A conceptual theoretical framework to integrally assess the possible impacts of climate change on domestic irrigation water use

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ABSTRACT

Southern Africa is likely to experience higher evapotranspiration and altered rainfall characteristics due to global warming and climate change. Climate-driven water use may potentially stress water supply facilities due to increased demand and reduced surface water yield. This paper presents a conceptual theoretical framework for assessing impacts of climate change on domestic irrigation water use. The prediction of climatic conditions that may potentially influence future water use is reviewed together with regional capacity for downscaling global climate projections. The impact assessment of water use is based on the modification and adaptation of an existing end-use model for water demand to include parameters for climate change. The Penman-Monteith equation and the soil water balance equation are incorporated for the estimation of daily water needs of vegetated areas in residential properties. The paper also discusses data requirements and a calibration procedure to improve model fit to the observed domestic irrigation water use. The proposed approach could form a basis for constructing a detailed model for planning various adaption measures relating to climate-driven domestic irrigation water use.

Keywords: climate change, outdoor water use, end-use model, irrigation water use

INTRODUCTION

Research context

Domestic water use comprises indoor and outdoor components. Water is needed outdoors mainly for garden irrigation – to water vegetation such as lawns, flowerbeds and trees. Other outdoor water uses include pool top-ups, washing of cars, washing of hard surfaces, etc.. Water may also be used for small-scale urban agriculture – to grow edible plants like herbs, fruit and vegetables. Various climatic parameters impact outdoor water use, including, for example, rainfall, evapotranspiration and ambient temperature (Balling et al., 2008; Praskievicz and Chang, 2009; Breyer and Chang, 2014). This climatically-driven water use profile is particularly true for edible plants with seasonal growth.

Climate change has been reported to affect parameters requisite for estimating irrigation requirements (Gutzler and Nims, 2005; Balling and Cubaque, 2009), and may thus have important implications for modelling residential outdoor water use. To study the impacts of climate change on residential outdoor water use, it is vital to incorporate biophysical interrelationships pertinent to outdoor water using features. In this regard, water end-use models are more likely to produce better results compared to models that are built on aggregated water use measurements (Bennett et al., 2013). Research is still needed to estimate the impact of climate change on water use at the end-use level, thereby augmenting other existing broad-scale efforts aimed at assessing the current and future capacity of water resources to meet domestic, agricultural and environmental water requirements.

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Objectives

The main objective of this paper is to present a conceptual theoretical framework for a Climate Impact Water Use (CIWU) model that would integrate climate change impacts into a residential end-use model for estimating domestic irrigation water use. The goal is to present a framework or tool that could ultimately feed into a more complex model in future to predict long-term impacts of climate change on outdoor water use. In this paper, the focus is on lawn and garden irrigation which, when present on a residential property, contributes significantly to water use (Jacobs et al., 2007).

Pricing, technological change and other socio-economic factors have also been reported to influence water use (Howe and Lineweaver, 1967; Butler and Memon, 2006). While such factors may change over time and thereby impact domestic irrigation water use, they have been disregarded in the modelling framework presented. Instead, the proposed end-use model allows for the analysis of the impact of predicted changes in climatic parameters on domestic irrigation water use of a specific residential property in a 'static environment' wherein non-climatic parameters remain constant.

Motivation

On a global scale, impacts of climate change on the water cycle are mainly manifested in the increased intensity and frequency of extreme events (Rana et al., 2014; Niang et al., 2014). The Mediterranean and southern Africa regions are generally expected to experience a significant decline in water resources due to global warming (IPCC, 2007; Niang et al., 2014). Thus, sustainable management of water resources and implementation of action plans to deal with possible water shortages require a good understanding of water end-uses and their response to climate change.

Water supply utilities are already facing pressure to

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