1. **Introduction**

Water Resources Management is an integrating concept for a number of water sub-sectors such as hydropower, water supply and sanitation, irrigation and drainage, and environment (Gasinov and Yenilmez [7]).

The water resources management includes (Jairaj and Vedula [10]):

- The quantitative and qualitative exploration of water resources;
- Water requiring inventory records;
- Measurement and matching of the water resources and water needs (demands) in a special system; and
- Decision support depending on the results.

Up to now, fuzzy set theory has been applied to broad fields. Fuzzy set theory introduced by Zadeh [28] creates a model that is set up using approximately known data. Fuzzy numerical data can be represented by means of fuzzy subsets of the real line, known as fuzzy numbers. For the fuzzy set theory development, we may refer to the papers of Kaufmann [12] and Dubois and Prade [3]. They extended the application of algebraic operations of real numbers to fuzzy numbers by using a fuzzy principle. Fuzzy linear constraints with fuzzy numbers were studied by Dubois and Prade [3]. Lu et al. [16] introduced the definition of an inexact rough interval fuzzy linear programming method and investigated the allocation of generated water to agricultural irrigation system. In the real-world problems, uncertainties may be estimated as intervals. Shaocheng [20] studied two kinds of linear programming with fuzzy numbers called interval numbers and fuzzy number linear programming. Tanaka et al. [22] formulated and proposed a method for solving linear programming with fuzzy coefficients. Wang and Huang [25] developed interactive two-stage stochastic fuzzy programming for managing water resources. They proposed an interactive resolution method within inexact two-stage stochastic programming. A two-stage optimization framework for planning reservoir operations was proposed by Wang and Adams [23], where hydrologic uncertainty and seasonal reservoir inflows were modeled as in a periodic Markov process. Through a two-stage dynamic programming approach, long-term hydrothermal scheduling of multi-reservoir systems was examined by Ferrero et al. [5]. Bellman and Zadeh [1] introduced the concept of a maximizing decision-making problem. Zhao et al. [29] introduced a complete solution set for fuzzy linear programming problems using linear and nonlinear membership functions. For water resources management, Huang and Loucks [9] proposed inexact two-stage stochastic programming. An interactive fuzzy resolution method for solving linear programming problems with fuzzy parameters was proposed by Jimenez et al. [11]. For enhancing water resources management, a number of optimization techniques were developed (Slowinski [21], Wu et al. [26], Jairaj and Vedula [10], and Maqsood et al. [17]). A model for obtaining an optimal multi-period operation within a multi-reservoir system was developed by Eiger and Shamir [4]. Xu et al. [27] investigated and applied an inexact two-stage fuzzy gradient chance-constrained programming method to the water resources management in Heshui River Basin, Jiangxi Province. To quantify the economic trade-offs when reducing groundwater abstraction to a sustainable level, Martinsen et al. [18] applied a multi-objective multi-temporal deterministic hydro economic optimization approach for this purpose. Fu et al. [6] proposed a two-level symmetric Nash-Harany leader-follower game model to resolve the conflict that arises when different water users compete for a limited water supply. Khalifa [14] studied the water allocation problem using the two-stage fuzzy random programming. An interval-valued fuzzy linear programming method for modeling parameters with high vagueness was represented by Wang et al. [24], Goralczany [8], and Cai et al. [2]. Khalifa and Al-Shabi [15] developed an approach for optimizing the water resources management problem based on the weighting method.

This paper aims to introduce and solve the problem of water resources management as two-stage stochastic fuzzy linear programming. The problem is considered by incorporating fuzzy numbers. A solution method for solving the problem with fuzziness in relations is suggested to demonstrate its applicability.

The remainder of the paper is organized as follows. Some preliminaries are given in Section 2. In Section 3, a water resources management problem introduced by Huang and Loucks [9] and Wang and Huang [25] is introduced; hence, the problem is investigated in a fuzzy environment. Characterization of $\alpha-$fuzzy optimal solution of the problem is presented in Section 4. A solution method for solving the problem is proposed in Section 5. In Section 6, a numerical example is given for illustration purposes. Finally, some concluding remarks are reported in Section 7.