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# Towards best practice implementation and application of models for analysis of water resources management scenarios

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ABSTRACT

Water resources management models are widely used to evaluate planning or operational scenarios to support water resource management decision-making. However, the approaches to modelling used in the past have led to problems, such as modellers having difficulty establishing the credibility of their model with stakeholders, and stakeholders having difficulty understanding and trusting model results. A best practice approach to the implementation and application of water resources management models based on a quality assurance procedure is an appropriate means of overcoming these difficulties, and there are a number of guidelines and papers available promoting this approach. However, guidance in these on the use of models to analyse water resource planning scenarios is limited or not provided. This paper therefore provides guidance on the implementation and application of water resources management models with an emphasis on scenario analysis. This guidance is principally intended for practising modellers, and also for peer reviewers and stakeholders such as managers, decision makers, and community-based groups. Adoption strategies and recommendations for future directions are also discussed.



## 1. Introduction

Commonly, water resources management models are used to evaluate a series of planning or operational scenarios to support the complex task of water resources management decision-making. Often the issues being addressed are contentious or sensitive to stakeholders (Mahmoud et al., 2009). Some modelling practices in the past, however, have led to problems including (i) modellers having difficulty in demonstrating to stakeholders that the models are credible in the way they are implemented and function (e.g. underlying model assumptions are explicitly presented) and fit for purpose, (ii) stakeholders having difficulty understanding and trusting results, and (iii) inconsistencies of approach between different implementations and applications of the same modelling platform (e.g. in adjacent river systems) making comparison of results from them difficult and where it is subsequently found to be necessary to connect them, making this impossible.

To address these problems there is now increased emphasis on stakeholder participation in water resources management (Soncini-Sessa et al., 2007; Voinov and Bousquet, 2010). There are also guidelines available promoting a best practice approach to modelling that are relevant to water resources management modelling (e.g. Bay-Delta Modeling Forum, 2000; CREM, 2009; Jakeman et al., 2006; Refsgaard et al., 2005a, 2010; Scholten et al., 2007; USEPA, 2002; Van Waveren et al., 2000). Steps in the procedures in these provide guidance on model implementation and application that is useful for scenario analysis, although not all the procedures include scenario analysis steps (e.g. Jakeman et al., 2006).

In addition, there is extensive literature available on scenario analysis (often referred to as "scenario development"). This includes a number of reviews specifically related to water resources management (e.g. Dong et al., 2013; Leenhardt et al., 2012; Mahmoud et al., 2009; March et al., 2012). More specifically, Dong et al. (2013), Leenhardt et al. (2012) and Mahmoud et al. (2009) propose procedures for model-based scenario analysis. However, while the scenario analysis procedures and modelling guidelines have common features, there are some differences. These could beneficially be reconciled and this topic is addressed in Section 6.

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Arguably, any water resources management modelling activity is either a project in its own right or a task within a project of wider scope. This includes activities that various stakeholders might consider to be part, or all, of ongoing programs. Further, it is arguable that projects (to implement and apply models to evaluate scenarios to support water resources management decision-making) need to include activities to provide decision support to stakeholders (Blackmore et al., 2009). This is on the basis that project team members (defined in Section 2), and particularly modellers, are best placed to advise on how to interpret model results. Including decision support steps enables the project to follow through, from simply delivering model results for a number of promising scenarios, to supporting the process of evaluating these and selecting the one that best meets the objectives. Therefore, guidelines on implementation and application of water resources management models for scenario analysis ought to provide guidance on project administration and decision support as well as on model implementation and application.

Of the above sources, USEPA (2002) provide detailed guidance on project administration with a step-by-step procedure for preparing QA project plans, and CREM (2009) refers to this. Refsgaard et al. (2010) and Van Waveren et al. (2000) recommend establishing a model study plan or model journal. Bay-Delta Modeling Forum (2000) discuss the role of a technical advisory committee as one of a number of mechanisms for involving stakeholders in modelling projects. The other sources do not discuss project administration.

The only two of these sources that discuss approaches for providing decision support are Leenhardt et al. (2012) and Mahmoud et al. (2009). Hence, none of the above sources cover both project administration and decision support.

This paper therefore proposes a procedure that includes project administration and decision support steps as well as steps for model implementation and application (Fig. 1). This enables all these steps to be seen in the one place. In view of the importance of scenario analysis for water resources management, it provides guidance on the steps in the procedure from the perspective of modelling requirements for scenario analysis.

The procedure draws on material in recent guidelines (Black et al., 2011; Black and Podger, 2012) that are consistent in principle with the earlier guidelines mentioned above. It also draws on guidance on developing and evaluating water management scenarios from the perspective of stakeholder interaction provided by Voinov and Bousquet (2010).

The overall guidance in this paper is principally intended for modelling practitioners. It is also intended to indicate to independent experts, including peer reviewers, and stakeholders, such as managers, decision makers and community-based groups, how modelling should be approached and assist in managing their expectations of model capability.

The remainder of this paper is structured as follows. Section 2 lists key participants in water resources management modelling. This is followed by a definition of the term “best practice modelling” in Section 3. Sections 4 and 5 discuss the meanings of the terms “scenario” and “scenario analysis”. Section 6 compares the scenario analysis procedures of Dong et al. (2013), Leenhardt et al. (2012) and Mahmoud et al. (2009) and reconciles these with the steps in the procedure in Fig. 1. The procedure advocated in this paper is then outlined throughout Section 7. The paper concludes with a discussion of adoption strategies in Section 8 and recommendations for future directions in Section 9.

## 2. Key participants

Key participants include:

- Modellers: anyone with knowledge of water resources management computer models and the underlying processes the models represent. Modellers use these models on behalf of stakeholders. Modellers are often referred to as scientists in the literature (e.g. Dong et al., 2013; Leenhardt et al., 2012; Mahmoud et al., 2009) but this may be too restrictive as the term is not always interpreted as including engineers, for

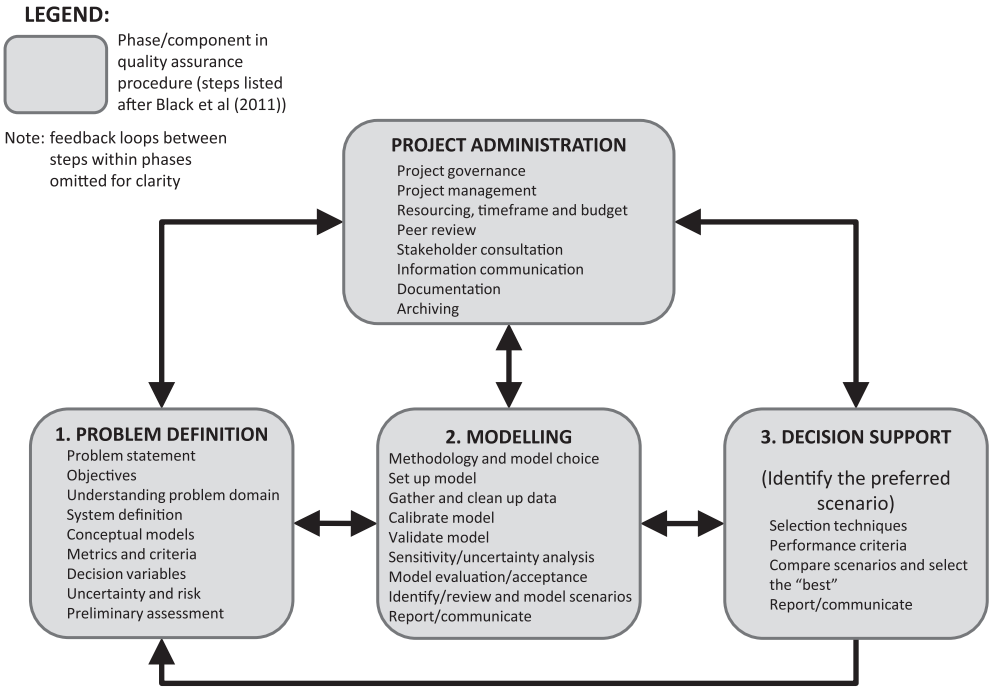


**Fig. 1.** Procedure for quality assured model implementation and application for scenario analysis.