Title

Discussion of “Multiobjective Management of Water Allocation to Sustainable Irrigation Planning and Optimal Cropping Pattern” by R. Lalehzari, S. Boroomand Nasab, H. Moazed, and A. Haghighi

Journal

Journal of Irrigation and Drainage Engineering, 143(4)

ISSN

0733-9437

Authors

Sarzaeim, Parisa
Bozorg-Haddad, Omid
Fallah-Mehdipour, Elahe
et al.

Publication Date

2017-04-01

DOI

10.1061/(asce)ir.1943-4774.0001146

Peer reviewed

Discussion of "Multiobjective Management of Water Allocation to Sustainable Irrigation Planning and Optimal Cropping Pattern" by R. Lalehzari, S. Boroomand Nasab, H. Moazed, and A. Haghighi

DOI: 10.1061/(ASCE)IR.1943-4774.0000933

Parisa Sarzaeim[1]; Omid Bozorg-Haddad[2]; Elahe Fallah-Mehdipour[3]; and Hugo A. Loáiciga, F.ASCE[4]

[1]M.Sc. Student, Dept. of Irrigation and Reclamation Engineering, Faculty of Agriculture Engineering and Technology, College of Agriculture and Natural Resources, Univ. of Tehran, Daneshkadeh St., Karaj, 3158777871 Alborz, Iran. E-mail: Parisa.Sarzaeim@ut.ac.ir

[2]Professor, Dept. of Irrigation and Reclamation Engineering, Faculty of Agriculture Engineering and Technology, College of Agriculture and Natural Resources, Univ. of Tehran, Daneshkadeh St., Karaj, 3158777871 Alborz, Iran (corresponding author). E-mail: OBHaddad@ut.ac.ir

[3]Postdoctoral Researcher, Dept. of Irrigation and Reclamation Engineering, Faculty of Agriculture Engineering and Technology, College of Agriculture and Natural Resources, Univ. of Tehran, Daneshkadeh St., Karaj, 3158777871 Alborz, Iran; National Elites Foundation, Tehran, Iran. E-mail: Falah@ut.ac.ir

[4]Professor, Dept. of Geography, Univ. of California, Santa Barbara, CA 93016-4060. E-mail: Hugo.Loaiciga@geog.ucsb.edu

Water supply has become a serious concern in many regions because of population growth and unbalanced spatial and temporal precipitation patterns. In Iran, about 90% of the available water resources is used for agriculture, which requires careful management. Evolutionary algorithms are suitable tools for aiding with water-resources management, as evidenced by previous works (e.g., Chang and Chang 2009; Fallah-Mehdipour et al. 2011, 2012; Aboutalebi et al. 2015; Yang et al. 2015; Lerma et al. 2015) and different fields of inquiry such as reservoir operation (Ahmadi et al. 2014; Bolouri-Yazdeli et al. 2014; Ashofteh et al. 2013a, 2015a), groundwater resources (Bozorg-Haddad et al. 2013; Fallah-Mehdipour 2013b), conjunctive use operation (Fallah-Mehdipour 2013a), design-operation of pumped-storage and hydropower systems (Bozorg-Haddad et al. 2014), flood management (Bozorg-Haddad et al. 2015b), water project management (Orouji et al. 2014), hydrology (Ashofteh et al. 2013b), qualitative management of water resources systems, (Orouji et al. 2013; Bozorg-Haddad et al. 2015a; Shokri et al. 2014), water distribution systems (Seifollahi-Aghmiuni et al. 2013; Soltanjalili et al. 2013; Beygi et al. 2014), agricultural crops (Ashofteh et al. 2015b), sedimentation (Shokri et al. 2013), and algorithmic developments (Ashofteh et al. 2015c).

Lalehzari et al. (2015) reported an optimal allocation of water resources for agriculture in the Baghmalek plain, which is located in Khuzestan province, Iran. Two objectives were considered in the discussed paper: (1) net benefit and (2) relative water use efficiency. This bi-objective optimization problem was solved by the nondominated sorting genetic algorithm (NSGAII). Their results in the discussed paper reported a successful application of the NSGAII in finding an optimal and accurate irrigation scheduling in the study area.

The NSGAII- is a multiobjective optimization tool introduced by Deb et al. (1999). The NSGAII has 5 steps: (1) random initialization, (2) nondominated sorting, (3) crossover, (4) mutation, and (5) elitist crowding comparison (Chang and Chang 2009). Firstly, a population that includes chromosomes is selected randomly. Next, the objective function of each chromosome (where a chromosome is the name given to a possible solution to the optimization problem) is calculated, and the population is sorted according to a comparison criterion such as crowding distance. Thereafter, a selection operator such as a tournament is used to select the appropriate parents. The tournament operator selects by comparison using two criteria: (1) a nondominated rank and (2) a crowding distance in the population. In the next step, the crossover and mutation operators are employed to produce a new population for the next iteration.

Because of the random initialization of the NSGAII process there is no assurance that optimal Pareto fronts can be achieved with a single run. Yet, in the discussed paper the NSGAII was run only once, casting doubt on the optimality of the reported Pareto front.

To illustrate the random nature of NSGAII solutions, the following bi-objective benchmark problem reported by Kursawe (1991) is solved:

$$\text{Minimize } F = [f_1(\vec{x}), f_2(\vec{x})] \quad -5 \le x_i \le 5 \quad i = 1, 2, 3 \tag{1}$$

$$f_1(\vec{x}) = \sum_{i=1}^{2} -10e^{-0.2\sqrt{x_i^2 + x_{i+1}^2}} \tag{2}$$

$$f_2(\vec{x}) = \sum_{i=1}^{2} [|x_i|^{0.8} + 5\sin(x_i^3)] \tag{3}$$

The problem described by Eqs. (1)–(3) was solved with the NSGAII, setting the number of chromosomes = 20 (population size) and running it for 500 generations (or populations). Fig. 1 shows that this problem has a different solution (expressed as a Pareto front) in each run. For this reason, the NSGAII must be run several times, say, 10 times, and the most suitable Pareto front chosen as judged by the decision maker.

The method for determining the crossover and mutation probabilities is also worth mentioning. The simplest method for determining these two operators is sensitivity analysis. According to the identification of the ideal point by the particle swarm optimization (PSO) method in the discussed paper, the crossover and mutation should be determined in such a way that the difference between the

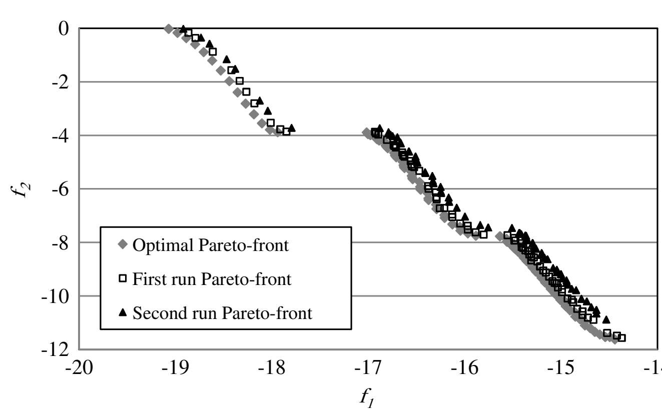

Fig. 1. Different sample Pareto fronts

J. Irrig. Drain Eng., 2017, 143(4): 07016023

ideal points of the final Pareto front of the PSO is a minimum. Therefore, sensitivity analysis should be implemented to determine the best crossover and mutation probabilities to achieve the minimal difference between the ideal points of PSO and of the Pareto front.

References

Aboutalebi, M., Bozorg-Haddad, O., and Loáiciga, H. A. (2015). "Optimal monthly reservoir operation rules for hydropower generation derived with SVR-NSGA II." *J. Water Resour. Plann. Manage.*, 10.1061/(ASCE)WR.1943-5452.0000553, 04015029.

Ahmadi, M., Bozorg-Haddad, O., and Mariño, M. A. (2014). "Extraction of flexible multi-objective real-time reservoir operation rules." *Water Resour. Manage.*, 28(1), 131–147.

Ashofteh, P.-S., Bozorg-Haddad, O., Akbari-Alashti, H., and Mariño, M. A. (2015c). "Determination of irrigation allocation policy under climate change by genetic programming." *J. Irrig. Drain. Eng.*, 10.1061/(ASCE)IR.1943-4774.0000807, 04014059.

Ashofteh, P. S., Bozorg-Haddad, O., and Loáiciga, H. A. (2015a). "Evaluation of climatic-change impacts on multi-objective reservoir operation with multiobjective genetic programming." *J. Water Resour. Plann. Manage.*, 10.1061/(ASCE)WR.1943-5452.0000540, 04015030.

Ashofteh, P.-S., Bozorg-Haddad, O., and Mariño, M. A. (2013a). "Climate change impact on reservoir performance indices in agricultural water supply." *J. Irrig. Drain. Eng.*, 10.1061/(ASCE)IR.1943-4774.0000496, 85–97.

Ashofteh, P.-S., Bozorg-Haddad, O., and Mariño, M. A. (2013b). "Scenario assessment of streamflow simulation and its transition probability in future periods under climate change." *Water Resour. Manage.*, 27(1), 255–274.

Ashofteh, P.-S., Bozorg-Haddad, O., and Mariño, M. A. (2015b). "Risk analysis of water demand for agricultural crops under climate change." *J. Hydrol. Eng.*, 10.1061/(ASCE)HE.1943-5584.0001053, 04014060.

Beygi, S., Bozorg-Haddad, O., Fallah-Mehdipour, E., and Mariño, M. A. (2014). "Bargaining models for optimal design of water distribution networks." *J. Water Resour. Plann. Manage.*, 10.1061/(ASCE)WR.1943-5452.0000324, 92–99.

Bolouri-Yazdeli, Y., Bozorg-Haddad, O., Fallah-Mehdipour, E., and Mariño, M. A. (2014). "Evaluation of real-time operation rules in reservoir systems operation." *Water Resour. Manage.*, 28(3), 715–729.

Bozorg-Haddad, O., Ashofteh, P.-S., Ali-Hamzeh, M., and Mariño, M. A. (2015a). "Investigation of reservoir qualitative behavior resulting from biological pollutant sudden entry." *J. Irrig. Drain. Eng.*, 10.1061/(ASCE)IR.1943-4774.0000865, 04015003.

Bozorg-Haddad, O., Ashofteh, P.-S., and Mariño, M. A. (2015b). "Levee layout and design optimization in protection of flood areas." *J. Irrig. Drain. Eng.*, 10.1061/(ASCE)IR.1943-4774.0000864, 04015004.

Bozorg-Haddad, O., Ashofteh, P.-S., Rasoulzadeh-Gharibdousti, S., and Mariño, M. A. (2014). "Optimization model for design-operation of pumped-storage and hydropower systems." *J. Energy Eng.*, 10.1061/(ASCE)EY.1943-7897.0000169, 04013016.

Bozorg-Haddad, O., Rezapour Tabari, M. M., Fallah-Mehdipour, E., and Mariño, M. A. (2013). "Groundwater model calibration by metaheuristic algorithms." *Water Resour. Manage.*, 27(7), 2515–2529.

Chang, L. C., and Chang, F. J. (2009). "Multi-objective evolutionary algorithm for operating parallel reservoir system." *J. Hydrol.*, 377(1–2), 12–20.

Deb, K. (1999). "Multi-objective genetic algorithms: Problem difficulties and construction of test problem." *Evol. Comput.*, 7(3), 205–230.

Fallah-Mehdipour, E., Bozorg-Haddad, O., and Mariño, M. A. (2011). "MOPSO algorithm and its application in multipurpose multireservoir operations." *J. Hydroinform.*, 13(4), 794–811.

Fallah-Mehdipour, E., Bozorg-Haddad, O., and Mariño, M. A. (2012). "Real-time operation of reservoir system by genetic programming." *Water Resour. Manage.*, 26(14), 4091–4103.

Fallah-Mehdipour, E., Bozorg-Haddad, O., and Mariño, M. A. (2013a). "Extraction of optimal operation rules in aquifer-dam system: A genetic programming approach." *J. Irrig. Drain. Eng.*, 10.1061/(ASCE)IR.1943-4774.0000628, 872–879.

Fallah-Mehdipour, E., Bozorg-Haddad, O., and Mariño, M. A. (2013b). "Prediction and simulation of monthly groundwater levels by genetic programming." *J. Hydro-Environ. Res.*, 7(4), 253–260.

Kursawe, F. (1991). "A variant of evolution strategies for vector optimization." *Lect. Notes Comput. Sci.*, 496, 193–197.

Lalehzari, R., Boroomand Nasan, S., Moazed, H., and Haghighi, A. (2015). "Multiobjective management of water allocation to sustainable irrigation planning and optimal cropping pattern." *J. Irrig. Drain. Eng.*, 10.1061/(ASCE)IR.1943-4774.0000933, 05015008.

Lerma, N., Paredes-Arquiola, J., Andreu, J., Solera, A., and Schi, G. (2015). "Assessment of evolutionary algorithms for optimal operating rules in real water resources systems." *Environ. Modell. Software*, 69, 425–436.

Orouji, H., Bozorg-Haddad, O., Fallah-Mehdipour, E., and Mariño, M. A. (2013). "Modeling of water quality parameters using data-driven models." *J. Environ. Eng.*, 10.1061/(ASCE)EE.1943-7870.0000706, 947–957.

Orouji, H., Bozorg-Haddad, O., Fallah-Mehdipour, E., and Mariño, M. A. (2014). "Extraction of decision alternatives in project management: Application of hybrid PSO-SFLA." *J. Manage. Eng.*, 10.1061/(ASCE)ME.1943-5479.0000186, 50–59.

Seifollahi-Aghmiuni, S., Bozorg-Haddad, O., and Mariño, M. A. (2013). "Water distribution network risk analysis under simultaneous consumption and roughness uncertainties." *Water Resour. Manage.*, 27(7), 2595–2610.

Shokri, A., Bozorg-Haddad, O., and Mariño, M. A. (2013). "Reservoir operation for simultaneously meeting water demand and sediment flushing: A stochastic dynamic programming approach with two uncertainties." *J. Water Resour. Plann. Manage.*, 139(3), 277–289.

Shokri, A., Bozorg-Haddad, O., and Mariño, M. A. (2014). "Multi-objective quantity–quality reservoir operation in sudden pollution." *Water Resour. Manage.*, 28(2), 567–586.

Soltanjalili, M., Bozorg-Haddad, O., and Mariño, M. A. (2013). "Operating water distribution networks during water shortage conditions using hedging and intermittent water supply concepts." *J. Water Resour. Plann. Manage.*, 10.1061/(ASCE)WR.1943-5452.0000315, 644–659.

Yang, T., Gao, X., Sellars, S. L., and Sorooshian, S. (2015). "Improving the multi-objective evolutionary optimization algorithm for hydropower reservoir operations in California Oroville-Thermalito complex." *Environ. Modell. Software*, 69, 262–279.