of the interaction between humans and forests is necessary (Bode *et al.,* 2000; Abdollahpour and Assadi Atui, 2002). therefore, identifying the impacts of human populations on forests is indispensable and requires techniques and methods that can measure the amount of disturbances caused by this presence to provide the opportunity of a proper and detailed planning for forest conservation. Based on studies conducted in Hyrcanian forest of Azerbaijan, it was proved that the tree density had significantly changed according to the distance between forest stands and population centers and the damage intensity was defined based on this issue (Sharnweber *et al.,* 2007). In addition, extensive researches have been performed in tropical forests of Cambodia about the impact of human population density on the structure and composition of forests (Top *et al.,* 2003; 2004a; 2004b; 2004c; 2009); while other studies about the complex issues of population related to the forests have been also done in other parts of the world including India (Karanth *et al.,* 2006), China (Wang *et al.,* 2001) and Turkey (Sivrikaya *et al.,* 2011). Generally, the ecologic and socio-economic aspects should receive special attention in the context of sustainable forest management (Wolfslehner *et al.,* 2005); In Hyrcanian forests of northern Iran found that forest availability (tree density) decreases with decreasing distance from the individual rural population focus areas. However, there was no significant alteration in forest structural characteristics and thus, studying how and to what extent the forest resources are influenced by demographic pressures is very important to determine the appropriate applications of forest management and have not yet been assessed. (Blasco *et al.,* 2000) showed that alterations made by the residents manifest itself through various configurations and often give rise to altered deterioration of forest resources. Thus, forest structure and tree density must be investigated to determine the rate of certain disturbance that influences forest structure (Onaindia *et al.,* 2004). This study presents a model human population pattern on tree density. In 2014, an inventory was arranged in Guilan Province including 62 clusters distributed in more than 30% of the Asalem forest area of Guilan Province. Also, in 2014, a georeferenced village record was acquired from the outcome of the census arranged in the relative year. Using these two main data, the purpose of this study was to acquire awareness of the relationship between forests structure and human population pattern to support forest conservation planning and to access a sustainable management. The results support a better learning of quantify changes in tree density, tree diameter at breast height (DBH) and stand density index as a result of human population in the Asalem Forests of the Guilan Province, Iran. Knowledge of the quantitative nature of these changes will be important to support local people's sustainable management within The Hyrcanian forests in Iran and nature conservation. This study was the first experiment to analyze the influences of human population pattern on tree density of Nav Asalem forest, Guilan Province in Iran. Local forest settlers are important for their Eco-systemic and social impacts, shaping even some of the forestry structures in the Hyrcanian forests. Yet, the compactness of the local residents are so significant in the sense threatens forest subsistence being the main point of focus in the current study. This study has been performed in Nav Asalem district located in Guilan Province of Iran during 2015.

MATERIALS AND METHODS

Materials

This area is a part of the forest catchment of Nav Asalem in west of Guilan Province. The study area lies between 48° 482 043 and 48° 402 223 E and 37° 412 223 and 37° 362 283 N with an area of about 21000 ha. The climate is temperate and very humid with average annual rainfall of 945 mm and annual average temperature of 12.4 °C. Long-term average precipitation, based on 18 rain gauge stations from west Guilan Province of a last 20 years ending in 2007.The dominant tree species in the area is beech with other species such as hornbeam, ironwood, alder, maple and ash, and embraces a human population of 5000 individuals, who temporarily and permanently reside in the area and have an occupation of ranching (Fig. 1). A total of 60,000 forest dweller families live in the forested regions of Guilan Province. Statistics show that consists of 370,000 in Guilan Province live temporarily and permanently in forest and their livelihood depends on the forest (Mohammadi, 2008).

Methods

Two methods were used to sample tree density associated with human population in the Asalem Forests. These included: 1) measurement of tree number, basal area and the stand density index (SDI) on plots, but the analysis was done in the cluster level

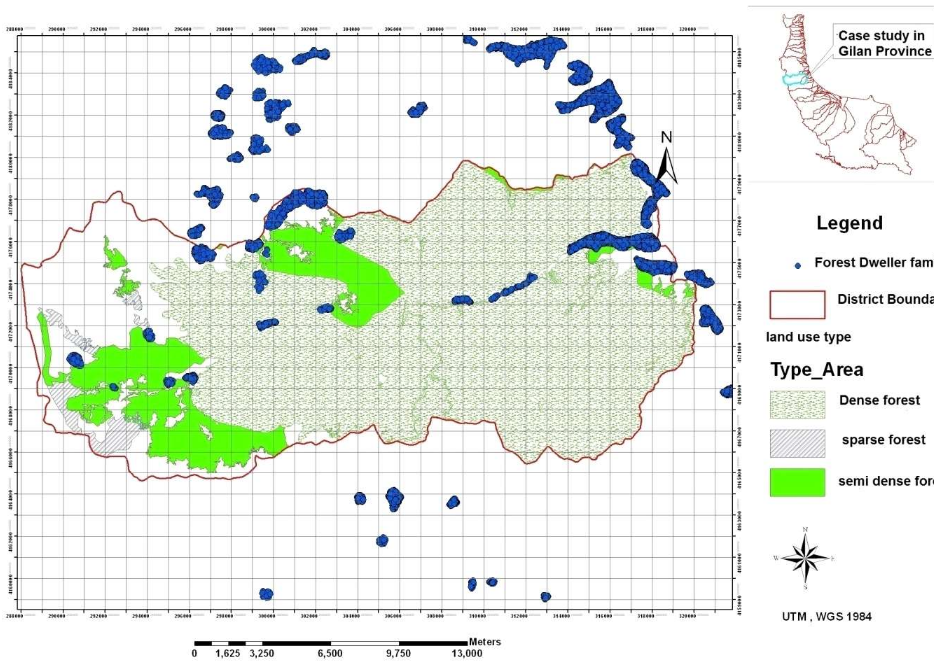

Fig. 1: Case study and land use type of Nav Asalem forest, Guilan Province, Iran

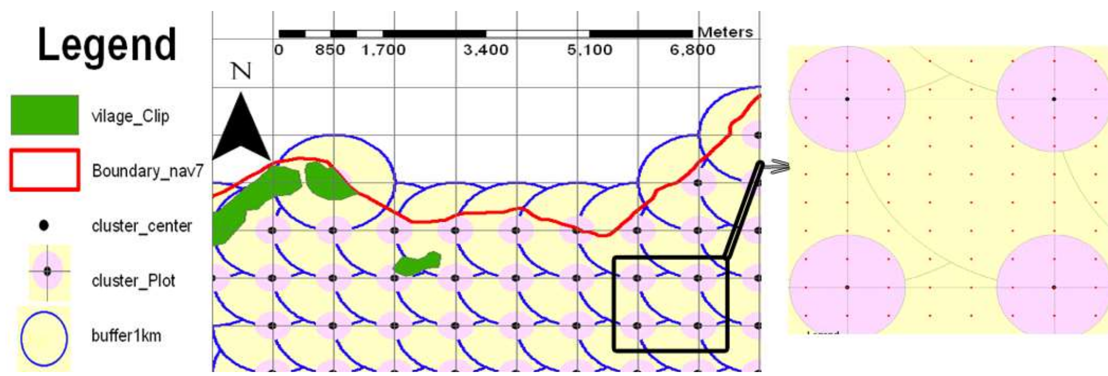

Fig. 2: Location of the villages and clusters (on the left), along with an expanded box (on the right) illustrating the circular buffers covering up to 1 km of each knot

and expressed in ha. 2) population buffer (1-7 km) along each cluster to determine quantitative characteristic three indices of tree density descriptor associated with human settlement.

Data sources

The forest inventory data (tree number, basal area, SDI) were gathered in Guilan Province in 2014 by the Forest organization. The inventory including 62 sampling clusters scattered over 30% of the total forest areal coverage of the province. Samples were arranged systematically on a grid of 1 × 1 km cell size. Nine plots of 200 × 150 m size which shaped the corresponding clusters (3 ha.), were distributed along with each direction (Fig. 2). All trees with diameter at breast height (DBH) $\leq$ 15 cm and number of these trees were measured in plots. These data used to determine three indices of tree density descriptor (Marshal *et al.,* 2000).

To calculate the population density, the buffering functions of Arc GIS 9.3 were used to create buffers between 1 and 7 km for each of the 62 clusters. (Top *et al.,* 2006). Circle shaped layers as population buffers were considered at intervals of one to seven km from the center of each cluster, which are in fact distinguished the influence area of three indices of tree density descriptor in each cluster from the surrounding population centers.

Data analysis

This study surveyed the relationship between tree density and human population density at distance 1 to 7 km from each of the 62 forest cluster. Trees of DBH exceeding 15 cm are generally collected by the local residents as fuelwood, therefore in this study large trees (DBHe” 15 cm) were considered as the primary response areas for the pressure imposed by residents. The following descriptions including: tree number, basal area, the stand density index (on a per hectare basis).

The Pearson method was conducted to investigate the relationship between forest compactness and the number of inhabitants (Zuur *et al.,* 2010). Fig. 2 shows the location of villages and 62 clusters in Asalem, Guilan Province of Iran. In each cluster, tree numbers, basal area, SDI were achieved from the set of plots assigned to each cluster. SDI could be used to regulate the number of trees by diameter class, and to determine the correct spacing between trees in even-aged groups and in uneven-aged stands based on the Eq. 1 (Page Douglas 1981; Marshal *et al.*, 2000).

$$SDI = N\ (10/QMD)^{-1.605} \quad (1)$$

N: number of trees per ha.
QMD: mean square of the trees diameter

To determine the relative density of trees using any of the above descriptors, the average of each of them was divided on its maximum. Also basal area is determined based on the Eq. 2.

$$\text{Basal area} = pi * (DBH \geq 15\ cm)^2/4 \quad (2)$$

To compute population density, we first in each village, the coordinates of each house was taken using global positioning system (GPS) and the number of population and households was measured. Then, using the buffer function (buffers of 1 to 7 km from each of the 62 clusters) in Arc GIS 9.3 the population was investigated in each buffer (Table 2).

RESULTS AND DISCUSSION

Three indices of tree density descriptor

Table 1 shows general statistics on three indices of tree density descriptor for large trees (DBHe” 15 cm). The range of three indices of tree density descriptor were 76-495 trees/ha for number of trees, 11.4-34.6 m^2 for basal area, and 81.1-244.93 for stand density index.

The results of the average basal area and number of trees per hectare in clusters by their specific coefficient of variation indicated the variability of stands condition using descriptors, which this confirms that stands are influences by various factors, including human densities (than the ratio of the correlation) (Table 1).

The noteworthy point about human population density results is that the demographics of upper layers is resulted from the cumulative frequency of lower layers, while each of the numbers related to each population layers in the table was the average number of population of each of the layers in a total of 62 clusters, which were calculated by the mentioned software (Table 2).

Table 1: Statistical results of the quantitative characteristics of the three indices of tree density descriptor in statistical clusters

Characteristics	Number of clusters	Average	Maximum	Minimum	Standard deviation	Coefficient of variation	Relative density
Basal area (m^2/ha)	62	23.16	34.66	11.41	4.59	19.81	66.8%
Number of trees (N/ha)	62	243	495	76	94.3	38.81	49.09%
Stand density index	62	178.25	244.93	81.15	34.51	19.36	72.2%

Table 2: Population average based on the seven layers

Buffer (population layer)	B1	B2	B3	B4	B5	B6	B7
Average person in buffer	35	245	540	784	1181	1700	2437

Table 3: Pearson correlation

index	RB_1	RB_2	RB_3	RB_4	RB_5	RB_6	RB_7
Basal area at breast height	-0/370**	-0/399**	-0/403**	-0/399**	-0/394**	-0/399**	-0/47**
Number of trees	-0/ 222ns	-0/ 212 ns	-0/ 212 ns	-0/ 206 ns	-0/ 194 ns	-0/ 215 ns	-0/ 291*
Stand density index	-0/381 **	-0/401**	-0/403**	- 0/396**	-./389**	-0/401 **	-0/482**

* Significant at 5% level; ** Significant at 1% level; NS: not significant

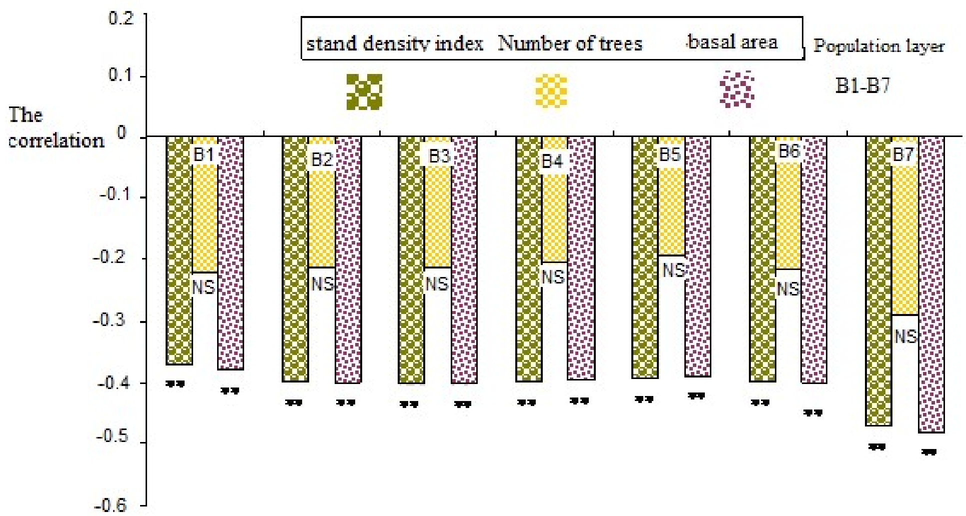

Fig. 3: Results of the Pearson product-moment correlation coefficient between tree and human compactness

Influences of human population pattern on three indices of tree density descriptor

Table 3 and Figure 3 show correlation coefficient between both variables within the radial distance from 1 to 7 km of each cluster. The first variable has been presented as the level of population distribution in capita.km^2 and the second as the forest compactness in terms of basal area, number of trees and stand density index). Significantly negative co-variation exists between the latter variables in the following manner: population density and basal area at 1-7 km (for DBHe" 15 cm); number of trees at 7 km (for DBH e" 15 cm); and stand density index at 1-7 km (for DBHe" 15 cm). However, no significant correlation was observed between number of trees (were restricted to the ≤15 cm DBH) and population density at 1-6 km.

Three indices of tree density descriptor

The Three indices of tree density descriptor in each cluster presented wide variation. Basal area in this study had similar mean (23.16 m^2/ha) with range (11.41-34.66). Also the case for number of trees had similar mean (243 trees/ha) with range (76-495 trees/ha) and stand density index had similar mean (178.25) with range (81.15-244.93). The wide range in measure of indices reflected human disturbance and corresponding basal area/stand density index reduction in clusters. This showed that higher values of forest compactness (basal area, number of trees, stand density index), could result in higher numbers of recorded tree species.

Influences of human population on three indices of tree density descriptor

Human activity meaningfully affects natural ecosystems (Wang *et al.,* 2001). It affects our natural resources through many ecological processes such as extinction of species, forest degradation on a different scale from site to region (Vitousek *et al.,* 1997). In Asalem about 16393 rural people live in 47 villages located within forest area and have traditionally depended on fuelwood from natural forests for house hold use (cooking purpose and home heating source).

Fuel-wood gathering could be the cause for forest loss in Asalem forest, Iran. This study showed significant relationship between tree and human size where former has been assessed in terms of three indices (basal area, number of trees, stand density index) of DBHe" 15 cm, especially at 7 km surrounding from clusters. Basal area and stand density index for DBHe" 15 cm reduced in clusters in the vicinity of residents focus areas. In the first six kilometer distance from each knot, there was no detectable correlation between the variables, however this did not hold for the distance of seven kilometer (Table 3, Fig 3). Therefore, this study suggests the importance of the radial distance size of 7 kilometer as the significant boundary limit of each cluster to manifest the outcome of anthropogenic interferences on the forest stands. Similar studies have been showed in other areas. For example in Tanzania Kimaro and Lulandala (2013) the impact of human on tree diversity and composition of a coastal forest ecosystem found economic activities including logging, charcoaling, and shifting cultivation were the most important disturbing activities affecting ecological functioning and biodiversity integrity of the forest. Sale and Agbidye (2011) revealed that Impact of Human Activities on the Forest and Their Effects on Climate Change. In Nigeria Judith *et al.,* (2011) revealed that population increase have seriously depleted the forest ecosystem. In Cambodia Top *et al.,* (2008) strong negative correlation were found between population density and tree density, basal area, stand volume, aboveground biomass, species diversity and richness In tropical rainforest Bulter (2012) showed that human overpopulation increase demands on the resources derived from the tropical rainforests. Wang *et al.,* (2001) strong negative correlation were found between population density and carbon density. Chittibabu and Parthasarathy (2000), Zhu *et al.,* (2004) and Bhuyan *et al.,* (2003) administrated the impact of human disturbance on species richness and found that species diversity decreased with increasing human density. Conducted studies in the tropical forests of Cambodia (Tap *et al.,* 2009), Western Ghats, India (Karanth *et al.,* 2006) and China (Wang *et al.,* 2001) confirm these results related to descriptors of trees' number and basal area per ha.

The proposed study has revealed a robust relationship between settlement compactness and forest stand characteristics at 5, 7, and 9 km radii from the centers. But the relation between SDI as a descriptor and human population density was assessed in this study for the first time and a higher correlation had been achieved compared to other descriptors. The corroboration of the significant negative relationship between human settlement compactness and trees in forest stands has been done by affirming a radial impact zone of 7 km around settlement focus areas. This zone could be the primary management blocks for managers and decision makers as it provides even the ground for further studies in this context where it seeks to find association between the above-mentioned parameters. While the relationship between the stand density and human community centers in the forest were qualitatively analyzed in Hyrcanian forests of Azerbaijan and similar results were obtained (Sharnweber *et al.,* 2007). Based on the results of this study, suggest that basal area and stand density index decreases with rising population density.

Human settlement in the forest, aside from negative impacts, could bring about curiously positive effects as well. Human settlement as part of the ecosystem has been an area of interest to the sociologists (Bode *et al.,* 2000). Bringing balance to the human population and forest density as an important component of forests, could also bring balance in human population. As with the existence of settlers, one could reach a forest stand with harmonious fauna and flora. This study showed that human influence on forest stand is meaningful in the 7 Km from local residence and further, no significant human influence could be discerned. This could managers to develop their management schemes based on the radius to bring balance to the forest stands in these areas. Further studies are recommended to establish a relationship between forest density and human population in a sustainable manner to be able to maintain forest stand's existence. Elsewhere, the effect of population have been evaluated based on two indices of the number of trees and surface are per hectare. Yet, this study has uniquely included further the SDI index and included positive facets of human presence in the forest stands in the sense that what population density is considered acceptable to seek forest sustainability.

CONCLUSION

Tree density is a important factor in choosing the extent of human activity on ecosystems because many ecological processes rely upon forest tree existence. Quantifying the human influences the tree density is very significant for sustainable forest management and conservation. In order to approximate actual tree density in Nav Asalem forest, number of trees, basal area and stand density index examined and found a relationship of tree density and population density. An effective relationship between tree density and human population density in three indices of tree density descriptor revealed that forest had been affected by human, a subject that can be the basis of sustainable forest management patterns. Despite the lack of a significant relationship between the number of trees per hectare and human population density in the study forest, a significant negative correlation was observed between other descriptors of tree density (basal area per hectare and SDI and human population density. In summary, the present study revealed that the human population significantly impacts on component of the three indices of tree density descriptor include basal area per hectare and SDI in Hyrcanian forests. In any case, the existence of or lack of relationship between each of the tree density components and human population density could be a major step towards an optimum forest management with regard to the density of natural and human factors; a topic that has been little studied and it seems that one of the main reasons is the lack of quantifying the impact of human presence in the forest. Today, various models of forest management resulting from the effects of human population on forest-related indices have been designed and following these models would greatly solve socio-economic problems in forests of the country. However, the use of such models and patterns requires necessary basic studies regarding the impact of human factors on three indices of tree density descriptor. This study suggests that introducing control of human disturbance is vital for sustainable forest management and conservation in Hyrcanian forests of northern Iran.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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