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# Selection of potential plantations for *Buxus hyrcana* Pojark using GIS near coastline of Caspian Sea in North of Iran

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Expansion of forests and forest species is impossible without considering the relevant standards and criteria. Therefore, plant species suited with and adaptable to natural conditions of any area should be used. In this paper, Lille Basin was selected using multi-criteria evaluation method (MCE) as a study area as it was suitable in zoning and evaluating ecological capability for *Buxus hyrcana* Pojark plantations, and the ecosystem did not fall out of the classification. For this purpose, GIS and AHP models were used. Eight selection criteria were: Elevation, soil type, canopy cover, wind direction, temperature, humidity, rainfall levels, and the gradient. Weights of the criteria were: 0.384, 0.2081, 0.1438, 0.0977, 0.658, 0.0444, 0.0353, and 0.0209, respectively. On this basis, elevation and gradient had the highest and the lowest values. The results suggested that *Buxus hyrcana* Pojark showed sensitivity to variations of the criteria and their distribution is directly correlated to ecological factors particularly climatic and physiographic ones. The layer of important zones and reserves of this species highly overlap the final layer resulting from MCE. Evaluation criteria and sub-criteria and their weights with an acceptable accuracy was 0.0467 (<0.1) that exhibited usefulness of GIS in site selection, composition and overlaying various criteria of this research.

[**Keywords**: Site selection; *Buxus hyrcana* Pojark; GIS; Lille basin; Gilan Province]

## Introduction

The main advantage of multi-criteria evaluation (MCE) is the ability to analyze effects of habitat factors on the criteria, combine habitat assessment for several species, and weigh them by various methods and unify empirical and specialized methods. Site selection for plantations of *Pinus brutia Ten* in a forest park using AHP and GIS[1] focused on determination of factors for planting *P. b. Ten* with the aid of AHP[2]. AHP method to introduce plant species adapted to forest expansion in Vasiyeh Valley Basin. An environmentally homogenous unit was produced by overlaying layers of gradient, geographical direction, hypsometry, rainfall, temperature, soil layers, geology, rivers and land uses. Species to be afforested were both endemic and non-endemic plant species adapted to ecological conditions of forest development units[3]. In terms of physiographical and climatic conditions, finding Mediterranean region of east Spain as the most favorable location for *Fagus orientalis* by GIS showed that the distribution of this species is recommended to use a combination of AHP and GIS for evaluating ecological potential of forest ecosystems (ash and pine)[4]. Recommended *Fraxinus mandshurica* (*Manchurian Ash*) and *Pinus sylvestris* (Scots pine) for evaluating capability of forest ecosystem[4]. Developed a framework to assess sustainability, which was used in the form a multi-criteria analysis in GIS to assess sustainability of sub-drainage basins[5]. According to this paper, this framework can illustrate the needs of sub-drainage basins for reaching sustainability. The results of this combination indicated usefulness of this method for collecting a large amount of information and evaluating agricultural-ecological capability. ANP-DEMATEL and FAHP multi-criteria decision-making models were used to assess land suitability for agricultural land uses[6,7]which is not suitable for agriculture due to proximity to mountains and hills, and presence of gypsum and lime geological formations.

This research is intended to find a match between ecological demands of *Buxus hyrcana* Pojark and ecological properties of the study area in Gilan province to select favorable areas using GIS.

## Materials and Methods

The study area in Gilan province is located at a mountainous area (Fig. 1) between 95.42 and 1086 m including plains, hills and mountains. Annual temperature varies between 16 to 18 °C and annual rainfall ranges between 900 to 1200 mm.

First, a database was established including digital topographic maps, satellite images, temperature and rainfall maps, relative humidity, soil type, density of canopy cover and lithology. Then, the map of box weed reserve locations was prepared and laid on the base map using a global positioning system (GPS) apparatus in the field to be compared with the selected sites.

Next, each layer was weighed by pair-wise comparisons and AHP based on the professional opinions using Expert_Choice software. Data analysis and conclusions were performed by MCE. This method use based on data combination according to their importance in decision making. Numerical algorithms determine suitability of a special solution based on values and criteria and they have many uses in applying GIS software for environmental site selections. Finally, the layers were valued (weighted) and combined based on natural occurrence of *Buxus hyrcana* Pojark resulting in a final map of locations favorable for planting the species in this basin.

## Results

The criteria of site selection for box weed were selected and added to Arc GIS maps including layers of physiographic factors, slope, elevation, climatic factors, temperature, humidity, rainfall, soil type and canopy cover (%).

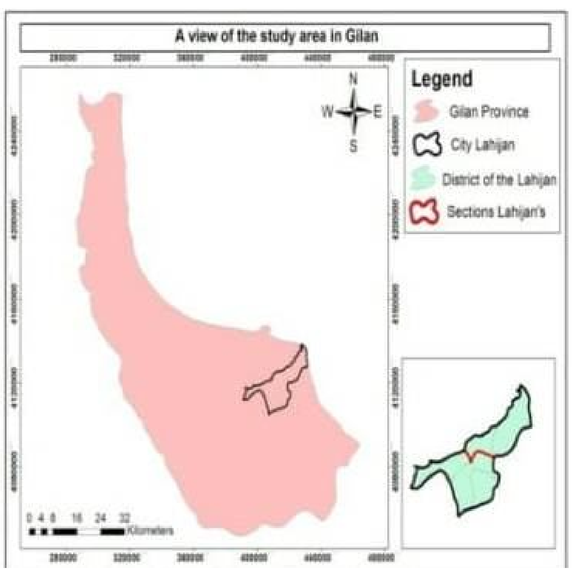


Fig. 1 — The study area in Gilan Province

### *Slope*

Slope varies with topography, environmental conditions and soil erosion. Trees on higher slopes become more vulnerable due to rockiness, increased erosion and decreased soil depth. Digital Elevation Maps (DEM) in seven classes were used to evaluate slope of the area. According to natural resources experts in Arc GIS and by using AHP, weights of the slope layer and its classes are shown in Table 1 and the weighted slope map in Figure 2.

### *Cardinal directions*

There is a significant relation between cardinal directions, distribution of box weed and capable growth areas. Direction maps were prepared by using DEM maps. When direction classes were created, weights allocated by experts were given to them based on their effects on box weed growth. Figure 3 and Table 2 shows the weighted map of directional classes.

### *Elevation*

Elevation classes are very useful in finding sites suitable for box weed because its distribution is

Table 1 — The slope classes

| Weight | Sub-class |
|---|---|
| 0.026 | 0-5 |
| 0.044 | 5-15 |
| 0.067 | 15-20 |
| 0.107 | 20-25 |
| 0.158 | 25-30 |
| 0.238 | 30-40 |
| 0.356 | 40< |

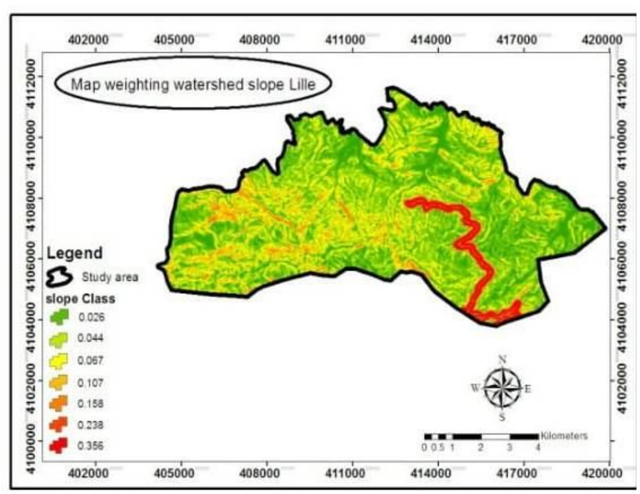


Fig. 2 — The map of slope classes in Lille Basin

400-800 m high. Based on their importance (expert opinions), they were weighted in AHP by Arc GIS. Table 3.

*Soil*

Soil orders (classes) in the study area are alfisols and inceptisols. The former receives higher weights by the experts (Figs 4 and 5). Table 4

*Climatic factors*

Maps of temperature, rainfall and humidity were prepared (using 14-year mean by interpolation), classified and weights were allocated to each class based on expert opinions. According to experts, classes of higher temperature, higher rainfall and higher receive higher weights (Tables 5-7 and Figs 6-8).

*Canopy cover percent*

As seen in NDVI map obtained from Landsat images, pixel values over 7.0 were regarded as suitable sites for box weed plantations. Table 8 and Figure 9 show canopy cover classes and their weights.

*Criteria weighting*

After weighting and pair-wise comparison of sub-classes, each pair of the criteria of this research needed be compared. For this purpose, AHP was used to compare the criteria. Pair-wise comparison matrix,

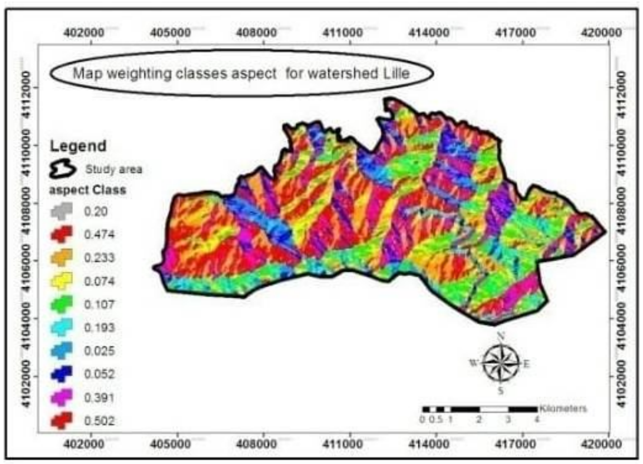


Fig. 3 — Map of geographical directions in Lille Basin

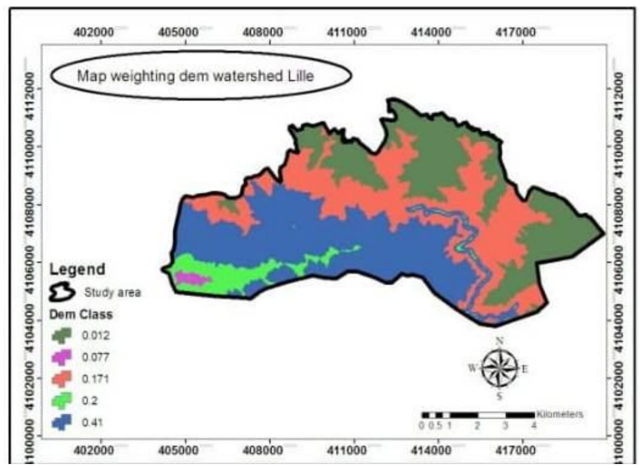


Fig. 4 — Map of weights of elevation classes in Lille Basin

Table 2 — Classes of geographical direction

| Weight | Sub-class |
|---|---|
| 0.201 | Flat (-1) |
| 0.474 | North (0-22.5) |
| 0.233 | Northeast (22.5-67.5) |
| 0.074 | East (67.5-112.5) |
| 0.107 | Southeast (112.5-157.5) |
| 0.193 | South (157.5-202.5) |
| 0.025 | Southwest (202.5-247.5) |
| 0.052 | West (247.5-292.5) |
| 0.391 | Northwest (292.5-337.5) |
| 0.502 | North (337.5-360) |

Table 3 — Elevation classes

| Weight | Sub-class |
|---|---|
| 0.077 | 42.95- 200 |
| 0.171 | 200- 400 |
| 0.41 | 400 - 800 |
| 0.2 | 800 - 1000 |
| 0.012 | 1000 - 1086 |

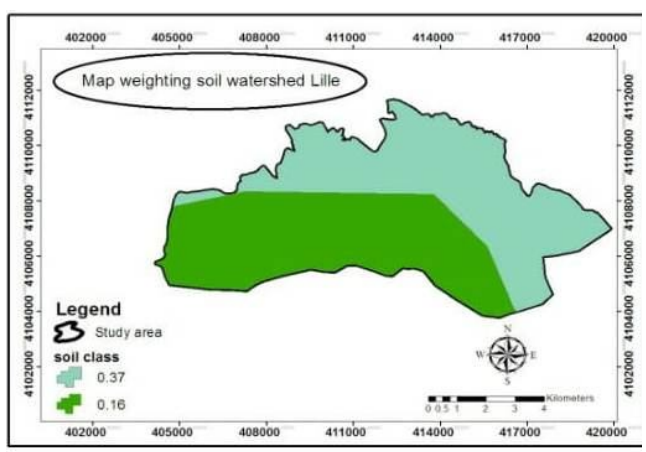


Fig. 5 — Map of soil class weights in Lille Basin

Table 4 — Soil classes

| Weight | Sub-class |
|---|---|
| 0.37 | Alfisols |
| 0.16 | inceptisols |

the resulting weights, and the map of criteria weighting are shown in Figure10, Table 9 and Figure11, respectively.

*Training sampling*

Field visits were carried out for taking samples and GPS points were taken (Fig. 12) suggesting that box weed distribution sites highly overlap those with highly potentials.

Table 5 — Temperature classes

| Weight | Sub-class |
|---|---|
| 0.03 | 13-13.4 |
| 0.06 | 13.4 - 13.7 |
| 0.16 | 13.7 - 14.06 |
| 0.25 | 14.06 - 14.41 |
| 0.5 | 14.41 - 15.03 |

Table 6 — Rainfall classes

| Weight | Sub-class |
|---|---|
| 0.28 | 1,434 - 1,495 |
| 0.19 | 1,495 - 1,525 |
| 0.14 | 1,525 - 1,544 |
| 0.09 | 1,544 - 1,560 |
| 0.06 | 1,560 - 1,573 |

Table 7 — Humidity classes

| Weight | Sub-class |
|---|---|
| 0.011 | 0-10% |
| 0.92 | 10-20% |
| 0.142 | 20-30% |
| 0.282 | 30-50% |
| 0.31 | >50% |

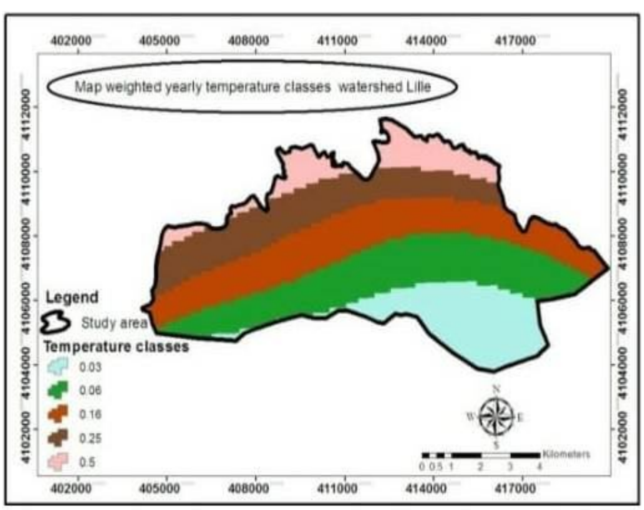


Fig. 6 — Map of temperature class weights in Lille Basin

## Discussion

Geographical Information System and AHP model were used to select sites suitable for *Buxus hyrcana* Pojark plantations in Lille Basin. The results showed that physiographical, physical and geomorphologic properties of a forest basin had great effects on habitat conditions, which should be taken into consideration for reasonable use of regional forests.

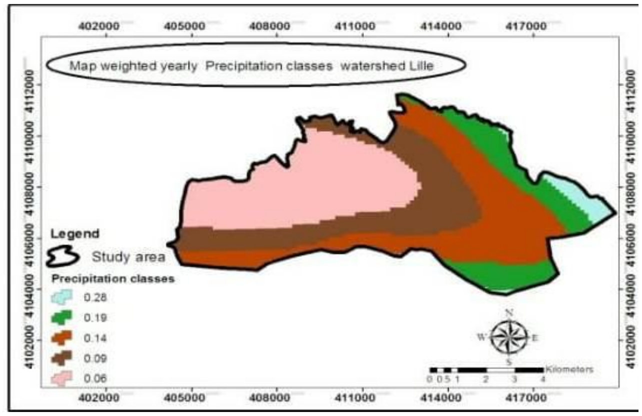


Fig. 7 — Map of rainfall class weights in Lille Basin

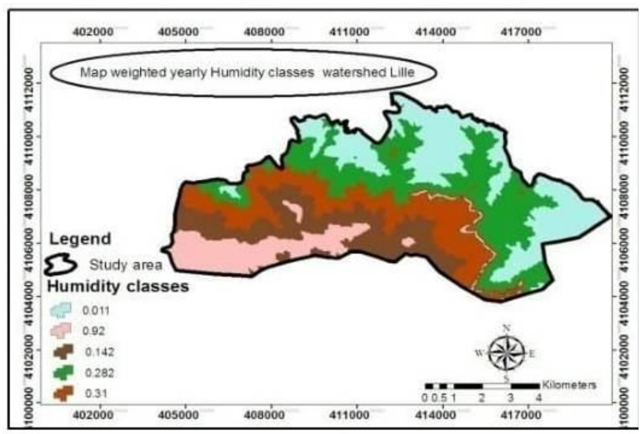


Fig. 8 — Map of humidity class weights

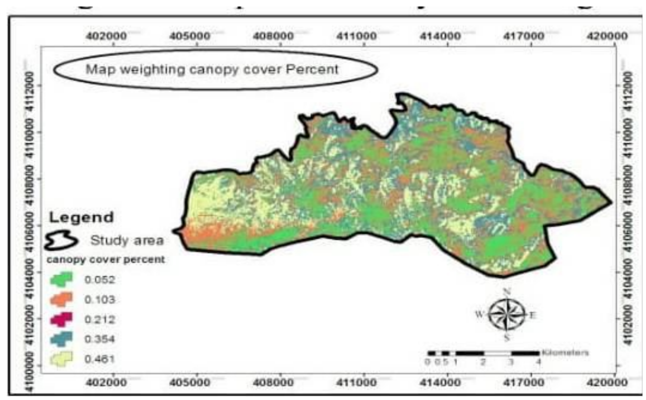


Fig. 9 — Map of canopy cover in Lille Basin

Table 8 — Canopy cover classes

| Weight | Sub-class |
|---|---|
| 0.052 | 0-20% |
| 0.103 | 20-40% |
| 0.212 | 40-60% |
| 0.354 | 60-80% |
| 0.461 | >80% |

Table 9 — Tthe criteria weights from pair-wise comparison

| Weight | Criteria |
|---|---|
| 0.384 | Elevation |
| 0.2081 | Soil |
| 0.1438 | Canopy cover (%) |
| 0.0977 | Direction |
| 0.0658 | Temperature |
| 0.0444 | Humidity |
| 0.0353 | Rainfall |
| 0.0209 | Slope |

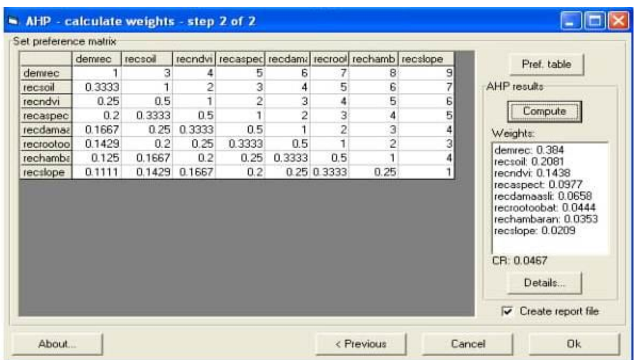


Fig. 10 — Matrix of pair-wise comparison of criteria

Physiographical properties including sea level elevation, geographical direction and slope of foothills highly influence climatic factors. Sea level is an indication of climate change. Due to sea level variations, any place on the planet earth receives adifferent amount of energy. As air pressure increases, and elevation decreases, humidity and rainfall change. Therefore, elevation changes can leave huge effects on three parameters: Temperature, humidity and rainfall. In higher elevations, pressure is low, radiation intensity decreases, and ultraviolet rays increase. Stages of plant growth reduce; pigment density increases and plants find a dark appearance. Relative humidity is high in elevations. For this reason, the vegetation is mostly in the form of shrubs to be able to withstand strong winds. On this basis, weights allocated to eight criteria discussed in this research (elevation, soil, canopy cover, direction, humidity and slope) are 0.384, 0.2081, 0.1438,

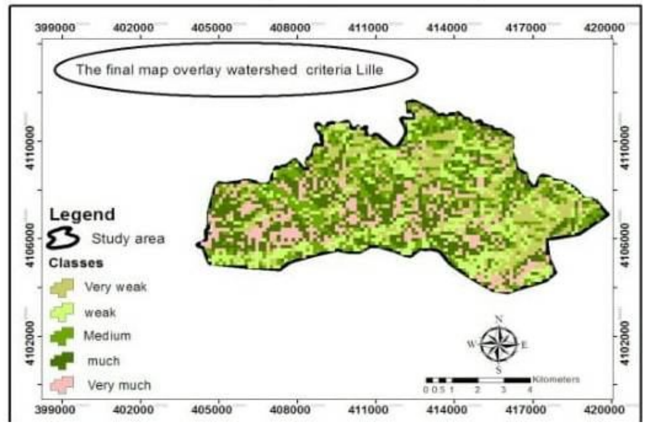


Fig. 11 — Criteria overlay map of Lille Basin

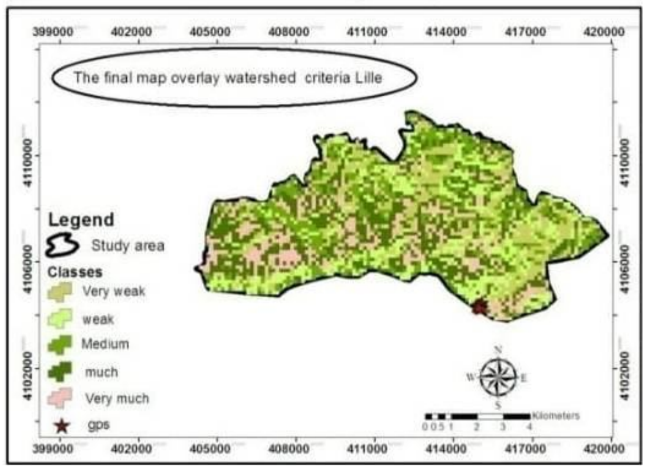


Fig. 12 — Samples taken from final overlay map in Lille Basin

0.0977, 0.0658, 0.0444, 0.0353, 0.0209, respectively. These weights indicate that elevation has the highest value and slope has the lowest value. The results also suggested that *buxus sp.* exhibits sensitivity to variations of different indicators and its distribution is directly correlated to ecological factors especially climatic and physiographic ones. The layer of box weed reserves in the region highly overlaps the final layer obtained from MCE method. Criteria and sub-criteria involved in evaluation and their weights (with an acceptable accuracy) was 0.0467 (<1), which corresponds with expert opinions about pair-wise comparison and AHP[8]. It also displays ability of GIS in site selection and overlaying a wide variety of ecologic criteria.

Due to disagreements between the experts, opinions of different experts were used. Elevation parameter that can affect rainfall and temperature had the highest final value. Introduced favorable plant species for afforestation in Vasiyeh Valley Basin using MCE and GIS with eight information layers (slope, direction, hypsometry, rainfall, temperature, soil, geology and rivers). The experts concluded that elevation information layer is more effective than other layers, which corresponds with the results of this research.

## Conclusion

To evaluate ecological capacities for forest expansion, all environmental factors including physical and biological ones were measured, and homogenous environmental units (vegetation sites) were identified. Used the same factors for forest expansion in an earth evaluation in Turkey[9]. This research can help find sites suitable for *buxus sp*. by using GIS, evaluation models and weighting, and implement a long-term plan to facilitate planting it in highly capable sites to increase its distribution throughout forests in northern Iran. Evaluation in a multidimensional space with a large number of ecosystem units necessitates a useful tool. Thus, due to its advantages, GIS was used. GIS advantages are: Increased speed, precision, power of the researcher in producing, combining, analyzing and evaluating the data with regard to its massive volume[10]. Another advantage is synchronized use of tabular and map information, which enables analysis of various maps. GIS is a system that uses utilities of other systems and is a full package of all systems. A privilege of GIS is in modeling. Based on above, this research also benefited from GIS for interpolating isoheight, isotherm, humidity and contour curves[11]. When research criteria were determined, since simultaneous comparison of several criteria was not possible in a traditional way, abilities of this system and AHP was the best option for this type of site selection, which was acceptable in terms of speed and accuracy[11]. This proves the research hypothesis and demonstrates high capability of GIS to identify sites of spreading *buxus sp.* Therefore, findings of this research can help select, evaluate and weight such sites by using GIS as a powerful tool, and implement systematic plans to facilitate planting it in highly capable places to increase distribution in forest of the Northern Iran.

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