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Implementing the Strategic Environmental Management Approach to Dams and Hydroelectric Power Plants for Optimizing Environmental Pollution Control Processes in the Utilizing Phase Using NEURO SOLUTIONS Software (Case study: The Dams of Siah Bisheh in Mazandaran)

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ABSTRACT

Introduction: The purpose of the present applied research is to design a comprehensive, inclusive and flexible process for a suitable strategic planning based on effective factors and parameters.

Materials and Methods: To this end, strategic operational programs for controlling environmental pollutants were identified using the logic and algorithm applied in the artificial neural network model and Neuro Solutions software, prioritizing the weight of the programs and predicting the probable future ecosystem conditions. The Delphi approach was used to screen and perform pairwise comparisons of criteria factors, sub-criteria and strategic action plans. The SWOT matrix technique was implemented to control environmental pollutants. Then, in the fuzzy neural network, Neuro Solutions software was used to prioritize weighting and predicting future probable conditions to form the matrices of decision as entrance ANN model was used.

Results: The output of the implementation of the Neuro Solutions software shows that the strategic action plan has developed a comprehensive and integrated landscape system consistent with the nature of the forest, mountain and valley of the Siah Bisheh with a score of weighing 0.6161 in the first priority and last priority (12th rank) which are subject to periodic audits. The environment has been allocated to increase the ecosystem's ability to return in the face of natural and human hazards with an odd weight of 0.5673.

Conclusion: Based on this fact, among the studied indices, economic, social and cultural factors ranked first among the criteria studied, and tourism ranked first among the sub criteria of the study.

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Introduction

Recently, the optimization and development of pumped storage plants are due to the strategies and policies of developing the increasing use of energy plants especially new energy plants in the global level [1]. As the most important role and task of the pumped storage plants in advanced and developed countries, the improvement of the electricity

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quality in the system of distribution and energy storage produced from new sources and its provision regarding the network at the time of need is defined [2]. In this way, the production of energy can be sold at an affordable price and uncertainty in the efficiency of wind and solar energy will be reduced to a considerable extent [3, 4]. It is worth noting that the total capacity of the world's pumped storage plants in 2009 is estimated to be around 127 GM, and currently there are the world's largest storage pumping projects in Japan, United States of America, China and Russia [3]. Pumped storage plants have at least two reservoirs or lakes at two different heights, one at a high level and another at low level [5]. The method of working is that at a low consumption time, the surplus energy available on the network, is pumping the water stored in the bottom tank to the top of the tank so that the water is used as a potential energy for high consumption in the lake [6]. When the consumption rate is higher than the capacity of the national power plants, the turbines of these plants will be activated by releasing the stored water from the high lake to the stored potential of water converting to electric energy (hydropower). The launching of these power plants, like other hydroelectric plants, usually takes about 1 to 4 minutes [7]. The dam plants and reservoir pumped plant of Siah Bisheh is the first and only pumped storage plant in Iran which is currently operating in the Mazandaran Province near a village with the same name. At the time of consumption, the capacity of the plant is 960 MW, and at the time of power generation, it is 1040 MW. The main objective of this project is to create a balance in the country's electricity grid in high load hours and low consumption [8]. The site is located in the heart of the Alborz area, 10 km away from the Kandovan tunnel, and its distance to Tehran is 125 km. The most important characteristic of the Siah Bisheh is its location in the vicinity of the Chalus road which affects the traffic on this strategic axis of commuting and the movement of machinery and transportation of related equipment. In addition, the presence of avalanches and the loss of the surrounding mountains, the cold and rainy seasons causes a slowdown in the operation of the plan [9]. Determining and prioritizing strategic action plans for environmental pollution control in dams and in hydroelectric power plants is one of the most important environmental needs of the present time. On the other hand, the processes of the implementation and operation of the plan and the synergistic occurrence and aggravation of the various environmental pollutants inside and outside the operating range of the upper and lower dams of Siah Bisheh can have interactive effects and repercussions on each other [10].Therefore, based on all the thinking and effective approach of strategic environmental planning, the determination and prioritization of strategic action plans for optimal control of environmental pollutants in the phase of operation of dams and pumping stations of the Siah Bisheh is located on the agenda of this study. For this purpose, the using Neuro Solutions software capabilities based on neural network models has been applied.

Materials and Methods

Methods and techniques for collecting information in the present research include: internet searches, review of information resources and useful records, library studies, and vector mapping from baccalaureate resources, field observations and organizational reviews. Then, the information was analyzed and summarized based on expert judgment, Delphi questionnaire, SPSS and Excel software, SWOT, Fuzzy Topsis model and Artificial Neural Network model (Neuro Solutions software) [11]. In terms of Siah Bisheh dams position, it is worth mentioning that Siah Bisheh's reservoir dams and reservoirs are located 125 kilometers far from the north of Tehran and 12 kilometers far from the north of Kandovan tunnel in Mazandaran Province along the Chalus River. The location of the site is near the village of Siah Bisheh, so it's called with the same name. (Iran Water and Power Resources Development Company, 2014). Access to the dams and the storage pumping stations of Siah Bishe is the communication axis of Tehran-Chalous (Kandovan Road) considering the fact that the site is located along the Kandovan Road. Therefore, in the position of high and low dams of the grove, the access road to the above sites from the main road is split into the above-mentioned dams.

Ethical issues

This research was approved at the research ethics committee of Shahid Sadoughi University of Medical Sciences, Iran with the Ethics Code of IR.SSU.SPH.REC.1399.058.

Results

The most reliable information on the pollution of water resources in the study area is the results of the sampling ordered by the Water and Power Resources Development Company of Iran and by the Water and Energy Research Center (affiliated to the University of Technology of Sharif), between February 2002 and March 2003 which is shown in Table 1:

Table 1: Contaminated sources of rivers in the study area

Pollutant sources		Pollutants	River name			
			Donna	Elica	Garm Rodbar	Chlus
Human Resource Pollutants	Sewage of villages and residential buildings	NH_3,NO_3,Coliform,TSS,pH	Lower Donna Higher Donna	Elica Klavanga Kamarben	There is no accommodation	Imam Ali's garrison Siah Bisheh Vali Abad
	Restaurant sewage and tourist sites	NH_3,NO_3,Coliform,TSS,pH	There are no tourist places or restaurants	There are no tourist places or restaurants	There are no tourist places or restaurants	Donna khakak Zagoleh Pole Abi
	Industrial and mineral wastewater	Heavy metals , TSS, TDS, pH, SO_4	There is no industrial and mining units	Donna Leading Mine Concentrate of Donna Lead and Zinc	There is no industrial and mining units Concentrate of Donna Lead and Zinc	There is no industrial and mining units
	Agricultural waste	PO_4, NO_3, pH, TSS,TDS	Agricultural lands of the lower and upper Dune villages	Agricultural lands of the villages of Elika, Cambria and Collagna	There are no agricultural lands in the region	There are no agricultural lands in the region
natural sources	Mineral deposits	metals,SO_4, TSS COLOR	Unknown	Unknown	Unknown	Unknown

In accordance with the methodological process of the present research, at this stage of research, the design of various four strategies during the previous stage was followed. In order to optimize the process of controlling environmental pollutants in the phase of operation of high and low dams of Siah Bisheh and also in the direction of operational objectives of these strategies, 12 strategic action plans have been designed and defined in the agenda of the proposed modeling process:

SAP1: Minimizing the loading of development activities of the dams of Siah Bisheh in unspoiled areas with emphasis on forest areas

SAP2: Compliance with legal requirements in the area of the protected area, the Chalus River as well as the lakes behind and above the dams in the Siah Bisheh region

SAP3: Paying attention to type, depth, permeability and type of soil in loading of upstream and downstream dam's development activities in Siah Bisheh region

SAP4: Paying attention to the condition of springs and surface water in the area of activities requiring structural loading in the operating range of high and low dams of Siah Bisheh region

SAP5: Periodic environmental audits and surveys to improve the reversible quality of Siah Bisheh ecosystems in the face of natural and human hazards

SAP6: Corrosive and slide areas are stabilized

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using natural preservatives and vegetation, especially around the internal access roads and the operational range of high and low Siah Bisheh dams

SAP7: Implementation of a comprehensive waste management mechanism for getting separated from the source and minimizing per capita waste production in Siah Bisheh region

SAP8: Maximum utilization of treated wastewater in non-greasy and unsustainable areas at the level of Siah Bisheh

SAP9: Developing a comprehensive and integrated system of landscapes consistent with the nature of the forest, mountains and valleys of the Siah Bisheh

SAP10: Implementation of afforestation and green space development in order to maintain the soil and to cope with pollution of water and soil at the operational level of the upper and lower dams of Siah Bisheh

SAP11: Determination of the required water permitting the capacity and providing suitable river engineering patterns to reduce sedimentation in the upper and lower dams of Siah Bisheh.

SAP12: Minimizing the use of fossil fuels, the use of renewable resources and new recycling energies, as well as the implementation of a pilot activity - a frame without production of CO_2 in the operational range of high and low dams of Siah Bisheh

The results of weighting and ranking of effective strategic parameters in the decision-making and the policy of environmental pollutants control during the exploitation phase of Siah Bisheh dams in this section of the studies and based on the methodological process approved by the research for prioritizing and weighing types of strategic parameters effective in the decision-making process and policy of controlling environmental pollutants in the phase of exploitation of high and low dams in different levels of influence, including strategic elements, strategic criteria, strategic sub-criteria, and ultimately, action strategies, in the form of the artificial intelligence and fuzzy artificial neural network models, software of Neuro Solutions, were used properly to carry out the research.

In line with the purpose of this study and the implementation of the Delphi approach based on the outputs, two relevant questionnaires were completed. Then, each of the above parametric levels including the main components, criteria, sub-criteria and strategic action plans based on the geometric mean of the variables of the Delphi questionnaires (previously analyzed in the SPSS software environment) as the input of the ANN model and the Neuro Solutions software were converted into the form of decision matrix . The results of the implementation are presented below. Results of weighting and ranking of factors (indices) affecting the decision-making process and policy of controlling environmental pollutants in the phase of exploitation of high and low Siah Bisheh dams, based on the implementation of the Delphi approach, is shown as follows:

Rank (1): Economic, social and cultural indices with a score of 0.453

Rank (2): indices of environmental pollution with a score of 0.421

Rank (3): physical indices with a score of 0.415

Rating (4): Dam design indices with a score of 0.189

- ***Ranking of criteria for economic, social and cultural factors:***

Rank (1): tourism criterion with a score of 0.697

Rank (2): Land use criterion with a score of 0.462

Rank (3): The criterion of distance between sensitive human centers and populated centers with a score of 0.448

Rank (4): demographic and sociological criteria with a score of 0.311

- ***Ranking of criteria for environmental pollution factors:***

Rating (1): The criterion of pollution caused by dam construction with a score of 0.627

Rating (2): The criterion of field pollution with a score of 0.313

- ***Ranking of criteria for physical factors:***

Rank (1): Water resources with a score of 0.544

Rating (2): Air and climate criteria with a score of 0.449

Rank (3): Topographic structure and shape of the ground with a score of 0.353

Rating (4): Soil criterion with a score of 0.347

Rank (5): Geological criterion with a score of 0.300

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- ***Ranking of dam design factors (indices):***

Rank (1): Damping criterion with a score of 0.291

Rating (2): Designing dam specifications with a score of 0.146

- ***Ranking sub-criteria of economic, social and cultural criteria:***

1. Ranking the following criteria for tourism

Rank (1): Natural sub-criterion with a score of 0.856

Rank (2): Historical sub-criterion with a score of 0.592

Rank (3): Sport sub-criterion with a score of 0.332

2. Ranking of sub-criteria for land use

Rank (1): Sub-criterion of land use pattern based on upstream designs with a score of 0.359

Rank (2): The sub-criterion of the current land use model with a score of 0.173

3. Ranking sub-criterion of distance from sensitive human centers and population centers

Rank (1): The sub criteria of distance from health centers with a score of 0.697

Rank (2): The sub criteria of distance from urban centers with a score of 0.691

Rank (3): Sub-criterion distance from educational centers with a score of 0.530

Rank (4): Rural sub criteria with a score of 0.428

4. Ranking sub-criteria for demographic and sociological criteria

Rank (1): The sub-criterion of the population growth rate with a score of 0.542

Rank (2): The sub-criterion of population with a score of 0.519

Rank (3): The sub-criterion of immigration rate with a score of 0.491

Rank (4): The sub-criterion of pyramid of the population with a score of 0.350

- ***Ranking the criteria for environmental pollution standards:***

1. Rank the standard sub-criteria for pollution caused by dam construction

Rank (1): The sub-standard of air pollution with a score of 0.803

Rank (2): The sub-criterion of water and soil pollution with a score of 0.795

Rank (3): The sub-criterion of visual contamination with a score 0.655

Rank (4): Under the noise pollution criterion with a score of 0.565

2. Ranking the following criteria for the pollution of the environment:

Rank (1): The sub-standard of air pollution with a score of 0.786

Rank (2): The sub-criterion of water and soil pollution with a score of 0.613

Rank (3): The sub-criterion of noise pollution criterion with a score of 0.395

Rank (4): The sub-criterion of visual contamination with a score of 0.385

- ***Ranking the sub criteria of physical criteria:***

1. Ranking the following sub-criterion of water resource

Rank (1): The following is the rate of water discharge with a score of 0.797

Rank (2): The sub-criterion of quality of water with a score of 0.691

Rank (3): Sub criteria of water resources types with a score of 0.671

Rank (4): The sub-criterion of the aquifer station level with a score of 0.552

2. Ranking the sub criteria for air and climate

Rank (1): The sub-criterion of the prevailing wind intensity with a score of 0.589

Rank (2): Sub-standard for wind direction with a score of 0.576

Rank (3): Sub- standard for the temperature, with a score of 0.488

Rank (4): The sub-criterion of the rate of raining with a score of 0.332

Rank (5): The sub-criterion of types of inclination of raining and snowing with a score of 0.227

3. Ranking of the criteria of the topographic structure and the shape of the land

Rank (1): The sub-criterion of altitude above sea level with a score of 0.747

Rank (2): The sub-criterion of the geographic orientation with a score of 0.696

Rank (3): The sub-criterion of the gradient with a score of 0.382

4. Ranking the following the sub-criteria for soil criteria

Rank (1): The Sub-criterion of land suitability with a score of 0.797

Rank (2): The sub-criterion of soil texture with a score of 0.740

Rank (3): The sub-criterion of the soil level criterion with a score of 0.697

Rank (4): The sub-criterion of the soil depth with a score of 0.688

5. Ranking the sub-criteria of the geological criterion

Rank (1): The sub-criterion of tectonic condition with a score of 0.748

Rank (2): The sub-criterion of lithology with a score of 0.458

Rank (3): Sub criteria for formations and geological organization with a score of 0.395

- ***Ranking sub criteria for dam designing:***

1. Ranking the sub-criteria for overlapping and breaking the dam

Rank (1): The sub-criterion of the reservoir area of the dam with a score of 0.741

Rank (2): The sub-criterion of the total reservoir capacity with a score of 0.736

Rank (3): The sub-criterion of the dam of lake with a score of 0.678

Rank (4): Sub-criteria for the length of the dam lake with a score of 0.381

2. Rated the sub-criteria for the design of the dam

Rank (1): The sub-criterion for the height part of the dam with a score of 0.622

Rank (2): The sub-criterion of a damper width with a score of 0.579

Rank (3): The sub-criterion of the crest dam with a score of 0.549

Rank (4): The sub-criterion of the dam's crown length with a score of 0.375

Discussion

In order to rank and propose strategic action plans in line with strategic decision-making on controlling the environmental pollution in high and low dams of Siah Bisheh, artificial neural network model (ANN) and the software environment Neuro Solutions were used. Firstly, the form of the Fuzzy Topsis model was used to formulate decision matrices. So, the options for these matrices are the same as the twelve extraction strategic action plans of the SWOT matrix [12, 13]. To this end, the outputs related to the Delphi questionnaire completion process were entered into the Excel software. After completing the Excel sheet, the results of prioritizing the strategic action plans for the environmental decision making of the Siah Bisheh were recorded in terms of weight and entered into the software of Fuzzy Topsis

Finally, the average of 12 sheets for the twelve action plans was calculated in Excel.

The Delphi approach has been used to screen and perform pairwise comparisons of factors, components, criteria, sub-criteria and strategies for controlling environmental pollutants. Also, for surveying experts in a variety of selected target groups according to the determined sample size based on Cochran reformed formula for limited population in two stages, Delphi questionnaire (total of 29 questionnaires) has been completed. In order to assess the validity of the research, the pretest method was used to validate the Delphi questionnaire and SPSS software was used to verify the results of completion of the Delphi questionnaire. The relevant Cronbach's alpha coefficient for the first and second stages of the questionnaire, were equal to 0.793 and 0.989, respectively. Then, using SPSS statistical analysis results, the components weighting, criteria and sub-criteria influencing the decision making of environmental strategy in Siah Bishe’s dams were compared. Based on this fact, among the studied indices, economic, social and cultural factors (with a score of 0.453) ranked first among the criteria studied, and tourism (with a score of 697) ranked first among the sub criteria of the study [13]. On the other hand, the implementation of the SWOT matrix technique has led to the extraction of external opportunities and threats and internal strengths and weaknesses. It also provided the definition and designing of 12 strategies on the range of scenarios and four various strategies of SO, ST, WO and WT. Then, a neo-Frazy model is used to prioritize weight and predict future probable conditions in relation to designed strategies in the framework of the fuzzy neural network model (ANFIS). To achieve this purpose,

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Fuzzy Topsis model and software for forming decision matrices are used as an input for artificial neural network mode [12, 14].

Conclusion

Implementing Artificial Neural Network algorithmic forecasting process (ANN) is based on training data graph and test data in order to analyze the approximation values of data with actual values and to obtain the result of the absolute ideal parameters matching the outputs of Real Output and the prediction (ANN Output). The result of the ideal conditions of information and data derived from the output of the second phase of the Delphi questionnaire are obtained through the output of Neuro Solutions software

Accuracy of Training Data: 58.99%

Accuracy of the Test: 37.99% (Figure 1, 2)

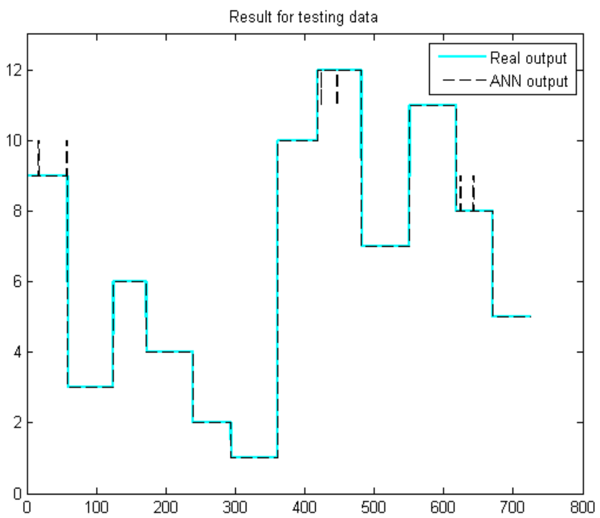

Figure 1: Neuro Solutions software test data graph in relation to the prediction of the weighting of priorities for strategic action plans of the environmental pollution control of Siah Bisheh

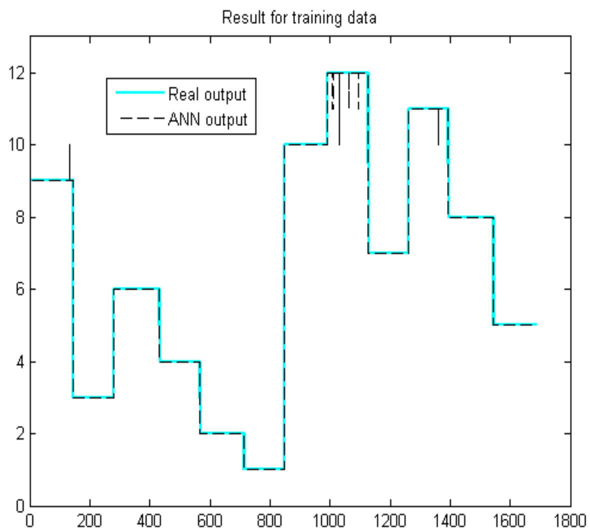

Figure 2: Neuro Solutions software training data graph in conjunction with the prediction of the weight of strategic plans for controlling environmental pollutants in Siah Bisheh

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Training index (blue line): equivalent to 70%
Testing index (red line): equivalent to 15%
Validation Index (Green Line): equivalent to 15%
All indices (blue, red, and green lines):
Equivalent to r = 0.99
Conclusion: Ideal condition (Figure 3, 4)

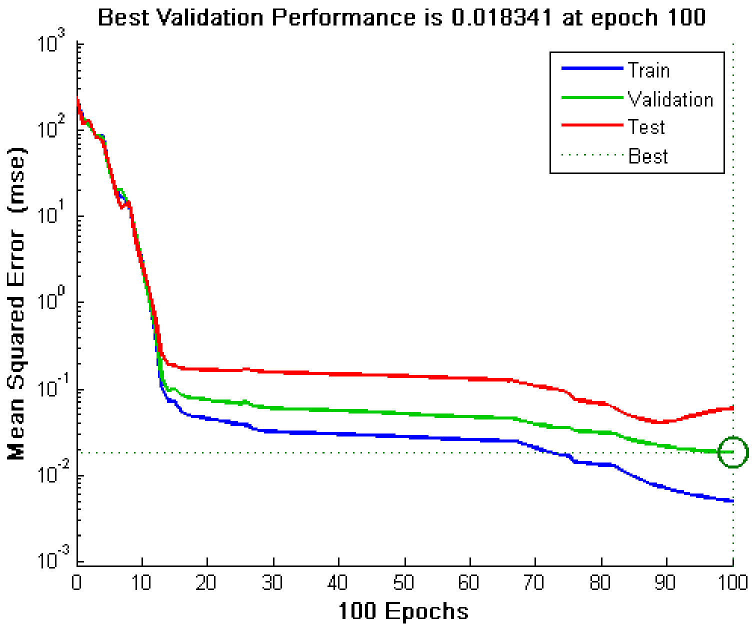

Figure 3: Curve graph of error of training in Neuro Solutions software environment in conjunction with the prediction of weighting the priorities of strategic action plans for environmental pollution control in Siah Bisheh dams

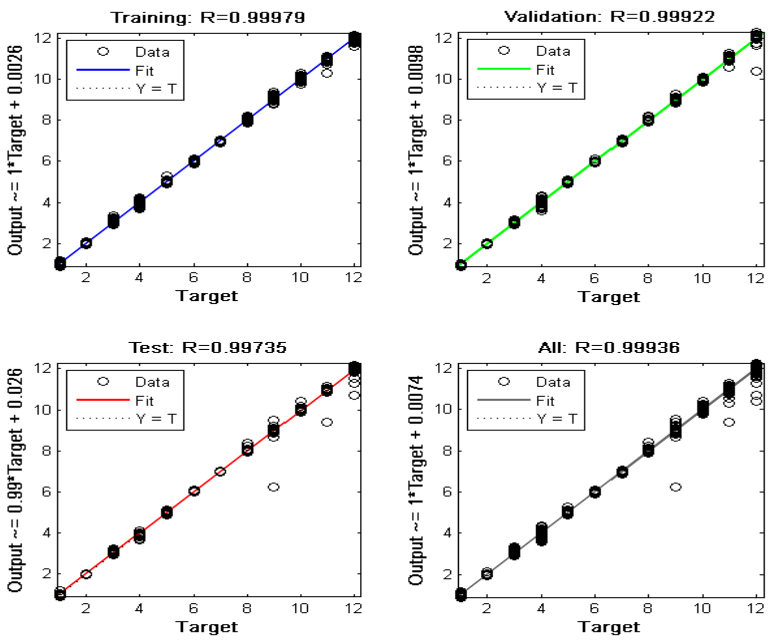

Figure 4: Data curve graph and error of training in Neuro Solutions software in conjunction with the prediction of weighting the priorities of strategic action plans for controlling environmental pollutants in the dams of Siah Bisheh

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Conflict of Interest

The authors confirm that there is no conflict of interest regarding the publication of this article.

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