Development of global power plant datasets

This document describes ongoing efforts and structure to develop a complete power plant dataset combining various sources for use within the ISWEL project

Key objectives:

- Transferability – Harmonization of data for easy input to and cross-reference with MESSAGE regions, ISWEL river basin units, IEA data tables, etc
- Reproducibility and flexibility – Maintained script that pulls in data sources, re-runs processes, and can be modified to output data according to user requirements (more/less info, aggregated, subsets, etc)
- Spatial information –
    - Latitude /longitude info
    - ability to locate and aggregate power plants within spatial regions e.g. river basins, MESSAGE regions, etc
    - procedures to output data to raster datasets for gridded applications
- Environmental impacts information
    - Estimates of water use
    - Cooling systems
    - Estimates of to-air and to-water pollution impacts

**Combining the three data sources**

Current work has focused on combining three best-of-best energy data sources:

1. Platts **WEPP** June 2013. Licensed database with no location information
2. **Carma** – based on Platts WEPP ~2010, with locations based on georeferencing algorithm.
3. **Raptis** – based on Platts WEPP March 2012, but only contains data on thermal power plants, with exact locations for some steam power plants, and others georeferenced.
4. *To be added* – dataset on global hydro power.

**Aggregation of fuel groups, unit types and cooling systems**

Combining the datasets has resulted in a multitude of different yet similar fuel, unit and cooling systems types. The data is now harmonized to a consistent set of fuel, unit and cooling options (Box 1).

Box 1. Harmonized fuel groups, units and cooling options

| Fuel groups | | Unit groups | | Cool groups | |
|---|---|---|---|---|---|
| | | | | | |
| gas | Gas | CC | Combined cycle | OT | Once through |
| bio | Biomass | IC | Integrated gasification cycle | INT | Intermediate* |
| foil | Heavy oil | ST | Steam turbine | CL | Closed loop tower |
| loil | Light oil | RE | Renewables | DRY | Dry cool |
| coal | Coal | GT | Gat combustion turbine | NCN | No cooling needed |
| wind | Wind | FC | Fuel cell | CHP | CHP heat removal |
| wat | Water | HY | Hydro-electric | N/A | Not available |
| sun | Solar | | | | |
| msw | Municipal solid waste | | | | |
| geo | Geothermal | | | | |
| nuc | Nuclear | | | | |
| | | | | | |
| *e.g. Pond or once through combination tower cooling | | | | | |

**Basic data quality checks, coverage and completeness**

Comparison of the total installed capacity for operational plant shows that the three datasets have similar levels of data coverage.

Table 1 Installed capacity by fuel group (operational only).

| IIASAPP<br>Fuel | 2014<br>Sum of MW |
|---|---|
| bio | 35,164 |
| coal | 1,815,663 |
| gas | 1,509,187 |
| loil | 15,937 |
| foil | 417,898 |
| geo | 11,582 |
| nuc | 344,108 |
| sun | 20,130 |
| wat | 1,030,096 |
| wind | 204,515 |
| msw | 11,735 |
| **Grand Total** | **5,428,700** |

Table 2. Installed capacity by location availability

| STATUS | Operational | | | |
|---|---|---|---|---|
| | Sum of MW | % | Count of units | Source |
| Exact | 1,183,403 | 21.80% | 5,714 | *Raptis* |
| Georeferenced | 1,840,159 | 33.90% | 15,043 | *Raptis* |
| (no location) | 749,057 | 13.80% | 47,740 | |
| Carmageo | 1,656,080 | 30.51% | 68,880 | *Carma* |
| **Grand Total** | **5,428,700** | **100.00%** | **137,377** | |

Further analysis of this capacity with no location information, shows that the majority of capacity is split between the fuel groups: wat; gas; wind; foil and coal (table 2.1). Approximately:

- A quarter of this capacity belongs to 500 units (~125 plants) with unit sizes > 220 MWe.
- Half of this capacity belongs to ~2000 units (~500 power plants) with unit sizes > 100 MWe.
- Filling in the data for these units can be done at a rate of approximately 10 power plants / hour using satellite imagery.

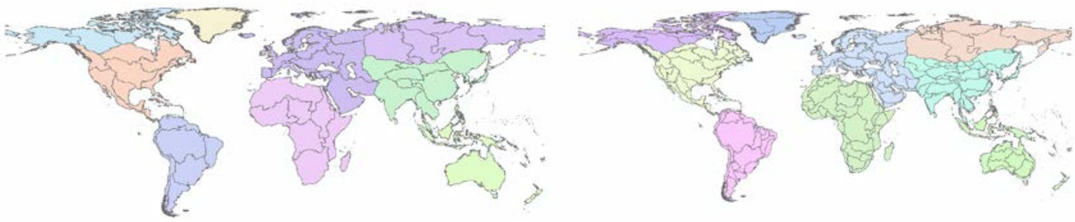
Below, the dataset split by cooling systems is presented by continent (Table 3). Could also be split by country, or river basin, accordingly.

| Table 3. Cooling system shares by continent | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cooling system | AFRICA | ANZ-OCEANIA | ASIA | CIS | EUROPE | LATIN | MIDEAST | N AMERICA | Grand Total |
| CL | 43% | 37% | 49% | 29% | 40% | 19% | 30% | 34% | 40% |
| NCN | 44% | 48% | 25% | 25% | 33% | 71% | 45% | 39% | 34% |
| OT | 10% | 9% | 19% | 32% | 19% | 8% | 15% | 20% | 19% |
| CHP | 1% | 4% | 4% | 8% | 6% | 2% | 9% | 3% | 4% |
| INT | 0% | 2% | 0% | 5% | 1% | 0% | 0% | 3% | 1% |
| DRY | 2% | 1% | 2% | 0% | 1% | 1% | 1% | 1% | 1% |
| (blank) | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| **Grand Total** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Mapping capacity within spatial zones**

We have developed scripts to map the capacity with x-y location data into shapefiles for more powerful GIS analysis. This allows us to analyze what capacity lies within a spatial area, for example, administrative zones, river basins, electricity transmission zones / power pools.

HydroBASINS is a series of polygon layers that depict watershed boundaries and sub-basin delineations at a global scale. The data contains 6-levels of hierarchically nested sub-basins as a range of scales (example shown in Figure 1).



Level 2: ~62 river basins          Level 3: ~292 river basins

Figure 1. HydroBASINS hierarchical classification (Level 2 and 3)

| Table 4. Levels of capacity within each HYBAS basin (level 1) | | |
|---|---|---|
| HydroBASIN | HydroBASIN code | Sum of MW_x |
| Africa | 1010000010 | 127,322 |
| Europe | 2010000010 | 1,300,957 |
| Siberia | 3010000010 | 94,360 |
| Asia | 4010000010 | 1,637,289 |
| Australia | 5010000010 | 124,625 |
| South America | 6010000010 | 201,886 |
| North America | 7010000010 | 1,168,883 |
| Arctic | 8010000010 | 7,774 |
| Greenland | 9010000010 | 63 |
| No location | (blank) | 765,505 |
| | **Grand Total** | **5,428,700** |
| | All capacity with no basin | 765,505 |
| | Capacity with no location and no basin | 749,057 |
| | Capacity with location but no basin (islands) | 16,448 |

Allocation in this way allows to powerful subset analysis from both the perspectives of power plant capacity, and from basin-level perspectives, e.g.:

- Approximately one-third of all thermal power plant capacity that requires cooling is concentrated in 10 river basins, 7 of which in Asia (Table 5, Figure 2)
- For the basin Missisippi Missouri with 260 GW of capacity, three quarters of all estimated cooling water withdrawals can be attributed to coal power plants with once through cooling, which comprise only one quarter of the power plants (300 out of 1,196), totaling 60 GW (Table 6).

| Table 5. Top 10 basins (level 3) with capacity that need reliable cooling water | | |
|---|---|---|
| **Basin name** | **HydroBASIN code** | **Sum of MW_x** |
| Mississippi Missouri | 7030047060 | 257,386 |
| Yangtze | 4030009880 | 200,674 |
| Gironde France West Coast | 2030020320 | 175,940 |
| Japan III | 4030039450 | 154,181 |
| Huang He | 4030007850 | 132,464 |
| China Coast | 4030011690 | 118,941 |
| Ziya He Interior | 4030006940 | 111,299 |
| North and South Korea Bo Hai Korean Bay North Coast | 4030003020 | 108,105 |
| Gulf of Mexico, North Atlantic coast | 7030042040 | 104,056 |
| China Coast 1 | 4030009890 | 90,908 |
| | **Grand Total** | **1,453,955** |

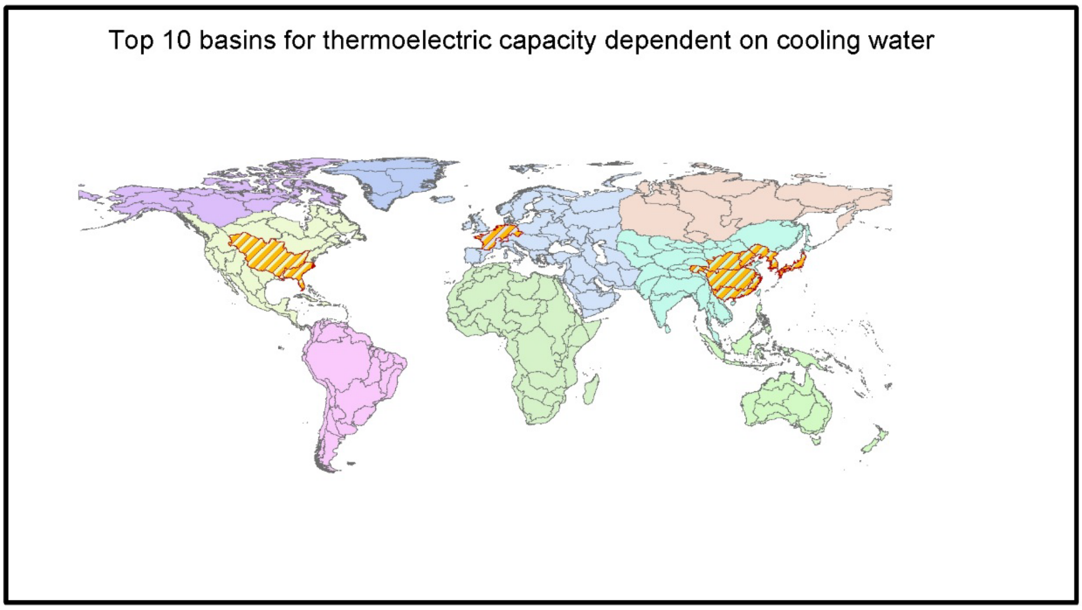



Figure 2. HydroBASIN thermoelectric capacity

Table 6. Single basin (Mississippi Missouri) estimated annual cooling water withdrawals by fuel group and cooling system type

| Fuel type | OT | INT | CL | CHP | DRY | Grand Total |
|---|---|---|---|---|---|---|
| bio | 0% | 0% | 0% | 0% | 0% | 0% |
| coal | 75% | 2% | 1% | 0% | 0% | 79% |
| gas | 13% | 0% | 0% | 0% | 0% | 14% |
| loil | 0% | 0% | 0% | 0% | 0% | 0% |
| msw | 0% | 0% | 0% | 0% | 0% | 0% |
| nuc | 5% | 1% | 1% | 0% | 0% | 7% |
| foil | 0% | 0% | 0% | 0% | 0% | 0% |
| Grand Total | **94%** | **4%** | **3%** | **0%** | **0%** | **100%** |

**Description of rasterization process and capability**

Rasterization procedures have also been developed for gridded datasets in .tiff and .netcdf formats. This allows for more direct comparison with other gridded data products, such as population, climate model and hydrological data.

- We have flexibility to define the resolution, e.g. to ½, 1/8$^{th}$ degree or other
- We can output any table parameters e.g.
  - Sum of MW
  - Estimated water withdrawals / consumption
  - Count of units
  - Power plant age
  - HydroBASIN, administrative region, hydro-economic unit e.g. netCDF file at 1/8$^{th}$ degree with all powerplants grouped by fuel-type and year of construction.

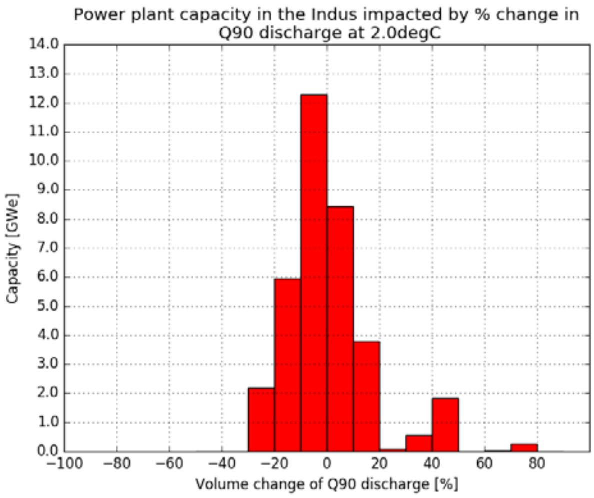



Figure 3. [Example] - Histogram showing the power plant capacity impacted by Q90 “low flows” in the Indus river basin in a 2.0

# Annex II: Preliminary stakeholder process draft

## Purpose of this document

This document is intended to provide a short, clear, shared and up-to-date description of the stakeholder engagement in the ISWEL project so that we have a joint shared understanding of the purpose and proposed methods, outputs and outcomes.

**This draft is provided to initiate discussion between members of ISWEL staff at IIASA.**

## Introduction

High stakes and deep uncertainties about the future suggest that there are mutual benefits for scientists and policy makers to work together applying model-based scenarios in order to develop solutions resilient with respect to a wide range of future threats and opportunities. However, many big challenge remain concerning how to address the specific needs of diverse stakeholder groups (Parsons 2008).

Model-based scenarios are useful to support policy-making process at different stages. Many reviews and evaluations of scenarios processes reveal that they have been quite successful in the business context, supporting strategic decisions at all stages of policy cycle. The beneficial uses of scenarios in this context are summarized here.

| *Policy stage* | *Form of scenario-based decision support* |
|---|---|
| Policy issue identification and framing | Stimulating wider debate about possible futures<br>Getting stakeholders engagement and buy-in<br>Clarifying issues importance with respect to stakeholders' needs and expectations<br>Agreeing objectives |
| Policy measure development | Generating solutions' options for future actions<br>Appraising robustness of options for future actions |
| Policy measure implementation | Using scenario framework and indicators for monitoring of results |
| Policy evaluation | Using shared understanding about stakeholders' needs, expectations and objectives as well as monitoring results to assess solutions effectiveness and efficiency. |

Unfortunately, scenarios use in the public sector has so far been mostly limited to the first stage of the policy cycle (Volkery and Ribeiro 2009), which can be called an indirect support. These findings stand in sharp contrast with the clear need for public policy to address future challenges and uncertainties. Can the success of the private sector in successful application of scenarios to tackle critical strategic problems be replicated? Further background information on stakeholder engagement in the context of model-based scenario development and knowledge brokering is presented in the Supplementary Information (SI) 2.1.

The ISWEL project will develop new approaches to enable institutions from the water, energy, and agricultural sectors to better understand the synergies and trade-offs among sectors and to identify holistic solutions for the sustainable management of water, energy, and land resources that both improve and sustain human welfare and avoid environmental degradation. In addition to global stakeholders, the case studies (The Zambezi and Indus River Basins) will work with regional institutions and country-based stakeholders to inform cross-sectorial assessments and to provide strategic advice on nexus interactions, infrastructure investments, and opportunities for transboundary cooperation. In the context of documented challenges to involve stakeholders in a meaningful way, the ISWEL project will put a special emphasis on careful designing and implementing of stakeholder engagement.

## Why is stakeholder involvement needed in the ISWEL project?

Although the integrated approach to systems analysis that IIASA is undertaking in the project is designed to address complex policy challenges, it is important to go further and understand the needs, demands and priorities of stakeholders in both case study basins. The overall stakeholder engagement strategy needs to include the more complex view of knowledge brokering, going beyond informing and consulting policy makers about the outcomes of model scenarios. Michaels (2009) distinguishes six strategies of knowledge brokering: informing, consulting, matchmaking, engaging, collaborating, and capacity-building. All strategies are complementary to each other and should be adopted for different issues in order to lead to meaningful outcomes. Well executed stakeholder engagement should create greater ownership and use of project outputs as well as contribute to enhancing understanding and capacity.

The possible important objectives for stakeholder involvement are:

- Inform project team about Nexus challenges and considered solutions at the river basin and national scale
- Inform stakeholders about modeling and scenario tools available to address these challenges and analyze solutions pathways
- Jointly frame the most pressing Nexus problems, that require system analysis
- Provide data by stakeholders for calibrating models and shaping future scenarios
- Provide the results of the systems analysis to stakeholders including trade-offs and synergies between solutions
- Enrich modeling frameworks based on insights provided by stakeholders
- Build capacity for using models and systems analysis for policy support

## Who should be involved?

There will be 3 different groups of stakeholders with their corresponding processes:

1. Global
2. Zambezi River
3. Indus River

Private sector actors should be included in all 3 groups.

The full list of proposed stakeholders for each group is under construction in the SI 2.2, to be discussed and updated. In this document there is a list of stakeholders compiled for the proposal.

*Global*

It is proposed the global group of stakeholders will consist of representatives of GEF, UNIDO, TWI2050, World Bank, members of the Project Steering Committee, World in 2050 Initiative, and other invited stakeholders. It should be considered to invite private sector representative(s). Additionally representatives of both case studies will be invited to join this group.

*Zambezi River*

The first contacts will be made through the Zambezi Watercourse Commission (ZAMCOM) - a river basin organization set up by countries that share the Zambezi River Basin. Based on their recommendations as well as the other connections from the ISWEL project (IIASA programs, project steering committee, GEF, UNIDO) the preliminary list of stakeholders will be prepared. Additionally, synergies with the DAFNE (Decision Analytic Framework to explore the water-energy-food Nexus in complex transboundary water resources of fast developing countries; https://dafne.ethz.ch) project will be explored. Initial introduction to the project is scheduled for February 2017. As a result of this more detailed planning, full consultation and engagement will be planned, with an expectation for this to occur in summer 2017.

*Indus River*

The initial entry point for work on the Indus has been to explore the use of the Indus Forum. The next meeting of which is in Sri Lanka in June 2017. It may be that this is not appropriate and we want to set up a parallel, complementary process. This may be facilitate by closer engagement with NMO's and our alumni (Asif Khan) in Pakistan. Also trough Dr. Srivastava contacts with the Water Resources Department of India.

### How the process should be designed and executed?

Stakeholder involvement is planned as a "two-way street" – a mutual learning and exchange process between modelers and policy makers. The first steps in the case studies should concentrate on understanding the broader context of water-energy-land nexus in the basin countries. It is suggested that the activities will proceed as follows:

1. Use a level 'zero' run of the models using SSP's and global data sets to provide stakeholders with a feel of the modelling framework and capabilities (see vison statement).
2. Assess specific policy challenges and stakeholder conflicts and needs in the basin countries,
3. Perform stakeholder analysis producing a list of stakeholders, their interests and relative influence,
4. Detail process of co-design of future scenarios of global and case studies
5. Design specific communication, uptake and capacity strategies (e.g. interactive workshops, policy exercises) to maximize project impact,
6. Outline the timeline of the whole process – events in time, their objectives and expected results.

The big challenge for the ISWEL project is that the models already developed may not be fully matching stakeholders' needs. Also, the new modeling developments in the project, may not fully address their expectations. Therefore, the existing matches between stakeholders' needs and IIASA modeling capacity should be identified early in the project and the stakeholder process should be planned to utilize these matches. One way to achieve this is to start the process is to organize a match-making event at the basin level as a first step of the process.

In the process planning it will be important to identify and engage different stakeholder groups for different purposes (for example, providing model input can be better done by experts using specific methods - e.g. Delphi surveys). Different IIASA teams may also contact specific stakeholders to acquire necessary data, however, such activities need to be coordinated in order to avoid duplicate requests and confusion on the part of stakeholders who may be contacted by different people from the same project.

Other important activities that will be a part of the case study involvement will include raising awareness and capacity building.

### Next steps

Meet to agree, edit and shape this process and document to ensure it meets all requirements.

Specifically:

- Agree outcomes, activities and processes to reach outcomes,
- Discuss and agree who are most appropriate stakeholders,
- Discuss the matchmaking stakeholder event (Workshop set for September 2017)
- Outline timeline towards the first regional meeting and workflow.

SI 2.1: Background information on stakeholder processes

SI 2.2: List of stakeholders – planned for the project activities and Preliminary list of stakeholders (from the proposal)

## Annex III: Project Steering Committee Bios

### Professor David Grey

Professor David Grey has almost 40 years' experience worldwide in inter-sectoral water assessment, management and development. He is a water policy analyst, practitioner and researcher, who has been a manager of interdisciplinary, multi-national teams and large budgets. He is now a visiting professor at the universities of Exeter and Oxford while continuing to work with many governments around the world on water security issues. Professor Grey was a water specialist at the World Bank for 26 years until 2009, becoming its Senior Water Advisor with responsibility for corporate water policies and advisory oversight of the water community and the portfolio of water resources, irrigation, water supply and sanitation and hydropower.

He has had many affiliations over his career, including as Manager of the UNDP-World Bank Water and Sanitation Program, Chair of the World Bank's Water Resources Management Group, Board member of the World Water Council, founding member of the Water and Sanitation Collaborative Council and member of its Preparatory Committee, and a founding partner of the Global Water Partnership. He is a Fellow of the Geological Society. Major current activities include: membership of an International Panel of Experts for the Mekong River Commission and an Advisory Panel for the World Bank's Ganges Strategic Assessment; advising the UN on negotiations on the Euphrates-Tigris River; and a leading role in an international policy and research partnership on water security.

### Professor Youba Sokona

With over 35 years of experience addressing energy, environment and sustainable development in Africa, Dr Youba Sokona is a well-known, leading global figure. Reflecting his status, Dr Sokona was elected Vice-Chair of the Intergovernmental Panel on Climate Change (IPCC) in October 2015. Prior to this, Dr Sokona was Co-Chair of IPCC Working Group III on the mitigation of climate change for the Fifth Assessment Report after serving as a Lead Author since 1990. In addition to these achievements, Dr Sokona has a proven track record of organisational leadership and management, for example as Coordinator of the African Climate Policy Centre (ACPC) and as Executive Secretary of the Sahara and the Sahel Observatory (OSS). Dr Sokona's advice is highly sought after, and as such, he is affiliated with numerous boards and organisations, including as a Member of the Board for the Institute of Development Studies, as a Visiting Professor at the University of Surrey, an Honorary Professor at the University College London (UCL), and as a Special Advisor to the African Energy Leaders Group. In short, Dr Sokona is a global figure, with deep technical knowledge, extensive policy experience and an unreserved personal commitment to African led development.

### Dr Leena Srivastava

Dr Srivastava has over thirty years of experience in the fields of energy and environment, including climate change, policy and economics. She is a member of various committees and boards both at the international and national levels, including; the Executive Committee of the Sustainable Energy for All (SE4ALL) initiative of the UN Secretary General. She is an Independent and Non-Executive Director on the Boards of; Bharti Infratel Ltd. and Shree Cement Ltd. and a Board Member of the; Meridian Institute; World Environment Center and Stockholm Resilience Centre.

She was a member of the Advisory Group on Energy and Climate of the UN Secretary General; Expert Committee to formulate India's Energy Policy, Planning Commission, Government of India, National Security Advisory Board, Government of India; International Advisory Panel, Global Carbon Capture and Storage (CCS) Institute and International Advisory Committee, The Coca Cola Company; Foresight Advisory Council of Suez Environment, Energy Advisory Board of the World Economic Forum and the Expert Committee on Auto Fuels, Government of India. She was a Co-ordinating Lead Author for Working Group III of the Third Assessment Report of Intergovernmental Panel on Climate Change (IPCC) and cross-cutting theme Anchor on "Sustainable Development" for the Fourth Assessment Report of the IPCC.

In 2008, Dr. Srivastava was awarded the Knight of the Order of Academic Palms. She has also received a Certificate of Recognition from the Prime Minister of India a of Richard von Weizsacker Fellowship of the Robert Bosch Stiftung 2012 for her contribution to the work of the IPCC.