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Abstract

Simulating the Hydrology of Small Coastal Ecosystems in Conditions of Limited Data

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The impacts of water resources and irrigation development need to be quantified in order to understand the environmental costs of such development activities. Complex data-intensive simulation methods are normally used for this purpose in the developed world. However, lack of reliable data prohibits the use of such models in developing countries where it is more practical to apply models with less data requirements. The report illustrates three applications of simple and pragmatic simulation models to small coastal water bodies in Sri Lanka and South Africa.

Water resources and irrigation development have direct impacts on aquatic ecosystems. These impacts need to be quantified and predicted to understand the environmental costs of water projects. Quantification of such impacts is normally carried out by various simulation methods. However, in most of the developing world such an assessment is hampered by the lack of reliable observations on physiographic characteristics and continuous hydrological and climatic variables used either as input to simulation models or as the data against which models are tested. Complex and information-consuming models may not always be appropriate in such conditions, whereas more simple, pragmatic simulation approaches may perform well, whilst their data requirements can be more easily satisfied.

The report illustrates the use of such pragmatic methods to simulate the hydrology of several small coastal water bodies. Such water bodies are normally ungauged, not well studied throughout the world and are ignored when development projects are planned and implemented. At the same time, they often represent a source of livelihoods for local communities, may have a high recreational value and/or serve as habitats for rare species.

Three examples are illustrated in the report. The first deals with the assessment of the impacts of a future irrigation scheme on a coastal lagoon in southern Sri Lanka. The catchment upstream of the lagoon and the lagoon itself are simulated by water balance models, which operate with a weekly time step. The description of the hydrological processes in the models is simplified, physical details of the upstream tanks and paddy systems are ignored and large parts of the catchment are represented by dummy reservoirs to be commensurate with the level of input information available. Field surveys were conducted and a short-term monitoring program of water levels in the lagoon and two major upstream tanks was established to supply the models with the required input data. Interviews with local residents were also carried out and their results were used for indirect ("soft") model calibration. Several realistic scenarios describing irrigation development and lagoon management are defined and simulated. They include different levels of inflows from the proposed future scheme into the lagoon, envisaged upstream catchment changes associated with the scheme and some aspects of lagoon water-level management, which cope with increasing drainage inflows.

The second example deals with coastal lagoons in Sri Lanka, which are already receiving additional drainage flows from upstream irrigation schemes. The goal in this case is to establish and simulate the reference hydrological condition, which existed prior to irrigation

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development. This reference condition is necessary to quantitatively assess the current impacts on lagoon hydrology and to design a set of management measures to alleviate adverse impacts. This example illustrates how information about lagoons, obtained through interviews with local residents can be translated into quantitative measures describing water level fluctuations. It also shows how a simple spatial interpolation algorithm can be used to simulate a daily time series of reference water levels in the lagoon.

The third example focuses on small temporarily closed/open ungauged estuarine ecosystems along the East Coast of South Africa. The duration of the closed and open phases of an estuarine mouth are determined by the interaction of river inflow and the sea in the mouth region whilst the dynamics of the mouth affects the structure and functioning of the estuarine biotic community. The report describes a simple approach for simulating upstream inflows to estuaries based on duration curves (cumulative probability distributions of flow or rainfall-related catchment wetness index). The report further illustrates how the generated inflows could be used for the simulation of a continuous time series of estuary mouth openings/closures. Inflows are routed through a reservoir model and the estuary mouth is considered open on days when the spillage from an estuarine "reservoir" occurs. The approach is illustrated using limited observed data on estuary mouth conditions from the South African coastline.

The conclusion is that parsimonious simulation methods may serve as a sound basis for the quantification of impacts and generation of required hydrological data of different types, regardless of the number of assumptions and simplifications of the processes involved. Such methods require much less input information and parameters to operate, compared to more complex, distributed, information-consuming and labor-intensive techniques. The methods presented and illustrated in the report are not limited to any specific region. The examples described focus on small coastal water bodies, but the techniques could be used in principle for any ungauged natural coastal system or river/stream and for the simulation of variables other than just water level or flow. Such methods may also identify research and management priorities and specify the requirements for monitoring networks.

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