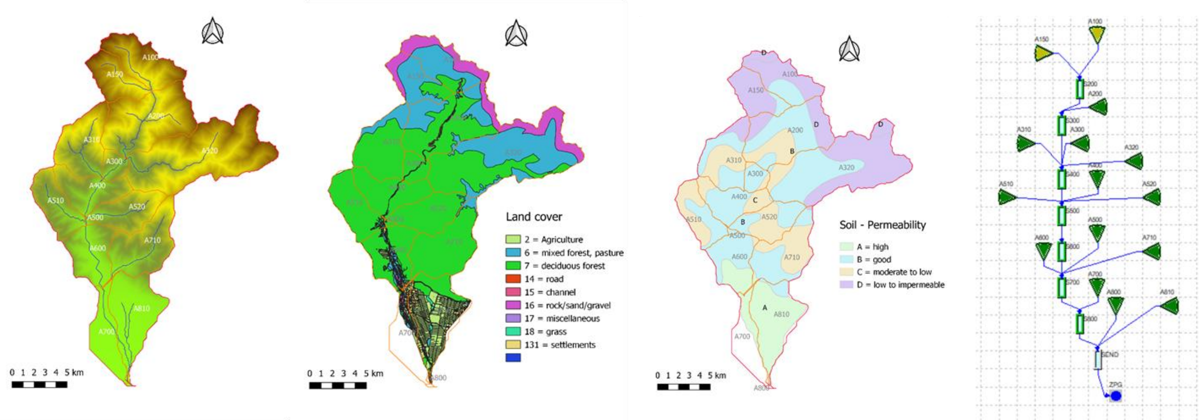
INTERNATIONAL WATERS EXPERIENCE NOTES

Hydrological Modelling for Integrated Water Resources Management



Abstract: Hydrological Modelling was a component within the capacity building module for water managers across sectors and also embedded in the water supply and demand management building block of the Kura II Project. The goal was to introduce state-of-the-art hydrological modelling approaches as well as to assess water resources by means of modelling techniques. The use of hydrological models is not common in both countries. First experiences were gained in Georgia due to international pilot projects covering the Rioni River. Modelling in Azerbaijan gains gradually ground at universities. In essence, modelling has not yet become a standard neither in Georgia nor in Azerbaijan. Hydrological modelling has truly a high potential for replication because it rests on generic principles that are applicable to all watersheds. Thus, hydrological modelling is relevant for all fields of work with respect to water resources management. The replication in the countries will depend on the number of qualified modellers and their access to software and data, which links the success of modelling to the effort of managing hydrological observations efficiently so that data retrieval for modellers is enabled and feasible.

Hydrological Modelling for Integrated Water Resources Management

Experience of the GEF – sponsored

UNDP GEF/IW: Kura II: Advancing IWRM across the Kura river basin through implementation of the transboundary agreed actions and national plans

GEF- ID: 5325

PROJECT DESCRIPTION

UNDP-GEF Kura II Project was developed to address the priority needs in the ministerially endorsed Strategic Action Plan (SAP) through implementation of the SAP and national Integrated Water Resources Management (IWRM) Plans to strengthen and harmonize coordinated conjunctive transboundary ground and surface water management. It comprised five components: Support for institutional governance protocols; professional development and capacity building for water managers across sectors; stress reduction measures in critical areas; stakeholder education and empowerment; and, enhanced science for governance.

Hydrological Modelling was a component within the capacity building module for water managers across sectors and was also integrated in the water supply and demand management building block of the Kura II Project. The capacity building consisted of a set of training blocks which were subdivided in introductory and advanced courses. The training was accompanied with the modelling of two river basins one in each country. The goal was to introduce state-of-the-art hydrological modelling approaches, tools and data sources. The advance course was designed to work closely with national consultants who conducted modelling on their own including data acquisition, data interpretation and presenting on results. Their experience will be used to bring modelling into the water sector as a standard application in both countries.

THE EXPERIENCE

Issue

The use of hydrological models is not common in both countries. Modelling is neither established nor commonly applied. First modelling experiences were gained in Georgia due to international pilot projects covering the Rioni River. Modelling in Azerbaijan gains gradually ground at universities. Georgia has continued modelling through the GCF funded project Scaling-up Multi-Hazard Early Warning System and the Use of Climate Information in Georgia and is currently developing capacity on hydrological and hydraulic modelling within the National Environment Agency. Model applications in water resources management in Azerbaijan are not yet established. In essence, modelling has not yet become a standard neither in Georgia nor in Azerbaijan. This holds also true for climate data products from remote sensing as input into hydrological models.

The number of modelling applications in hydrology is so rich that hydrological modelling has become a must in water resource management. Hydrological models enable the development of scenarios, for example water resources development under climate change, increase in domestic or agricultural water demand, integration of planned infrastructure, or serve as basis of Early Warning Systems, to mention some possible applications.

Another problem is the use of outdated hydrological information, especially in Georgia. Hydrological handbooks dating back to Russian time are still in use. These handbooks neither consider climate change nor contain time series. Using these data for planning purposes has caused problems with the design of hydropower plants in Georgia, which became obvious when generated power falls short more than 50% of what was planned and expected.

Data not incorporating climate change are also in use in the agricultural sector in Azerbaijan. The country has developed standard codes for irrigation for a wide range of crops. The application of these codes assumes climate conditions of a pre-climate change era. It can be expected that the reality might deviate more and more from the standard codes and puts unnecessary risk on irrigation and thus crop yield.

Other examples which call for the application of models is the calculation of water balances, the development of inundation and flood risk maps, establishment of flood early warning systems, environmental impact assessments and reservoir operation and many more.

Addressing the issue

Hydrological modelling was addressed in two training blocks and follow-up activities. The first block introduced hydrological modelling in general and focused on model types and requirements. The trainees must first understand, that modelling is basically about abstraction of the real world. Modelling requires to understand that processes occurring in the real world must be broken down into smaller calculation units (hydrological elements).The real world is sub-divided into hydrological elements each of which consists of parameters, methods and system states. Parameters are distinguished into measurable and estimated. The trainees need to learn how accurate these hydrological elements represent the real world. System states like water level, flow, infiltration and so on can be used to verify a modelling approach through observations and thus account for calibration and verification.

Data sources and GIS are essential parts of modelling. The whole process chain from retrieving data sources in freely available data portals up to watershed extraction to stream reconnaissance and sub-basin development was introduced during the trainings. The GIS is considered the first step it takes to abstract the real world. Maps and terrain models are components of GIS.

The data and GIS sessions revealed the problem that publicly available data sources, web-sites, tools come in English. This is manageable for the young generation, predominantly those who come from the universities, but constitutes a hurdle for all those without proper command of English.

Due to COVID-19 pandemic restrictions from March 2020 the advanced training block was changed to virtual meetings. The purpose of the second block was to apply modelling in both countries, in Georgia for the Stori River Basin, in Azerbaijan for the Shamkir Chay River Basin. The model setup was already settled in the training block one but was revised and updated with soil data and recalibrated using updated time series of rainfall and streamflow. The advanced modeller group was then introduced into more detailed aspects of modelling applications like

- Bias correction of Satellite Rainfall Estimates from remote sensing
- Soil moisture accounting for crop water demand calculations
- Performing long-time continuous simulations
- Calibration and sensitivity analysis of parameters
- Interpreting and presenting results

The virtual training was accompanied with the generation of YouTube videos on hydrological modelling where each video addresses a particular topic. In addition, an Excel-based precipitation-runoff module was developed and translated into Georgian and Azerbaijani.

The virtual training turned into a working group character that facilitated the discussion on data issues, current water management problems in the countries.

RESULTS AND LEARNING

Summary of work and outputs

The lack of experience on hydrological modelling, especially by senior staff, required to start from the scratch. The entire process chain from data acquisition, data interpretation, data processing, modelling setup, calibration, verification, simulation and presenting on results is a task for a full-fledged university course. The difficulty is to balance theoretical background with practical applications.

Based on the training blocks, the following topics could be identified as critical and will require the continuation in terms of capacity building and inclusion into the day-to-day business of the participants.

Measurable versus non-measurable parameters

The parameter set of a model always consists of two kind of parameters. Each model requires calibration in the sense that uncertain parameters need adaptation affecting results. It is the experience of a modeller that tells him, which of the uncertain parameters help improve model performance. A negative example is to adjust the size of a catchment area to change the quantity of runoff. But it is not always easy like that. Soil parameters occur as measured but still are subject to a high uncertainty. The reason is that soil parameters are measured at a specific location and extrapolated to an area. Most of the trainees do not yet have a solid understanding of

- which parameter is relevant
- the range in which a parameter can meaningfully be changed
- why it is allowed to change an obviously “measured” parameter

The lesson learnt is to make stakeholders familiar with the possible ranges and effects of parameters on

Suitable alternatives for missing data and data rescue

Records from ground stations are rare and contain gaps. Many river basins within Georgia and Azerbaijan lack records and if records are available they date back to Soviet time and/or show large gaps. Additionally, there is a lack of knowledge what kind of alternative and publicly available data exist, how to retrieve it from the Internet and how to process it. The key is data processing and file conversion to known formats and subsequent post processing. Good data sources will continuously remain untapped unless knowledge will increase.

Lesson learnt: The data processing needs to be addressed, predominately in Azerbaijan more than in Georgia. Basically, it has nothing to do with hydrological modelling but is a prerequisite. It is strongly suggested that Universities offer courses on data pre- and post-processing with a particular focus on satellite-based datasets and bias correction.

Plausibility checks

Results of a hydrological model must be checked whether or not they are plausible. Performing plausibility checks is a general task for hydrologists and water resources managers and therefore should be well understood and established in practice. There is a need to deepen plausibility checks from the viewpoint of various water resources assessments.

Accuracy of hydrological models

The question of the accuracy of models was a topic. Results from modelling will always deviate from observed records. The point is what difference is acceptable in relation to what parameter. Is the tolerable level of deviation between model and observations for flood peaks and baseflow the same? There is no general approach which level of deviation is tolerable and which not. This cannot be generalised and is site specific. It is basically the modeller's experience that determines the trustworthiness of model results.

Simplification of complex processes – the problem of groundwater recharge

A topic that should be further developed is the non-linear characteristics in terms of water storage and water releases from soil. This is one of the most complex topics in hydrological simulation. The more soil layers exist each with different texture and physical parameters like wilting point, field capacity, saturation and hydraulic conductivity, the more complex is the runoff behaviour. This is superimposed with the delay of surface runoff, interflow and sub-surface flow components until they arrive at an observation point. A simple approach is often preferred over a complex one because it is easier to apply and easier to understand. Hence, there is a risk of oversimplification. One of the crucial hydrological processes, above all in Azerbaijan, is groundwater recharge. Groundwater recharge requires a complex non-linear soil moisture approach including the impact of vegetation (root depth, interception, transpiration, cropping patterns etc.). In other words, any oversimplification with respect to groundwater recharge modelling induces the risk that the process is not adequately covered and triggers wrong conclusions

REPLICATION

Hydrological modelling is truly the topic which has the highest level of replication due to a simple reason: Hydrological modelling rests on general principles that are made specific to a particular location through a variation of parameters and not through a variation of principles.

Hydrological modelling is relevant for all fields of work within water resources management. The replication will depend on the number of qualified modellers and their access to software and data. This means that the success of modelling is linked with the effort to manage hydrological observations efficiently so that data retrieval is enabled. This calls for clear technical standards in terms of database structures, description of metadata and import/export interfaces.

SIGNIFICANCE

Hydrological modelling is essential in integrated water resources management as only modelling enables scenario development for planning, allocating and managing water resources with sufficient details.

The need for foresighted planning of water resources in Georgia and Azerbaijan will increase and thus the need for proper modelling capacities. All climate change related scenario development, for example, relies on modelling. Early warning systems make use of modelling techniques and cross-sectoral assessments are difficult to imagine without suitable tools.

In essence, the number of modelling application in the course of the Kura II project grew steadily the more water issues were addressed and information gathered.

REFERENCES

UNDP-GEF Kura II Project: https://kura-river.org/

KEYWORDS

Hydrology, Hydrological Modelling, Software, Interactive Simulation, Flood, Drought, GIS, River Basin Planning, Early Warning System, Precipitation-Runoff, Water Basin, Integrated Water Resources Management