Using multicriteria analysis to develop environmental flow scenarios for rivers targeted for water resource management

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Abstract

DRIFT is an interactive, holistic approach for advising on environmental flows for rivers. The DRIFT methodology, together with multicriteria analysis (MCA), can be used to provide flow scenarios and descriptive summaries of their consequences in terms of the condition of the river ecosystem, for examination and comparison by decision-makers. The essential features of DRIFT, the output of workshops where it is applied, and the development of the DRIFT database are described. Modules within the database include DRIFTSOLVER and DRIFT CATEGORY. DRIFTSOLVER contains an integer linear programming MCA method, which generates optimally distributed flow scenarios for different total annual volumes of water. DRIFT CATEGORY facilitates evaluation of these in terms of river condition. These two modules are explained in detail and illustrated with examples.

Keywords: environmental flows; interactive holistic approach; DRIFT; multicriteria analysis; scenarios; river condition; integer linear programming.

Introduction

Environmental flows may be defined as water that is left in a river system, or released into it, for the specific purpose of managing the condition of that ecosystem. During the last five decades, about 100 different approaches have been described for advising on environmental flows, and more than 30 countries have begun to use such assessments in the management of water resources (Arthington et al., 2003; King et al., 1999).

There are essentially two kinds of approaches to flow assessments: prescriptive and interactive (Brown and King, 2001). Prescriptive methods usually address a narrow and specific objective in terms of river condition and result in a recommendation for a single flow value or flow regime to achieve it. Outcomes tend not to lend themselves to negotiation, because insufficient information is supplied on the implications of not meeting the recommended value to allow an informed compromise (Stalnaker et al., 1995). Interactive approaches, on the other hand, focus on the relationships between changes in river flow and one or more aspects of the river ecosystem. Once these relationships are established, the debate is no longer restricted to a single interpretation of what the resulting river condition would be. Methods based on the interactive approach are thus better suited for creating scenarios to be used in negotiations.

DRIFT (Downstream Response to Imposed Flow Transformations) is an interactive, holistic approach (Arthington et al. 2003) to advising on environmental flows for rivers (Fig. 1), developed from earlier prescriptive holistic methodologies (King and Louw, 1998), through several applications in southern Africa. It is described in detail in King et al. (2002). The methodology allows data and knowledge to be used to their best advantage within a structured process. The central rationale of DRIFT is that different parts of the flow regime, e.g., lowflows, and small, medium and large floods, maintain different parts of the river ecosystem. Thus, manipulation of one or more kinds of flow will affect the ecosystem differently than manipulation of some other combination. In its totality, DRIFT consists of four modules (biophysical, social use, scenario development and compensation economics, Fig. 1). In the first, or biophysical module, the river ecosystem is described and predictive capacity developed on how it would change with flow changes. In the second, or subsistence module, links are described between riparian people who are common-property subsistence users of river resources, the resources they use, and their health. The objective is to develop predictive capacity of how river changes would impact their lives. In the third module, scenarios are built of potential future flows and of the predicted impacts of these on the river and the riparian people. The fourth, or compensation-economics, module lists compensation and mitigation costs (King et al., 2002).

This paper concentrates on the first part of the third module, in which the outputs from the biophysical module are used with multicriteria analysis (MCA) to create the flow scenarios and their biophysical consequences (Fig. 1). The essential features of DRIFT, the output of DRIFT work sessions and the development of the DRIFT database are described. The use of MCA within the database, specifically within the DRIFTSOLVER and DRIFT CATEGORY routines, to generate flow scenarios and evaluate them in terms of river condition is then explained and illustrated using examples.

Essential features of DRIFT

DRIFT has several features that impart structure to specialist deliberations on the consequences of flow changes (King et al., 2002). Data collection and subsequent deliberations are centred on river sites, each of which is representative of a river reach. The present-day long-term daily flow data for each site are separated

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