

# Hydrologic-economic appraisal of life-cycle costs of inter-basin water transfer projects

PH van Niekerk\* and JA du Plessis

Department of Civil Engineering, University of Stellenbosch, P/Bag X1, MATIELAND 7602, South Africa

## ABSTRACT

This article describes research that compares actual water transfers of an inter-basin transfer (IBT) scheme with its original, appraisal stage, prediction. Transfers are shown to be significantly less and also more variable than predicted. Further research reveals that the state of the receiving system has a large bearing on year-to-year decisions regarding water transfers. Past appraisals, following what is called the Incremental Approach, do not adequately consider the stochastic nature of the likely future inter-basin transfer operating regime.

Examination of six case studies, four South African, one Chinese and one Australian, shows that the Incremental Approach is still in general use – despite tools available for an improved approach. A new approach, called the Comprehensive Approach, is proposed to upgrade estimations of variable costs associated with water transfers – often substantial life-cycle cost components of IBTs.

A demonstration of the Comprehensive Approach, by means of an example of an IBT with significant pumping costs associated with water transfers, is provided. Uncertainty regarding future water transfers and associated variable costs are provided for by stochastic simulation modelling. The Incremental Approach is shown to be severely biased with respect to variable costs and it is shown that this bias leads to significantly different estimations of likely life-cycle project costs. Such differences conceivably lead to suboptimal decision-making.

**Keywords:** Water resources, inter-basin water transfer, project appraisal, life-cycle costs, stochastic modelling

## INTRODUCTION

This article reviews the methodology of appraising inter-basin transfer (IBT) projects and proposes an improved approach. To meet water requirements, especially in arid and semi-arid parts of the world, a large number of IBT projects have been constructed or are planned (see extensive listing of IBTs in Snaddon et al. (1999)). In South Africa, due to its geographic and climatic characteristics and coupled to its mineral endowment, the complex interconnected Vaal River System, with the inclusion of a number of IBTs, has been developed over the years to serve the economic heartland of the country (Triebe et al., 1994). In the future, in addition to non-conventional measures such as water demand management and water re-use, more IBTs will be required (Van Rooyen et al., 2010).

IBTs often involve pumping water to overcome differences in elevation. The associated energy costs typically form a significant part of the life-cycle costs of IBTs and it is expected that such energy costs will proportionally increase in future as water has to be sourced from more distant basins (DWA, 2010f). It is therefore important that a robust appraisal methodology be followed when assessing the costs of water transfers of future IBT projects.

## METHODOLOGY

Case study research and secondary data analysis (Van Niekerk, 2013) was employed to examine the accuracy of the appraisal

approach, called the Incremental Approach, originally followed during the planning of the Usutu-Vaal Government Water Scheme (GWS) (Second Phase) – an IBT scheme. Differences between forecasted and actual water transfers were examined further to identify causal factors. This included an in-depth analysis of 22 years of annual operating analyses. From the results of this research, shortcomings of the Incremental Approach are identified.

Having established the shortcomings of the Incremental Approach, further case study research was conducted to assess whether the planning approach today differs materially from that of the earlier studies, particularly in the light of the far more sophisticated systems analysis modelling tools currently available. Six case studies, four from South Africa, one from the People's Republic of China and one from Australia, were selected.

The four South African case studies were selected on the basis of these being recent investigations conducted by different sets of service providers, well recognised locally and internationally in the field of water resource engineering and management. The two international case studies were chosen on the basis of geographic spread, the recognised status of the agencies involved, and the availability of information. Criteria for the evaluation were developed and these were used to classify the appraisal approaches followed in the case studies.

To address the shortcomings of the Incremental Approach, a new appraisal approach, called the Comprehensive Approach, involving integrated systems simulation and application of decision analysis theory, is proposed. The application of the new approach, as well as the differences in outcomes regarding the estimation of the present value of water transfers and associated variable operational costs, is illustrated by means of an example.

\* To whom all correspondence should be addressed.

☎ +27 82 807 4981; e-mail: [peter.v.n@mweb.co.za](mailto:peter.v.n@mweb.co.za)

Received 30 November 2012; accepted in revised form 8 July 2013.