Original Article: Importance of Water in Iran, Using Game Theory

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ABSTRACT

Due to its special geographical location, between 25 to 40 degrees north latitude and 44 to 64 degrees east longitude, Iran is one of the world's arid regions because its average annual rainfall is less than one third of the average rainfall in the world (860 mm). This amount of rainfall is not evenly distributed throughout the country due to lack of rainfall, and except for the northern and northwestern regions and to some extent in the west of the country, there are fewer permanent rivers. There are areas in the country that are not only facing a shortage of surface water, but their groundwater is salty. Of course, this water shortage in our country is not related to the present era, people have faced water shortages since long time ago. The existence of dams and historical dams in the country is a proof of this claim. However, since in the past the level of people's expectations was low due to low living conditions, they used water and soil resources in a coordinated manner for centuries and obtained the required water in different ways. Hence, the problem of water scarcity did not arise. However, the main problem was exploiting it. In the present era, on the one hand, there is a shortage of usable water, and population growth, water consumption, most importantly, rising living standards, machinery and technology growth, raise the issue of water need and scarcity.

Introduction

Dynamic play is the repetition of a limited number of static games in specific time stations (daily, monthly, etc.) where each player is aware of the results of the game in the past time stations. Consider a dynamic game consisting of two players II and I. Suppose that the decision of player II and I at time t is DtI and DtII, respectively. According to the definition of the previous section, Mi is a set of pure i player strategies. t is a counter of time stations [1-3]. If we show the initial state of the system at station t with Rt and also the minimum and maximum possible value of the initial state of the system with Rmax and Rmin, respectively, then the discrete variable of the initial state of the system in month t can be: Rt = {Ri | Rmin <Ri <Rmax, I = 1 …… k}, as Shown [4-6]. If we represent the outcome of players I, II in time station t with PtII and PtI, respectively, the outcome of each player is a function of the state of

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his decision system as well as the decision of the rival player:

$$P_t^{I} = g(R_t, D_t^{I}, D_t^{II}) \;,\; P_t^{I} = f(R_t, D_t^{I}, D_t^{II})$$

g and f are the desired outcome functions for players I, II, respectively. There will be such consequences for players throughout all game stations. The optimal decisions of each player during the game is a set of decisions that will bring him the most profit. In this way, a dynamic stage game can be expressed as follows:

$$U_t^{*I}\left(R_t, D_t^{I}, D_t^{*II}\right) = \max_{D_t^{I}}\left\{P_t^{I} + U_{t+1}^{*I}\left(R_{t+1}, D_{t+1}^{*I}, D_{t+1}^{*II}\right)\right\}$$

$$U_t^{*II}\left(R_t, D_t^{*I}, D_t^{II}\right) = \max_{D_t^{II}}\left\{P_t^{II} + U_{t+1}^{*II}\left(R_{t+1}, D_{t+1}^{*I}, D_{t+1}^{*II}\right)\right\}$$

Where Ut * II and Ut * I have the highest outcome for players II and I, respectively, from station t to the final station Tf. Dt * II and Dt * I are the balance decisions of players II and I at this station, respectively [7-9]. The accuracy to the right of the above equations shows that players must consider the short-term interests of PtII and PtI in choosing the equilibrium decision in stage t, as well as the long-term interests of Ut * II and Ut * I. How to solve dynamic games In order to solve dynamic games, a combination of dynamic programming and static games has been used [10-13].

Dynamic programming is a method widely developed by Bellman (1957). Planning starts from the end time station (t = Tf). For each possible case of the initial state of the system at the end of the planning period (RTf = RI …… Rk) and for all player decisions (Dei Tf ∈Mi, i = I, II), the outcome matrix of players I, II is formed. By solving each of the k static games using Equation 2, a balanced decision of the players is obtained. Moving backwards, at the time station t = Tf -1, for each of the possible states of the initial state of the system and for all the decisions of the players, their outcome is calculated at the time station t = Tf -1. Considering that the final state of the period t = Tf -1 is equal to the initial state of the next period t = Tf and in the time station t = Tf the results of players' decisions are calculated if they are in any of the initial conditions, so by summing the current outcome (Station t = Tf -1) and future outcome (station t = Tf) the cumulative outcome matrix of players will be created in the period t = Tf -1. By solving the game formed in this stage, the players make a decision that will lead to the maximum result from the station t = Tf -1 to the end of the planning period for them. By moving backwards until reaching the time station t = 1, the above operation continues [14-16].

Therefore, the players in the first station are faced with a consequence matrix whose elements are the cumulative consequence of the players from the beginning to the end of the game, and from solving it, the players' balance strategy in the first station will be calculated. The following is a dynamic game solving algorithm [17-19].

$for\ t = T_f : 1$

$\quad for\ R_t = R_t^1 : R_t^k$

$\quad\quad for\ D_t^{I} = 1 : m_I$

$\quad\quad\quad for\ D_t^{II} = 1 : m_{II}$

$\quad\quad\quad\quad P_t^{I} = f(D_t^{I}, D_t^{II}, R_t)\ ,\ P_t^{II} = g(D_t^{I}, D_t^{II}, R_t)$

$\quad\quad\quad\quad if\ t = T_f$

$\quad\quad\quad\quad\quad U_t^{I}(R_t, D_t^{I}, D_t^{II}) = P_t^{I}\ ,\ U_t^{II}(R_t, D_t^{I}\ D_t^{II}) = P_t^{II}$

$\quad\quad\quad\quad else$

$\quad\quad\quad\quad\quad U_t^{I}(D_t^{I}, D_t^{II}, R_t) = P_t^{I} + U_{t+1}^{*I}(D_{t+1}^{*I}, D_{t+1}^{*II}, R_{t+1})$

$\quad\quad\quad\quad\quad U_t^{II}(D_t^{I}, D_t^{II}, R_t) = P_t^{II} + U_{t+1}^{*II}(D_{t+1}^{*I}, D_{t+1}^{*II}, R_{t+1})$

$\quad\quad\quad end$

$\quad\quad end$

$\quad end$

$\quad Construct\ A_t(R_t)\ and\ B_t(R_t) \Rightarrow Calculate\ D_t^{*I}\ and\ D_t^{*II}$

$\quad if\ t = T_f$

$\quad\quad U_t^{*I}(R_t) = f(D_t^{*I}, D_t^{*II}, R_t)\ ,\ U_t^{*II}(R_t) = g(D_t^{*I}, D_t^{*II}, R_t)$

$\quad else$

$\quad\quad U_t^{*I}(R_t) = f(D_t^{*I}, D_t^{*II}, R_t) + U_{t+1}^{*I}(D_{t+1}^{*I}, D_{t+1}^{*II}, R_{t+1})\ ,$

$\quad\quad U_t^{*II}(R_t) = g(D_t^{*I}, D_t^{*II}, R_t) + U_{t+1}^{*II}(D_{t+1}^{*I}, D_{t+1}^{*II}, R_{t+1})$

$\quad end$

$\quad end$

end

Scenarios of Players Interacting with Each Other

In this section, based on how players interact with each other, their behavior is examined in the form of the following three scenarios:

Static Game Model without Cooperation (Scenario 1)

In this model, it is assumed that players follow myopic policies in determining the amount of monthly pumping [20]. In other words, the players do not have the ability to foresight and their monthly decisions are in order to reach the equilibrium point in the same month. Therefore, during the operating period, Tf is formed by static game independent of each other between players [21].

$$\begin{aligned}&for\ t=1:T_f\\&\quad for\ i=1:2\\&\qquad \max_{D_t^i\in M}\ U_t^i=P_t^i\\&\quad end\\&end\end{aligned}$$

Dynamic Game Model without Cooperation (Scenario 2)

In dynamic stage games, the goal of each player is to earn the maximum possible profit while paying attention to the equilibrium point and the decisions of the rival player. Players in this scenario have far-sighted policies. The specifications of this model are mentioned in detail in Section 3. The following equation shows the process of this scenario briefly and mathematically.

$$\begin{aligned}&for\ i=1:2\\&\qquad \max_{D_t^i\in M}\ \sum_{t=1}^{T_f} P_t^i\\&end\end{aligned}$$

Formation of Full Cooperation between Players (Scenario 3)

In order to better evaluate the results of scenarios 1 and 2 in resolving the differences between the operators of the common groundwater aquifer, another model was developed with the aim of optimizing the exploitation of the groundwater aquifer. The objective function of the model is to maximize the total profit of the two players during the period of operation [22].

The last relation shows the objective function of the optimization model. In other words, in the optimization model, instead of assuming the existence of two decision makers who each have a well (game theory conditions), it is assumed that a decision maker such as the government owns both wells and that they are formed together in water abstraction and intend to maximize the total operating income during the operation period [23].

$$\max_{\left(D_t^{\mathrm{I}},D_t^{\mathrm{II}}\right)\in M_{\mathrm{I,II}}}\left(\sum_{t=1}^{T_f}\sum_{i=1}^{2}(P_t^i)\right)$$

Surface Water Recognition Issues

To prevent surface water wastage and damage caused by them, two infrastructure works are: 1-Providing manpower 2-Establishment of water measuring stations and regular statistics of them Today, no construction and infrastructure project is possible without the use of statistics in various fields, so the statistics used must be accurate and reliable, and also the number of statistical years must be high. River flow measuring stations in Iran have been established, but their number is small and their statistical period is short according to the year of establishment, but in developed countries, the statistical period reaches more than 150 years. In our country, the number of stations that have a statistic of more than 50 years is very small and only includes stations that are on the rivers of Jajrud, Laroglipaygano or one or two other rivers [24-26].

Today, there are many water flow measuring stations in the country and it is expanding. Not only is the number of stations and the length of the statistical period important, but also the accurate determination of hydrometric stations which must be determined by experts. According to the United Nations, 31 countries will face water shortages in the near future, and Iran will be named as one of the largest countries in the water crisis in the future. It is expected that by 2025, more than two thirds of the world's population will face severe water shortages and the remaining third live in water scarcity (Figure 1). In another 50 years, Saudi Arabia will be completely empty of water [27-29].

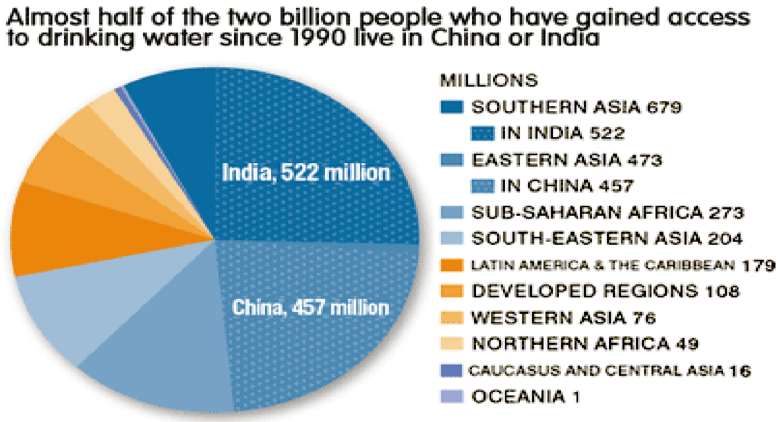

Figure 1. Asia and the Pacific | International Decade for Action 'Water for Life' 2005-2015

The crisis is already looming large in China, Africa, India, Thailand, Mexico, Egypt and Iran. The world's major rivers, including the Nile in Egypt, the Ganges in South Asia, the Yellow River in China, and Colorado in the United States, are under severe threat. In Iran, the main source of rainwater is naturally 252 mm or 413 billion cubic meters per year. This is one third of the world average (831 mL) and one third of Asia (732 mL). About 30% of precipitation is in the form of snow and the rest in the form of rain. Thus, while one percent of the world's population lives in Iran, Iran's share of renewable water resources is only 36 percent. From 413 cubic meters of annual rainfall, 269 cubic meters are lost in various forms. 2.93% of the remaining water is used for agriculture, but in an unprincipled way. 7.1 percent is allocated to industry and mining and the rest is used for other purposes. Mentioning these percentages is important because the water crisis is changing them and international organizations warn that with the increase in population in Iran in 2025, the country will be involved in a serious water crisis. The population of Iran was 16 million people and now it is over 70 million people, while the amount of water remains constant as more water is consumed and more water is polluted.

Tehran does not have a single river, but it has three rivers of sewage in which one drowns. Our country is located in the Middle East and is poor in terms of rainfall. It is true that there is a lot of rain in the north, but it rains when it is not needed much, and these areas do not have water for three months of summer, when it is rice time, so we use groundwater even in the rainiest place. While the use of groundwater is timely, the high use of groundwater has caused its levels to drop everywhere (Figure 2). So, in 200 plains, most of which are in Khorasan, no one has the right to dig wells except to get some drinking water and industrial use. The critical consequence that occurs in Iran as a result of water scarcity and increasing demand is that various sectors of agriculture, industry and manpower compete to use this water. Another consequence of the water crisis is that the same usable resources and rivers become polluted and unhealthy, and even the fishing industry faces problems [30-33].

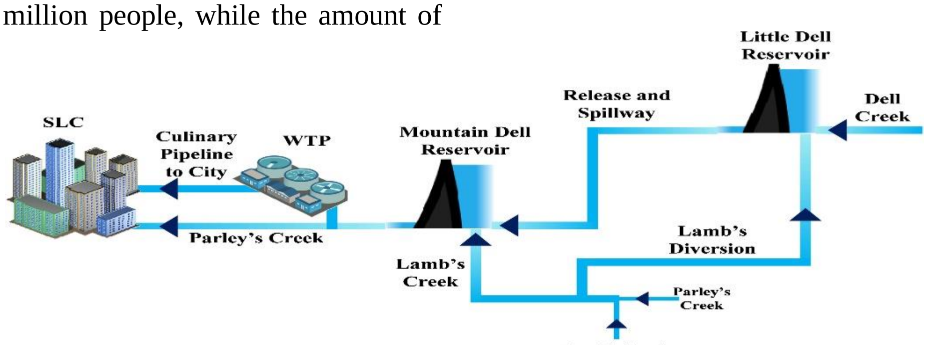

Figure 2. Incorporating Potential Severity into Vulnerability Assessment of Water Supply System

For example, it is not unreasonable to expect that the water of rivers in the north of the country will be polluted, especially since the sewage system of the northern cities is not developed. This issue has attracted the attention of the World Bank to Iran. In any case, as the world's population grows steadily and needs more food, water resources will dwindle. Part of the current crisis in Asia and Latin America is due to the industrialization of their societies and the disruption of the balance between man and nature. In Mexican capital, Mexico City, small children sometimes drink Coca-Cola and Pepsi instead of water. During the countries water crisis, the government cuts off farmers' water to supply water to predominantly foreign industries. The consequence of such a situation is that the world's food security is endangered. Lack of agricultural water in a country like China is enough to jeopardize this security. China tops the list of countries facing the water crisis. Naturally, China, due to its huge economic development, compensates for the food shortage by importing it, but the point is that as a result, food prices in world markets rise sharply, and this is a disaster for poor countries. Of course, Iran will also be involved in the water crisis in the same years, and it is natural that with the reduction of agricultural production, it will have to supply its food from the world market at a high price, and as a result, it will become dependent on other countries. Water scarcity, population growth, rising living standards and health, and an even greater increase in water consumption and food shortages in the coming decades pose a crisis for Iran, whose outlook is already bleak and disappointing. The crisis depends on how fast the government acts [34-36].

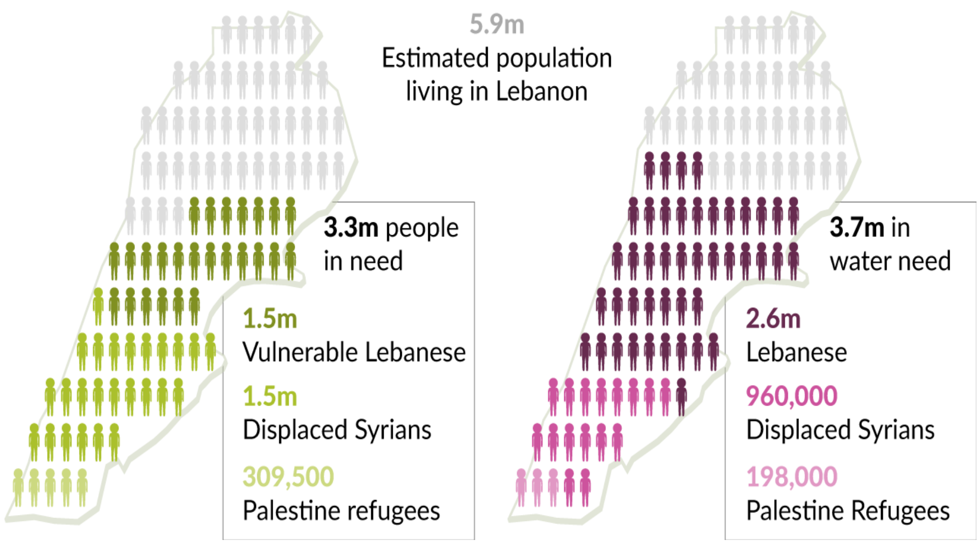

Figure 3. Five fundamentals to keep Lebanon's water flowing

Increasing the Vulnerability of Different Water Supply Systems

In many large cities, the rapid pace of increasing water needs from the total resources available in the area in one hand and the mismatch of peak supply with peak consumption on the other hand, has doubled the need for more accurate planning to meet needs and consumption management. These challenges, along with the occurrence of periods of dehydration and wetting, as well as crises caused by the failure of the supply system, transmission or distribution and widespread pollution in the system, have increased the need for specific policies and system operation. To achieve the above goal, it is necessary to increase the readiness of the system to deal with critical situations.

Lack of Integrated Use of Surface and Groundwater Resources

This is especially important in the case of groundwater resources. If groundwater resources are over-exploited, it will lead to the destruction of these resources and groundwater depletion. In many aquatic systems, groundwater is not used alone and may be available as a supplement to surface water. Therefore, integrated exploitation is one of the managerial analyses in the exploitation of water resources. Also, lack of proper management has caused water resources to be more susceptible to pollution than their self-purification capacity. As a result, they have lost their potential for various uses and are practically unusable. Unfortunately, in our country, the optimal use of water as a culture has not yet found its special place, so achieving "relative balance" in the field of water supply and consumption is a basic and necessary principle, which is certainly possible with proper planning. The set of measures that have been taken so far in connection with the supply of agricultural, urban and industrial water, is mainly in the field of water production and supply management and less attention has been paid to consumption management. Rapid population growth and the growing need for resources and products, especially non-renewable resources such as water, require governments to plan for controlling consumer demand [37].

Today, water is more important than ever as one of the three factors in the formation and survival of the environment. Undoubtedly, the preservation and protection of water resources and the optimal, economical and fair use of water is a global issue today, and therefore in the 21st century, water is mentioned as a pervasive human challenge. Governments and nations are expected to look at water as the key to development. Water resources remain the same while the population has tripled. In this way, the per capita water for the people of the world is decreasing, and on the other hand, unfortunately, pollutants such as industrial effluents, agricultural drains and urban and rural sewage pollute water resources and take them out of consumption standards [38]. Therefore, the optimal use of water resources is very important. In addition to the need for optimal operation and in order to develop methods to increase the confidence of users and managers due to the complexity of water resources systems, today the use of models has developed a lot and different types of models are used in micro and macro decisions of water resources systems. In addition to using the existing set of models, there are many opportunities and challenges for managers and planners who, by recognizing them and using them properly, can take very effective steps in using up-to-date knowledge and applying it in the service of water supply [39]. Taking this basic human need into account, planning, designing and managing water resources systems to achieve sustainable development goals in an area requires public participation. All those involved in the development and management of water resources must always evaluate the effects of the system on economic, social, as well as environmental changes. To achieve sustainable development, the issue of sustainability in all aspects of planning, design, construction and operation must be considered. Economic and environmental analyzes should not only consider the stage of development, operation and maintenance of the system, but also the possibility of its destruction and the need for its replacement.

Conclusion

According to the latest studies, 5 billion years have passed since the life of the Earth, and evidence shows that water has played an important role in the evolution and habitableness of the planet as the only viable planet since its inception. With the formation of oceans and seas and the formation of steam from them and the creation of clouds and rain and in general the circulation of water in nature and the flow of water in rivers and its return to the oceans in different ways, early life began with plants and lowlife and then excellent plants and animals came into being. The earth, which was composed of cooled igneous rocks, was continuously affected by weathering due to contact with air and atmosphere, and simultaneous changes in water, temperature, and frost caused the rocks to fragment. The floodwaters displaced them, creating vast plains covered with soil. This soil cover along with water available in nature provided a suitable environment for plant growth and a suitable environment for human life was prepared. Early humans used water only for drinking, and gradually, as civilization progressed and over time, they also used it for mills, agriculture, and transportation. Simultaneously with the development of civilizations, the use of water has taken on a new form, so that in many fields, from agriculture to industry and most importantly, energy production is used from water, and today access to sufficient water and appropriate quality in time and is a suitable place and considers any water shortage as an obstacle to sustainable development. Therefore, every year a lot of capital is allocated for the development of water resources and related projects such as dams and construction of irrigation and drainage networks, watershed management, containment. The circulation of water in nature, which is called the hydrological cycle or water cycle, is the movement and displacement of water in different parts under the influence of different forces such as gravity, gravity, pressure changes and solar energy. This rotation takes place in three different parts of the earth, the atmosphere (atmosphere) or the hydrosphere or water sphere, lithosphere or rock sphere.

Water runs inside and between these three layers in a layer 16 km thick, of which 15 km is in the atmosphere and only 1 km is inside the lithosphere. The hydrological cycle is actually a cycle without beginning and end, in which water evaporates from the surface of the seas and lands and enters the atmosphere, and then the water vapor entering the atmosphere re-evaporates into the atmosphere through various processes, and then again. Water vapor entering the atmosphere during various processes in the form of precipitation falls on the surface of the earth or on the surface of the seas and oceans. So precipitation can be encountered in three ways:

1. Before reaching the ground, they are taken by the leaves of plants.
2. They flow on the ground.
3. They penetrate into the soil. Some of the water that penetrates into the soil either returns to the air due to evaporation or enters groundwater sources, which eventually reappears on the surface through springs or seepage into rivers.

In all these cases, water completes the hydrological cycle or circulation of water in nature by evaporating and returning to the atmosphere.

References

[1]. Kosaki, Psomiadau AE, Tsimidou M, Rlopia A, Tienonen A, kefalas P. European Food Research and Technolgoy., 2002, 2(4), 294.

[2]. Kramer DJ. Amer. J. Bot., 1983, 37, 280-284.

[3]. Krogman KK, Hobbs EH. Can. J. Plant Sci. 1975, 55, 903-909.

[4]. Krzymanski J. Agronomy of oilseed Brassicas.Acta. Hort., 1998, 459: 55-60.

[5]. Kumar A, Singh DP, Singh P. J. Agric. Sci. Camb., 1987, 109, 615-618. Kumar, A. and J.Elston.1993.

[6]. Labana KS, Ahuja KL, Banga SS. Evaluation of Some Ethiopian mustard (Brassica Carinata) genotypes under lndian conditions in: 7th internal. Rapeseed Congress. Poznan. Poland., 1987, 115.

[7]. Levitt J. Response of plants to environmental stresses: water, radiation, salt and other stresses. Academic press, New Yourk. 1980, 187-211.

[8]. Levitt J. Response of plants to environmental stresses: water relation, salt and other stresses. Academic press, New York. 1983

[9]. Lewis GL, Turling N. Aus. J. of Experimental Agriculture., 1994, 34, 93-103.

[10]. Ludlow MM, Muchow RC. Adv. Agron. 43,107-153.

[11]. Ma.Q., Turner DW, Cowling WA, Levy D. Searching for Physiological markers that indicate drought tolerance in Brassica oilseed. Agribusiness crop updates. 2004.

[12]. Mailer RJ, Cornish PS. Can. J. plant Sci., 1987, 70, 399-407.

[13]. Maliwal GL, Thakkar KR, Sonani VV, Patel PH, Trivedi SN. Ann. Agric. Res., 1998, 19, 353-355.

[14]. Mastro G. Rape, Metapontum area. Informatore Agrario., 1995, 51, 26-27.

[15]. Mathur D, Wattal PN. Indian. J. Plant Physiol., 1996, 1(3), 171-174.

[16]. May WE, Hume DY, Hale BA. Can. J. of plant Sci., 1994, 74, 267-274.

[17]. Bozorgian A, Zarinabadi S, Samimi A. Journal of Chemical Reviews, 2020, 2(2), 122.

[18]. Bozorgian A, Zarinabadi S, Samimi A. Chemical Methodologies, 2020, 4 (4), 47.

[19]. Samimi A. Progress in Chemical and Biochemical Research, 2020, 3(2), 140.

[20]. Farhami N, Bozorgian A. In Int. Conf. on Chem. and Chem. Process IPCBEE, 2011, 10, 223.

[21]. Bozorgian A, Nasab NM, Mirzazadeh H. Engineering and Technology International Journal of Materials and Metallurgical Engineering, 2011, 5(1), 21.

[22]. Bozorgian A. Advanced Journal of Science and Engineering, 2020, 1(2), 34-39.

[23]. Bozorgian A, Ghazinezhad M. J. Biochem. Tech 2 (2018), 149.

[24]. Bozorgian A. International Journal of New Chemistry, (2021), Articles in Press.

[25]. Bozorgian A, Zarinabadi S, Samimi A. Journal of Chemical Reviews, 2020, 2(2), 122.

[26]. Opoku E. Journal of Chemical Review, 2020, 2(4), 211.

[27]. Bozorgian A. Chemical Review and Letters, 2020, 3(2), 79.
[28]. Pourabadeh A, Nasrollahzadeh B, Razavi R, Bozorgian A, Najafi M. Journal of Structural Chemistry, 2018, 59(6), 1484.
[29]. Bozorgian A, Advanced Journal of Chemistry-Section B., 2020, 2(3), 91.
[30]. Kavousi K, Zarinabadi S, Bozorgian A, Progress in Chemical and Biochemical Research, 2020, 7.
[31]. Bozorgian A. Chemical Review and Letters, 2020, 3(3), 94.
[32]. Bozorgian A, Majdi Nasab N, Memari A. interaction, 2011,1 ,4.
[33]. Bozorgian A. International Journal of Advanced Studies in Humanities and Social Science, 2020, 9(3), 229.
[34]. Bozorgian A. International Journal of Advanced Studies in Humanities and Social Science, 2020, 9(3), 205.
[35]. Bozorgian A. Advanced Journal of Chemistry, Section B: Natural Products and Medical Chemistry, 2021, 3(1), 54.
[36]. Bozorgian A. International Journal of New Chemistry,(2021), Articles in Press.
[37]. Bagherisadr M, Bozorgian A. International Journal of Advanced Studies in Humanities and Social Science, 2020, 9(4), 252.
[38]. Bozorgian A. International Journal of Advanced Studies in Humanities and Social Science, 2020, 9(4), 241.
[39]. Bagheri Sadr M, Bozorgian A. Journal of Chemical Reviews, 2021, 3(1), 66.