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Climate diversity in line with agroforestry systems: studying technicalities of agroforestry systems and allied components in two diverse climatic regions (Warm climate vs. cold climate) (Case study: Kazeroun & Sepidan in Fars Province, I.R.Iran)

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Abstract

There has been some decline in the land potential capacity in many developing countries, and depending on location, the multi objective management strategy of Agroforestry can make effective use of natural resources to be feasible. Environmental principles which are effective on Agroforestry systems and their components, together with climatic factors, are the important parameters which been evaluated in this study. Two cities, Kazeroun (with warm climate) and Sepidan (with cold climate) in Fars province, were chosen for the purpose of this research, and after proper identification and classification of the Agroforestry systems, the effects of climatic factors were analyzed. Nineteen points were identified in these two cities by field investigations, with each type of Agroforestry systems and their corresponding components determined in each point. From the results, most of the systems in Kazeroun, characterized with warm climate, were Agrosilvopastoral, while Sepidan with a characteristic cold climate was the Agrosilvicultural system. Also, the components of each system clearly changed with change in climate, owing to the great importance of the livestock and crop components in Kazeroun and Sepidan, respectively. In general, it can be concluded that the impact of climatic factors on Agroforestry systems and their components has been approved in this study, and the results can be applied in developing these systems in other regions.

Keywords: Agroforestry systems; Agrosilviculture; Agrosilvopasture; Climate; Component

1. Introduction

There is a gradual decline in the potential land use in many developing countries. According to studies conducted by the Food and Agriculture Organization (FAO), the increasing population of human and livestock, combined with the increasing need for food, fodder and fuel will mount high pressure into the agricultural ecosystem. This may be a valid cause of the present disturbing biodiversity balance in concerned regions. Depending on the situation, Agroforestry practices can enhance the efficient use of natural resources, increase production (Lott *et al.*, 2000), improve the quality of food products, and provide wood fuels, raw materials and other kinds of trees and shrubs, in order to assist the subsistence farmers (Nair, 1984). Also, it provides opportunities for local market as well as exports in villages (Franzel *et al.*, 2001; Werf *et al.*, 2007). Moreover, in rural areas, Agroforestry improves socio-economic conditions by creating job opportunities and provides income, thereby reducing the scarcity of food production and improving financial state. Reducing the risks of monoculture plantations and increasing income

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through modification and sustainability of its productive capacity, improving nutrition and health by enhancing the quality and variety of food input-output systems, are among the socio-economic benefits of Agroforestry systems (Shamekhi, 2006; Neupane and Thapa, 2001). Understanding the functions of these systems is essential to its management, therefore effective environmental factors on the Agroforestry systems must be studied.

Alcamo *et al.* (2005) stressed on the importance of focusing on climate change in agriculture, as well as global biodiversity components under ecological variations. Ecological regions are influenced by environmental, animate and inanimate factors. The type of crop grown and the domestic animals in an ecological region are determined by the characteristics of the region and this account for the great diversity in terms of their ecology. The main environmental factors which affects the four aspects of Agroforestry systems include, plant vegetation (including trees and crops), land management and land or the environment degradation, and interactions between trees with crops. The climate and soil factors, and subsequent vegetation, are the most important factors (Shamekhi, 2006; Javanshir *et al.*, 2004) affecting Agroforestry systems. Hence, based on the aforementioned information, the principles of effective environment on Agroforestry systems should be carefully reviewed.

Climate change is one of the effective factors affecting Agroforestry systems, and its corresponding components are the important factors which will be investigated in this study. Any system is made up of three main components, trees, livestock and crop, and climate change have great impact on these components. Ahmad *et al.* (2006) provided evidences of climate components on Agroforestry in the same regional alliances. The influence of environmental factors on Agroforestry systems is seen through components like effect of growing trees and crops on animal behavior, management practices and the interactions between trees or shrubs with the other three components. These interactions are mainly through micro- climate and soil moisture and may have beneficial or detrimental effects on the individual trees, crops, livestock, or the whole (Shamekhi, 2006). Therefore, this research is necessary in order to investigate these effects. So far, a lot of research has been done about Agroforestry (e.g, Comb, 1982; Ibrahim *et al.*, 2004; Gladen, 2004; San Miguel-Ayanz, 2004; Murgueitio, 2004). These studies are very limited in Iran (Matinkhah *et al.*, 2003; Goudarzian *et al.*, 2013). However, the present study dealt intensively on environmental factors. Grewal *et al.* (1994) dealt with the environmental factor in soil and water. So far, there has been no study on the impact of the climate on systems, which is one of the most important environmental factors in the present research.

Howden and Meinke (2003) elaborated the climate impact on agriculture and forests in the summer and the winter seasons in certain ecological zones, together with the future challenges expected on. The area selected for the study, according to the extent of Agroforestry systems is the Fars province on one hand and present climate variability with variable temperature and rainfall in this province on the other hand. It should be noted that both cold and warm research areas which have the greatest variety and concentration of Agroforestry systems in the province have been selected. Therefore, this study aimed to investigate the effect of climate on Agroforestry systems and the components of each system for effective evaluation and preparation of Agroforestry plans in accordance with their climate.

2. Materials and Methods

2.1. The study areas

Based on the results of having the greatest diversity of climate and variety of Agroforestry systems in the Fars province in both the cold and warm region from initial studies, Sepidan and Kazeroun were selected.

2.1.1. Kazeroun

Kazeroun is situated in the West province, with an area of 406,000 hectares and is located in '35° 51 east longitude and '35° 29' north latitude (Fig. 1). It is one of the most important cities in the Fars province which plays a key role in the production of agricultural crops. According to the provincial meteorological station statistics, it experiences rainfall mostly in December, January and February, with an average annual rainfall of 400 mm. The city's climate is mild in the winter and hot in the summer. According to statistics, the

average maximum temperature is 43.7°C in July and average minimum is 4°C in January. Relative humidity is between 30 to 58 percent and from climate classification point, this city is considered warm and semi- arid to semi- humid (Fig. 2).

2.1.2. Sepidan city (Ardekan)

Sepidan is situated in Northwest of the Fars province with an area of 286,000 hectares and is located in '59° 51 east longitude and '15° 30 north latitude (Fig.1). Its average rainfall ten-years past is 758 mm, with 35% and 65% relatively in the form of snow and rain, respectively, evenly distributed. The minimum determined degree is between -12° and 33°C. The weather is very cold in the winter and cool and mild in the summer. From the contemporary technicalities of climatic classification and general populace, this city is considered cool and moist to semi-dry. Figure 3 represents a sketch of the area.

Fig. 1. Location of the 2 study areas (Kazeroun and Sepidan) in Fars Province

2.2. Data Collection

Each study area is characterized by different Agroforestry systems. These systems have been separated and each component determined using Nair classification. In order to analyze the climate impacts on Agroforestry systems, the information about climate and the climate classifications in each city, and cultivation factors including location, time and plants, was gathered from the Department of Agriculture Management (DAM) and the Department of Natural Resources (DNR) in Fars province. After acquiring the initial data, field studies, questionnaires and interviews with people (especially farmers) were conducted. Questions were validated by specialist staff in order to define the research objectives. Upon completion of the questionnaire, content analyses were performed, followed by classification of the final answers. Selection of study area was done on purpose rather than randomly. In each region, interviews were conducted with 3 to 4 farmers. Data regarding the different species and components of Agroforestry were obtained and the range of Agroforestry systems was recorded through Global Positioning System (GPS). GPS allows for the latest and accurate measurements, coupled with the preciseness, in studying relative

regional areas globally. The technicalities involved in studying climate variations are helped solved by focusing on certain regional study areas.

2.3. Classification

It is essential to determine and classify systems and their components for better understanding. There are many methods for classify various Agroforestry systems. The method used in this study is among the proposed methods documented (Nair, 1987). This method has also been used and approved in previous studies, considering the three components of the classification which include tree, livestock and crops (Zou and Sanford, 1990; Sinclair, 1999; Torquebiau, 2000) (Fig. 2).

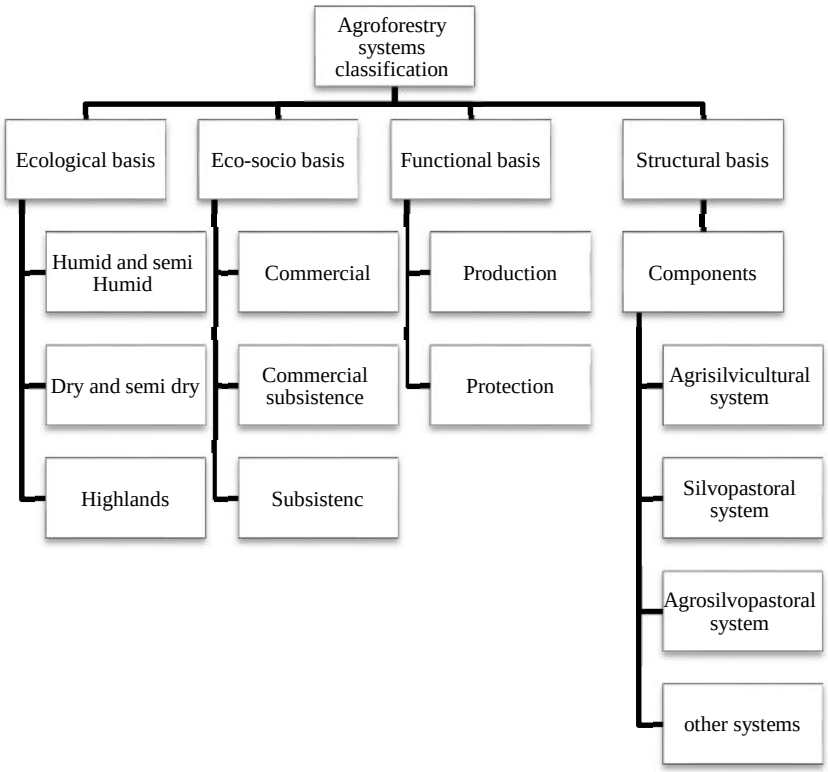

Fig. 2. General diagram of Agroforestry systems classification stages used in this study (Nair, 1987)

2.4. Climate Survey

Precipitation and temperature data has been used for the years 2006 to 2012, since the establishment of meteorological stations, in order to evaluate the climatic conditions and its changes. This data was obtained from the Meteorology and Climate department (MCD) and compared and verified with maps of the DNR (Fig. 3).

3. Results and discussion

A total of 19 points which have been introduced were identified and described with field studies in Kazeroun and Sepidan. Then, each plant species type, livestock and management were reviewed in order to analyze the effect of climatic factors on these systems. Investigations revealed three climate types, humid, semi-humid and dry in Sepidan (Fig. 4A) and four types dry, semi-arid, sub-humid and humid climate in Kazeroun (Fig. 4B).

Component of trees, crops and livestock were identified in Kazeroun (Table 1) and Sepidan (Table 2).

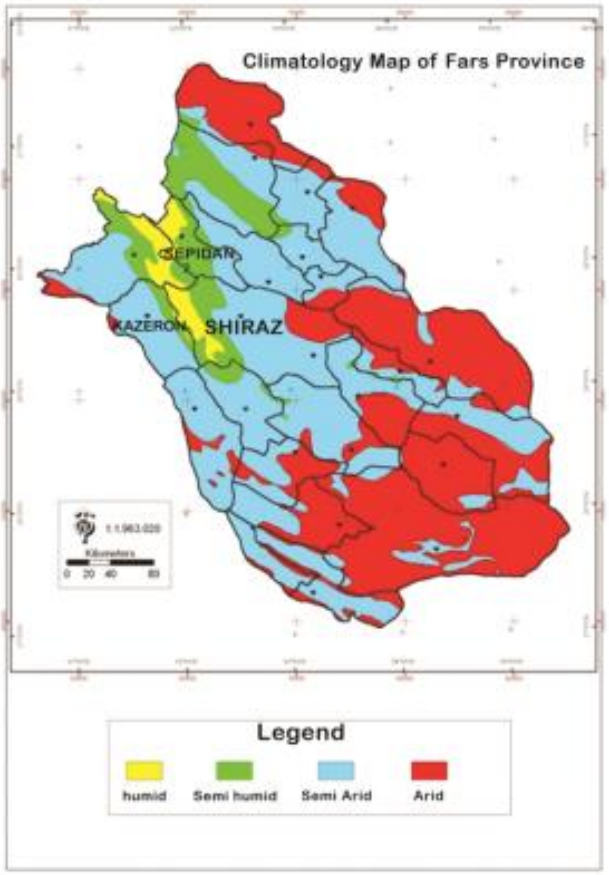

Fig. 3. Classification of Climate of Fars Province by Department of Natural Resources and Watershed Management in Fars province

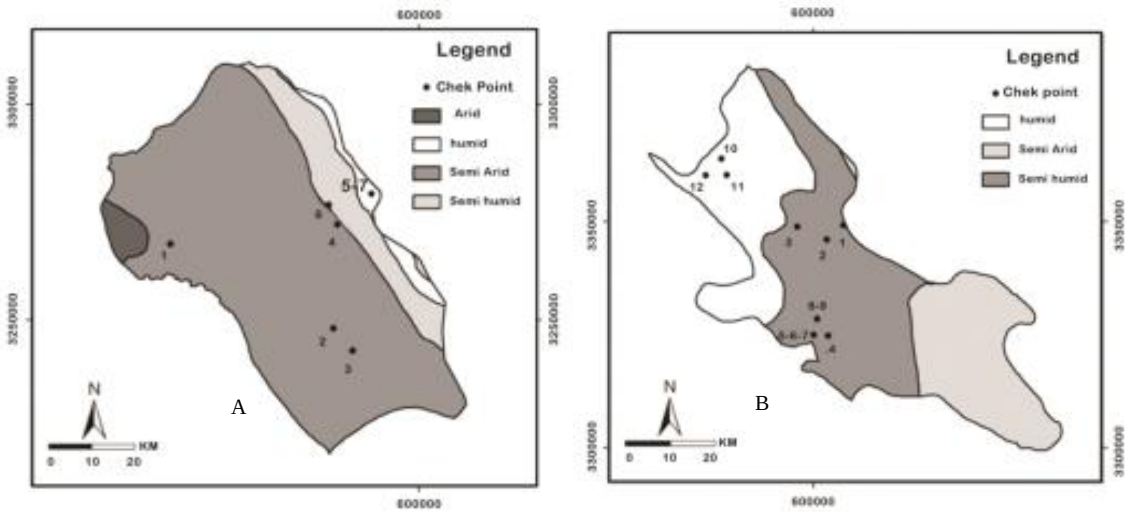

Fig. 4. Location of points in the cities of Kazeroun (A) and Sepidan (B) and their climatic classification

Table 1. The three components of trees, crops and livestock in the surveyed areas in Kazeroun

Row	location	Geographic coordinates	Tree component	Crop component	Livestock component
1	Konar Takhte	51.26.4E 29.32.5N	*Acaciasalisina,Prosopis juliflora, Acacia Arabica, Zizyphus spp*	*Hordeum vulgare, Capparis spinosa, Vicia sativa*	Goat, Sheep
2	Dadin	51.52.23E 29.21.17N	*Populus nigraPopulus euphratica, Zizyphus spp,Calotropis procera*	*Medicago sativa, Hordeum vulgare,Triticum spp,Atriplex spp*	Sheep
3	Narges Zar Dadin	51.52.21E 29.18.28N	*Zizyphus spp*	*Narcissus orientalis,Atriplex spp,Capparis spinosa*	Beekeeping
4	Dashte Barm	51.50.16E 29.34.26N	*Quercus brantii, Pistacia atlantica*	*Narcissus orientalis*	–
5	Kuh Tasak	51.55.13E 29.38.17N	*Citrus aurantium, Amygdalus spp, Quercus brantti*	*Rosa lutea, Prangos ferulacea*	Sheep, Bekeeping
6	Gav Koshak	51.49.1E 29.36.55N	*Crataegus aronia, Amygalus Scoparia, Acer monspessulanum,Quercus brantti*	*Narcissus orientalis*	–
7	Dashte Arjan	51.55.14E 29.38.17N	*Amygdalus orientalis, Crataegus aronia, Prunus avium, Quercus brantti*	*Hordeum vulgare, Medicago sativa, Cynara scolymus*	Goat

Table 2. The three components of trees ,crops and livestock in the surveyed areas in Sepidan

Row	location	Geographic coordinates	Tree component	Crop component	Livestock component
1	Shesh Pir	56.6.33E30 .16.8N	*Populus nigra,Malus domestica, Juglans regia*	*Lens culinaris medic,Triticum spp,Hordeum vulgare,Medicago sativa*	–
2	Cheshme Shesh Pir	52.4.14E 30.14.28N	*Populus nigra*	*Triticum spp,Hordeum vulgare,Medicago sativa*	–
3	Mur	52.0.11E 30.16.2N	*Malus domestica,Juglans regia, Populus nigra,Tamarix mannifera*	*Ferula assa-foetida,Ferula gummosa, Apuim graveolens,Astragalus spp.*	–
4	Homayjan	52.4.19E 30.2.57N	*Populus nigra, Malus domestica, Prunus avium*	*Cynara scolymus*	–
5	Ardeshiri 1	52.2.19E 30.3.5N	*Populus nigra, Malus domestica, Juglans regia*	*Cicer arietinum*	–
6	Ardeshiri 2	52.2.19E 30.3.5N	*Populus nigra. , Platanus orientalis*	*Lens culinaris medic, Medicago sativa, Glycyrrhiza glabra*	–
7	Ardeshiri 3	52.2.19E 30.3.5N	*Malus domestica, Prunus avium, Populus nigra*	*Triticum spp*	–
8	Rudbal 1	52.2.49E 30.4.58N	*Populus nigra.*	*Dhasaeo lous vulgaris*	–
9	Rudbal 2	52.2.49E 30.4.58N	*Populus nigra.*	*Crocus sativus*	–
10	Ahangari	51.49.42E 30.24.16N	*Amygdalus orientalis,Pyrus spp. , Crataegus aronia, Malus domestica, Juglans regia*	*Prangos ferulacea,Ferula assa-foetida*	Goat, sheep, beekeeping
11	Orfe miveyi	51.50.27E 30.22.17N	*Malus domestica, Juglans regia, Amygdalus orientalis, Crataegus aronia*	*Prangos ferulacea, Cynara scolymus*	Ewe
12	Cheshme Tizab	51.47.31E 30.22.17N	*Populus nigra*	–	*Oncorhynchus mykiss*

After collecting data about each Agroforestry system at both sites, each system was named, followed by the determination of the functional, ecological and economic – social base structures (Tables 3 and 4) using the Nair classification according to Figure 2.

Table 3. Classification of points in Kazeroun in terms of basic, functional, ecological and socio-economic structure

Row	Location	Geographic coordinates	Structural Basis	Functional Basis	Ecological Basis	Economic Basis
1	Konar Takhte	51.26.4E 29.32.5N	Agrosilvopastoral system	production	Arid and semi arid	Commercial subsistence
2	Dadin	51.52.23E 29.21.17N	Agrosilvopastoral system	production	Arid and semi arid	Commercial subsistence
3	Narges Zar Dadin	51.52.21E 29.18.28N	Agrisilvicultural system	production	Arid and semi arid	Commercial
4	Dashte Barm	51.50.16E 29.34.26N	Agrisilvicultural system	protection	Arid and semi arid	Commercial
5	Kuh Tasak	51.55.13E 29.38.17N	Silvopastoral system	production	Humid and Semi humid	Subsistence
6	Gav Koshak	51.49.1E 29.36.55N	Agrisilvicultural system	production	Humid and Semi humid	Commercial
7	Dashte Arjan	51.55.14E 29.38.17N	Silvopastoral system	production	Humid and Semi humid	Commercial subsistence

Table 4. Classification of points in Sepidan in terms of basic, functional, ecological and socio-economic structure

Row	Location	Geographic coordinates	Structural Basis	Functional Basis	Ecological Basis	Economic Basis
1	Shesh Pir	56.6.33E 30.16.8N	Agrisilvicultural system	production	Humid and Semi humid	Commercial subsistence
2	Cheshme Shesh Pir	52.4.14E 30.14.28N	Agrisilvicultural system	production	Humid and Semi humid	Commercial subsistence
3	Mur	52.0.11E 30.16.2N	Other systems	production	Humid and Semi humid	Commercial
4	Homayjan	52.4.19E 30.2.57N	Agrisilvicultural system	production	Humid and Semi humid	Commercial subsistence
5	Ardeshiri 1	52.2.19E 30.3.5N	Agrisilvicultural system	production	Humid and Semi humid	Commercial subsistence
6	Ardeshiri 2	52.2.19E 30.3.5N	Agrisilvicultural system	production	Humid and Semi humid	Commercial subsistence
7	Ardeshiri 3	52.2.19E 30.3.5N	Agrisilvicultural system	production	Humid and Semi humid	Commercial subsistence
8	Rudbal 1	52.2.49E 30.4.58N	Agrisilvicultural system	production	Humid and Semi humid	Commercial subsistence
9	Rudbal 2	52.2.49E 30.4.58N	Agrisilvicultural system	production	Humid and Semi humid	Commercial
10	Ahangari	51.49.42E 30.24.16N	Agrosilvopastoral system	production	Humid and Semi humid	Commercial subsistence
11	Orfe miveyi	51.50.27E 30.22.17N	Silvopastoral system	production	Humid and Semi humid	Commercial subsistence
12	Cheshme Tizab	51.47.31E 30.22.17N	fishery	production	Humid and Semi humid	Commercial

5. Conclusion

Since Iran is one of the few countries in the world that is characterized with varied climate, it is possible to study the impact of this variation on Agroforestry systems. Due to positive features of Agroforestry systems, this is one of the most practical solutions to improve the management of multiple problems. Arnell *et al.* (2003) pondered over the climate change scenarios from a regional climate model in order to study the Agroforestry systems and relaitve components in likewise manner. Goudarzian *et al.* (2013) approved Agroforestry as a multi-manager approach in their study and expressed the necessity of pplying Agroforestry systems in a country like Iran. Agroforestry is being practiced traditionally in many parts of Iran. Climate variability has led to the creation of different Agroforestry systems in Iran which have been influenced by these major environmental factors. Thus, this study was conducted with the aim of understanding the impact of climate on Agroforestry systems and its components, which can be useful in implementing Agroforestry systems in other regions with similar climate, and also to reform, develop and improve the existing Agroforestry systems. In general we can say that despite the limitation of resources, such as water because of global warming, Agroforestry systems have created an appropriate efficiency in recent years when there were no revenues coming in. Moreover, with Agroforestry

systems as a multi objective management, the problem of land shortage can be resolved. Government supports also plays an important role in encouraging the farmers. Protective measures were also taken in order to encourage the farmers, thereby increasing efficiency. With higher efficiency, many economic problems facing the government will be resolved and this in turn will prevent the attack of villagers on forests.

Selection of suitable tree species which have drought resistance mechanisms, such as having a deep root system, water storage mechanisms, shedding of leaves to conserve moisture in summer and having characteristics such as a waxy coating and resistance to soil and water salinity is very important for the arid and semi -arid ecosystems. Crops should be planted in accordance with these characteristics. The arid region is characterized by special features owing to its special climate, and therefore some proportional Agroforestry systems with regional condition are best options to combat these special conditions. The climate change may cause some positive as well as negative long term variations in areas worldwide. Hence, the cropping pattern may be adjusted as done over the centuries by the ancient populace of regional segments in and across continents. Iran has a variety of seasonal similar to those in Afghanistan, Bangladesh, Hindustan and Pakistan. The components of Agroforestry varied in the Asian continent. Identification and evaluation of observed Agroforestry systems in Sepidan showed that Agrosilvicultural systems is more developed and are seen in 8 of the 12 points (Table 2). The main component in this system is the *Populus nigra* and this was as a result of the ecological requirements of these species in the systems of Sepidan city. This specie plays a carminative role. The preservation of other system components also provides the opportunity to earn a stable income for the villagers. Other trees in Agroforestry systems are also closely related to climate and are mostly effective. Furthermore, crop species are also selected and planted based on the humid and semi-humid cold climate on which the systems have been established. Due to the cold winters in the region on one hand and suitable earnings from the combination of tree and crop components on the other hand , the presence of livestock is very limited in the Sepidan Agroforestry systems (3 points out of the 12 points) (Table 2). Most systems have production role from the functional base and from the economic- social point of view, but almost all of them make economic benefits in addition to the production of the villagers needs, and they all play both roles from these aspects (Table 4).

Comparison of Agroforestry systems in Kazeroun city according to the climate classes showed that there is Silvopastoral system in 4 points out of the 7 points, and this shows the important role played by animals in the systems of this city. Therefore it can be said that this is one of the effects of climate on Agroforestry systems (Table 1) and that livestock component play a productive role in the functional base in most observed systems of Kazeroun (6 points, 7 points) (Table 3). Agricultural component in this system is also composed of crop species which are commensurate with the tropical condition of this city. Based on the ecological term, there are 4 points out of the 7 points in the dry and semi-dry tropical climate and 3 points in the humid and semi- humid tropical climate (Table 3). A comparison of these points showed that the available system in the dry and semi-dry climate have two-steady component of crop and tree, while in two points (points 5 and 7), livestock component was steady and it also reflected the impact of climate on component of Agroforestry systems. From the functional base, there are commercial-subsistence role in 3 points out of 7 points, while 9 points out of 12 points showed more economical dependence of the income in Sepidan city residents on agriculture (compared with Kazeroun).

Overall, we can conclude that climate change have a direct impact on Agroforestry system components in the two studied areas. A comparison of these two regions suggests that with climate change from warm to cold, i.e, Kazeroun to Sepidan, the component of livestock became less important and crop component became more important. Only 3 points out of 12 points in Sepidan had livestock component, with all the three in a humid climate class, while 4 points out of 7 points were in two climate class of semi-arid (points 1 and 2) and semi-humid (points 5 and 7) (Table 1 and 2). This shows the the use of livestock components in Agroforestry systems is most common in the tropical regions of Kazeroun.

The comparison between two study areas revealed that with changing climate, crop and tree component changed clearly and drought -friendly

species change to hygroscopic species. Species like *Acacia salisina, Prosopis juliflora, Acacia arabica, Zizyphus spp,Tamarix mannifera, Hordeum vulgare, Capparis spinosa, Vicia sativa, Narcissus orientalis, Atriplex spp,* became scarce in the cold climate of Sepidan while species like *Populus nigra,Malus domestica, Juglans regia, Ferula assa-foetida,Ferula gummosa, Apuim graveolens*, *Astragalus spp*. became predominant.

Therefore, it can be said that the use of tree and crop components plays a priority role in humid and semi-humid parts, while application of livestock component in dry and semi-dry climate class provide the requirements of the villagers and farmers. Generally, in humid and semi humid climate, both components are present in order to maximum the earnings (livestock and crop component) (such as points 10 and 11 in Sepidan). The is a basis for socio– economical structure because the more favorable condition results in commercial role of systems becoming more important by moving from drier parts to more humid parts (such as fishery, point 12 in Sepidan). In harsh climatic conditions, providing the basic needs of the farmers is the only aim as outlined in an in point 5 in Kazeroun. The presence of drought resulted in farmers purchasing livestock feed in order to keep livestock component in Agroforestry system and provide their needs. Also, under favorable conditions, considering Agroforestry systems in the humid climate, with respect to the functional base, the production role of the systems become important while the protective role become less important (such as points 10 and 11 white) (Table 4). This effect also shows the impact of climate on the components from functional base.

Evaluating the effect of climatic factors on Agroforestry systems in two different climatic regions shows that selection of the components should be according to the climatic conditions in order to achieve the desired goals in any basis and maximum ecological efficiency.

Zou *et al.* (1990) approved the relation between each component of Agroforestry systems with environmental factors. In addition to the impact of climate on each Agroforestry system component in two study areas, the role of this environmental factor in the type of Agroforestry systems is obvious. It becomes clear with comparison of Agroforestry systems based on the functional base in two city, Kazeroun and Sepidan (Tables 3 and 4). For reasons outlined in Sepidan, more points (8 points of 12 points) have been attributed Agrosilvicultural system and the most important component is crop component which has a suitable income, while most of the systems in Kazeroun (4 points out of 7 points) are Silvopastoral system and livestock component which play the role of providing income. Therefore, it can be said that farming in the cold and livestock in the tropical zone have more priority in this study. Evaluating the effect of climatic factors on Agroforestry systems and components of each system showed that climate will have effect on the type of systems through interactions between components and the environment, cropping systems and management practices and components of each system, including the type species of the crop, and the trees or the lack of livestock. Development of Agroforestry systems and components are recommended for areas having similar climate and agricultural ecosystems with the present study areas.

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