Optimal Allocation of Rainfall in the Sichuan Basin, Southwest China

Weihua Zhang · Chaofu Wei · Jia Zhou

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Abstract  Traditional water allocation at a regional or basin scale can be too coarse to be used in a local area such as a village. For example, in the hilly area of Sichuan Basin the landform is fragmented and land use pattern consists of small farms. Furthermore, seasonal drought occurs frequently due to spatially and temporally variability in rainfall patterns. These droughts often lead to a reduction in crop yield or no yield at all. Due to the remoteness and scale of the farms, the farm populations are dependent on the annual crop yield. A poor harvest can mean serious hardships to the farmers. In order to mitigate the seasonal drought we first analyzed the drought characteristics from both meteorological and soil aspects. The results showed that both the spring droughts and canicular days (dog-day) droughts had in excess of a 60% chance of occurring. Using a water balance approach, we found that a series of storage ponds and bunds could greatly reduce the impact of these droughts.

Keywords  Seasonal drought · Water allocation · Crop evapotranspiration · Soil reservoir · Water balance

1 Introduction

It is well known that two of the greatest problems of the modern society are water shortage, degradation of the environment due to population growth and human interference in the natural eco-system. Among various water users, agriculture is the largest one, consuming more than 70% of all available freshwater (García-Vilaa et al. 2009). Hence, it is a primary task to improve water use efficiency and develop water
saving agriculture (Falkenmark 2007). Hence, the aim of this paper is to explore ways to make efficient use of natural precipitation and to improve irrigation efficiency.

Generally, inadequate rainfall leads to drought. In southern China, the overall amount of rainfall and evapotranspiration (ET) is almost the same, however, seasonal drought occurs frequently due to spatial and temporal variability in rainfall. Consequently, the agriculture sector is vulnerable to occasional inadequate rainfall. A number of studies have been undertaken on the characteristics of seasonal drought in Southern China (Zhang and Zhang 1995; Wang 1997; Liu et al. 2003; Huang et al. 2004). These propose various approaches and models to evaluate drought, however, due to the special soil characteristics of hilly area of Sichuan Basin, the soil drought index model was found to be the best method to represent the seasonal drought characteristics.

The soil water holding capacity can be considered as a soil reservoir and is a function of soil type, soil properties, land use pattern, vegetation cover, climate and human-made factors. Considering these properties, an effective way to improve water use efficiency is to use biological or engineering measure to enhance interception from runoff and hence to increase in situ infiltration into soil (Guo et al. 2003; Zhang et al. 2010). Approximately 60% of the world staple food production relies on rainfed irrigation (Savenije 2002). Therefore, improving the efficiency of rainfall use must be beneficial. Hence, much research on rainwater use has focused on the soil water balance and the potentials of catching and storing rain (Coroza et al. 1997; Alemaw and Chaoka 2003; Ochola and Kerkides 2003; Jain et al. 2004; Dashrath 2005). However, there is still a problem with effectively distributing rainwater catching facilities or engineering structures in order to water use efficiency.

Current research on water balance under human influence were mainly focused on micro or field-scale, macro or provincial-scale, or river basin scale (Jasrotia et al. 2009; Pachpute et al. 2009; Tang et al. 2002; Wang et al. 2003; Yang et al. 2005). However, to our knowledge, there are no existing studies on local water allocation for agriculture in the Sichuan Basin of Southwest China. The study was prompted by the seasonal drought in the hilly area of Sichuan Basin, which brings huge economic losses for agriculture sector. Hence the objective was to analyze the characteristics of seasonal drought and the water balance between supply and demand and proposes a design of ponds in order to mitigate the seasonal droughts.

2 Material and Methods

2.1 Description of the Study Area

Sichuan Basin locates in southwest China, including the whole Chongqing and most part of Sichuan Province, with a southern sub-tropics warm and humid climate. The annual precipitation is 1,200 mm; however, 80% of the rainfall falls from May to September in the form of rainstorms. Seasonal or local droughts occur frequently following the wet period. Due to historical reasons, the water use efficiency is quite low with its surface irrigation system. Similarly, the hilliness of farmland results in poor water holding capacity of the soil. Furthermore, the landform of the study area is fragmented. Thus, to use the rainwater resources in situ becomes an ideal way to mitigate the seasonal drought.