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Effects of selected dams on river flows of Insiza River, Zimbabwe

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Abstract

This paper examines effects of three dams on flow characteristics of Insiza River on which they are located. The storage capacities of these dams varies from an equivalent of 48–456% of the mean annual runoff. Mean annual runoff and annual maximum flood flows have not been modified by the presence of these dams. The average number of days per year without runoff had decreased downstream of two dams. A comparison was made of flow duration curves at sites upstream and downstream of the selected dams. Significant differences were detected between the flow duration curves of upstream and downstream sites. Exceedance frequencies of low flows had decreased downstream of two dams, while these had increased downstream of the other dam. The study recommends development of operating rules for these dams that will ensure that changes detected in low flows do not adversely affect instream flow requirements.

Keywords: Dams; Flow duration curve; Flow modification; Low flows

1. Introduction

Zimbabwe like most of the southern African region receives rainfall during a four month rainy season (mid-November to mid-March) with the rest of the year being dry. Most rivers have flows during the rainy season only due to the seasonality of rainfall. Rainfall has also a high inter-annual variability resulting in water shortages during some years if there is no adequate carry-over storage. The development of dams to store water during the rainy season for use in the dry season, and also storing water during years with above average rainfall for use during years with below average rainfall has been a major strategy for improving the reliability of water supply (Mazvimavi, 1998). The development of commercial agriculture, mining, and urban areas has always been associated with dam development in Zimbabwe. There are over 10000 dams of various capacities in the country, and the proportion of the total storage capacity to mean annual runoff, the storage ratio, varies from 1 to 4 on several catchments particularly on the central part of the country (Mazvimavi, 1998). Flow regimes for catchments with high storage ratios (>1) are likely to have been modified by the developed dams (Graf, 1999; Batalla et al., 2004). There has not been a study which has investigated effects of dams on flow regimes in Zimbabwe. Previous studies on anthropogenic influences have examined effects of land use changes on river flow characteristics (Andrews and Bullock, 1994; Lørup et al., 1998). The importance of identifying and managing environmental effects of dams including modification of river flows was highlighted by the World Commission on Dams (WCD, 2000). Within southern Africa, knowledge of effects of dams on river flows is increasingly becoming important as national legislation (e.g. Water Act of Zimbabwe, Water Act of South Africa) require allocation of water for environmental uses before a permit for abstracting or storing water is granted (King

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et al., 2000; Hughes, 2001; Hughes and Hannart, 2003). This paper aims to determine the effects on river flows of dams developed across a selected river in Zimbabwe. Such a study will provide information which can be used to derive operating rules that satisfy instream flow requirements.

2. Study area

The study has been done on the Insiza River catchment (3401 km^2) located within the semi-arid southern part of Zimbabwe (Fig. 1). Insiza River is a tributary of Mzingwane River that drains into the Limpopo River, and contributing around 9% of the runoff of the latter river (Görgens and Boroto, 1997). Mean annual rainfall varies within the study area from 480 mm/y on the southern lower part which is at an altitude of about 1100 m, to 690 mm/y on the northern upper part with altitude of 1420–1500 m. Precipitation tends to occur in the form of wet spells followed by dry spells during the rainy season which extends from November to March.

The catchment of Insiza River is underlain by gneissic and granitic rocks, giving rise to moderately shallow, coarse grained kaolinitic sands, and moderately shallow clays and loams (Ashton et al., 2001). Land use is mainly a mixture of croplands, pastureland and woodland (Hearn et al., 2001). The northern part with moderately high rainfall has low open woodland of *Combretum–acarcia–terminalia* on granitic or gneissic derived sandy soils. Towards the south sparse low *mopane* woodland is gradually replaced by *Terminalia sericea* open woodland (Kileshye Onema, 2004; Timberlake, 1989). Cropping includes commercial farming (largely resettled) in the north, often under irrigation, and smallholder farming (mostly rainfed) in the south. Irrigation in the south includes schemes managed by farmer committees, and household vegetable gardens (Maisiri et al., 2005; Chigerwe et al., 2004).

The Zimbabwe National Water Authority Water Permit Database shows that there were 59 water permits for both abstraction and storage of water within the Insiza catchment in year 2004. The total capacity of all the impoundments within the Insiza catchment was $27\,860 \times 10^3$ m^3. Table 1 presents the year of first filling, and full supply

Table 1
Fully supply capacity of dams on Insiza River which have been selected for investigating their effects on river flows

Name of dam	Year constructed	Full supply capacity (10^3 m^3)
Silalabuhwa	1966	23 454
Upper Insiza	1967	8 829
Insiza	1973	173 491
Total		205 774

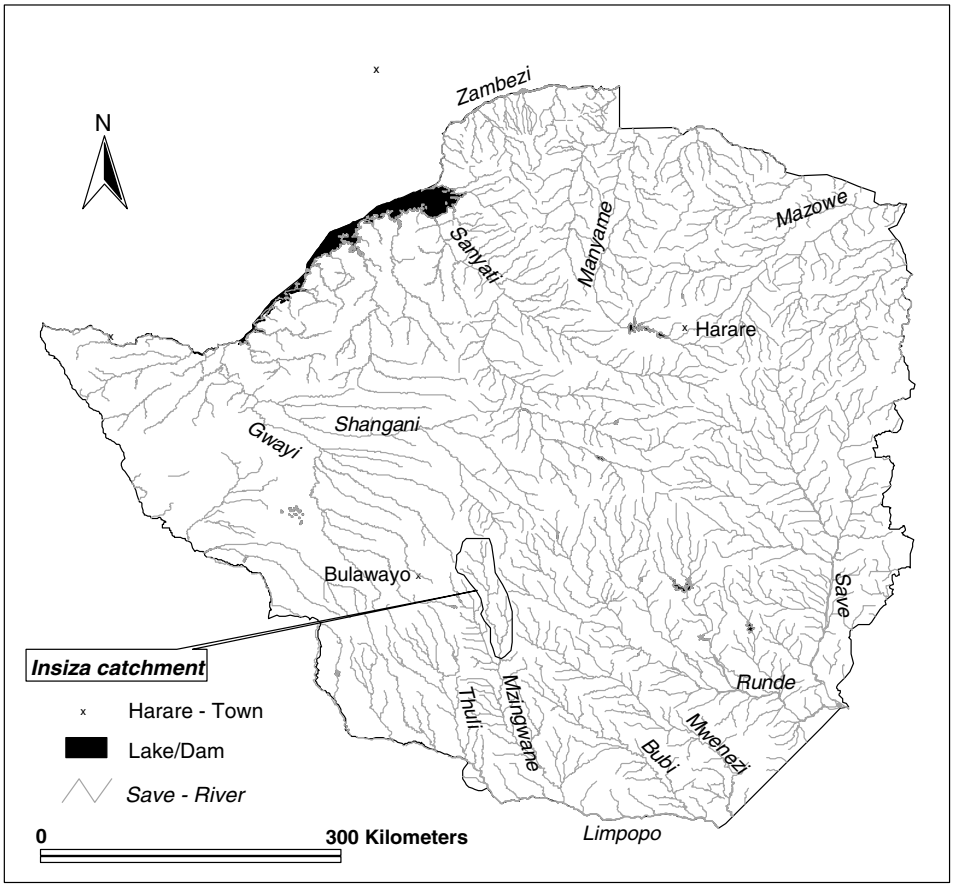

Fig. 1. Location of the study area in Zimbabwe.