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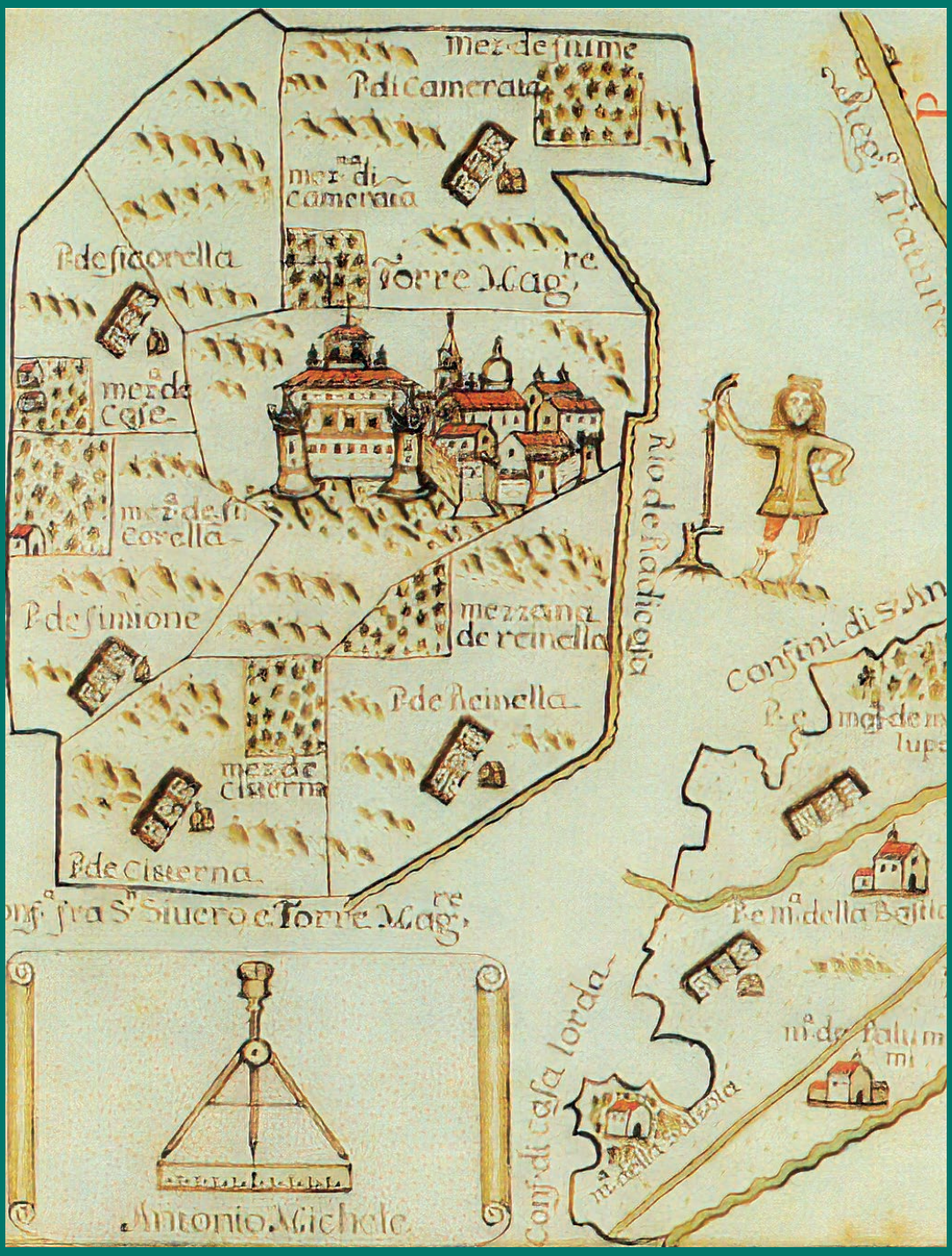

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Developing a new model for ecological capability evaluation of irrigated lands in Firouzabad Township, Iran

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Abstract. Agricultural planning is a very complex task, since there are numerous goals, which should be achieved simultaneously, and various components and elements, which must be considered at the same time. The process of agricultural suitability evaluation for crop production requires specialized geo-environmental information and the expertise of a computer scientist to analyze and interpret the information. The main objective of this paper is to test a new model (based on Iranian ecological and FAO models) for ecological capability evaluation with geometric mean evaluation for better planning management of irrigated lands. Next, the proposed method was verified and compared with other well-known methods such as the Iranian ecological model with Boolean logic, arithmetic mean, and WLC. To test the models, we used the normalized difference vegetation index (NDVI). The test results indicated that the method revised by geometric mean evaluation (overall accuracy %=95 and Kappa coefficient =0.91) was the best among the used methods, and the arithmetic mean method (overall accuracy %=46 and Kappa coefficient =0) had the lowest accuracy. Thus, this method (Geometric mean evaluation) has high flexibility in locating agricultural lands. Overall, this study can be used as a basic method to evaluate ecological suitability for other regions with similar conditions owing to its simplicity and high precision.

Keywords: Ecological Capability, Irrigated Farming, Boolean, Geo-Mean, GIS.
JEL codes: Q01, Q15.

1. INTRODUCTION

The increase of food production in line with growing population is the major challenge for the coming decades, especially in countries with limited water and land resources. Iran is one of those countries, as it suffers from limited renewable water resources due to low rainfall, high evaporation, and excessive withdrawal of ground water. The increasing and competitive demand for land, for both agricultural production and other purposes, requires that decisions be made on the most beneficial use of the limited land resources (Ayalew, 2015; Lahmian, 2016). Failure to achieve a perfect match

between land capability and use can be particularly problematic for agricultural production, since cultivating wrong crops on wrong soils can result in poor yields and its associated financial and other losses (Froja, 2013; Jokar, 2015; Masoudi, 2014; Mokarram and Zarei, 2021).

Agriculture in Iran is an important activity, and agricultural economy is a significant part of the country's economy. Iran is one of the first lands, where agriculture appeared. Some ancient migrations to this country were also due to finding better lands for agriculture. According to official statistics in 2016 (Jalali, 2020), 17.6% of the Iranian workforce is engaged in the agricultural sector. Accordingly, the share of the added value of the agricultural sector at constant prices in Iran is 6%, including 71% of cultivation and horticulture, 24% of animal husbandry, 4% of the aquatic sector, and 1% of forestry. Nearly one-third of Iran's lands are suitable for agriculture; however, due to the poor quality soil and inappropriate water distribution in most areas, only 12% of Iran's land is used for agriculture. Nevertheless, less than a third of the agricultural land is irrigated, and in other cases, it is rainfed. The alluvial plain of the Sefidroud River in the north and the Mughan plain in the northwest and the plain of Karun, Dez and Karkhe rivers in Khuzestan have more fertile soil than other agricultural areas in Iran. According to the FAO statistics, Iran is among the top 7 countries in agricultural production of 22 important products. Iran ranks first in pistachio, saffron and barberry production in the world. It also ranks second in date production and fourth in apple production. The most important agricultural products of our country are wheat, rice, cereals, sugar beet, fruit, nuts, cotton, and tobacco (Jalali, 2020).

The Food and Agriculture Organization (FAO) (1983) defined land evaluation as the process of assessment of land performance when used for specified purposes. Hence, land evaluation can be useful for predicting the potential use of land based on its attributes (Jahantigh et al., 2019; Jokar, 2015; Lee and Yeh, 2009; Martin and Saha, 2009; Masoudi and Sonneveld et al., 2010; Rossiter, 1996; Zonneveld, 1989). Land suitability evaluation is considered one of the most effective methods for proper agricultural land use planning regarding decisions on specific crops (He et al., 2011; Masoudi and Zare, 2019; Mu, 2006; Nwer, 2006; Pan and Pan, 2012; Prakash, 2003).

Since the study by McHarg (1969), land suitability assessment has become a standard method in land use planning. Furthermore, land is regarded as a complex system resulting from the interaction of physical, biological, and anthropological phenomena operating over different scales of time and space. Therefore, the choice of the proper method of evaluation for planning is crucial (Hosseini, 2018; Masoudi et al., 2017; Pan et al., 2021).

Recently, most studies have combined physical parameters affecting the yield agricultural crops and socio-economic factors in the process of land suitability assessment (Elsheik et al., 2010; Keshavarzi, et al., 2010; Yohannes and Soromessa, 2018). Nowadays, technological advancements in the geo-spatial domain have brought ease for decision-makers to utilize land resources at maximum (Alavi Panah et al., 2001; Mapedza et al., 2003; Nazari Viand et al., 2019). Mitra and Ilangova (2004) have reported that Geographical Information Systems (GIS) play a very strong role in site selection. GIS is typically used to store and analyze extensive information in the map-based format (Amarsaikhan et al., 2004). Fallah Miri et al. (2008) investigated agricultural suitability in the Kasilian watershed by GIS. The results revealed that approximately 30% of lands were appropriate for agriculture. In another paper, Pourkhabbaz et al. (2014) investigated the suitability of agriculture using multi-criteria evaluation (MCE) methods such as analytic hierarchical process (AHP) and (Serbian name) VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) and Simple Additive Weighting (SAW) in the Takestan-Qazvin plain. Their results indicated that the application of MCE could be useful in agricultural evaluation (Safaripour and Naseri, 2019). Feng et al. (2014) utilized AHP and FUZZY methods for the land suitability evaluation of China's coastal improvement. The outputs demonstrated that the FUZZY method had high flexibility in land capability evaluation. Other scientists in other regions of the world mentioned the usefulness of MCE methods in evaluating the ecological potential of different uses (Amici et al., 2010; Ananda and Herath, 2009; Liao and Wu, 2013; Perveen et al., 2013).

Contrary to the above methodologies, Iranian ecological model (Makhdoum, 2006), Boolean logic and geometric mean models have been utilized for agricultural capability assessment with an ecological perspective. Although Boolean logic is a simple method, it can be qualitative and strict enough to locate suitable regions for each land-use (Jokar and Masoudi, 2016; Jokar et al., 2021). The geometric mean method for ecological capability evaluation is proposed as a new MCE method, which has a quantitative and easier evaluation approach than other MCE methods (such as WLC and genetic algorithm) that are usually difficult for users. Thus, the present study was conducted to develop a new method newer than Boolean logic, and average-based methods. This proposed method may assess the irrigated land capability more simply, systematically, and accurately.

2. MATERIALS AND METHODS

2.1 Study area

Firouzabad Township (Fig. 1) is located in Fars Province, southern Iran. Firouzabad is in the southwestern part of Fars Province. This township has an area of 3559 km^2. This city is placed in the range of 53 degrees 31 minutes east longitude and 29 degrees 15 minutes north latitude. The average height is approximately 1600 m. The climate is wet and moderate. According to the 2015 census, the population of this city is 121,417 people, being the eighth most populated city in Fars Province. Currently, the cultivation of plants such as wheat, barley, rice, rapeseed and corn is carried out to manage water resources and optimally use agricultural lands in Firouzabad county. According to the surveys and experts, products such as grapes, walnuts, pomegranates, peaches, pistachios, figs and citrus fruits are the most important garden products of the city, and the production of more of these products enjoys an advantage owing to its compatibility with the climatic conditions of the region and its better sales market.

2.2 Method

This paper was conducted based on 2 overall sections: A. Models Description and Reclassification of Parameters (Section 2.2.1); and B. Evaluation and Formulation of the Proposed Model Based on Boolean Logic, Arithmetic Mean and Geometric Mean, and WLC (Section 2.2.2). Figure 2 depicts the platform structure of the designed model.

2.2.1 Models description and reclassification of parameters

The Iranian evaluation model of ecological capability for agricultural use (Makhdoum, 2006) consists of 7 classes. The Food and Agriculture Organization (FAO) ecological model (6 classes) is also a classical model. We used both mentioned models to define a proposed model. Both models have many similarities; however, there are differences such as the lack of climate indicators in the FAO model and the drought index, and the lack of a series of indicators related to water criteria in both models. By examining classes 1 and 2 of the indicators of both models, as well as classes 3 and 4, contributed to the determination of classes 1 and 2 of the indicators of the new model, respectively. Additionally, the examination of classes 5 and 6 of the Iranian ecological model indicators, along with class 5 of the FAO model indicators, helped in determining class 3 of the new model indicators. Finally, the examination of class 7 of the Iranian model indicators and class 6 of the FAO model indicators, helped in determining class 4 of the new model indicators (Masoudi, 2018). Hence, the proposed model and its indicators were reclassified as four classes,

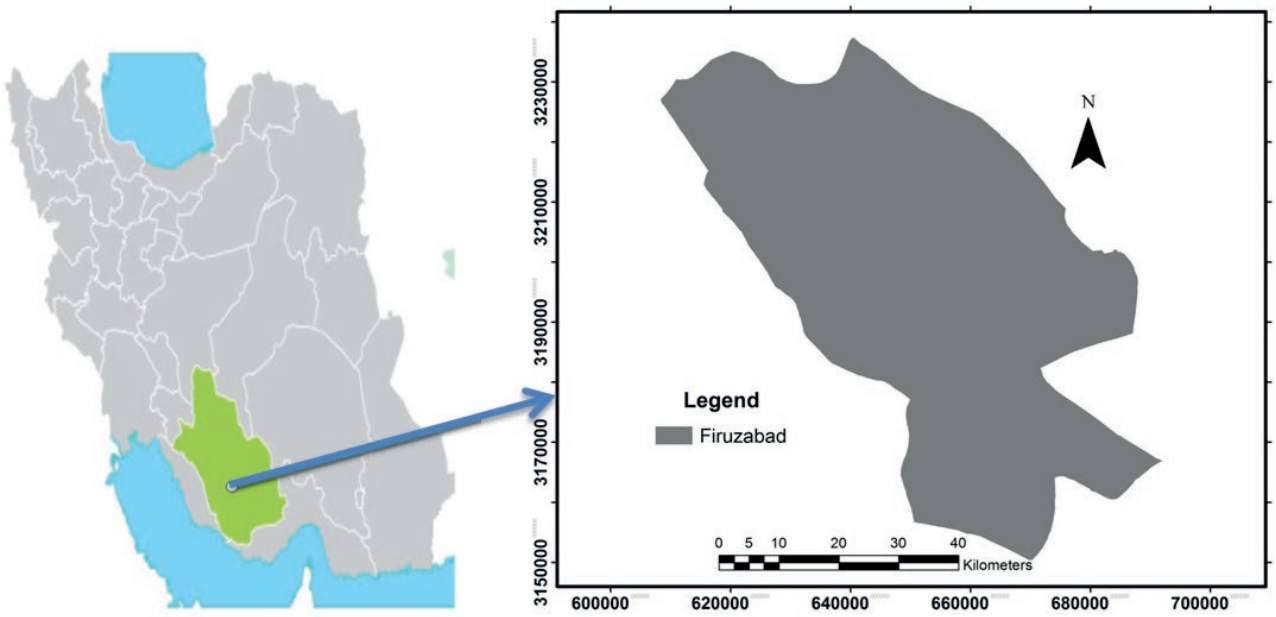

Figure 1. Location of Study Area in Iran.

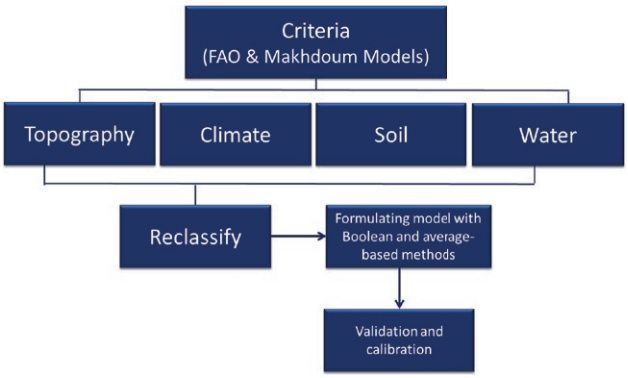

Figure 2. Flowchart showing the methodology adopted for ecological capability evaluation in this study.

including suitable (good), moderate, poor and unsuitable (Tables 1 and 2).

It should be noted that the parameters included in the revised proposed model of Iranian ecological and FAO models are based on geographical and environmental conditions of the study area (such as drought and degradation of water resources). Another reason for using two models was based on the selection of the suitable order in their parameters and range of classes (Masoudi, 2018). Therefore, the proposed model was adjusted based on the integration of Iranian ecological and FAO models (Table 2).

2.2.2 Evaluation and formulation of the proposed model based on boolean logic, arithmetic mean, and geometric mean

The ecological capability models of irrigated agriculture were based on climate, physiographic, water and soil criteria and according to different evaluation methods. The prepared maps include methods of the Iranian ecological model with Boolean algebra with 7 classes, its reclassified model of evaluation with the maximum limitation way in 4 classes, different MCE and WLC methods, and the proposed method of geometric mean.

Boolean algebra: Boolean logic has three basic operators: Intersection (logical term AND), Union (logical term OR), and Inverse (logical term NOT) (McHarg, 1969; Malczewski, 2004).

Arithmetic mean: In the Arithmetic mean method, the scores related to the parameters were averaged.

Weighted Linear Combination (WLC): The WLC method was used for the weighted overlay of the input data layers. In the weighted linear combination, first, indicators (or factors) are combined by applying weights to each indicator to determine the score of each criterion (Equation 1). The criteria are then combined by applying weights to each criterion to obtain the final score for the suitability map classification (Equation 2). In each equation, constraint factors (C_i) were also considered. Calculation of weightings was performed in the Expert Choice software. The results of the study showed the weights of indicators and criteria with the compatibility ratio or CR<0.1.

$$Criterion\ score=[(W_1\times indicator_1)+(W_2\times indicator_2)+\cdots+(W_n\times indicator_n)]\times C_i \quad (1)$$

$$Suitability\ score=[(W_1\times Criterion_1)+(W_2\times Criterion_2)+\cdots+(W_n\times Criterion_n)]\times C_i \quad (2)$$

Geometric Mean: To each indicator listed in Table 2, a weight from 0 to 3 is given based on its ecological (quantitative or qualitative) range (0 shows the ecological condition of unsuitable and 3 indicates the ecological condition of suitable for irrigated use). For example, score 2 is given to the coarse granulation of soil. Next, every criterion is calculated according to the geometric mean of the parameters in Equation 3:

$$Criterion=(indicator_1\times indicator_2\times\cdots\times indicator_n)^{1/n} \quad (3)$$

Table 1. Suitability classes of agriculture use in different models (Masoudi, 2018).

Iranian Ecological Model Classes	Suitability Description	FAO Classes	Suitability Description	Proposed Model (Reclassified)	Suitability Description
1	High Suitable	1	High Suitable	1	Suitable
2	Suitable	2	Suitable		
3	Moderate	3	Moderate	2	Moderate
4	Somewhat Moderate	4	Moderate to low		
5	Low to Moderate	5	Low	3	Low or Poor
6	Low				
7	Non-Suitable	6	Non-Suitable	4	Non-Suitable

Table 2. The parameters classes for ecological capability assessment of irrigated farming (Jokar and Masoudi, 2022; Masoudi, 2018).

Criteria	Indicators	Class limits and their ratings score			
		Highly Suitable (3)	Moderately Suitable (2)	Poorly Suitable (1)	Not Suitable (0)
Topography	Land type	Plain	-	Hill	Mountain
	Slope (%)	0-8	8-15	15-30	>30
Climate	Current state of climate	Semi-arid to wet	Arid	Super arid	-
	Drought	Slight	Moderate	Severe and very severe	-
Soil	Texture	Heavy, moderate, light	Coarse	Very Coarse	-
	pH	6.1-8.5	4.2-6,8.5-9	9-9.5	>9.5
	Depth	Deep	Semi deep	Shallow	Very Shallow to None
	Gravel percent	0-35	35-75	>75	-
	Drainage	Good to moderate	Poor	-	-
	Erosion	None, slight	Moderate	Severe	Very Severe
	Granulation	Fine to Moderate	Coarse	-	-
	Evolution	Perfect	Moderate	Low	None
	EC(mmhos/cm)	<8	8-16	16-32	>32
	ESP	<15	15-30	30-50	>50
	Fertility	Good	Moderate	Low to Very Low	-
Water	Quantity of water(m^3/year)	>3000	1500-3000	<1500	None
	Lowering of water table(cm/y)	None, 0-20	20-30	>30	-
	EC(μmhos/cm)	0-750	750-2250	>2250	-
	SAR	0-18	18-26	>26	-

Where *Criterion* is a criterion like soil and climate, indicator is a parameter of a criterion like the slope for topography, and n is the number of indicators for a criterion, such as 2 for climate and topography criteria and 4 for the water criterion. Next, all criteria are multiplied using the geometric mean to define the final score of the ecological capability for the irrigated agriculture in each polygon (Equation 4):

$$\textit{Final score of land capability for irrigated agriculture} = (\textit{Topography} \times \textit{Soil} \times \textit{Climate} \times \textit{water})^{1/4} \quad (4)$$

Then, the final scores of polygons help us to prepare quantitative classes of the final ecological capability map for the irrigated agriculture in GIS based on Table 3.

Table 3. Suitability classes for Irrigated planning based on scores of polygons (Jokar and Masoudi, 2022; Masoudi, 2018).

Suitability classes	Good (1)	Moderate (2)	Poor (3)	Non-suitable (4)
Quantitative classes	> 2.5	1.5 – 2.5	0.5 – 1.5	< 0.5

2.3 Calibration and validation

To evaluate the accuracy of the obtained map quantitatively, it is compared pixel by pixel to ground reality (Makhdoum et al., 2009). In the current research, first the maximum production was calculated by the normalized difference vegetation index (NDVI) images of the MODIS satellite data for the year 2014 with the pixel size of 250 m (Holben, 1986). To evaluate the maximum production with the NDVI index in agricultural lands, the images should be from the spring season, when the maximum greenery can be observed in the region, and be selected from a year when there is neither drought nor high precipitation, which have a negative effect on the evaluation of the region's production. Therefore, the spring images of 2014 were selected, since during this year, the precipitation was normal compared with the recent years of study. To prepare this image ($NDVI_{max}$), the image having the maximum production (maximum NDVI per year) among the three spring images was selected. Then, the average and standard deviation of production in current irrigated lands were calculated by $NDVI_{max}$ images. In general, NDVI data should be normal (statistically) to calculate the parameters. Next, samples of irrigated lands (Table 4) and non-irrigated

Table 4. Error Matrix for irrigated use in Study Area.

Model		Ground reality	
Classify	Class	Agricultural land with production more than or equal to the average (NDVI value ≥ μNDVI)	Agricultural lands with poor production (NDVI value < $\mu_{NDVI} - SD_{NDVI}$), and natural resource lands in mountains and hills, desert lands
	1,2	*	
	3,4		*
Number of points		964	1097

lands were systematic randomly gathered by the "Create Fishnet" algorithm in the ArcGIS 9.3 software. Then, these points were overlaid on the land capability maps. The result is observed in a table namely, "Error Matrix" or agreement matrix (Table 4), and quantitative indices such as overall accuracy and Kappa coefficient were calculated (Congalton, 1991). Overall accuracy is used to measure the correct classification of all reference or test samples. The overall accuracy is usually expressed as a percent. The Kappa coefficient is generated from a statistical test to evaluate the accuracy of a classification. The Kappa coefficient essentially evaluates how well the classification is performed as compared with just randomly assigning values, i.e. did the classification do better than random. The Kappa coefficient ranges from -1 to 1.

To calibrate the model, omission and commission errors from the Error Matrix of the geometric mean map were used to increase the level of accuracy. Hence, according to the omission and commission error and maps of parameters in the geometric mean method, the quantitative ranges of suitability classes (Table 3) were changed slightly. This kind of calibration was performed in other classifications like Mediterranean Desertification and Land Use (MEDALUS) Method (Sepehr et al., 2007; Zakerinejad and Masoudi, 2019).

3. RESULTS

Figure 3 depicts the final map of ecological capability with the best accuracy (geometric mean). Table 5 also shows accuracy assessment indices in the different used models.

The results demonstrated that the proposed method (4 classes) using the geometric mean was better than the Iranian ecological model (Table 5). Moreover, the calibrated proposed method (4 classes) using geometric mean evaluation (with overall accuracy %=95 and Kappa coefficient =0.91) is the best among the different used models (Table 5). It should be noted that the arithmetic mean method (with overall accuracy %=46 and Kappa coefficient =0) has the lowest accuracy. Additionally, WLC method with considering constrains (with overall accuracy %=95 and Kappa coefficient =0.91) has higher accuracy than those without constrains. These results are close to the geometric mean (Geomean); however, the geometric mean model is simpler than WLC with considering constrains (Masoudi, 2018).

Figure 4 shows the percent area for different classes in four different models. In the maximum limitation method, the whole area is under poor and unsuitable classes, and the study area does not have the suitable capability in classes 1 and 2. In the arithmetic mean method, much of the study area is under the moderate class with approximately 90%. Poor and unsuitable capability classes are not observed in this method. In the geometric mean method, much of the study area with almost 76% is under the class of unsuitable, and the other ratios are 18% (moderate), 6% (suitable), and 0 % (poor). In the WLC method with considering constrains, the percentage of each class is almost similar to that of the geometric mean method. Indeed, in the range of 0 to 1 (grade of fuzzy members) and in sum-based methods like the arithmetic mean, the prepared map tends to be 1 or good. Therefore, this method has low sensitivity in location. On the contrary, the map prepared based on the Boolean method tends toward 0 or the unsuitable class. Thus, this method has high sensitivity in location. The proposed method of the geometric mean is placed from 0 to 1 (Fig. 4). Therefore, this method has high flexibility in differentiating classes and locating them. These results indicate that the geometric mean (with 4 classes) can be a useful model for finding the potential area for agriculture. It should be noted that the geometric mean evaluation with higher accuracy is simpler than WLC methods, since it does not need the weighting process.

4. DISCUSSION

The Iranian ecological land use models introduced by Makhdoom (Makhdoum, 2006) and the FAO model

Table 5. Amount of overall accuracy, Kappa coefficients in the different used models.

A) Iranian Ecological Model, Boolean logic (Maximum limitation method), Arithmetic mean methods and Geometric mean

Model Type	Iranian Ecological Model	Revised method (4 classes)			
		Boolean logic	Averaged based		
			Arithmetic mean (indicators)	Arithmetic mean (criteria)	Geometric mean
Overall Accuracy (%)	82	53	46	81	95
Kappa Coefficient	0.64	0.01	0	0.60	0.91

B) WLC Method (with and without consideration of constrains)

Accuracy indicators	Revised method (4 classes)			
	Averaged based			
	WLC indicators analysis without constrains	WLC indicators analysis with constrains	WLC criteria analysis without constrains	WLC criteria analysis with constrains
Overall Accuracy (%)	46	95	82	95
Kappa Coefficient	0	0.91	0.65	0.91

Note: In Table 5B are presented results of Equation 1 (WLC indicators analysis without constrains and WLC indicators analysis with constrains) and results of Equation 2 (WLC criteria analysis without constrains and WLC criteria analysis with constrains).

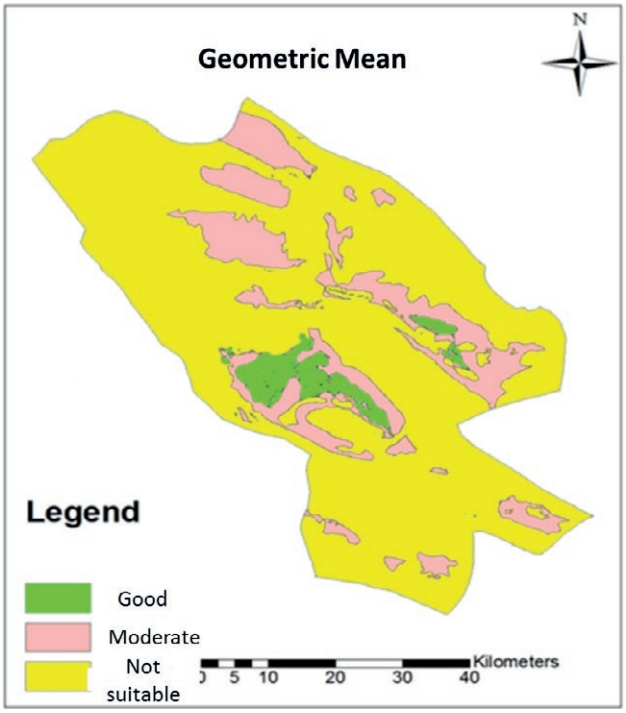

Figure 3. Ecological capability map prepared with the best accuracy.

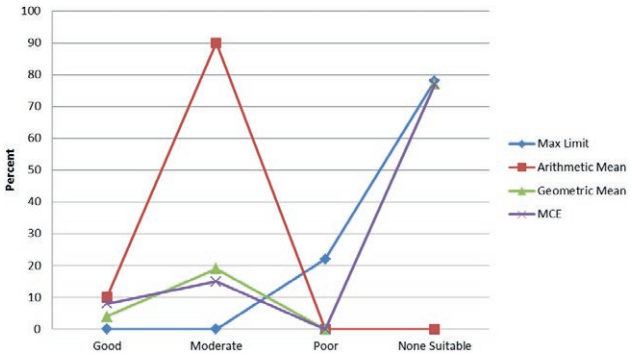

Figure 4. Percent of land under different capability classes for different methods of irrigation use.

(FAO, 1976) should be revised based on the areas under evaluation. Hence, it is essential to revise these models for different topographic and climatic conditions. In this research, firstly, the ecological capability models of land uses were studied by different methods (Boolean and mean-based methods) and with a general view of the environmental conditions of Firouzabad County. In this work, each irrigated agriculture model was evaluated by the criteria affecting it as follows:

Based on the current results acquired in the different attitudes of irrigated agricultural models with efficient criteria, it was defined that by considering important indices such as drought and degradation of groundwater resources, especially in arid and semi-arid zones,

which have unsuitable conditions for these parameters, the model accuracy was improved. In one study assessing desertification in arid and semi-arid regions based on the MEDALUS model, Sepehr et al. (2007) found that since the MEDALUS model was prepared for the Mediterranean area, it needed to be revised for use in arid and semi-arid areas, groundwater conditions.

As the results in Table 5 reveal, to evaluate the ecological capability for irrigated agricultural use (using the drought index and water resources degradation), the geometric mean method has the highest accuracy compared with other methods. The results show that Boolean methods tend to provide unsuitable classes, while arithmetic mean methods tend to provide suitable and moderate classes, and the geometric mean method is among the mentioned methods.

In addition, in the suggested model by the geometric mean, the average of ecological situations has been studied, and socioeconomic situations have been investigated indirectly, as agricultural use is a kind of use related to socioeconomic situations. The offered method by geometric mean evaluation is a simple system of ecological-socioeconomic status indicating restrictions and true potential of land together. In terms of irrigated farming modeling, the results of this study match well with those obtained by Jahantigh et al. (2019) and Masoudi et al. (2017). Their quantitative results confirm well with the current research.

In Boolean methods (like FAO, 1976), the classification process is difficult. However, the suggested model is more flexible than the Boolean model. This criticism of the Boolean method can also be observed in studies by Elaalem (2012), Jokar and Masoudi (2016), and Asadifard et al. (2019). Furthermore, Amiri et al. (2010) utilized two models, namely Boolean and AHP-Fuzzy (Analytic Hierarchy Process and Fuzzy) methods, to evaluate the ecological capability of forestry in Mazandaran Province, northern Iran. Their results confirm the improvement of the AHP-Fuzzy method versus the common assessment of Boolean for the ecological capability of forests in the northern part of Iran. The results of the current study confirm the same findings. Moreover, contrary to the above studies, Amici et al. (2010) employed the Boolean method to evaluate the rank of classification uncertainty in the Tuscany area of Italy and found that it was a helpful method for the comer ecological investigation of the vegetation area.

The other benefit of the new offered method of the geometric mean is lowering the wider effects of some parameters like soil criteria with many indicators against topography criteria using only two indicators.

Additionally, there are areas with ecological specifications of unsuitable conditions (e.g. very severe salinity). Determination of these lands as the zero number in equations 3 and 4 causes these lands to be evaluated as unsuitable. This evaluation method supports the strict view of the Boolean logic (Jokar et al., 2021). Obviously, in the WLC method, the number 0 is also used as a constrain factor, so that the presence of only one indicator or factor that is unsuitable makes that polygon or pixel unsuitable; however, other ecological indicators are suitable or partly-suitable.

5. CONCLUSION

Land use planning should be carried out with a unified attitude of development and nature conservation. Attaining this important aim in the point of sustainable development is possible with the attitude of capability evaluation and land management. Different criteria are required in the land evaluation procedure. The main aim of this research was to evolve a new method in comparison with various methods for land capability assessment. This research evaluated a type of modeling with Boolean logic and MCE (WLC) models by GIS. Then, the land capability maps for irrigated agriculture were prepared. Next, the best model was produced based on the geometric mean method. Indeed, the major evolution was the combination of the FAO model with the Iranian ecological model via the geometric mean method in GIS. The current research outcome can be used in land use planning in other areas with same situations. Therefore, the results of the study can be employed by numerous managers in natural resources and environmental field for suitable land management.

Generally, the results of this research demonstrated that in any study and field survey, it cannot be stated which method is the best one to evaluate land capability and land use planning. Obviously, in this case, the evaluator must investigate the ecological, social and economic conditions of each region in the process of ecological capability evaluation. The outcomes of this study led to a remarkable success in the land evaluation procure and will be regarded as beginning and reference points for further studies and assessments. Since land capability evaluation subjects are multi-criteria and have one aim, it is recommended that in further researches this model should be planned for each land use and that all land uses be evaluated using land use planning methods like MOLA (multi-objective land allocation).

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REFERENCES

Alavi Panah, S. K., De Dapper, M., Goossens, R., & Masoudi, M. (2001). The use of TM thermal band for land cover/land use mapping in two different environmental conditions of Iran. *Journal of Agricultural Science and Technology*, 3(1), 27–36. https://20.1001.1.16807073.2001.3.1.2.5

Amarsaikhan, D., Ganzoring, M., Batbayar, G., Narangerel, D., & Tumentsetseg, S. (2004). An integrated approach of optical and SAR image for forest change study. *Asian Journal of Geoinformatic*, 4, 27–32.

Amici, V., Geri, F., Csontos, P., Neteler, M., & Rocchini, D. (2010). Fuzzy and Boolean forest membership: on the actual separability of land cover classes. *Applied Ecology and Environmental Research*, 8(1), 39–50. DOI: 10.15666/aeer/0801_039050

Amiri, M. J., Salman Mahini, A., Jalali, S. G. H., Hosseini, S. M., & Azari Dehkordi, F. (2010). a comparison of maps overlay systemic method and boolean-fuzzy logic in the ecological capability evaluation of no. 33 and 34 watershed forests in Northern Iran. *Environmental Sciences*, 7(2), 109–124.

Ananda, J., & Heart, G. (2009). A critical review of multi criteria decision making methods with special reference to forest management and planning. *Ecological Economics*, 68, 2535–2548. https://doi.org/10.1016/j.ecolecon.2009.05.010

Asadifard, E., Masoudi, M., Afzali, S. F., & Fallah Shamsi, S. R. (2019). Evaluating the ecological potential for rangeland use by various land-use planning methods in Firozabad County. *Rangeland,* 13, 14–25.

Ayalew, G. (2015). A geographic information system based physical land suitability evaluation to groundnut and sweet potato in East Amhara, highlands of Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 5(1), 33–38.

Congalton, R. G. (1991). A review of assessing the accuracy of classifications of remotely sensed data. *Remote Sensing of Environment*, 37, 35–46. https://doi.org/10.1016/0034-4257(91)90048-B

Elaalem, M. (2012). Land suitability evaluation for sorghum based on Boolean and fuzzy multi criteria decision analysis methods. *International Journal of Environmental Science and Development*, 3(4), 357–361. DOI: 10.7763/IJESD.2012.V3.247

Elsheik, A. R., Ahmad, N., Shariff, A., Balasundra, S., & Yahaya, S. (2010). An agricultural investment map based on geographic information system and multi-criteria method. *Journal of Applied Sciences*, 10, 1596–1602. DOI: 10.3923/jas.2010.1596.1602

Fallah Miri, S. H., Pirdashty, H., Zia Tabar Ahmadi, M. K., & Ghelich Nia, H. (2009). Ecological capability evaluation zoning of Kasilian representative catchment for agriculture utilization using GIS. *Journal of Environmental Studies*, 48, 115–126.

FAO (1976). *A framework for land evaluation.* Soils Bulletin 32, Soil resources development and conservation service land and water development division, Rome.

FAO (1983). *Guidelines: land evaluation for rainfed agriculture.* Food and Agriculture Organization of the United Nations, Soils Bulletin 52. Rome.

Feng, L., Zhu, X., & Sun, X. (2014). Assessing coastal reclamation suitability based on a fuzzy-AHP comprehensive evaluation framework: a case study of Lianyungang, China. *Marine Pollution Bulletin*, 89(1-2), 102–111. https://doi.org/10.1016/j.marpolbul.2014.10.029

Froja, N. (2013). Fuzzy-GIS development of land evaluation system for agricultural production in North West Libya. PhD Thesis, Heriot-Watt University, School of the Built Environment, UK.

He, Y., Yao, Y., Chen, Y., & Ongaro, L. (2011). Regional land suitability assessment for tree crops using remote sensing and GIS. In *2011 International Conference on Computer Distributed Control and Intelligent Environmental Monitoring (CDCIEM), February 19-20, 2011, Changsha, China*. IEEE (pp. 354–363).

Holben, B. N. (1986). Characteristics of maximum value composite images from temporal AVHRR data. *International Journal of Remote Sensing* , 7, 1417–1434. https://doi.org/10.1080/01431168608948945

Hosseini, S. (2018). Comparison ability between FAO and Iran ecological models to estimate of capability ecological land for using pasture (case study: Meydavood area in the east of Khuzestan). *Journal of Environmental Science and Technology*, 18(1), 89–103. Doi: 10.22034/jest.2018.11156.1969

Jahantigh, H. R., Masoudi, M., & Jokar, P. (2019). A quantitative approach to land use planning using GIS

– a case study of Chabahar County, Iran. *European Journal of Environmental Sciences*, 9(1), 12–20. DOI: https://doi.org/10.14712/23361964.2019.2

Jalali, H. (2020). *Agricultural statistics*. Agricultural Bureau of Iran Statistical Center.

Jokar, P. (2015). Mapping of land use planning based on modification and quantitative method of current model. A case study: Jahrom Township. M.Sc. Thesis, Faculty of Agriculture, Shiraz University, Iran.

Jokar, P., & Masoudi, M. (2016). Land suitability for urban and industrial development by a proposal model, case study: Jahrom Township, Iran. *Journal of Environmental Studies*, 42, 135–149. DOI: 10.22059/jes.2016.58111

Jokar, P., & Masoudi, M. (2022). Evaluation of ecological capability and land use planning for different uses of land with a new model of EMOLUP in Jahrom County, Iran. *Frontiers of Earth Science*. https://doi.org/10.1007/s11707-021-0957-y

Jokar, P., Masoudi, M., & Karimi, F. (2021). An MCE-based innovative approach to evaluating ecotourism suitability using GIS. *Cuadernos de Investigación Geográfica*, 47(2), 545–556. DOI: https://doi.org/10.18172/cig.4291

Keshavarzi, A., F. Sarmadian, A. Heidari, & Omid, M. (2010). Land suitability evaluation using fuzzy continuous classification (A case study: Ziaran region). *Modern Applied Science*, 4(7), 72–81. DOI:10.5539/mas.v4n7p72

Lahmian, R. (2016). The use of geographical information system in identifying suitable locations for planting plants at risk of north of Iran. *Journal of Current Research Science*, 4(2), 27–30.

Lee, T. M., & Yeh, H. C. (2009). Applying remote sensing techniques to monitor shifting wetland vegetation: a case study of Danshui River estuary mangrove communities, Taiwan. *Ecological Engineering*, 35, 487–496. DOI:10.1016/J.ECOLENG.2008.01.007

Liao, H. L., & Wu, Q. H. (2013). Multi objective optimition by learning outomata. *Journal of Global Optimization*, 55(2), 459–487. https://doi.org/10.1007/s10898-012-9973-5

Makhdoum, M. (2006). *Principles of Land Use Planning*. Tehran, Iran, University of Tehran.

Makhduom, M., Darvishsefat, A., Jafarzadeh, H., & Makhdom, A. (2009). *Environmental evaluation and planning by Geographic Information System*. Tehran, Iran, University of Tehran.

Malczewski, J. (2004). GIS-based land-use suitability analysis: a critical overview. *Progress in Planning*, 62, 3–65. https://doi.org/10.1016/j.progress.2003.09.002

Mapedza, E., Wright, J., & Fawcett, R. (2003). An investigation of land cover change in Mafungautsi forest, Zimbabwe, using GIS and participatory mapping. *Applied Geography*, 23, 1–21. https://doi.org/10.1016/S0143-6228(02)00070-X

Martin, D., & Saha, S. K. (2009). Land evaluation by integrating remote sensing and GIS for cropping system analysis in a watershed. *Current Science*, 96, 569–575.

Masoudi, M. (2014). Risk assessment of vegetation degradation using GIS. *Journal of Agricultural Science and Technology*, 16, 1711–1722. https://20.1001.1.16807073.2014.16.7.14.0

Masoudi, M. (2018). *Land use planning using computer*. Tehran, Iran, Payame Noor University Publisher.

Masoudi, M., & Jokar, P. (2015). Land-use planning using a quantitative model and geographic information system (GIS) in Shiraz Township, Iran. *Ecopersia*, 3, 959–974. https://20.1001.1.23222700.2015.3.2.1.7

Masoudi, M., & Zare, R. (2019). Different irrigation methods and their comparisons based on the parametric evaluation method in Khosouyeh Dam Subbasin, Iran. *Journal of Resources and Ecology*, 10, 504–510. https://doi.org/10.5814/j.issn.1674-764x.2019.05.005

Masoudi, M., Jokar, P., & Sadeghi, M. (2017). Land use planning using a quantitative model and geographic information system (GIS) in Darab County, Iran. *Journal of Materials and Environmental Sciences*, 8(8), 2975–2985.

McHarg, I. L. (1969). *Design with Nature*. New York, USA, Wiley.

Mitra, D., & Ilangovan, D. (2004). Site selection for harbour facilities in the gulf of Cambay, India using Geographic Information System. *Asian Journal of Geoinformatic*, 4, 81–86.

Mokarram, M., & Zarei, A. R. (2021). Determining prone areas to gully erosion and the impact of land-use change on it by using multiple-criteria decision-making algorithms in arid and semi-arid regions. *Geoderma*, 403, 115379. https://doi.org/10.1016/j.geoderma.2021.115379

Mu, Y. (2006). Developing a suitability index for residential land use: a case study in Dianchi Drainage Area. MS.c. Thesis in Environmental Studies in Geography, University of Waterloo, Ontario, Canada.

Nazari, V. F., Koohestani, H., Zarifian, S., & Kazemieh, F. (2019). Land suitability assessment for agriculture using analytical hierarchy process in northern parts of Khalkhal County. Case Study: Mikaeel Abad catchment. *Journal of Agricultural Science and Sustainable Production*, 30(1), 225–239.

Nwer, B. (2006). The application of land evaluation technique in the North-East of Libya. Published PhD Thesis, Faculty of Environment, Cranfield University, Silsoe.

Pan, G., & Pan, J. (2012). Research in crop land suitability analysis based on GIS. In Li, D., & Chen, Y. (Eds.). *Computer and computing technologies in agriculture V*. CCTA 2011. IFIP Advances in Information and Communication Technology, 369. Berlin, Heidelberg, Springer. https://doi.org/10.1007/978-3-642-27278-3_33

Pan, T., Zhang, Y., Su, F., Lyne, V., Cheng, F., & Xiao, H. (2021). Practical efficient regional land-use planning using constrained multi-objective genetic algorithm optimization. *ISPRS International Journal of Geo-Information*, 10(2), 100. https://doi.org/10.3390/ijgi10020100

Perveen, S., Arsalan, M., Siddiqui, M. F., Khan, I. A., Anjum, S. H., & Abid, M. (2013). GIS-Based multicriteria model for cotton crop land suitability: a Perspective from Sindh Province of Pakistan. *FUUAST Journal of Biology*, 3(1), 31–37.

Pourkhabbaz, H. R., Javanmardi, S., & Faraji Sabokbar, H. A. (2014). Suitability analysis for determining potential agricultural land use by the multi-criteria decision making models SAW and VIKOR-AHP (Case study: Takestan-Qazvin Plain). *Journal of Agricultural Science and Technology*, 16, 1005–1016. https://20.1001.1.16807073.2014.16.5.10.2

Prakash, T. N. (2003). Land suitability analysis for agricultural crops: a fuzzy multicriteria decision making approach. MS.c. thesis in Science in Geoinformatics, International Institute for Geo-information Science and Earth Observation, Enschede, Netherlands.

Rossiter, D. G. (1996). A theoretical framework for land evaluation. *Geoderma*, 72, 165–190. DOI: 10.1016/0016-7061(96)00031-6

Safaripour, M., & Naseri, D. (2019). Ecological land capability evaluation for agriculture and range management using WLC method (Case study: Onarchay watershed, Ardabil province). *Journal of Environmental Science and Technology*, 21(8), 113–123. doi: 10.22034/jest.2020.22063.3120

Sepehr, A., Hassanli, A. M., Ekhtesasi, M. R., & Jamali, J. B. (2007). Quantitative assessment of desertification in south of Iran using MEDALUS method. *Environmental Monitoring and Assessment*, 134, 243–254. DOI: 10.1007/s10661-007-9613-6

Sonneveld, M. P. W., Hack-ten Broeke, M. J. D., Van Diepen, C. A., & Boogaard, H. L. (2010). Thirty years of systematic land evaluation in the Netherlands. *Geoderma*, 156, 84–92. https://doi.org/10.1016/j.geoderma.2010.02.023

Yohannes, H., & Soromessa, T. (2018). Land suitability assessment for major crops by using GIS-based multi-criteria approach in Andit Tid watershed, Ethiopia. *Cogent Food & Agriculture*, 4(1), 147048. https://doi.org/10.1080/23311932.2018.1470481

Zakerinejad, R., & Masoudi, M. (2019). Quantitative mapping of desertification risk using the modified MEDALUS model: a case study in the Mazayejan Plain, Southwest Iran. *AUC Geographica*, 54, 232–239. https://doi.org/10.14712/23361980.2019.20

Zonneveld, I. S. (1989). The land unit – a fundamental concept in landscape ecology, and its applications. *Landscape Ecology*, 3, 67–86. https://doi.org/10.1007/BF00131171

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The Land Cadastre in Italy and some fiscal implications: a case study

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Abstract. The Land Cadastre, as an inventory of all relevant real estate in a territory, and most importantly, as a national tax system is, or at least should be, the protagonist of fiscal, social and civil implications affecting the Italian context. According to unitary farmland incomes, the last revision dates back to 1978-1979, a period that no longer reflects the country's current socioeconomic situation and does not consider the changes the land market has undergone over the years. Through the analysis of 183 purchases and sales of agricultural land in two districts in western Sicily, this research aims at verifying the adequacy or inadequacy of the current cadastral tariffs. Based on the prices surveyed and the cadastral farmland incomes, some indicators were constructed showing, on the one hand the absence of a strict correspondence between these two values and on the other hand the actual presence of fiscal inequality for all the crop qualities examined; and, consequently, the need for revising cadastral tariffs or for reforming tax system of Italian Cadastre by replacing tariffs with market values.

Keywords: Land values, Equity, Tax policy.
JEL codes: H21, H31, R38, R51.

1. INTRODUCTION

In 1861 – at the time of the establishment of the Kingdom of Italy – 24 land registers already existed, each structured differently (Magni, 2002).

"The heterogeneity of the various land registers posed a major obstacle for a necessary and urgent reorganization of the finances by the nascent Italian government". (Colombo, 2003, p. 11). In 1886, Law No. 3682, known as the Land Equalization Law, was passed, which resulted in the establishment of the 'New Land Cadastre', the first national land cadastre[1] (Zangheri, 1980).

A succession of four phases marked its establishment over 70 years: Establishment; Publication; Activation; and Management. In the first phase,

[1] At the same time the Urban Building Cadastre was established.

the operations of measurement and appraisal led to the formation of the 'New Land Cadastre'.

The appraisal procedures were distinguished as follows: qualification, classification, grading and tariff calculation. In order to determine the latter, a farm balance sheet was drawn up on typical land parcels in the municipality in question, from which the Land Cadastral Taxable Income prior to 1886 was obtained.

In later years, the Land Cadastre underwent four revisions: the first revision dates back to 1923 and updated the tariffs and the reference census time period (1904-1913); the second one took place in 1939 (R.D.L. 4 aprile 1939, n. 589) and entailed the splitting of the cadastral taxable amount into Farmland Income and Agrarian Income – quantified on the basis of balances drawn up no longer on standard plots but on actual and ordinary farms – and the updating of the census reference time period (1937-1939); the third revision concerned only the updating of tariffs to a new census time period (1978-1979), excluding any new definition or updating of crop qualities and related productivity classes. Finally, the fourth, which provided for the updating of the Farmland Income and Agrarian Income and the census period of reference to the two-year period 1988-1989, was authorized by Ministerial Decree No. 3/355 of 20 January 1990, but was never implemented.

With "old born" cadastral tariffs, the agricultural sector could only be characterized by "taxable incomes determined in a totally conventional way with values that are very far from the Italian scenario both in magnitude and in the distribution among the various crop qualities" (Cristofaro, 2015). As of now, the Italian Land Registry is not legally authoritative as it does not provide legal proof of ownership and real rights. In fact, in order to ascertain the legal ownership of a property, it is necessary to possess official documents such as sale deeds or succession deeds or to carry out a mortgage survey.

Since 2001, the Land Registry has come under the jurisdiction of the "Agenzia del Territorio" (*Land Registry Agency*) which, in turn, was merged with the "Agenzia delle Entrate"[2] on 1st December 2012. Currently, professionals and authorised users are able to access cadastral data via the *SISTER* online platform, which is directly connected to the "Agenzia delle Entrate" database.

Thanks to the computerisation process, cadastral document request operations have been simplified and waiting times have been significantly reduced, marking an important turning point for the cadastral system.

In addition, in accordance with the European Directive INSPIRE (INfrastructure for SPatial InfoRmation in Europe), the "Agenzia delle Entrate" provides two services for the consultation of cadastral cartography: the cadastral cartographic consultation through the Web Map Service (WMS) and the Cadastral Cartographic Geoportal.

The process of computerisation and the use of new topographical instruments have only partially solved the problems related to measuring operations that took place many years ago and were never updated, except through the direct intervention of the professionals appointed by the owners or possessors of the real estate and through AGEA for the update of crop variations surveyed in relation to the Single Payment Scheme (SPS) (Decreto Legge 03/10/2006 n. 262).

In fact, according to a survey carried out by the "General Directorate of Cadastre" and of the "Technical Revenue Services", about a quarter of all cadastral maps (recognised as official state cartography by Law no. 68 of 2nd February 1960) show an inadequate geometric representation (Coletta et al., 2009). According to Zanchi et al. (2018), the practical use of cadastral cartography – and its continuous feedback on the territory thanks to the use of modern topographic and aero-photogrammetric techniques – has highlighted its evident inadequacy in responding to increasingly complex and operational urban planning needs (identification of individual properties on the ground). This inadequacy is due to the dated nature of the land survey, the obsolescence of the instruments used, the wear and tear on paper cadastral maps, and the deformation of maps caused by the use of scanners to digitalise them. In this regard, by way of example, the images shown in Figure 1 represent two distinct map sheets concerning the territory of Santa Flavia (PA) municipality, whose representations are doubled and shifted; hence it is impossible to obtain simple information (such as the cadastral parcel number) and, above all, reliable information.

It is necessary, therefore, to consider a revision of the Land Cadastre that concerns not only the tariffs, the classification and the grading but also the cartography aspects (Ribaudo, 2001). Physical and appraisal aspects are closely linked, since having an adequate cartography makes it possible to have a suitable description of the physical base useful for assessing taxable income (Coletta et al., 2009).

It is clear that the cadastral mapping sector needs a thorough reformulation, perhaps with the help of innovative tools that can, in some way, simplify the difficulties in surveying, processing, and therefore managing, a large number of cadastral maps.

In this regard, Ferrante and Garnero (2016) provide a new and innovative perspective on the restructuring of the cadastral mapping sector: they hypothesise the

[2] The Italian Internal Revenue Service.

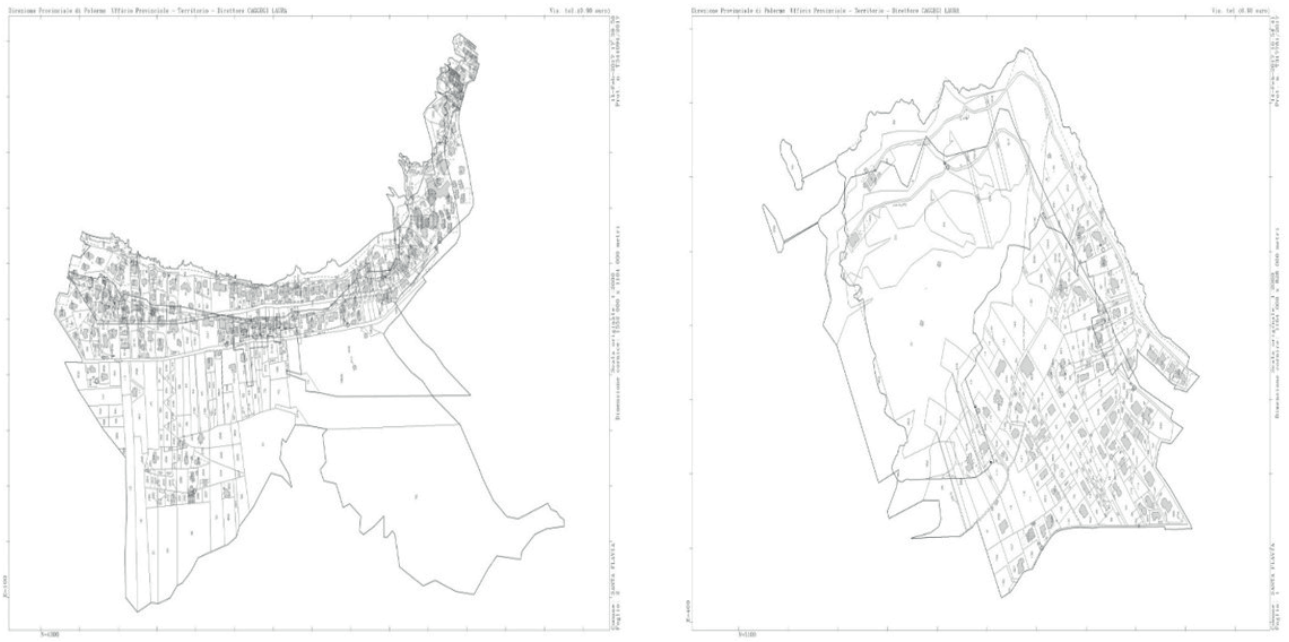

Figure 1. Map sheets of the municipality of Santa Flavia (PA) (source: Agenzia delle Entrate – SISTER).

use of innovative instrumentation such as drones for the cartographic updating of individual maps and, thus, of restricted portions of the territory.

This would allow a plano-altimetric representation capable of fully capturing the territorial geomorphologic characteristics, and therefore parcel characteristics that can influence both the value and profitability of land ownership.

With reference to the tax aspect, the last revision of the unitary farmland incomes dates back, as already pointed out, to more than 40 years ago. Since then, there has been no further change, even though Presidential Decree No. 917 of 22 December 1986 and Article 2 of Law No. 75 of 24 March 1993 establish, respectively, that every ten years there should be a revision of the tariffs and that new criteria for the classification and determination of cadastral unitary rents should be defined, considering the productive potential of the land. This shows self-awareness on the part of the State of the malfunctioning of the cadastral system as it is structured. Over the years, the only implementation intervention has concerned the revaluation of the unitary Farmland Income and the Agrarian Income, using percentage rates with no connection to the reference market trend[3].

As also argued by Simonotti (2008), the valuation method (by classes and tariffs) of Italian Cadastre appears to be as a rigid system, which is not able to adapt to the dynamics of the real estate market, is not compliant with international valuation standards and does not have its own standard.

The problem, therefore, lies not only in the obsolescence of the cadastral farmland unitary rents but also in the procedure adopted for their determination, related to the 1939 classification, which is no longer adequate to the national socio-economic situation as it does not respond to the production systems and current structural conditions of the agricultural sector (Pierri, 2015). Moreover, changes in quality and classes do not always take place, so it is advisable to verify the actual correspondence between the cadastral certificates and the state of the places.

Furthermore, as Colombo (2003) argues, the concept of ordinariness that underlies the procedure for determining cadastral taxable incomes has long been distorted and outdated 'due' to a constantly evolving national and EU regulatory framework where entrepreneurs are constrained by the EU incentive or disincentive system that affects their production choices.

Similarly, it is important to point out that the succession over time of various changes in the economic, financial, social and environmental spheres has led to profound changes in the relationship between property and labour, in the form of tenure and land use. With

[3] For IRPEF purposes, the Farmland Income and Agrarian Income have been increased by 80.0% and 70.0% respectively (since 1998, with a further increase of 15.0% since 2013 and 30.0% since 2016); for IMU (formerly ICI) purposes, the Farmland Income has been increased by 25.0%.

reference to the latter and as reported by Schimmenti et al. (2013), when, as a result of economic development, agriculture does not contribute substantially to the formation of national income, investors' interest in non-agricultural land uses increases. In this way, land is not only seen as a factor in agricultural production but also as a commodity to be used in different sectors such as tourism, industry and with different uses such as residential, recreational, etc. (Grillenzoni, 1970). Over the years, the guidelines of the Common Agricultural Policy (CAP), also aided by 'Climate Change', have led agricultural entrepreneurs to modify their land-use choices, favouring the concept of multifunctionality and the rapid spread of crops that were previously completely absent, and causing the sharp reduction of others that were once representative of vast rural areas of Italy (Colombo, 2003).

In this situation, the concept of ordinariness is inappropriately applied in the cadastral area, and consequently in the taxation field. In this sense, the problem of calculating tariffs does not only concern the drawing up of financial statements on ordinary farms. Indeed, once the farm balance sheet had been drawn up and the relevant tariff quantified, the appraisal procedure for typical values was applied. Following this procedure, the surveyor's task was, firstly, to assign a score to the study plot (based on its cultivation quality and relative class) and, only afterwards, he could extend the results obtained to all the other plots falling within the same municipality, by means of the so-called connecting scales. In this way, the reference parcel constituted the starting point for the determination of the scores for all the other plots (merit scales), through a comparative procedure, carried out with "empirical and subjective criteria" (Simonotti, 2002, p.576).

In fact, if a cadastral parcel was considered worse or better than the reference one then it was given a lower or higher score respectively, in comparison to the estimated score for the reference land parcel.

In this regard, it is worth recalling that in traditional valuation, the method is only one, i.e. comparison, an aspect that could, to some extent, justify the procedure adopted to calculate land rents. However, it is also true that appraisal is a discipline that tends towards objectivity without ever achieving it precisely because appraisal judgments are formulated on the basis of practical-theoretical knowledge and affected by the appraiser's discretion. The latter, as a matter of professional ethics, should implement procedures aimed at reducing the degree of subjectivity to zero. For this reason, appraisal by typical values is often a fallback to be taken into account only in the absence of market price data, while compensating for the limitations of this procedure with excellent knowledge of the real estate market (Simonotti, 2002).

At present, therefore, the tax base provided by the cadastral system is inadequate due to the calculation system and progressive evolution of the agricultural sector (Coletta et al., 2009) and unreliable while reliability is an indispensable component of taxation (Colombo, 2003). The result is a systematic inequality in taxation due to the discrepancy between the unit incomes – actual and cadastral – of real estate in the same productivity class, which, in turn, leads to the underestimation and overestimation of the assets themselves (Simonotti, 2008).

A few research studies have showed the presence of inequality at national level (Agnoletti et al., 2020) and in a territorial context (Cenciarelli, 2006) with regard to buildings and in a specific territorial context (Asciuto et al., 2008) concerning agricultural land.

However, despite the lack of fairness mentioned above, the Italian Cadastre obtains the favour of taxpayers who, in this way, do not have additional expenses and tax inspections and the tacit approval of public institutions who are guaranteed not only simplicity in carrying out control operations but also peace of mind in their relations with taxpayers, avoiding in this way the emergence of numerous tax disputes (Coletta et al., 2009). Proposals for the reform of cadastral tariffs, so far found in the literature, are divided into two different lines of thought:

a) maintenance of the cadastral tariffs, always determined on the basis of farm balance sheets, while proposing an appropriate and radical renewal;

b) taxation based on market values so as to reduce the gap between cadastral and market values.

a) Maintenance, upon remodulation, of the current method by classes and tariffs

A Cadastre where fiscal system is based on tariffs is utilised, besides in Italy, in other four EU countries (Austria, Belgium, Hungary, Portugal), illustrated in section 2. Guerrieri (2003) proposes that the Land Registry be left with only its civil functions, thus making it probative, and suggests that the new tariffs (average annual farmland income per hectare) are determined from the product between average land prices, grouped by homogeneous areas and specific crop qualities, and an interest rate called 'cadastral rate', variable according to the profitability of the various crop qualities. However, the difficulty in determining an adequate capitalisation rate is now widely recognised in the valuation field and it is strongly conditioned by the appraiser's discretion.

According to Ragni and Luccarini (2003), the income values of areas characterised by productive isopotentiality – called micro-zones – could be calculated on the basis of larger areas called macro-zones. Other authors (Seroglia and Tellarini, 2003; Tellarini and Seroglia, 2003) propose, on the other hand, a modification of the census areas, of the analytical crop account and above all of the crop qualities. The latter would be drastically reduced from 116 to 13 homogeneous "aggregates" from the income point of view in order to make the taxation system more adherent to the current reality of Italian agriculture and the new tariffs, in place of the Farmland Income and Agrarian Income, would be calculated analytically on the basis of data from the Agricultural Accountancy Information Network (RICA).

b) Taxation based on market values

The alternative to maintaining tariffs, albeit reformed, could be the introduction of a Cadastre with a tax system based on market values as is the case in several EU countries (Cyprus, Denmark, Estonia, France, Germany, Latvia, Lithuania, Poland, Romania, Slovenia, Spain). As early as the mid-1980s, Schifani (1985) pointed out that in Italy land taxation – based on the income parameter – did not consider two important factors (as opposed to market price). These factors are the proximity to population centres and the availability of land susceptible to be made suitable for the crops characterizing a given area. Therefore, Schifani implicitly suggested the adoption of a taxation system based on market values. In this regard, Simonotti (2008) calls for the rapid decentralisation of the valuation function to municipalities so that they entrust 'cadastral valuers', qualified professionals with a broad and precise knowledge of the real estate market and possessing specialist skills consistent with the Property Valuation Standards, with the delicate task of ensuring taxpayers fiscal fairness, transparency and organisational efficiency in valuations. The decentralisation of cadastral functions from the "Agenzia del Territorio" to the municipalities was sanctioned by the Ministerial Decree, on 14 June 2007[4] (published in the Official Journal no. 154, of 5 July 2007), with the aim, among others, of carrying out a census of real estate and complete retrieval of cadastral data to be integrated into the relevant database (Asciuto et al., 2010).

The determination of market values would be done through the application of large-scale valuation methodologies recognised by the International Valuation Standards (IVS), as is the case in modern cadastral systems. These methodologies, called "Mass Appraisal", represent a flexible system as they allow the use of all valuation procedures: empirical and rational, single and multi-parametric, synthetic and analytical.

Considering the problems highlighted so far and the lack of response from public institutions, the aim of this research is to verify the current level of the link between market prices and farmland incomes, through the concrete case of two districts in western Sicily (South of Italy). This research also aims at verifying the fiscal equalisation or the inequality of the system of land registry tariffs in Italy, through the construction of indicators to be submitted to public decision-makers in order to verify the fulfilment of the conditions of horizontal and vertical equity[5].

The research is composed of a preliminary analysis of the fiscal aspects adopted by EU countries for the land cadastre; a description of the study area; a description of the methodology for the analysis of the collected data; an analysis and discussion of the results obtained and some final considerations.

2. THE FISCAL FUNCTION OF THE LAND REGISTER IN EU COUNTRIES

The European Union (EU), as can be seen from its founding treaties, has no direct competence in cadastral matters. However, through the CAP, environmental policy, pre-accession programmes, etc., it has oriented its member countries to develop multi-purpose cadastres, given the wide availability of data and the development of information systems, which have extended the use of cadastral information also to the consolidation of the spatial data infrastructure indispensable for eGovernment in the member countries (Permanent Committee on Cadastre in the European Union, 2018).

Various cadastral models can be found in the EU countries, depending on their historical, cultural and traditional diversity, from what we can define as traditional models, developed since the late 19th century to a greater extent in Western European countries, to the more modern ones in the former communist countries

[4] The Regional Administrative Court of Latium, in its sentence no. 4259 of 15 May 2008, had censured only the part of the decree in which the municipalities were entrusted with the authoritative power to proceed with the grading and therefore with the definition of the relative cadastral income. Only this specific option should have been annulled. However, the Regional Administrative Court emphasised the need to reformulate the decree, a reformulation that never took place.

[5] According to the principle of horizontal equity, two goods with the same market price should have the same tax value and thus the same amount of tax for taxpayers; whereas according to the principle of vertical equity, two goods with different market values should be subject to different taxes.

Table 1. Groups of EU countries according to cadastral function (Source: our elaborations).

Group I (non-fiscal function)	Group II (fiscal function)		
	Section I (area)	Section II (income)	Section III (value or price)
Bulgaria, Croatia, Finland, Greece, Ireland, Luxemburg, Malta, Netherlands, Sweden	Czech Republic, Slovakia	Austria, Belgium, Hungary, Portugal, Italy	Cyprus, Denmark, Estonia, France, Germany, Latvia, Lithuania, Poland, Romania, Slovenia, Spain

of Eastern Europe. For these latter, Osskó and Hopfer (1999), emphasise that the transition from a planned economy to a market economy made the development of modern Land Registry systems necessary to develop an active real estate market that can support sustainable development.

A comparison of national Land Registri's shows, as Iovine et al. (2006) argue, that the historical origin is linked to the ascertainment of property ownership and the application of land tax; in fact, in most countries the Land Registry is directly or indirectly connected to property taxation, since it may contain the valuation of real estate and other data used by the tax authorities to calculate tax, as well as the identification of the property and the owner (legal land registries).

Therefore, taking into consideration the official documents of the Permanent Committee on Cadastre in the European Union (PCC) on the cadastral systems of the EU member states (Permanent Committee on Cadastre in the European Union–- Cadastral information system: a resource for the E.U. policies overview on the cadastral system of the E.U. member states Rome, 2008; Prague, 2009; Gävle, 2009; Sofia, 2010) the twenty-seven countries are here divided into two groups, in relation to the absence or presence (9 and 18 countries respectively) of the cadastral tax function (Tab. 1).

The first group, made up of countries where the Cadastre is not used for tax purposes, includes: the Netherlands, where the Cadastre over the years has lost importance in relation to this function but has mainly improved the technical aspects, although for statistical purposes it includes the price of the real estate transaction (Muniz Perez, 2012); Croatia, which since 1998 (Bacic, 2004), repealed the cadastral annual tax with the consequent loss of the cadastral fiscal function; Bulgaria and Finland which exempt farms and forestry from property tax; Greece where the value of a property is not stored in the cadastral database, although the price of the purchase and sale is archived and linked to the property; Luxembourg, which has not used the Land Registry for valuation and taxation since 1945; Sweden, where the Taxation Authority deals with the valuation of property; and finally Ireland and Malta which do not have a Tax Registry (Tab. 1).

The second group, which includes all countries with a tax-related cadastre, was further divided into three sections – area, income, value or price respectively – according to the data used to determine the tax base for land tax purposes.

In the Appendix 1 a brief description of the methodology adopted in the EU countries of the second group is reported.

3. MATERIALS AND METHODS

3.1 Study area

The study area (Fig. 2) includes two different districts, both located in western Sicily (in the Province of Trapani, Zone 1, and in the Province of Palermo, Zone 2, respectively). The first one includes territories of the coastal hills (Municipalities of Valderice, Erice, Custonaci, Buseto Palizzolo, San Vito Lo Capo) and of the plains (Municipalities of Paceco and Trapani). The second zone includes municipalities of the inland mountains (Godrano), the inland hills (Caccamo, Baucina, Ciminna, Bolognetta, Marineo, Mezzojuso, Villafrati, Ventimiglia di Sicilia, Cefalà Diana, Misilmeri, Campofelice di Fitalia, Santa Cristina Gela, Piana degli Albanesi), the coastal hills (Casteldaccia) and the plains (Palermo and Partinico).

The municipalities classified as "Rural Areas" o "Sparsely populated Areas"[6] in Zone 1 represent 42.8%, while in Zone 2 they make up 58.8% of the total number.

In order to outline the structural characteristics of agriculture and the relative forms of tenure and ownership present in the two territorial areas, some data published with the 6th General Agricultural Census 2010[7]

[6] Since 2011, Eurostat classifies municipalities according to the degree of urbanization (DEGURBA). This indicator identifies three levels of urbanisation (high, medium and low) in relation to the criteria of geographical proximity and thresholds of minimum population. The classification identifies three typologies of municipalities: 1) "Cities" or "Densely Populated Areas"; 2) "Small Cities and Suburbs" or "Medium Population Density Areas"; 3) "Rural Areas" or "Scarcely Populated Areas".

[7] To this day, data from the 7th Agricultural General Census are not available since ISTAT is still processing the information collected. The

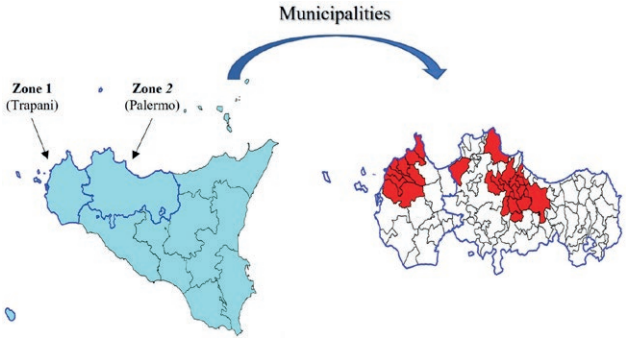

Figure 2. Study area.

were analysed, from which the indicators shown in Table 2 were extrapolated.

Zone 1 (Trapani area)

According to reports from the 6th General Census of Agriculture 2010, there are a total of 6,214 farms falling within the municipalities in the surveyed area. Total Farm Area (TFA) and Utilized Agricultural Area (UAA) occupy 56.0% and 52.6% of the total land area, respectively. Relating TFA and UAA to the number of farms, it is showed that each farm owns, on average, about 5.7 and 5.4 hectares, respectively.

With reference to the classes of UAA, as many as 31.7% of the farms have a UAA of less than 1.00 hectare; 19.8% of the farms have a UAA between 1.00 and 1.99 hectares; 11.6% between 2.00 and 2.99 hectares; 13.5% between 3.00 and 4.99 hectares; 11.4% between 5.00 and 9.99 hectares; and finally, 12.0% have a UAA of more than 10.00 hectares. The UAA of the district covers 33,397 hectares, of which 17,015 hectares are arable lands (50.9% of the total UAA). More in detail, cereals for grain production, with 7,627 hectares, represent 22.8% of the UAA; fallow lands represent 18.0% of the UAA (with 6,003 hectares), forage crops approached 4.9% (1,626 hectares), and dry legumes and vegetables occupy 2.6% and 2.4% (857 and 808 hectares), respectively.

Arable lands are followed by agricultural tree crops that occupy 37.9% of the UAA with 12,660 hectares. Among these, grapevine is the most widespread crop quality with 7,933 hectares, accounting for 23.7% of the total UAA; it is followed by olive, which represents 13.5% of the UAA with its 4,515 hectares. On the contrary, the incidence of areas with citrus and fruit trees on the UAA is barely significant (overall 0.5%). In addition, permanent meadows and pastures represent 9.7% of the total UAA with an area of 3,226 hectares; family-size vegetable gardens, on the other hand, are not very widespread in the area, occupying only 0.4% (119 hectares) of the UAA.

According to the form of farm management, the gap between the various categories present is even larger, since as many as 97.3% of farms are managed directly by the farmer, 2.4% are managed by hiring outside employees, and only 0.3% are managed in another way.

In terms of legal form, the majority of farms in the district (99.3%) are sole proprietorships, while a small proportion are part of holding-groups (0.7%).

Table 2. Main structural indicators of farms in the two districts (Source: Our data elaboration from the 6th General Agricultural Census 2010).

Indicators		Zone 1	Zone 2
TFA/land area (%)		56.0	47.8
TFA/no. of companies (Ha/company)		5.7	4.5
UAA/ Territorial area (%)		52.6	44.4
UAA /TFA (%)		94.0	92.9
UA /no. of companies (Ha/company)		5.4	4.2
Arable crops/*UAA* (%)		50.9	49.3
Permanent crops/*UAA* (%)		37.9	26.9
Vine/UAA (%)		23.7	4.5
Olive/UAA (%)		13.5	15.6
Other Fruit trees/UAA (%)		0.5	6.7
Permanent grasslands and pastures /UAA (%)		9.7	23.5
Incidence no. of owned farms (%)		76.3	80.0
Incidence no. of individual farms (%)		99.3	99.2
Incidence no. of farms with direct farmer management (%)		97.3	97.5
Percentage incidence class of UAA	Ha	%	%
	Up to 0.99	31.7	41.6
	1.00-1.99	19.8	20.6
	2.00-2.99	11.6	9.8
	3.00-4.99	13.5	9.9
	≥ 5.00	23.4	18.1
Degree of farm fragmentation	No. parcels	%	%
	1	33.4	44.3
	2	24.3	26.4
	3-5	29.4	23.5
	6-10	10.4	4.8
	≥ 11	2.5	1.0

6th Census, however, is able to portray the situation of the agricultural sector in the period (2005-2017) when sample sales took place.

As for land tenure, however, 76.3% of the farms in the area are located on land owned by the entrepreneur, farms operated on land that is partly owned and partly in free use account for 13.3%, while 1.2% of the farms are conducted exclusively on land that is leased. The remaining percentage (9.2%) can be attributed to the unmentioned combinations of land tenure titles. Regarding the degree of farm fragmentation, it appears that about 33.4% of the farms consist of a single farm body. In contrast, the rest of the farms are divided into multiple bodies: 24.3% into 2 bodies; 29.4% into 3-5 bodies; 10.4% into 6-10 bodies; and 2.5% into 11 or more bodies.

Referring to the Provincial Landscape Plan of Trapani, the area was characterized according to its use (Assessorato dei Beni culturali e dell'Identità siciliana, 2010).

In the municipal areas of Trapani and Paceco, traditional agricultural crops (olive groves, vineyards and arable lands) in the peri-urban areas – where there is a fragmented agrarian-pattern – are endangered by the expansion of industrial and residential settlements and by road and rail infrastructure. The traditional agrarian landscape is more continuous in inland areas with limited scattered settlements.

In the municipality of Erice, settlement transformations have affected the coastal plain, resulting in the abandonment of traditional agro-pastoral activities on the mountain slopes and the exodus of inhabitants to the valley.

In the coastal plain between Custonaci and Valderice, vast areas of cultivated land alternate with large areas of abandoned and built-up areas. In the hilly area of Custonaci, phenomena of landscape degradation caused by intense mining activities are evident.

The open-field agricultural landscape of arable lands, vineyards, and olive groves, punctuated by cores and threadlike rural centres branching along roads, such as Buseto Palizzolo, is predominant. On the coastal area of San Vito Lo Capo, the obvious processes of degradation of the rural landscape are mainly due to the intense seasonal tourism that causes congestion and inappropriate transformations of places for second homes. Degradation factors include abandonment of agro-pastoral activities and fires that destroy the natural environment.

Zone 2 (Palermo area)

There are a total of 10,437 farms in the municipalities of Palermo zone which participate in the survey.

The TFA and the UAA account for 47.8% and 44.4% of the total land area, respectively. Relating the TFA and UAA to the number of farms, it is possible to note that each farm covers an average of about 4.5 and 4.2 hectares, respectively.

In terms of farm size, the UAA per farm is distributed as follows: 41.6% of the farms have a UAA of less than 1.00 hectare, 20.6% between 1.00 and 1.99 hectares, 9.8% between 2.00 and 2.99 hectares, and 9.9% and 9.0% fall in the classes between 3.00 and 4.99 and between 5.00 and 9.99 hectares, respectively. Farms owning UAA over 10.00 hectares are only 9.1% of the total.

The territorial UAA of the district covers 44,041 hectares: arable land is the most widespread land use, with about 21,696 hectares, accounting for 49.3% of the total UAA, followed by agricultural tree crops, covering about 11,836 hectares – corresponding to 26.9% of the UAA – and permanent meadows and pastures, which occupy 23.5% of the total UAA with their 10,359 hectares; family-size vegetable gardens (149 hectares) represent only 0.3% of the UAA.

With regard to arable lands, UAA accounts for 25.1% of cereals for grain production (with 11,052 hectares), for almost 15.6% of forage crops (6,866 hectares), for 1.6% of dry legumes and vegetables, and 1.5% of the UAA (693 and 663 hectares). In addition, fallow land, with 2,230 hectares, accounts for 5.1% of the total UAA.

In contrast, in terms of agricultural tree crops, olive is the most represented crop with 6,877 hectares, accounting for 15.6% of the total UAA. It is followed by grapevine, which accounts for 4.5% of the UAA with its 1,971 hectares; citrus and fruit-growing areas account respectively for 3.8% and 2.9% of the UAA.

In terms of farm management, 97.5% of the farms are directly managed by the farmer, while the remaining farms either use temporary employees (2.4%) or have a completely different form of management (0.1%).

From the point of view of legal form, 99.2% of the farms in the area of Palermo, are sole proprietorships, while only 0.8% are part of holding-groups.

Furthermore, 80.0% of the farms in the area are located on land owned by the entrepreneur; 7.3% of the farms are run on land that is partly owned and partly in free use; while 2.1% of farms are run exclusively on leased land. The remaining percentage (10.6%) can be accounted for the unmentioned combinations of land tenure titles. With reference to the degree of farm fragmentation, most of farms, about 44.3%, consist of a single body. Within the remaining farms, 26.4% are divided into 2 bodies; 23.5% into 3-5 bodies; 4.8% into 6-10 bodies; and only 1.0% into 11 or more bodies.

The Provincial Territorial Plan describes the area, highlighting its strong contrasts (Provincia Regionale di Palermo, 2004).

Agrarian landscape surrounding Palermo – once known as the "Conca d'Oro" – is characterized by so-called "gardens" (lemons and tangerines above all), culti-

vated on artificial terraces made on the hillsides, and by corridors from the valleys inward.

The proximity of the capital city in the past favoured the development of this type of agriculture, which, however, requires services, capital and, not least, labour. The latter contributed to its decline in recent decades. With the massive establishment of vacation housing in Palermo and the consequent loss of land used for citrus farming, the most fertile countryside close to the sea has become highly urbanized. On the other hand, agriculture in the Partinico plain is still characterized by intensive cropping systems (orchards, open fields vegetables, vineyards, etc.) despite the strong imbalances caused by uncontrolled urbanization. Away from the coast and past the hills that abut it, the landscape changes drastically, as altitude exacerbates climate conditions: barren rocky ridges dominate over hilly humps, typical of the old latifundia, now generally replaced by a fragmented ownership, where promiscuous crops are also common.

In most of this territory, which connects with the interior plateau, the cultivation of durum wheat dominates.

The area is affected by widespread hydrogeological disruption caused by adverse weather conditions, which poses a serious threat to the agricultural sector and to road infrastructure, further accentuating the isolation of rural areas. This marginalization is especially perceived due to the lack of basic services. Many outlying areas are, in fact, unreachable: they lack road infrastructure, broadband, and are often subject to critical environmental issues, such as fire risk.

3.2 Methods

The work carried out involved the use of primary data and secondary data in the two districts examined within the Zone 1 and Zone 2. The primary data, collected directly from a few notary offices, were extracted from deeds of sale signed in the period 2005-2017. The choice of considering two different spatial areas is motivated by the need to verify in both cases the current level of the link between market prices and cadastral farmland incomes, as well as the fiscal equalisation or inequality due to the calculation methods of the Farmland Income tariffs envisaged by the cadastral system of the "Agenzia delle Entrate". The secondary data (6th General Census of Agriculture – ISTAT, 2010), described in the section 3, were used to verify the sample representativeness with reference to the structural characteristics of the farms.

In particular, the following elements were collected for each purchase and sale: date the contract was stipulated, cadastral identifiers (municipality, map sheet, parcel, crop quality, profitability class, Farmland Income, area), sale price, presence or absence of kinship ties between buyers and sellers, ownership share and the Homogeneous Territorial Zone. At this stage, therefore, only deeds relating to agricultural land and with no kinship ties between the parties involved were taken into consideration in order to avoid sampling bias (potential outliers).

The analysis of the land market was based on a sample of 176 deeds of purchase and sale of agricultural land, distributed between Zone 1 (No. 57 deeds) and Zone 2 (No. 119 deeds). Within each deed, it was checked whether there was a single price or more than one sale price; in the latter case, the number of sales corresponded to the number of prices indicated in the deed. From this count, the sample consisted of 183 observations, of which 57 in the Trapani area and 126 in the Palermo area. The following characteristics were initially analysed, both for the entire study area as well as separately for the two study areas:

- average and median values for the total price paid, the average unit price and the land area bought and sold;
- the spatial distribution of observations by municipality in Zone 1 and Zone 2, with particular reference to their number, to total and average area bought and sold (sq. m.), and crop qualities found;
- the distribution by area classes (Ha) of land bought and sold and the corresponding average unit price paid (€/Ha) matched to each area class;
- the distribution of the number of sales and purchases according to the average unit price paid (€/Ha).

In order to determine whether the sample observations reflected actual conditions, the characteristics listed above were compared with census data.

It was, therefore, taken into account the regulatory developments for taxation purposes (Personal Income Tax "IRPEF", Municipal Property Tax "ICI", Municipal Single Tax "IMU" by applying to the Cadastral Farmland Income calculated for each purchase and sale the respective revaluation rates in force at the time of the signing of the deed. In this regard, it should be noted that, according to the objectives of this research, only the Farmland Income was considered within the cadastral tariffs.

To calculate the IRPEF taxable base, the Farmland Income (expressed in €/Ha) stated in each deed was revalued by 80.0% for purchases and sales between 2005 and 2011, and by 15.0% and 30.0% for purchases and sales between 2012 and 2014, and between 2015 and 2017.

Instead, for the calculation of the taxable base for ICI and IMU, the Farmland Income was revalued by 25.0 percent.

All percentages applied are consistent with the updates provided by the sector regulations.

In order to answer the research question, two groups of indicators were subsequently constructed: the first group aims to simulate the capitalization rate[8], while the second group aims to analyse the relationship between market price and tax value for ICI and IMU purposes. With reference to the first group of indicators, the ratio of the revalued Farmland Income of the land bought and sold to the relative market price observed was calculated for each sample observation. This is used to understand whether the Farmland Income adequately performs the function that is normally a prerogative of the Land Benefit (LB) since the Farmland Income represents the pre-tax LB.

In order to estimate market value through capitalization of continuous annual average incomes, the inverse formula was applied (known as Analytical Appraisal, Eq. 1). In fact, for each surveyed trade, it is possible to derive its specific capitalization rate (r_{cap}) from the ratio of LB to market value (V) (Eq. 2).

$$V = \frac{LB}{r_{cap}} * 100 \quad (1)$$

$$r_{cap}\ (\%) = \frac{LB}{V} * 100 \quad (2)$$

This procedure was applied to both the Farmland Income used for calculating the IRPEF tax base (Eq. 3a) and that one adopted for calculating the tax base for ICI and IMU purposes (Eq. 3b). As a result of the considerations above, the percentage indices resulting from the application of equations (3a) and (3b) were found to be similar to r_{cap}.

$$r_{IRPEF}\ (\%) = \frac{F.I_{\ IRPEF}}{MP} * 100 \quad (3a)$$

where $F.I_{IRPEF}$ represents the Farmland Income revalued for IRPEF purposes; MP is the market price of each observation; and r_{IRPEF} is the indicator assimilated to the capitalization rate.

$$r_{ICI,IMU}\ (\%) = \frac{F.I_{\ ICI,IMU}}{MP} * 100 \quad (3b)$$

Where $F.I_{ICI,IMU}$ represents the Farmland Income revalued for ICI and IMU purposes; MP is the buying and selling price of each observation; and $r_{ICI,IMU}$ is the indicator assimilated to the capitalization rate. The results obtained through the application of equations (3a) and (3b) were compared with what emerged from the literature review on an acceptable range of r_{cap} values for farmland, related to the economic performance of farmland. A further comparison was made with the rates of return of the Multi-Year Treasury Bonds (BTPs) net of inflation rates. For this purpose, both the average annual rates of return on 30-year BTPs and the average annual inflation rates were collected for the entire period under observation (2005 – 2017). The former were obtained from the website of the Ministero dell'Economia e delle Finanze (2022), the latter derived from the website of the Federal Reserve Economic Data (FRED) (2022).

In view of the appraisal literature (Amicabile, 2018; Gallerani, 2011; Michieli, 1993), because land assets are characterised by a different risk class than government bonds, an adjustment to net BTP rates was made, conservatively assessed at 0.5% due to the lack of specific guidelines.

The second group of indicators, on the other hand, is the ratio between the market price of a landed property and its cadastral value for ICI and IMU purposes, the latter obtained by construction by multiplying the revalued Farmland Income by a coefficient periodically set by the legislature.

The unit Farmland Income's (expressed in €/Ha) of each purchased land in the sample were revalued – in accordance with the development of tax legislation – to calculate the tax value, which is the taxable base for the payment of ICI (until 2011) and IMU (formerly ICI starting in 2012). In particular, the Farmland Incomes were revalued by 25.0%. Then, to calculate the taxable base for ICI, they were multiplied by a coefficient of 75 for all purchases and sales that occurred between 2005 and 2011. Instead, to calculate the taxable base for IMU these were multiplied by a coefficient of 110 for purchases and sales in 2012 and finally by a coefficient of 135 for those concluded between 2013 and 2017 (from 2018 to the present, the multiplier coefficient has remained unchanged and equal to 135)[9].

Tax values were calculated with reference to both the date the purchase and sale was concluded – applying the relevant revaluation coefficients in force – and to the present day by employing the current multiplier coefficient (equal to 135) for all observations. The latter calculation was based on the assumption that the purchase

[8] In the appraisal discipline, the capitalisation rate relates the owner's continuous average annual income (Land Benefit, LB) to the value of the land capital that generated it.

[9] It should be noted that this paper does not consider the benefits (exemptions or reductions) provided for territories, or parts thereof, located in mountainous or hilly areas, for minor islands and for the figures of farmer and professional agricultural entrepreneur regardless of location.

and sale prices of the land in the sample (referring to the period 2005-2017) can be considered valid to date.

Including the present Tax Value was motivated by the need to determine whether or not the increased multiplier coefficient (135) has bridged the gap with the buying and selling prices. Considering a methodological perspective, we should have also updated the prices from the dates of purchase and sale to the present through the application of price variation rates. Nevertheless, due to the lack of studies on this topic, in this research prices have not been "updated" to the present day in order to avoid applying rates with no link to the real market.

From the above data, the indicators i (Eq. 4a) e i_0 (Eq. 4b) derived respectively from the ratio of purchase and sale price (MP) to tax value for ICI and IMU ($FV_{ICI,IMU}$) purposes and the ratio of MP to tax value for IMU purposes with reference to present (FV_{IMUo}), respectively, were calculated.

$$i = \frac{MP}{FV_{ICI,IMU}} \quad (4a)$$

$$i_0 = \frac{MP}{FV_{IMU_0}} \quad (4b)$$

Through these computations it was possible to assess the extent of the variance between the two terms and to verify whether or not the cadastral values, calculated from the FIs, were connected with the trend – in the years examined – of the land market in the two case study land areas.

The indicators obtained were analysed by calculating key descriptive statistics both with reference to the entire study area and later separately for Zone 1 and Zone 2. As a result, the initial sample "*n*" of 183 trades was subdivided into two sub-samples: the first includes Zone 1 trades (*n* = 57), and the second includes Zone 2 trades (*n* = 126).

Successively within each zone, municipalities characterised by the same tariffs – crop quality and productivity class being equal – were identified.

For each sub-sample observations were divided into homogeneous groups based on the above-mentioned criterion.

Based on these groups, for each of the two subsamples, the percentage divergence (Δ%) between the unit cadastral values for the payment of ICI and IMU referred to the date of purchase and sale (ICI and IMU Unit Tax Value) and the average unit prices observed (Average Unit Market Price) was calculated. Both are expressed in €/sq.m, in order to demonstrate the actual presence or absence of tax inequality (Eq. 5a).

$$\Delta\,(\%) = \frac{\text{ICI and IMU unit tax value} - \text{Average unit market price}}{\text{Average unit market price}} * 100 \quad (5a)$$

The above procedure was repeated by substituting the unit cadastral values for ICI and IMU purposes for those in force for IMU payment (IMU_0 Unit Tax Value) by applying Eq. 5b.

$$\Delta_0\,(\%) = \frac{\text{Unit tax value } IMU_0 - \text{Average unit market price}}{\text{Average unit market price}} * 100 \quad (5b)$$

The results indicate whether taxpayers own real estate with asset values greater than, less than, or equal to the cadastral value. In fact, a Δ% result with a positive sign would mean that to date the taxpayer is being taxed more than the actual value of his/her land should suggest. On the other hand, numerical values of Δ% with a negative sign would indicate that the taxpayer is paying less in relation to the actual value of his property.

Additionally, tax equalization was verified by comparing the market prices of land with identical fiscal values.

With reference to the two procedures described above, the crop quality most examined was arable land of Class I, II, III, IV and V, given that it represents the most frequent agricultural use for both Zone 1 and Zone 2. In addition, limited to few observations of Zone 1 the analysis was carried out for other crop qualities such as arboreal arable land, vineyards and olive groves. A significant proportion (about 35.0% of the total) of purchases and sales in our sample involved several cadastral parcels with different crop qualities but all having the same buyer, which we call "mixed crop qualities."

As a result, the transaction involves several parcels of different cultivation systems for which a single price was paid and a single sale deed was stipulated. Since it was not possible to extrapolate the unit price paid for each crop quality involved in the transaction, the above procedure for tax equalization testing could not be applied to the above trades by adopting Equations (5a) and (5b).

4. RESULTS AND DISCUSSION

The study sample analysed, as already mentioned, consisted of 176 notarial deeds and 183 observations[10] of which 57 referred to Zone 1 and 126 to Zone 2.

For Zone 1, the largest number of sales, again with reference to the sample size, refers to agricultural land

[10] Although the sample is made up of 183 sales, for some calculations a smaller one (n=179) was used, net of 4 observations whose land sold was located in more than one municipality and for which a single price was paid.

located in the municipalities of Valderice (17.3%), Erice (7.3%) and Custonaci (6.1%). In Zone 2, the distribution of agricultural land bought and sold is most concentrated in the municipalities of Baucina and Marineo, with a percentage incidence of 17.9% and 13.4%, respectively. In other municipalities, however, the incidence of land sales is significant, especially in Villafrati (4.5%), Ciminna (3.9%) and Ventimiglia di Sicilia (3.9%).

Principal key descriptive statistics were calculated for some parameters, showing that for the entire sample size the mean (μ) and median (Me) values for the total price (€) amount to 9,816 € and 5,000 €, respectively. In the two study areas, the above central tendency indices take substantially different values (μ_{Zone1}: 11,521 €; M_{eZone1}: 6,000 €; μ_{Zone2}: 8,899 €; M_{eZone2}: 4,800 €). Taking into consideration the average unit price (€/sq.m), the sample μ is 3.00 €/sq.m, while the Me is 1.31 €/sq.m; again, the two areas investigated present different situations: an average price of 4.31 €/sq.m was paid for land falling in area 1, while the corresponding average price of land falling in area 2 is 2.30 €/sq.m. The median values of the two sample distributions are both significantly lower than the average values described above, and specifically 1.48 €/sq.m (Zone 1) and 0.94 €/sq.m (Zone 2). The areas being bought and sold averaged 8,955 sq.m (n=183) with a median value of the sample distribution of 3,340 sq.m. The average figures for the two sub-samples are again markedly different from each other: the areas bought and sold in Zone 1 are on average (5,756 sq.m) significantly smaller than those in Zone 2 (10,675 sq.m.), while the relative medians are very similar in the two distributions (3,165 sq.m and 3,573 sq.m.) and also to the sample median value 3,340 (sq.m). The total area bought and sold amounts to about 1.5 million sq.m (154 hectares), distributed at the municipal level as follows: for Zone 1, Valderice (8.4%), Erice (6.1%) and Custonaci (5.3%) are still the municipalities with significantly higher percentage values than the others in the same zone to which they belong; in Zone 2, Casteldaccia is the municipality with the highest area bought and sold (24.4%), followed by Mezzojuso (12.7%), Baucina (9.8%) and Marineo (7.1%).

The remainder of the municipalities in Zones 1 and 2 not mentioned so far have a lower incidence value in terms of number and area bought and sold of 3.5% and 4.2%, respectively. From the results obtained, the average unit area bought and sold for the entire sample is 8,611 sq.m (n=179). This result is in line with the census data shown in Table 3, from which it can be seen that most farms in both Zone 1 and Zone 2 have an average farm size of less than 1 hectare. Therefore, on the basis of this comparison, it can be asserted that, in terms of size, the sample is fairly representative of the farms in the areas considered.

Table 3. Comparison of the percentage distribution by size classes between collected and census data (%).

Area class (Ha)	Collected data		Census data	
	Zone 1	Zone 2	Zone 1	Zone 2
until 0.99	79.6	82.4	31.7	41.6
From 1.00 to 1.99	17.2	13.4	19.8	20.6
From 2.00 to 2.99	1.6	0.8	11.6	9.8
From 3.00 to 4.99	1.6	0	13.5	9.9
≥ 5.00	0	3.4	23.4	18.1
Total	100	100	100	100

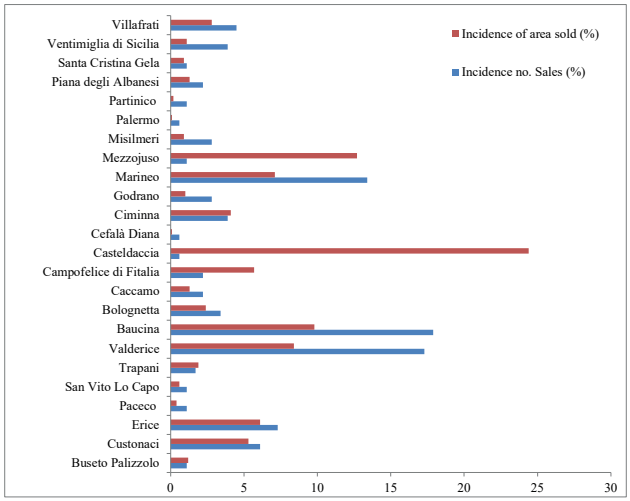

Figure 3 Incidence of area sold and no. of sales by municipality in the study area.

Due to the relatively small size of the land purchased, it seems likely that buyers are either agricultural entrepreneurs, including young ones, seeking to expand their farm base, or non-farm buyers who engage in farming for family consumption in their spare time.

The results described heretofore are reported in Figure 3 and schematised in Appendix 2 (Tab. 1a).

Figures 4 and 5 – which summarized data reported in Tab. 2a (Appendix 2) show the percentage incidences calculated as a function of the number of observations and the area bought and sold, distributed by the crop qualities found in the municipalities of both study areas. The crop qualities included are as follows: arable crops, permanent crops, permanent pastures and meadows, and mixed crop qualities.

The item "arable land" groups arable and arboreal arable land; within the item "permanent crops" olive

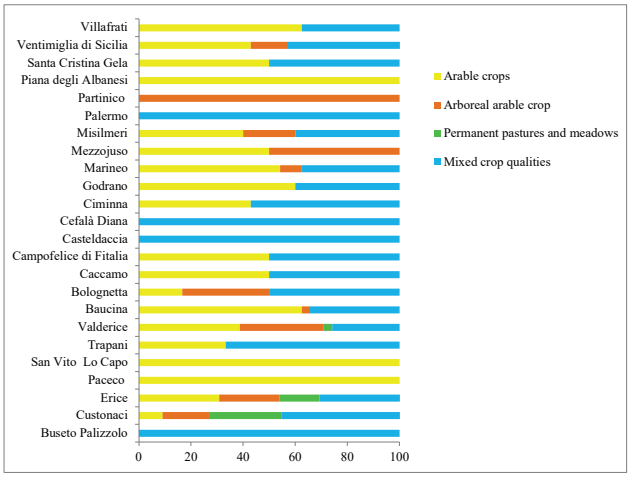

Figure 4. Number of sample sales by municipality and crop quality (%).

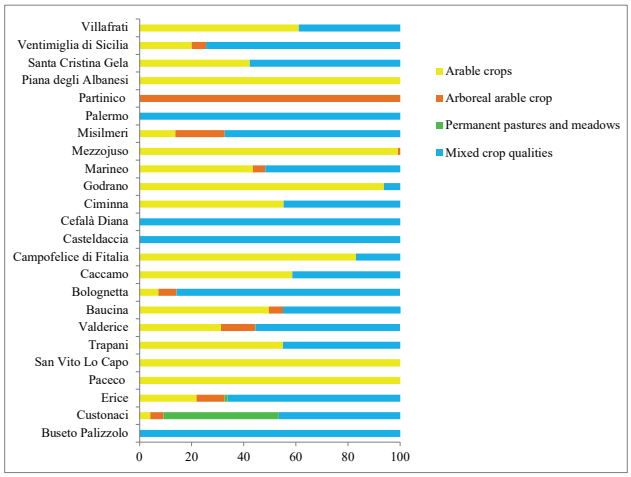

Figure 5. Area of sample sales by municipality and crop quality (%).

groves, vineyards and other fruit trees have been considered; the item "permanent pastures and meadows" encompasses pastures and arboreal pastures; finally, mixed crop qualities represent a heterogeneous item within which fall less common crop qualities and trades involving more than one crop quality and therefore not classifiable within a specific crop category.

The results obtained show that mixed crop qualities have a high percentage incidence in terms of the trades' number (amounting to 66) and of the area bought and sold (amounting to 839,144 sq.m), since, as mentioned above, they encompass multiple crop qualities ascribable to a single selling price. It should, however, be noted that most of the plots bought and sold are arable lands.

Within the mixed crop qualities category, arable lands are the most bought and sold in the two districts (no. equal to 82), totalling 608,608 sq.m. These are followed by permanent crops, whose area purchased amounts to 56,154 sq.m for a total of 25 sample observations, and more in detail: olive groves (no. equal to 9 and 19,501 sq.m sold), vineyards (no. equal to 10 and 24,011 sq.m sold) and other fruit crops (no. equal to 6 and 12,642 sq.m sold). Permanent pastures and meadows represent, with 6 observations and 37,414 sq.m, only a small part of the sample.

Analysing and comparing the sample data and the ISTAT data, it emerges that, for both sources examined, the most bought and spread crop quality for the two study areas is arable land, which is characteristic of extensive systems such as cereal and cereal-forage, in the face of a rather limited average farm economic size in the area. This validates again the representativeness of the sample. Table 4 shows the distribution of sales by land area classes (for Zone 1, Zone 2 and for the total of the entire study area) and the corresponding average unit price paid. The results show that 81.4% of the land sold (79.6% Zone 1 and 82.4% Zone 2) had an area of less than 1.00 hectare and were paid an average of 18,947 €/Ha; 14.7% of the sample had an area between 1.00 and 1.99 hectares (17.2% Zone 1 and 13.4% Zone 2) and an average unit price of 11,613 €/Ha; on the other hand, the presence of land from 2.00 up to 2.99 hectares (incidence of 1.1% and average unit price paid of 8,505 €/Ha), from 3.00 to 4.99 hectares (0.6%; 12,450 €/Ha) and over 5.00 hectares (2.2%; 4,993 €/Ha) is less significant. Table 4 shows that size class distribution is also consistent with the corresponding one related to census data, so the sample data reflect the agricultural situation of the surveyed areas and are representative of the statistical population of farmland.

Furthermore, Table 4 shows that average unit prices tend to decrease as the area bought and sold increases[11]: for the smallest class (up to 0.99 Ha) the average unit price is about 19,000 €/Ha; instead, for the largest class (over 5.00 Ha) land is priced at about 5,000 €/Ha.

The assertion of Simonotti (2011) that the total price curve is increasing with the area sold, while average and marginal prices are decreasing, corroborates this trend. According to the study area, average prices for Zone 1 are higher for all acreage classes; this can be attributed to a higher incidence of non-agricultural purpose in the sample purchases of Zone 1.

[11] The only conflicting figure is the average unit price of 12,450 €/Ha referring to the class ranging from 3.00 to 4.99 hectares. However, the figure refers to a single observation so it was reported in the table since it is part of the sample but, for the purpose of statistical inference, it is not significant as opposed to the other values shown in Table 3.

Table 4. Area classes of land sold and relative average unit price.

Area class (Ha)	Incidence (%)			Average unit price (€/Ha)		
	Zone 1	Zone 2	Study area	Zone 1	Zone 2	Study area
until 0.99	79.6	82.4	81.4	23,274	17,061	18,947
From 1.00 to 1.99	17.2	13.4	14.7	20,626	5,399	11,613
From 2.00 to 2.99	1.6	0.8	1.1	9,256	7,815	8,505
From 3.00 to 4.99	1.6	0.0	0.6	12,450	-	12,450
≥ 5.00	0.0	3.4	2.2	-	4,993	4,993
Total	100.0	100.0	100.0			

Table 5. Classes of average unit price and percentage incidence of sales.

Class of average unit price (€/Ha)	Incidence (%)		
	Zone 1	Zone 2	Study area
until 7,500	14.1	42.0	32.2
7,501 – 17,500	37.5	23.5	28.5
17,501 – 30,000	10.9	16.0	14.2
30,001 – 50,000	23.4	7.6	13.1
> 50,000	14.1	10.9	12.0
Total	100.0	100.0	100.0

Further elaborations (Tab. 5) concerned the distribution of the number of trades in relation to the average unit price paid. This showed that for most of the plots (32.2%) an amount up to 7,500 €/Ha was paid, and only for 12.0% of the observations the price paid was greater than 50,000 €/Ha. Trapani (Zone 1) has higher unit prices on average than Palermo (Zone 2). According to Zone 2, 81.5% of sales fall into the first three price classes, with generally lower average unit prices than in Zone 1.

Through the analysis of the main descriptive statistics of the sample, the results regarding the determination of capitalization rates for each sample observation by relating the Farmland Income – revalued for IRPEF and ICI or IMU purposes – to the land sale price (eq.3a and 3b), can be summarized as follows.

With reference to r_{IRPEF} (eq.3a), the range of variation (R) was found to be between the values- minimum and maximum – of 0.0022% and 3.16%. Instead, the main measures of position, namely μ and M_e, are 0.84% and 0.73%, respectively. Among the dispersion measures, the standard deviation (σ) of the sample is 0.69%.

The results for the shape measures, kurtosis (K) (1.0088) and skewness (s) (0.9761), show that the curve of the sample rates is positively skewed (with tails on the right-hand side) with a greater concentration of values on the left-hand side, far from the Gaussian normal distribution.

Taking a closer look at the results obtained separately for the two zones under study, it can be seen that for Zone 2, in terms of r_{IRPEF} (3a), the values of μ and M_e are quite similar . In Zone 1, μ and M_e are equal to 0.74% and 0.60%, respectively.

The coefficient of variation (CV) shows a greater distribution variability for Zone 1 than for Zone 2.

Comparing the data for both zones, a two-sample t test for the difference of means has been carried out. The null hypothesis (the means are equal) has not been rejected thus confirming that this central tendency measure of r_{IRPEF} is not statistically different for the two zones.

With reference to $r_{ICI,IMU}$ (3b), the R was found between the values of 0.002% and 2.190%. On the other hand, the main measures of position, namely μ and M_e, are 0.56% and 0.48%, respectively. Among the dispersion measures, the σ of the sample is 0.47%.

The results for the shape measures, K (1.5638) and s (1.1074), show that the curve of the sample rates is positively skewed (with tails on the right-hand side), and with a greater concentration of values on the left-hand side, far from the Gaussian normal distribution.

Zone 1 is characterized by lower μ and M_e values than Zone 2.

Differently from the previous indicator (r_{IRPEF}), from the two-sample t test for the difference of means, it comes out that the $r_{ICI,IMU}$ for two zones are characterized by statistically different means.

The calculated Coefficients of Variation (CVs) are identical to the previous ones, which means that the sample distribution of Zone 1 is more dispersed than Zone 2.

The above results were compared with the net yield rates of 30-year BTPs and with the capitalisation rates found in the appraisal literature. The former, collected for the period 2005-2017, range from a minimum of 1.8% to a maximum of 4.5%. This makes them significantly higher than the ranges of the rates obtained in this research. Just as the 3.40% average figure for the period – with the 0.50% adjustment – is far higher than those ones calculated for zones 1 (0.74% and 0.44%, respectively) and 2 (0.90% and 0.63%).

The same applies to capitalization rates that can be retracted from the appraisal literature, which vary between 1.0% and 3.0-4.0% depending on profitability, management riskiness, production system and location (Gallerani et al., 2004; Grillenzoni and Grittani, 1994; Michieli and Michieli, 2002), and can take values up to 6.0% and even more for livestock enterprises with an

Table 6. Descriptive statistics of the four indicators by Zone 1, Zone 2 and study area.

	Zone 1							Zone 2							Study area					
	R	μ	M_e	σ	s	K	CV (%)	R	μ	M_e	σ	s	K	CV (%)	R	μ	M_e	σ (%)	s	K
r_{IRPEF} (%)	2.4	0.7	0.6	0.6	0.7	-0.6	86.5	3.2	0.9	0.9	0.7	1.1	1.4	79.3	3.2	0.8	0.7	0.7	1.0	1.0
$r_{ICI,IMU}$ (%)	1.6	0.4	0.3	0.4	0.9	0.3	86.4	2.2	0.6	0.6	0.5	1.1	1.4	79.3	2.2	0.6	0.5	0.5	1.1	1.6
i	246.9	14.9	2.7	37.7	4.7	24.6	252.9	864.9	13.5	2.1	79.6	10.5	113.5	589.4	864.9	14.0	2.5	67.8	11.2	138.3
i_0	246.9	12.4	2.2	36.4	5.2	29.9	294.1	480.5	7.5	1.2	44.2	10.5	113.5	589.4	480.5	9.2	1.5	41.6	9.3	96.9

industrial configuration (Grillenzoni and Grittani, 1994).

In order to answer the research question, the other indicator adopted is the ratio of the sale price to the tax value. The latter was calculated with reference to both the transaction date, i (4a), and to present, i_0 (4b).

The results obtained for the sample (n = 183), related to indicator *i*, are reported below describing the main descriptive summary statistics. Among central tendency measures, μ of the sample stands at 14.0, M_e is 2.53. The sample variability is quite pronounced, as shown by the figure regarding σ, which was found to be 67.85. Results regarding the shape measures of the data distribution, namely K (138.26) and S (11.25) indicate substantial distance between the sample curve and the Gaussian normal curve, respectively. They also indicate the presence of a significant tail of observations in the right-hand side.

The σ is large for both territories but is far higher in Zone 2 than in Zone 1. Such high values of σ affect the CV, showing a higher dispersion of Zone 2 distribution than Zone 1, as confirmed by F test.

Regarding statistical elaborations on the ratio of price to tax value calculated with reference to present, i_0 (4b) for IMU purposes, according to the results obtained the values of μ and M_e stand at 9.21 and 1.55, respectively. The σ (41.63) indicates again a high degree of dispersion in the sample data.

In terms of shape indices, the distribution has a K index of 96.90 and a positive S index of 9.32. The values obtained indicate that the sample distribution is not Gaussian and that these data are more concentrated on the right side of the curve.

Compared with the previous situation (i), the differences in terms of i_0 (4b) between Zone 1 and Zone 2 are more pronounced, especially for the values of μ and M_e. Contrary to this, the differences between the σ calculated for the two areas are smaller and according to the F test the ratio between the variances is statistically equal to one. CVs maintain the same magnitudes and confirm that data for Zone 1 are more dispersed than those related to Zone 2.

In both cases (i and i_0), according to the two-sample t test the statistical difference between the means is equal to zero for the two zones.

All the results above mentioned are reported in Table 6.

To sum up, in relation to the evolution of tax-related revaluations, the results show that r_{IRPEF} takes on higher values than $r_{ICI,IMU}$. The same applies to the ratio of Price to Tax Value, which decreases using the tax value calculated at the present time while remaining far from equality or similarity with the Market Price. Ultimately, despite the revaluations of tax values (IMU) over the years, the spread with prices is still apparent. In addition, it is worth noting that the distance between the two magnitudes could have been even greater if prices had been updated to current time. Such a high dispersion around the mean of i and i_0 indicates how the price is dependent on countless variables, which cannot be standardized for tax purposes.

This further demonstrates the inadequacy of the tax value. This is derived from outdated incomes that are disconnected from the current scenario and is "normalized" through the application of multiplier coefficients that are the same for all land assets, regardless of the characteristics that each of them may have.

Figure 6 relates the ICI and IMU Tax Values (€) to the Sale Prices (€) of each sample observation. It shows a marked difference in non-correlation their magnitudes and a high degree of dispersion in the data. If the points were located on the line – which represents the bisector of the I quadrant (y = x) – then there would be a correspondence between the ICI and IMU Tax Values and the Sale Prices. In contrast, in situations where the points are above and below the bisector, the Tax Values are respectively lower and higher than the Prices. The point cloud (Fig. 6) appears to be most concentrated above the bisector, and only few points are located at or below it[12].

[12] It should be noted that in figs. 6 and 7, due to problems related to a significant difference in the intervals assumed by the two quantities (Price and Tax Value) on the two Cartesian axes, all sample observa-

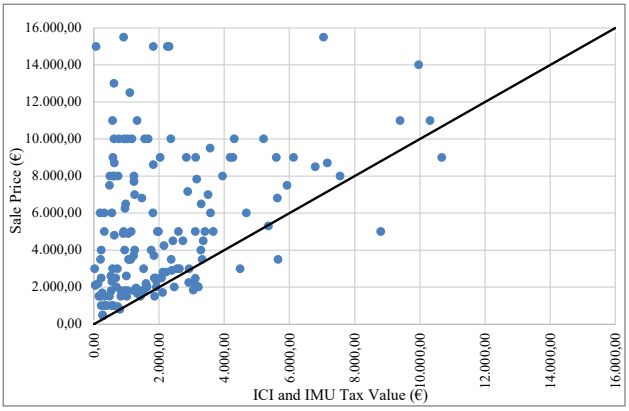

Figure 6. Comparison between Sale Prices and Tax Values (ICI and IMU) for the sample observations.

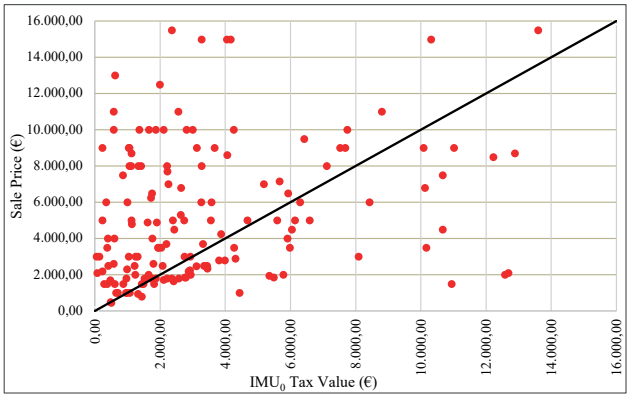

Figure 7. Comparison between Sale Prices and IMU_0 Tax Values for the sample observations.

Similarly, Figure 7 shows a comparison between IMU_0 Tax Values and Sale Prices. In fact, there is a slight improvement at the graph compared to the previous situation (Fig. 6), which is fully justified considering that IMU_0 Tax Values are, as of 2013, always higher than ICI and IMU Tax Values, due to the increase in the multiplier coefficient applied.

In Figures 6 and 7, the magnitudes of the two economic indicators on the axes do not vary proportionally because Price follows the laws of the land market instead of Tax Value which is the result of policy decisions made and adopted.

There are few studies in the appraisal literature that investigate the tax fairness of the Italian cadastral system through an examination of taxable incomes – cadastral rent for buildings and Farmland Income for lands – which are compared with the corresponding market prices. Among them, referring to surveys conducted at the national and regional levels, the following pieces of work are worth mentioning.

In a survey conducted throughout Italy, Cenciarelli (2006) estimates a national average ratio between market values (based on data from the Osservatorio del Mercato Immobiliare, OMI) and cadastral values, equal to 2.93. At the provincial level, on the other hand, the author identified different classes (averaging data at the municipal level) of this ratio. In particular, for Trapani (covered by Zone 1) the class is between 2 and 2.5, while for the province of Palermo (reference territory for Zone 2) the range is between 3 and 3.5. In the latter case, the author points out that the figure for the provincial capital significantly influences the overall provincial result and that of the metropolitan hinterland. Although this is a survey aimed exclusively at the housing market and not at the land market, its conclusions can be considered fully consistent with the results of this paper.

Always in relation to buildings, Iommi and Marinari (2013) in Tuscany find a median value of 2.60 with a range between 1.5 and 5.7.

Agnoletti et al. (2020) in a more recent work, investigate the unresolved issue of the alignment between cadastral values, i.e., the tax base for IMU, and market values of buildings registered in the Cadastre. During their study, the authors examine vertical and horizontal equity in the Italian property taxation system. For this purpose, they resort to the ratio between OMI listings – used as a proxy for market prices – and tax values, the fiscal base subject to taxation. From their nationwide survey with data disaggregation at the municipal level, it comes to light that the actual value is on average one and a half times higher than the cadastral value. This ratio was found to be subject to significant variations rather than remaining constant in accordance with horizontal and vertical tax equity criteria.

To validate the findings of their research, the authors calculate the ratio of market value to cadastral value for typical residential properties with specific characteristics, obtaining values between 1.3 and 3.4. And they calculate it for several Italian localities. In conclusion, the study conducted by the aforementioned authors is perfectly in line with the results of the present research, albeit in different real estate fields (urban real estate versus landed property).

In the only work concerning the Italian Land Cadastre, Asciuto et al. (2008), aim at verifying the reliability of the cadastral tariffs in force for some crop qualities (vineyards and olive groves), and proceed to a

tions with prices above 16,000 euros (n = 22) were excluded to avoid distorting effects in the graphical representations such that the trend of the analyzed phenomenon would be visually unappreciable.

comparison of the market prices of a sample of land sold in the province of Trapani with the corresponding tax values. In this way, they reach results similar to those of the present study. In fact, tax values (for ICI purposes) are consistently lower than market prices, with percentage divergences ranging from 58.0% to 71.0% for olive groves and 53.0% to 69.0% for vineyard land. However, the authors do not have punctual property data and therefore have attributed a productivity class to each observation considered, based on certain surveyed characteristics.

The last step in the present research involved checking whether tax inequality actually exists in the land fiscal system. As already anticipated, this step was found to be possible only for trades characterized by a single crop quality, which in our case are mostly arable lands, by applying equations (5a) and (5b). Sample observations were grouped according to the location of land sold. Specifically, for municipalities with equal cadastral tariffs for given crop qualities and productivity classes.

Despite the high presence of mixed crop qualities, which strongly limited the sample size on which to carry out the comparisons, the elaborations are to consider able to provide an adequate answer to the initial research question.

The comparison between prices and tax values was made on a unit basis (€/sq.m). On the contrary, it would not have been possible to identify cases where taxpayers pay IMU less or more than the asset value of the property owned. It was preferred to use the current tax value for IMU purposes for the calculations since it is obtained through a higher multiplier coefficient, in order to be in line with the current situation (year 2022). In this way, it was possible to verify whether or not the increased multiplier coefficient (135) has bridged the gap with the buying and selling prices. In Zone 1, the crop qualities analysed were as follows: arable land, arable land with permanent crops, olive grove and vineyard.

With reference to arable lands, the comparisons covered land in all existing productivity classes except the first one. In most cases there was a significant discrepancy between the tax value and the price paid. This distance is expressed with the indicator of percentage divergence (Δ_0) (whereby with positive values the tax value is higher than the market price and vice versa for negative ones). It follows that the taxable tax burden on the owner- if the land were taxed in relation to its market value instead of its tax value – would be markedly different from that calculated on its Farmland Income. The Δ_0 calculated for all arable land in Zone 1, which was 16 observations, ranged from +29.0% (tax value higher than market price) to -99.0% (market price greater than tax value). The only exception is one observation whose market price was almost identical to the tax value.

When comparing the market prices of land with the same cadastral tariffs – which are thus matched by identical taxable income- the considerable magnitude of the variations in the prices paid (expressed in percentage terms) highlights the unequal treatment in which landowners incur. This occurs because of the marked differences in the market prices of the respective land assets.

In fact, the maximum percentage divergences within each productivity class range from +584.0% to +8,806.0%. This shows that if the current Land Cadastre were transformed into a Cadastre based on market values, the tax liabilities burdening landowners would vary between them. In particular, these would vary by the rates shown above, having taken the extreme values of each productivity class as benchmarks.

On the other hand, the observations concerning comparable arable land with permanent crops – only two 3rd class observations within the sub-sample – the Δ_0 between tax value and average unit price varies between about -43.0% and -78.0%; therefore, in a value-based cadastre the taxable income calculated on both lands would be significantly higher than at present. Alternatively, a cadastre based on market values would show a Δ_0 percentage difference of 156.0% between the two sample observations, and therefore an analogous divergence in the taxable incomes between the two owners (taxpayers), who are currently subject to the same taxable amount.

With reference to olive groves, verification was only possible on 4 sample observations of 2nd class olive groves. The calculated Δ_0 between current tax value and market price for IMU purposes was found to be between -5.0% and -61.0%, while in terms of taxpayer comparisons, the range between market prices (at the extremes) was roughly 147.0%, tax value being equal.

Finally, the vineyard lands under analysis were found to be only 4, two of which belonged to the second class and two others fell under the third class.

In the comparisons made for the second class, the Δ_0 between the current tax value for IMU purposes and the market price for each observation was not particularly high, varying between approximately -10.0% and +17.0%. In contrast, the comparison between the two observations showed a Δ_0 of approximately 31.0% between the two market prices.

For third-class vineyards, the Δ_0 between the current tax value and the market price ranged from -12.0% to +24.0%, while the prices of the two transactions diverge from each other by about 42.0%, again denoting a not insignificant tax inequality.

Ultimately, for the Trapani area, in both the inter- and intra-parcel comparisons, there is a rather significant difference for arable crops and a less marked one for tree crops.

In Zone 2, where arable crops are significantly present, it was only possible to verify them for parcels of the same productivity class (from first to fourth) in municipalities with the same Farmland Income tariff.

For first class arable crops, of which there are only three plots compared, the Δ_0 calculated between the tax value and the market price of each observation varies between +11.0% and +45.0%, while the comparison of plots with the same tax value leads to the identification of a market price variability of around 30.0%, calculated between the two extreme values of the variation interval.

Concerning the second productivity class arable crops, these were assigned to two homogeneous groups by Farmland Income; the results of the verification show for the first of the two (five plots) a wide Δ_0 between tax value and market price, ranging between +22.0% and-79.0%; while the inter-plot comparison shows a divergence between the sale prices of 604.0% – with the same tax value – which again implies a considerable inequality between plot owners. In the second group, the Δ_0 per sample observation is between approximately +31.0% and -73.0%, and the inter-parcel comparison results in a market price variability of approximately 386.0%.

There are a total of 23 observations concerning third class arable land, divided into three homogeneous groups. In particular, the first group includes 12 plots whose Δ_0 approximately varies from -84.0% to +189.0%, while the comparison of plot prices revealed a high variability of approximately 1,700%, with prices sometimes lower and sometimes higher, even by far, than the tax value.

On the other hand, the second group presents few observations (4) with a range of Δ_0 ranging from -9.0% to +43.0% and a divergence between the sale prices of 57.0%. In the third group (n=7) the Δ_0 is between -83.0% and -16.0%, while the comparison between the prices of the various observations – tax value being equal – showed a divergence between the sale prices of 400.0%. With regard to fourth class arable crops, only three observations were verified, showing variations in terms of Δ_0 approximately between -88.0% and -42.0% and with a percentage deviation of up to 393.0% in terms of market prices.

The last check on the potential correlation between market price and tax value was carried out with the aim to verify the vertical equity in the two areas by running the test for statistical correlation through the Pearson rank correlation coefficient. The analysis was performed on the arable lands falling into all the profitability classes, (n_{Zone1} = 16; n_{Zone2} = 35) due to a reduced sample size of the observations concerning the other crop qualities. The results obtained (α = 5%) for both areas indicate an absence of statistical correlation between the two indicators (the coefficients are -0.267 for Zone 1 and +0.304 for Zone 2) and consequently the failure to comply with the vertical equity principle.

In conclusion, the analysis described above shows, for all the arable land parcels in the Palermo area, a significant level of fiscal inequality with the current Land Register tariff system in relation to both the gap between the current tax value and the unit market price, and the range between market prices when comparing parcels with equal unit farmland income and therefore with the same tax value.

Calculating both i_0 and Δ_0 further demonstrated that, although the legislator has progressively increased the multiplier coefficients over time, resulting in a reduction of the deviation between tax value and price, to date tax inequality in Italy is a widespread and undeniable phenomenon.

The findings above described cannot be extended to the other crops (e.g. permanent crops as olive trees and vineyards) due to a reduced number of sample observations in both areas which does not allow to perform a valid statistical analysis.

5. CONCLUSION

The present study highlighted, for both zones of the study area, the lack of correspondence between the revalued farmland incomes and the actual landowners' incomes (land benefit). This was highlighted by the values of the capitalisation rates calculated in the sample examined. These rates are well below the lower limit of the range indicated in the literature for agricultural land and of the values interval obtained by the indirect method.

This evidence is also confirmed by the comparison between tax values and market prices, which showed a considerable discrepancy between the two economic parameters, demonstrating the erroneous quantification of the multiplier coefficients used to calculate tax values from the revalued farmland incomes.

Both findings show that the tariff system adopted by the Italian Land Cadastre for tax purposes is obsolete and should therefore be reorganised in order to make it representative of the current agricultural scenario, in continuous and progressive evolution.

An additional objective of the research was to verify the tax fairness of the current land tax system. The data processing showed, for all crop qualities and productivi-

ty classes analysed, that the conditions of horizontal and vertical equity were not met.

In light of these findings, it is clear that the current cadastral tax system is unfair, benefiting some taxpayers to the detriment of others.

Therefore, some of the proposals for revision, already mentioned in the introductory section – including a redetermination of the unitary farmland incomes and of the classification system (the latter still standing at the 1939 revision) – should be welcomed in order to realign them to the current socio-economic conditions of agriculture. However, such a system requires a periodic updating of production factors costs and of prices regarding farm goods and services. Besides numerous farm balances are needed, whose outcomes must be extended from the reference Municipality to the entire census circle. Likewise, the cartographic part of the Land Cadastre should be improved given the close link between physical and appraisal aspects.

Another more radical proposal concerns its transformation into a Cadastre based on market values, as it is already successfully done in several EU countries. With this approach, continuous and, above all, facilitated updating over time would be ensured, as well as the possibility of using Mass Appraisal techniques to process the considerable amount of data.

As a result, it would be advisable the creation of a market prices database for cadastral purposes to be made accessible to all land market operators. This way monitoring of the land market trends would be simplified by assuring at the same time the application of innovative techniques addressed to the appraisal of market values.

REFERENCES

Act of 21 August 1997 Real Estate Economy. *Journal of Laws 2004 no. 261*. Republic of Poland.

Agnoletti, C., Bocci, C., Ferretti, C., & Lattarulo, P. (2020). Equità nell'imposizione immobiliare attraverso la rivalutazione della base catastale. *Argomenti*, (17), 48–69.

Asciuto, A., Mandanici, S., Schimmenti, E., & Viviano, P. (2008). Conservazione del Catasto nella recente normativa nazionale. *Estimo e territorio*, (6), 11–26.

Assessorato dei Beni culturali e dell'Identità siciliana (2010). Piano Paesaggistico dell'Ambito 1 ricadente nella provincia di Trapani. Palermo, Assessorato dei Beni culturali e dell'Identità siciliana.

Bacic, Z. (2004). Transition of Land Administration in Post-War Croatia. In *2004 Symposium on Land Administration in Post Conflict Areas UN-European Headquarter, April 29-30, 2004, Geneve*. International Federation of Surveyors.

Cenciarelli, S. (2006). Catasto e mercato immobiliare: confronto dei valori delle abitazioni in Italia. Roma, Agenzia del Territorio.

Coletta, A., Ribaudo, F., & Venzi, L. (2009). Fiscalità e catasto terreni. In *Atti del XXXVIII Incontro di Studio Ce.S.E.T, Il catasto nelle politiche di fiscalità immobiliare e di governo del territorio, Viterbo 10-11 ottobre 2008, 63-100*.

Colombo, G. (2003). Catasto Terreni: struttura attuale, principale normativa e problemi di utilizzazione. A cura di Seroglia, G. *La revisione del Catasto Terreni: contributi per un dibattito*. Roma, collana INEA.

Cristofaro, A. (2015). Per il settore agricolo privilegi fiscali assegnati senza equità. Nuova economia nuova società. Available at: https://www.nens.it/archivio/il-settore-agricolo-privilegi-fiscali-assegnati-senza-equit%C3%A0 (Accessed 24 October 2022).

Estonian Land Board (2021). Annual report on land valuation and transactions. Estonia, Estonian Land Board.

Federal Reserve Economic Data (2022). *Inflation, consumer prices for Italy (2005-2017)*. Available at: https://fred.stlouisfed.org/series/FPCPITOTLZGITA (Accessed 23 June 2022).

Ferrante, F., & Garnero, G. (2016). I droni nelle applicazioni catastali: possibili impieghi. *Territorio Italia*, (1), 45–59.

Gallerani, V. (2011). *Manuale di estimo*. Milano, McGraw-Hill.

Gallerani, V., Zanni, G., & Viaggi, D. (2004). *Manuale di estimo*. Milano, McGraw-Hill.

Grillenzoni, M. (1970). La "Banca dei prezzi" per una maggiore trasparenza del mercato fondiario. *Genio Rurale*, 5, V/21–V/25.

Grillenzoni, M. & Grittani, G. (1994). *Estimo. Teoria, procedure di valutazione e casi applicativi*. Bologna, Calderini.

Guerrieri, G. (2003). Considerazioni sulle proposte di accertamento fiscale dei redditi agrari. In Seroglia, G. (Ed.). *La revisione del Catasto Terreni: contributi per un dibattito*. Roma, collana INEA.

Iommi, S., & Marinari, D. (2013). Distribuzione territoriale dello scarto tra valori catastali e prezzi di mercato e politica fiscale dei governi locali. Un'applicazione alla Toscana. In *XXXIV Conferenza Italiana di Scienze Regionali, Crescita economica e reti regionali: nuove industrie e sostenibilità, Palermo 2-3 settembre 2013*.

Iovine, A., Fusacchia, G., & Cino, N. (2006). *Pregeo 9. Il catasto on-line*. Napoli, Sistemi Editoriali.

ISTAT (2012). Dati 6° Censimento generale dell'agricoltura 2010. Roma, Istituto nazionale di statistica ISTAT.

ISTAT (2020). Annuario Statistico italiano 2020. Roma, Istituto nazionale di statistica ISTAT.

Magni, D. (2002). Storia del catasto. Parte 3, Corso di Sistemi Catastali a.a. 2004-2005.

Michieli, I., & Michieli, M. (2002). *Trattato di estimo*. Bologna, Edagricole-New Business Media.

Ministero dell'Economia e delle Finanze (2022). *Archivio dei tassi di interesse dei titoli di Stato dal 1990 al 2020*. Available at: https://www.dt.mef.gov.it/it/debito_pubblico/dati_statistici/principali_tassi_di_interesse/archivio_tassi_interesse/. (Accessed 23 June 2022).

Muniz Perez, J. C. (2012). *Europa e Catasto*. Tesi di Dottorato di ricerca in Diritto tributario europeo. Bologna, Alma mater studiorum – Università di Bologna.

Osskó, A., & Hopfer, A. (1999). Eastern Europe's lessons from the past and aspirations for the future: running to catch-up or blazing a new path? In *1999 UN-FIG Conference on Land Tenure and Cadastral Infrastructure for Sustainable Development, Vol. 10. 1999. Melbourne, Australia*.

Permanent Committee on Cadastre in the European Union (2008). Cadastral information system: a resource for the E.U. policies overview on the cadastral system of the E.U. member states. Rome, Permanent Committee on Cadastre in the European Union.

Permanent Committee on Cadastre in the European Union (2009). Cadastral information system: a resource for the E.U. policies overview on the cadastral system of the E.U. member states. Prague, Permanent Committee on Cadastre in the European Union.

Permanent Committee on Cadastre in the European Union (2009). Cadastral information system: a resource for the E.U. policies overview on the cadastral system of the E.U. member states. Gävle, Permanent Committee on Cadastre in the European Union.

Permanent Committee on Cadastre in the European Union (2010). Cadastral information system: a resource for the E.U. policies overview on the cadastral system of the E.U. member states. Sofia, Permanent Committee on Cadastre in the European Union.

Permanent Committee on Cadastre in the European Union (2018). Let's Talk About (Legal) Reliability of the Cadastre. Vienna, Permanent Committee on Cadastre in the European Union.

Provincia Regionale di Palermo (2004). Piano Territoriale Provinciale. Palermo, Provincia Regionale di Palermo.

Pierri, A. (2015). La riforma del catasto si dimentica dei terreni. *Agriregionieuropa*, (40).

Ragni, P., & Luccarini, F. (2003). La potenzialità produttiva dei terreni agrari e l'individuazione delle microzone. In Seroglia, G. (Ed.). *La revisione del Catasto Terreni: contributi per un dibattito*. Roma, collana INEA.

Ribaudo, F. (2001). Ipotesi per una revisione generale del Catasto Terreni. L'informatore agrario n. 42, pp. 33–39. Bologna, Edagricole.

Schifani, C. (1985). La stima dei redditi e dei valori immobiliari a fini fiscali: aspetti metodologici ed applicativi. *In 1985 Atti del XV Incontro Ce.S.E.T: La stima dei redditi e dei valori immobiliari a fini fiscali, 23 febbraio, 1985, Viterbo*.

Schimmenti, E., Asciuto, A., & Mandanici, S. (2013). Andamento dei valori fondiari in Italia ed in Sicilia. *Aestimum*, (62), 89–110.

Schimmenti, E., Mandanici, S., & Asciuto, A. (2010). L'amministrazione del catasto italiano: il processo di decentramento delle funzioni catastali. *Aestimum*, (56), 91–117.

Ragni, P., & Luccarini, F. (2003). La potenzialità produttiva dei terreni agrari e l'individuazione delle microzone. In Seroglia, G. (Ed.). *La revisione del Catasto Terreni: contributi per un dibattito*. Roma, collana INEA.

Seroglia, G., & Tellarini, V. (2003). Gli elementi del nuovo sistema estimale: zone censuarie, qualificazione e conto colturale analitico. In Seroglia, G. (Ed.). *La revisione del Catasto Terreni: contributi per un dibattito*. Roma, collana INEA.

Simonotti, M. (2011). *Valutazione immobiliare standard*. Stimatrix editore.

Simonotti, M. (2008). Il metodo catastale per classi e tariffe. *Estimo e Territorio*, (2), 8–14.

Simonotti, M. (2002). I procedimenti di stima su larga scala (Mass Appraisal). In Quaderni Ce.S.E.T n. 8 a cura di Riccardo Roscelli, *Mercato immobiliare, innovazione e gestione dei catasti urbani*. Firenze.

Tellarini, V., & Seroglia, G. (2003). Potenzialità produttiva e potenzialità reddituale: le metodologie e i risultati, la trasferibilità e l'aggiornamento. In Seroglia, G. (Ed.). *La revisione del Catasto Terreni: contributi per un dibattito*. Roma, collana INEA.

Zanchi, E., & Lenzi, G. (2018). Procedure numeriche per l'omologazione di mappe catastali informatizzate. Applicazione alle mappe e catastali del Comune di Calcinate (Bg). In Scanu, G. (Ed.). *Conoscere per rappresentare. Temi di cartografia e approcci metodologici*. Trieste, EUT Edizioni Università di Trieste, pp. 277–298.

Zangheri, R. (1980). *Catasti e Storia della proprietà terriera*. Torino. Einaudi.

APPENDIX 1

Brief description of the methodology adopted in the EU countries of the second group (fiscal function Cadastre).

Section 1 (area)

This section includes two countries that are bound to use cadastral surface data for tax purposes. In particular, in the Czech Republic, the tax base is derived from the cadastral land area and varies depending on the quality of the land (agricultural, forest with a predominantly commercial function, etc.), while in Slovakia, the administration of the property tax system (municipalities) is obliged by law to comply with the property data in the cadastral system (common law, parcel identification number, surface area, nature, land use, location, etc.) and use the area to calculate the tax base.

Section 2 (income)

This section includes five countries (Austria, Belgium, Hungary, Portugal and Italy) that use income valuation to determine the tax base. In Austria, land taxation is based on the appraisal of the average annual yield; agricultural enterprises are assessed on the basis of their value of income capacity, which can be acquired in an average year, assuming a production capacity according to proper cultivation practices.

The main parameters for the evaluation are natural yield conditions (soil quality, topography, climate and water resources) and economic performance conditions for productivity (external and internal accessibility, farm size).

The yield value (called EMZ), resulting from the evaluation of the natural conditions of each parcel, is used to calculate for each farm the valuation index (total sum of all yield values divided by the total area), which indicates the average value for all crops.

The economic return conditions are used in the form of discounts and supplements to the valuation index. The rateable value is then derived from the farm index together with the total area.

In Belgium, property tax is based on the cadastral income, which indicates the normal average net income for a year; according to the official valuation procedure, it is assumed that the cadastral income corresponds to the income that can be obtained on average; that it is ordinary, since the highest or lowest income is not taken into account; and finally that it is net since a defined percentage can be deducted for the maintenance costs of land improvements. The cadastral income refers to 1975 and has been indexed since 1990.

The Hungarian cadastral system contains data on property income for agricultural land only. For each property it reports the 'Gold Crown' value, which does not show the real value, but expresses the value for the quality of the land. The valuation is based on an estimate of the average annual yield considering the different cultivation uses (arable land, pastures, forests, vineyards, etc.) and quality classes (between 1 and 8); the classification procedure is supported by a network of sample areas so that the characteristics of the land to be classified are compared with the corresponding sample area. The tax base for land tax purposes is the net cadastral rent.

In Portugal, the land tax is determined on the basis of the agricultural income (tax value of the parcel), which corresponds to the balance of an annual crop account in which the asset is the total revenue and the liability is the production cost defined by law.

Italy has already been mentioned in the previous chapter.

Section 3 (value or price)

The third section includes eleven countries that use the cadastral value or market price of property to determine the tax base.

The cadastral system in Cyprus shows the estimated value and the market price of the property, which are the basis for taxation. The former, determined by the Department of Land Registry, is used in the case when the property was acquired prior to 1st January 1980 (it is based on the general valuation of all real estate on the island), while the latter, applied in the case of a property acquired subsequently, is based on the purchase price.

In Denmark, land tax is calculated for all private property, according to the concept of cadastral ownership as defined by law, based on the estimated market value of land.

Also in Estonia, the land tax is based on the estimated value of land. Since 1997, the Land Board has been collecting transaction data in a database; the last periodic valuation in 2001 was mainly based on the information collected in this database. Land valuation is a mass valuation, i.e., based on the analysis of real estate transactions and land data, using statistical analysis methods. The result of the valuation is the division of land into homogeneous zones by price level.

A new periodic evaluation started in 2021, and by 2022 the results will be made public (Estonian Land Board, 2021).

The French Land Registry provides property valuation for the purpose of determining taxable value. The valuation of land properties follows several procedures based on rental contracts, on comparison, on market value and direct appraisal.

The preferred system is valuation by leases, based on rents paid for different crops and land productivity classes. Valuation by comparison is used to a greater extent for farms subject to certain operating regimes or for land leased under extraordinary conditions, for quarries, canals, railways, etc. Market value appraisal is usually carried out for building areas by applying a percentage rate to the sale price of the property.

The direct appraisal procedure is subsidiary to the others; the appraisal procedure involves calculating the gross yield per hectare and applying to it the crop selling price at the time of appraisal, from which the discounted production costs are to be subtracted. This procedure is frequently used for the valuation of vineyards and forests, and sometimes also for orchards.

The real estate cadastre in Germany contains the results of the last official land valuation, which dates back for the former West Germany to 1964 and for the former East Germany to 1935. Property tax (Grundsteuer) is divided into two types: 'A' for rural land and 'B' for buildings and urban building areas. The tax is calculated on the unit values (Einheitswert), with reference to the type of property, through the use of a federally fixed tariff related to the type of property and a multiplier that varies according to the different geographical areas. The unit value of properties does not correspond to the market value but is generally much lower.

Cadastral valuation in Latvia is performed on the basis of information on the real estate market and on real estate data registered in the Land Registry. Cadastral valuation is a mass appraisal and is regulated by national legislation that establishes the principles and indicates the order of cadastral valuation.

The cadastral value estimate is performed automatically in the Cadastre in the valuation section. In the event of changes to the good subject to appraisal, the data is updated. The tax base for rural land, since 1998, corresponds to the cadastral value, which refers to the zoning of values (map with homogeneous zones), to the base values of land used in agriculture for each quality group (six groups), and to the base values of forest land for each quality group (four groups). The appraisal to determine cadastral base values rests on the transaction comparison method (used for buildings and rural land) and the income capitalisation method (used for forest land).

The Lithuanian property valuation system ensures the collection of qualitative data and values on properties and explains why certain qualitative attributes have been established and what their value is. Since 2002, property tax takes the value of the property, which is derived from the mass valuation of land, as the tax base. The procedure is based on an economic approach and involves collecting all the necessary information according to the same standard, using up-to-date market data; it also allows for periodic re-evaluation taking market developments into account. If the value determined in the valuation of an individual property differs from the market price by more than 20 per cent, a mark-up may be applied to the value of the property (Muniz Perez, 2012). Based on the analysis of the real estate market and average market values, statistics are compiled for state and local institutions.

In Poland, the determination of the cadastral value of real estate, which is the basis for the calculation of the agricultural property tax (adopted in 1985), is based on the mass valuation according to the rules defined in the Act of 21 August 1997 on Real Estate Management (Journal of Laws, 2004).

Romanian National Cadastre Agency is required to provide necessary data to the tax system to calculate taxpayers' levies. The government programme for 2009-2012 emphasised the implementation of the necessary measures for the taxation of real estate on the basis of its market value. Therefore, actual data was collected on the properties bought and sold (characteristics, size, types and transaction price). Furthermore, through statistical processing of information on the sales prices of different types of properties located in a given area, it was possible to calculate the tax value of different properties.

A real estate mass appraisal system has also been developed in Slovenia for estimating the market values of all real estate registered in the land register in order to develop common criteria for determining land tax. The estimated market values are stored in the publicly accessible real estate register.

The Spanish cadastre, which does not cover the entire state area (four provinces have their own cadastre), has databases of cadastral values of rural areas and urban properties that form the basis for calculating property tax. The cadastral value is defined as an 'objectively determined' value based on the data held by the cadastre; in determining it, account is taken of location, construction cost, production expenses and revenues, taking the market value as a reference, which is its upper limit since the cadastral value of real estate cannot exceed the market value, that is the most probable price at which the property could be sold in the free market.

APPENDIX 2

Table 1a. Number and area of sample sales by municipality in the study area.

	Municipality	Sale (no.)	Incidence no. sales (%)	Sold area (sq.m)	Incidence of area sold (%)	Average area sold (sq.m)
Zone 1	Buseto Palizzolo	2	1.1	18,467	1.2	9,234
	Custonaci	11	6.1	81,538	5.3	7,413
	Erice	13	7.3	93,981	6.1	7,229
	Paceco	2	1.1	6,500	0.4	3,250
	San Vito Lo Capo	2	1.1	8,660	0.6	4,330
	Trapani	3	1.7	29,163	1.9	9,721
	Valderice	31	17.3	130,091	8.4	4,196
Zone 2	Baucina	32	17.9	151,815	9.8	4,744
	Bolognetta	6	3.4	37,012	2.4	6,169
	Caccamo	4	2.2	19,905	1.3	4,976
	Campofelice di Fitalia	4	2.2	87,904	5.7	21,976
	Casteldaccia	1	0.6	376,075	24.4	376,075
	Cefalà Diana	1	0.6	1,513	0.1	1,513
	Ciminna	7	3.9	63,773	4.1	9,110
	Godrano	5	2.8	15,863	1.0	3,173
	Marineo	24	13.4	109,668	7.1	4,570
	Mezzojuso	2	1.1	195,850	12.7	97,925
	Misilmeri	5	2.8	14,366	0.9	2,873
	Palermo	1	0.6	1,545	0.1	1,545
	Partinico	2	1.1	3,582	0.2	1,791
	Piana degli Albanesi	4	2.2	20,349	1.3	5,087
	Santa Cristina Gela	2	1.1	13,356	0.9	6,678
	Ventimiglia di Sicilia	7	3.9	16,622	1.1	2,375
	Villafrati	8	4.5	43,722	2.8	5,465
	Total Study area	179	100.00	1,541.320	100.00	8,611

Table 2a. Number and area of sample sales by municipality and crop quality.

	Municipality	Arable crops		Permanent crops		Permanent pastures and meadows		Mixed crop qualities	
		No. (%)	Area (%)	No. (%)	Area (%)	No. (%)	Area (%)	No. (%)	Area (%)
Zone 1	Buseto Palizzolo	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
	Custonaci	9.1	4.1	18.2	5.1	27.3	44.2	45.5	46.6
	Erice	30.8	21.8	23.1	10.8	15.4	1.2	30.8	66.2
	Paceco	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
	San Vito Lo Capo	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
	Trapani	33.3	55.0	0.0	0.0	0.0	0.0	66.7	45.0
	Valderice	38.7	31.3	32.3	13.1	3.2	0.2	25.8	55.3
Zone 2	Baucina	62.5	49.6	3.1	5.5	0.0	0.0	34.4	45.0
	Bolognetta	16.7	7.2	33.3	7.0	0.0	0.0	50.0	85.7
	Caccamo	50.0	58.6	0.0	0.0	0.0	0.0	50.0	41.4
	Campofelice di Fitalia	50.0	83.1	0.0	0.0	0.0	0.0	50.0	16.9
	Casteldaccia	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
	Cefalà Diana	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
	Ciminna	42.9	55.3	0.0	0.0	0.0	0.0	57.1	44.7
	Godrano	60.0	93.8	0.0	0.0	0.0	0.0	40.0	6.2
	Marineo	54.2	43.5	8.3	4.7	0.0	0.0	37.5	51.8
	Mezzojuso	50.0	99.2	50.0	0.8	0.0	0.0	0.0	0.0
	Misilmeri	40.0	13.7	20.0	19.0	0.0	0.0	40.0	67.3
	Palermo	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
	Partinico	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0
	Piana degli Albanesi	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
	Santa Cristina Gela	50.0	42.3	0.0	0.0	0.0	0.0	50.0	57.7
	Ventimiglia di Sicilia	42.9	20.0	14.3	5.5	0.0	0.0	42.9	74.5
	Villafrati	62.5	61.1	0.0	0.0	0.0	0.0	37.5	38.9

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House price prediction modeling using machine learning techniques: a comparative study

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Abstract. In the literature, there are two basic approaches regarding the determination of house prices. One of them is the prediction of house price using macroeconomic variables in the country where the house is produced, and another one is the price prediction models, which we can express as micro-variables, by considering the features of the house. In this study, the price of the house was attempted to be predicted using machine learning methods by establishing a model with micro variables that reveal the features of the house. The study was conducted in Turkey' Antalya province, where household housing demand of foreigners is also high. The house advertisements in locations belonging to the lower, middle- and upper-income groups were selected as the sample. In the results, it was observed that the artificial neural network (ANN) method made predictions with more meaningful results compared to support vector regression (SVR) and multiple linear regression (MLR). These results appear to be a viable model for institutions that supply housing, mediate housing sales, and provide housing financing and valuation. It is considered that this model, which can be used to predict fluctuating house prices, especially in developing countries, will regulate the housing market.

Keywords: Home price, Prediction, Support Vector Regression, Artificial Neural Networks, Multiple Linear Regression.
JEL codes: O18, R33.

1. INTRODUCTION

Human needs are endless, however, some basic needs such as nutrition, shelter and protection should be first met for the continuation of their lives. Housing need is a multidimensional problem that is necessary for people's shelter, health, security and various socio-cultural needs. People want to buy a house in order to have their own house only when their welfare reaches a certain level. At this stage, the important thing is to choose a house that will meet the budget they have and the needs of their family members. In this respect, affordable housing prices are very important for households. Hous-

ing suppliers prioritize the needs of these households while designing the house they will produce architecturally. It is very important that the house to be produced meets these needs appropriately and that it is built in the right location in terms of the costs to be incurred. It is of vital importance for these institutions to determine the housing price correctly, to meet these costs, to sell the produced houses easily and to achieve a desired amount of profit margin. Because the institutions that supply housing make huge capital investments and the wrong construction projects that cannot be sold cause these institutions to go bankrupt very quickly. Banks, mortgage and real estate companies that provide housing financing allocate loans to households that demand housing based on the housing price and the appraisal valuation they will make. Therefore, the creation of an effective and effective credit policy by these financial institutions directly depends on the accurate price prediction of the house. Since the maturities of these loans will be medium and long term, incorrect loan allocation will reduce their assets and reduce their direct return on assets (ROA), because of these companies making an inefficient use of assets on their balance sheets in the long run. Thus, the main deciding factor for the three important actors in the housing market is the sale price of the house.

The factors that determine the sale price of the house are primarily the basic features of the house. The first of them is the location of the house. In general, it is seen that houses are built according to the lower, middle- and upper-income groups and their needs depending on the features of the location (by the sea, in the forest, distance from the city center, school, hospital, religious places, and proximity to organized industrial zones, which are production zones, etc.). Another factor is the volume and situation of the house. The usable size and the number of rooms of the house are a direct factor for the selling price due to both the demographic characteristics of the demanding households and the cost of the housing to be built. Furthermore, the fact that the house sold is a new or secondary house directly affects the firm sale price of the house in high-type houses. Moreover, whether the house is designed as a complex of buildings (security, pool, Spa, gym, etc.) is a determining factor on the sales price of the house.

These variables, which we describe as micro-variables, were made into a model in the study. With this model, it was attempted to predict the house prices using machine learning methods, which are among the advanced prediction techniques. It is considered that the obtained results will contribute to correct pricing in terms of housing suppliers, mediators in house sales and institutions that provide financing. The results of the model created in the study are also important in terms of an effective and active housing market. Especially in housing markets where price fluctuations are high and there are housing supply and demand imbalances, the use of advance price prediction mechanisms will ensure the proper operating of the markets.

The use of three different machine techniques in the study and especially the testing of the support vector regression technique in this regard differs from similar studies in the literature. The aim of this study is to create a model that can accurately predict the housing prices in the locations in the portfolios of the institutions that offer housing and mediate its sale. Testing the success of the designed model using machine learning methods is the second main objective of the study. At the same time, it is aimed to be an exemplary reference study for more appropriate housing production planning by considering the preferences of those who supply housing and those who demand it. To achieve these goals, the main hypothesis of the study is that the variables that reveal the characteristics of the house in the estimation of housing prices will be successfully predicted using machine learning methods.

In the second section of the study, reference was made to the studies on the basic dynamics affecting housing prices. In addition, studies using machine learning and other methods for housing prices are included. Section 3 describes the model of the study and the machine learning methods used by focusing on the data set of this model. In section 4, the results obtained by machine learning are included in the study and these findings are discussed. Section 5 presents the conclusions drawn from the study and the policies and recommendations drawn from these conclusions.

2. LITERATURE

In this section, first of all, the basic economic structure affecting housing prices is emphasized.

Houses meet the shelter needs of people and are also an investment tool. The housing market differs from other markets in that housing is both a consumption and an investment good. Housing markets differ from other markets in that the housing supply is very costly, the housing is permanent and continuous, heterogeneous, fixed, causes growth in the secondary markets, and is used as a guarantee (Iacoviello, 2000).

The housing market is formed through a mechanism of housing supply and demand. In the housing market, unlike the goods and services market, the housing sup-

ply is inelastic. Supply and demand for housing change and develop over time depending on the economic, social, cultural, geographical, and demographic realities of the countries. Meeting the housing demand is associated with housing policies and economic conditions. Housing demand arises for different purposes such as consumption, investment, and wealth accumulation. The supply and demand factors change according to the type of housing demand. In addition to the input costs of the house as a product, the determination of the price of the house is affected by many variables such as people's income level, marital status, industrialization of the society and agricultural employment rate, interest rates, population growth and migration, and all variables also affect the price. Since changes in housing prices affect both socio-economic conditions and national economic conditions, it is an important issue that concerns governments and individuals (Kim and Park, 2005). Housing demand arises for different purposes such as consumption, investment, and wealth accumulation.

In this part of the literature, some studies that estimate housing prices are cited.

The prediction of houses with real factors is important for the studies. With the developments in artificial intelligence methods, it now allows the solution of many problems in daily life such as purchasing a house. The competitive nature of the housing sector helps the data mining process in this industry, processing this data and predicting its future trends. Regression is a machine learning tool that encourages to build expectations from available measurable information by taking the links between the target parameter and many different independent parameters. The cost of a house is based on several parameters. Machine learning is one of the most important areas to apply ideas on how to increase costs and predict with high accuracy.

Machine learning method is one of the recent methods used for prediction. It is used to interpret and analyze highly complex data structures and patterns (Ngiam and Khor, 2019). Machine learning predicts that computers learn and behave like humans (Feggella, 2019). Machine learning means providing valid dataset, and moreover predictions are based on it, machine learns how important a particular event might be on the whole system based on pre-loaded data and predicts the outcome accordingly. Various modern applications of this technique include predicting stock prices, predicting the probability of an earthquake, and predicting company sales, and the list has infinite possibilities (Shiller, 2007).

Unlike traditional econometrics models, machine learning algorithms do not require the training data to be normally distributed. Many statistical tests rely on the assumption of normality. If the data are not normally distributed, these statistical tests will fail and become invalid. These processes used to take a long time, however, today they can be completed quickly with the high-speed computing power of modern computers and therefore this technique is less costly and less timely to use.

Rafiei and Adeli (2016) used SVR to determine whether a property developer should build a new development or stop the construction at the beginning of a project based on the prediction of future house prices. The study, in which data from 350 apartment houses built in Tehran (Iran) between 1993 and 2008 were used, had 26 features such as zip code, gross floor area, land area, estimated cost of construction, construction time, and property prices. Its results revealed that SVR was a suitable method for making home price predictions since the loss of prediction (error) was as low as 3.6% of the test data. Therefore, the prediction results provide valuable input to the property developer's decision-making process.

Cechin et al. (2000) analyzed the data of buildings for sale and rental in Porto Alegre, Brazil, using linear regression and artificial neural network methods. They used parameters such as the size of the house, district, geographical location, environmental arrangement, number of rooms, building construction date and total area of use. According to the study, they reported that the artificial neural network method was more useful compared to linear regression.

Yu and Wu (2016) used the classification and regression algorithms. According to the analysis, living area square meter, roof content and neighborhood have the greatest statistical significance in predicting the selling price of a house, and the prediction analysis can be improved by the Principal Component Analysis (PCA) technique. Because the value of a particular property is closely associated with the infrastructure facilities surrounding the property.

Koktashev et al. (2019) attempted to predict the house values in the city of Krasnoyarsk by using 1,970 housing transaction records. The number of rooms, total area, floor, parking lot, type of repair, number of balconies, type of bathroom, number of elevators, garbage disposal, year of construction and accident rate of the house were discussed as the features in that study. They applied random forest, ridge regression, and linear regression to predict the property prices. Their study concluded that the random forest outperformed the other two algorithms, as evaluated by the Mean Absolute Error (MAE).

Park and Bae (2015) developed a house price prediction model with machine learning algorithms in

real estate research and compared their performance in terms of classification accuracy. Their study aimed at helping real estate sellers or real estate agents to make rational decisions in real estate transactions. The tests showed that the accuracy-based Repeated Incremental Pruning to Produce Error Reduction (RIPPER) consistently outperformed other models in house price prediction performance.

Bhagat et al. (2016) studied on linear regression algorithms for house prediction. The aim of the study was to predict the effective price of the real estate for clients based on their budget and priorities. They indicated that the linear regression technique of the analysis of past market trends and price ranges could be used to determine future house prices.

In their study, Mora-Esperanza and Gallego (2004) analyzed house prices in Madrid using 12 parameters. The parameters they used were the distance to the city center, road, size of the district, construction class, age of the building, renovation status, housing area, terrace area, location within the district, housing design, the floor and the presence of outbuildings. The dataset was created assuming that the sales values of 100 houses for sale in the region were the real values. Researchers, who used the ANN and linear regression analysis technically, reported that the ANN technique was more successful and achieved an average agreement of 95% and an accuracy of 86%.

Wang and Wu (2018) used 27,649 data on home appraisal price from Airlington County, Virginia, USA in 2015 and suggested that Random Forest outperformed the linear regression in terms of accuracy.

In their study in the case of Mumbai, India, Varma et al. (2018) attempted to predict the price of the house by using various regression techniques (Linear Regression, Forest regression, boosted regression) and artificial neural network technique based on the features of the house (usage area, number of rooms, number of bathrooms, parking lot, elevator, furniture). In conclusion, they determined that the efficiency of the algorithm with the use of artificial neural networks was higher compared to other regression techniques. They also revealed that the system prevented the risk of investing in the wrong house by providing the right output.

Thamarai and Malarvizhi (2020) attempted to predict the prices of houses from real-time data after the large fluctuation in house price increases in 2018 at the Tadepalligudem location of West Godavari District in Andhrapradesh, India using the features of the number of bedrooms, age of the house, transportation facilities, nearby schools, and shopping opportunities. They applied these models in decision tree regression and multiple linear regression techniques, which are among the machine learning techniques. They suggested that the performance of multiple linear regression was better than decision tree regression in predicting the house prices.

As examined in the literature, the general characteristics of the housing are often used as a model in the estimation of housing prices. Therefore, in the study, a model was created over the variables that contain the characteristics of the housing rather than the general economic conditions. However, unlike other studies, three different machine learning methods were used to compare the success of these methods against each other. While creating the model, different economic, location and social cultural neighbourhoods are selected and the work from other studies is made original.

3. MATERIAL AND METHOD

3.1 Case study data set

In the study, the data of the three biggest and most advertised neighborhoods of three largest districts in Antalya province of Turkey were selected. These districts are the locations of houses that appeal to different income groups and have different features. In particular, these neighborhoods with a heterogeneous demographic and economic structure were selected to test the machine learning techniques to be used in the model created. Kepez, Erenköy and Ahatlı districts of Kepez district, Çağlayan, Fener and Meydankavağı districts of Muratpaşa district, and Gürsu, Hurma and Uncalı districts of Konyaaltı district were selected as locations. According to economic characteristics, Kepez district is low income, while Muratpaşa and Konyaaltı districts are preferred by middle- and high-income groups. Since Antalya is a tourism city, culturally these districts have a heterogeneous structure and receive migration from both different provinces and countries. Especially the citizens of Ukraine, Russia, Arab Countries, and Iran prefer Antalya, which is a tourism city, due to the economic and political reasons experienced in the world and in Turkey. This creates a very cultural diversity in all three districts. Konyaaltı and Muratpaşa districts have a seacoast. Kepez district has no coast to the sea. In addition, Konyaaltı and Muratpaşa districts have more alternatives than Kepez district in terms of art, sports, and recreation areas. The locations of the districts and their neighbourhoods subject to the study are presented in Figure 1.

The numbered districts and neighbourhoods' information in Figure 1 is shown in Table 2.

The data of a total of 900 house for sale advertisements in these locations were obtained from the website

Table 1. Literature synthesis table.

References	Summary of Findings
Cechin, A., Antonio, S. & Gonzales, M. A. (2000)	They used parameters such as the size of the house, district, geographical location, environmental arrangement, number of rooms, building construction date and total area of use. According to the study, they reported that the artificial neural network method was more useful compared to linear regression.
Yu, H., & Wu., J. (2016)	They used classification and regression algorithms. According to the analysis, in the estimation of the sale price of a house, the living space square meter, the roof content and the neighbourhood are of the greatest statistical importance.
Koktashev, V., Makee, V., Shchepin, E., Peresunko, P., & Tynchenko, V. V. (2019).	They tried to estimate the housing values in his city. In this study, the number of rooms, total area, floor, parking, repair type, number of balconies, bathroom type, number of elevators, garbage disposal, construction year and accident rate of the house were discussed. They applied random forest, ridge regression, and linear regression to predict property prices. Their study concluded that the random forest performed better than the other two algorithms, as evaluated by mean absolute error (MAE).
Park, B. H., & Bae, J. K. (2015).	In his real estate research, he developed a residential price prediction model with machine learning algorithms and compared their performance in terms of classification accuracy. His work aims to help real estate sellers or real estate agents make rational decisions in real estate transactions. Experiments show that the RIPPER algorithm based on accuracy consistently outperforms other models in housing price prediction performance
Bhagat, N., Mohokar, A., & Mane, S. (2016)	They worked on linear regression algorithms for the prediction of homes. The purpose of the article is to estimate the effective price of real estate for clients according to their budgets and priorities. Analysis of past market trends and price ranges, predicted future home prices.
Mora-Esperanza, J. G., & Gallego, J. (2004)	In their study, they analysed housing prices in Madrid using 12 parameters. The data set is the actual value of the sale values of 100 houses for sale in the region. The results were more successful than the regression analysis, with an average compliance rate of 95% and an accuracy rate of 86%.
Wang, C. C., & Wu, H. (2018).	In 2015, they used 27,649 home valuation price data from Airlington County, Virginia, and suggest that Random Forest outperforms linear regression in terms of accuracy.
Rafiei, M. H., & Adeli, H. (2016).	He used SVR to determine whether a property developer should build a new development or stop construction at the start of a project based on a forecast of future home prices. Using data from 350 apartments built in Tehran (Iran) between 1993 and 2008, the research trained a model with 26 characteristics such as zip code, gross floor area, land area, estimated construction cost, construction time, real estate prices, etc. Nearby housing developments, exchange rate and demographic factors. Their results showed that SVR is a viable method for making house price predictions, as the loss of prediction (error) is as low as 3.6% of the test data. Forecast results, therefore, provide valuable input into the property developer's decision-making process.

Figure 1. Locations of districts and neighbourhoods.

sahibinden.com, Turkey's largest advertisement site, and analyzed. As data, housing sales announcements in the period of August 2022 were examined. The variables of location, usable area, number of rooms, age of residence, floor and social facilities, and the presence in complex buildings, which are the main features of the house, were used as the input unit in the model. The advertised sales price of the house was used as the output unit. A total of 5,400 data entries were made for these input and output units. The variables used in the study and the characteristics of the houses in the input variables obtained from the housing sales announcements and the number of data are shown in Table 3.

Table 2. Numbered districts and neighbourhood information in Figure 4.

1- Kepez- Kepez	6- Konyaaltı- Gürsu
2- Kepez- Erenköy	7- Muratpaşa- Çağlayan
3- Kepez- Ahatlı	8- Muratpaşa- Fener
4- Konyaaltı- Uncalı	9-Muratpaşa- Meydankavağı
5- Konyaaltı- Hurma	

The data set of the studies was manually entered into the Excel program from the advertisements on the

Table 3. Features of housing.

Output Variable	Data Entry Range
House Price	0-2,000,000 Turkish Liras: 297 data 2,000,001-4,000,000 Turkish Liras: 348 data +4,000,000 Turkish Liras: 255 data
Input Variables	**Data Entry Range**
Location	Kepez-Kepez neighbourhood 100 data Kepez-Erenköy neighbourhood 100 data Kepez-Ahatlı neighbourhood 100 data Konyaaltı-Uncalı neighbourhood 100 data Konyaaltı-Hurma neighbourhood 100 data Konyaaltı-Gürsu neighbourhood 100 data Muratpaşa-Çağlayan neighbourhood 100 data Muratpaşa-Fener neighbourhood 100 data Muratpaşa-Meydankavağı neighbourhood 100 data
Usable Area	40-100 m2: 270 data 101-150 m2: 282 data +150 m2: 348 data
Number of Rooms	2 rooms: 78 data 3 rooms: 320 data 4 rooms: 364 data +5 rooms: 138 data
Age of residence	0-4 years: 290 data 5-10 years: 274 data 11-15 years: 170 data +16 years: 166 data
Floor	0-3rd floor: 624 data 4th-7th floor: 198 data +8th floor: 78 data
Social facilities, and the presence in complex buildings	Yes: 357 data No: 543 data

sahibinden.com site. The relevant machine learning methods were run in the open-source program Knime.

3.2 Method

Three different machine learning techniques were used to perform the prediction of house prices. Artificial neural networks, multiple linear regression and support vector regression were used in the study and the most successful model with the least error was determined.

3.2.1. Artificial neural networks

Cybernetics refers to analyzing the behavior of living things, modeling them mathematically, and producing similar artificial models. Artificial neural networks (ANNs) have emerged because of mathematical modelling of the learning process by taking the human brain as an example. The machines are intended to be trained, learn, and make decisions through artificial neural networks, just like humans (Jain, 1996; Kayakuş and Terzioğlu, 2021). It mimics the abilities to learn, remember and generalize the structure of biological neural networks in the brain. Artificial Neural Network applications are mostly used for prediction, classification, data association, data interpretation and data filtering.

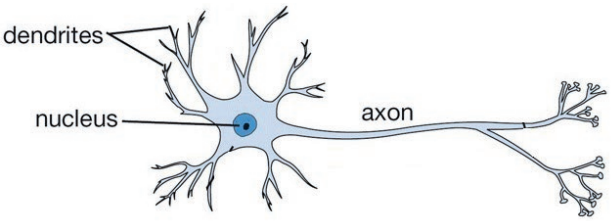

Figure 2. Biological Representation of a Nerve Cell (Abraham, 2005).

The structure of a human nerve cell (neuron) is presented in Figure 2.

Dendrites are the system inputs that collect signals from other cells. Nucleus provides periodic reproduction of marks along the axon. Synapse provides the connection of the axons of the cells with other dendrites. Axon is the system output from which the output pulses are generated.

Artificial nerve cells form the structure of ANN with the connections they have established. Artificial nerve cells have five basic elements. Each artificial nerve cell has inputs that receive external information, weights that process incoming information and create connections, summation function, activation function, and outputs or output elements that present the processed information to the outside world (Krogh, 2008).

The inputs represent information from other cells or the outside world. The summation function is the function that calculates the net input into the cell. Various functions can be used according to the ANN model to be applied. Generally, the summation function is the sum of the information coming into the cell by multiplying the weights of that information. Equation 1 shows the calculation of the net input value in the kernel.

$$NET = \sum_{i}^{N} X_i W_i \tag{1}$$

Here, X represents the entries, W represents the weight value, and N represents the total number of entries in a cell.

The activation function establishes the connection between input and output. It generates output information by processing the information from the summation function. This function, like the summation function, has various functions according to the ANN model to be applied. The "Sigmoid function" is generally used as the activation function in the "Multilayer perceptron" model, which is the most widely used today. Sigmoid function is presented in Equation 2.

$$f(NET) = \frac{1}{1 + e^{-NET}} \quad (2)$$

Output is the values generated by the activation function. The working principle of ANN is presented in Figure 3.

Artificial neural network models can be examined in four groups as single-layer perceptrons, multi-layer perceptrons, feed-forward neural networks and feedback artificial neural networks. Single-layer networks consist of input and output. They may have more than one input value. In single layer perceptron, the output function is linear and takes a value of 1 or -1. Multilayer neural networks consist of input layer, hidden layers, and output layers. Multilayer artificial neural networks are used to solve complex problems. Therefore, they are preferred for nonlinear problems. They may have multiple inputs and hidden layers. The number of hidden layers can be increased or decreased according to the flow of the problem. The hidden layer enables the problem to be processed with different functions and transferred to the output layer according to its structure (Kayakuş et al., 2022).

In feedforward neural networks, neurons are in the form of regular layers from input to output. There is only a connection from one layer to the next layers. The information coming to the input of the artificial neural network is transmitted to the middle point, in other words to the cells in the hidden layer, without any change. It is then processed through the output layer, respectively, and transferred to the external environment. In feedback artificial neural networks, unlike feedforward networks, the output of a neuron is not only given as an input to the next neuron layer. It can be connected to any neuron in the previous layer or its own layer as an input. With this structure, feedback artificial neural networks display a nonlinear dynamic behavior. According to the connection type of the connections that give the feedback feature, feedback artificial neural networks with different behavior and structure can be obtained with the same artificial neural network (Hassoun, 1995).

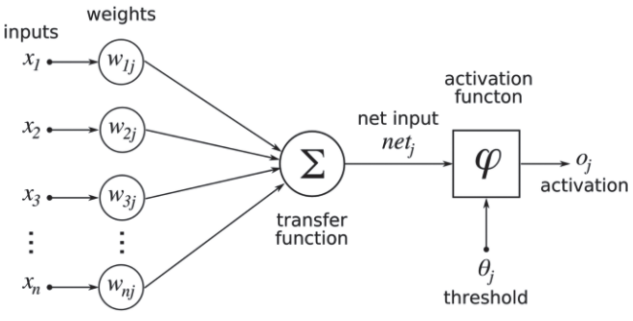

Figure 3. ANN working principle.

3.2.2. Multiple linear regression

Linear regression analysis is one of the statistical methods that are commonly used in the analysis of normally distributed dependent variables.

In simple linear regression, a bivariate model is established to predict an independent variable (x) and a dependent variable (y). If the model contains more than one independent variable to predict the dependent variable (y), then multiple linear regression techniques can be used (Eberly, 2007; Kayakuş and Terzioğlu, 2021).

Multiple regression analysis is a type of analysis for predicting the dependent variable based on two or more independent variables associated with the dependent variable. It enables to interpret the total variance explained by the independent variables in the dependent variable and to comment on the direction of the relationship between the independent variables and the dependent variable. In the regression analysis, it is aimed to establish the best model that can predict the dependent variable from the independent variables or to determine which independent variables are more affected by the dependent variable (Kayakuş, 2022; Tranmer and Elliot, 2008).

The mathematical model showing the true linear relationship can be written for n independent variables as follows:

$$y=\beta_0+\beta_1X_{i1}+\beta_2X_{i2}+\beta_3X_{i3}+\cdots+\beta_kX_{ik}+\varepsilon_{ij} \quad (3)$$

defined as i=1,2,3,…,n and j=1,2,3,…,n. X_{ij}, j. represents the value of the independent variable at the i. level, B_j, j. represents the regression coefficient, e_{ij}, represents the error term, k, represents the number of independent variables. The coefficient β refers to the amount of change that will occur in Y in terms of its unit, as opposed to 1 unit change in X in its unit.

Multicollinearity may lead to incorrect estimation of the regression coefficients, exaggeration of the stand-

ard errors of the regression coefficients, resulting in an increase in the confidence intervals and a decrease in the t-test value. The increase in the standard error may cause statistically significant regression coefficients to be insignificant, thus resulting in incorrect results. The correlation matrix between the independent variables is used to detect whether there is a multicollinearity (Olive, 2017).

The basic assumptions of the multiple linear regression model are that the error term is normally distributed with zero mean and constant variance, there is no autocorrelation between the error terms, there is no relationship between the error term and the independent variables, there is no multicollinearity between the independent variables, in other words, the absence of a linear relationship between the independent variables (Bahçecitapar and Aktaş, 2017; Yamane, 1969)

3.2.3. Support vector regression

Support vector machine (SVM) is a supervised machine learning algorithm that can be used for classification or regression problems. It can be used for linear or non-linear classification and regression problems. SVM is mainly used to separate data belonging to two classes in the most appropriate way. To this end, decision boundaries, or in other words, hyper planes are determined. In other words, it can be defined as a vector space-based machine learning method that finds a decision boundary between the two classes that are furthest from any point in the training data. Support vector machines were first proposed by Vapnik (1995). They are based on statistical learning theory. This method was originally designed to solve classification and regression problems, and then, Support Vector Regression (SVR), which is used for prediction, was developed (Drucker et al., 1997). SVR ensures that the range we will draw includes the maximum point.

SVR is the regression model that allows to define how much error can be accepted in the model created. According to the errors entered, it finds a suitable line or creates a hyperplane. Therefore, the SVR method attempts to minimize the error of estimation and thus aims to find a function that approximates the training data set. In this process, the flatness of the function is maximized and the risk of getting stuck in local values is reduced (Çoban and Demir, 2021; Demir and Akkaş, 2018).

Consider a $\{(x_1, y_1), \ldots, (x_l, y_l)\}$ dataset of training points with $x_i \in R^n$ vector and $y_i \in R$ target output. The nonlinear relationship between input and output data is formulated with a linear function. A nonlinear SVR is presented in Figure 4.

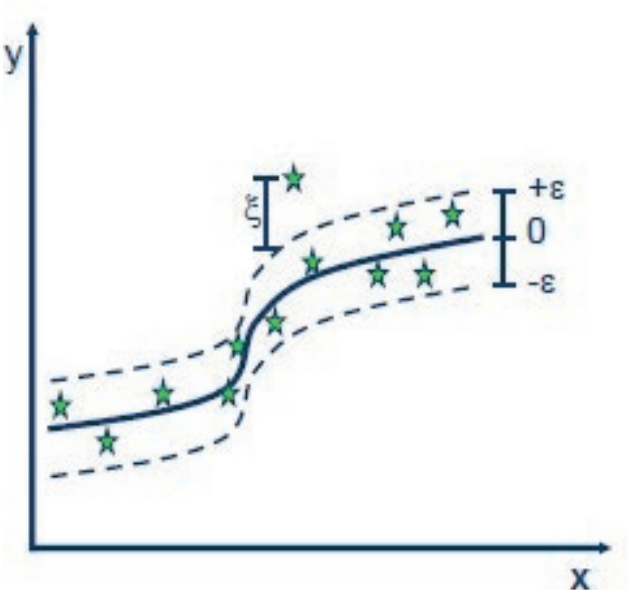

Figure 4. Non-linear SVR.

The function showing this relationship is presented in Equation 4.

$$f(x)=w^T \phi(x)+b \tag{4}$$

where, f(x) is the predicted values. Φ; is the nonlinear mapping function and $w(w \in R^n)$ and $b(b \in R)$ are adjustable coefficients. The standard form of the SVR is defined as below, with C>0 and ε>0:

$$\min_{w,b,\xi,\xi^*} \frac{1}{2} w^T w + C \sum_{i=1}^{l} \xi_i + \xi_i^* \tag{5}$$

Constraints,

$$\begin{cases} w^T \phi(x_i) + b - y_i \leq \epsilon + \xi_i \\ y_i - w^T \phi(x_i) - b \leq \epsilon + \xi^* \\ \xi_i, \xi_i^* \geq 0; i = 1,2,3, \ldots, l \end{cases} \tag{6}$$

ξ_i^* represents the training errors on ε, ξ_i represents the training errors under ε.

After solving the above quadratic optimization problem with inequality constraints, the parameter vector *w* in Equation 4 is found by Equation 7.

$$w = \sum_{i=1}^{l} (\lambda_i^* - \lambda_i)\, \phi(x_i) \tag{7}$$

where, λ_i^* and λ_i are Lagrange multipliers. Thus, the SVR formula is obtained as in Equation 8.

$$f(x) = \sum_{i=1}^{l} (\lambda_i^* - \lambda_i)\, K(x_i, x_j) + b \quad (8)$$

In Equation 8, $K(x_i, x_j)=\exp(-y\|x_i-x_j\|^2)$ function refers to the radial basis kernel function (RBF). In this method, classes that are normally not linearly separable are made linearly separable by applying the kernel function, and more successful results are obtained. The four basic kernel functions used in SVR are linear, polynomial, radial basis function (RBF) and sigmoid. In the literature, it is seen that the RBF kernel function is frequently used because it produces more satisfactory and successful results compared to other kernel functions (Abut et al., 2016).

4. RESULTS AND DISCUSSION

In the study, the data on a total of 900 house advertisements for Antalya province of Turkey were used. In the model established in the study, the property price was used as the dependent variable, and seven independent variables were used to predict this dependent variable. Three different machine learning techniques including artificial neural networks, multiple linear regression and support vector regression were used in the study. R^2, MSE and MAPE statistical methods were used to analyze the success and error of the models. The main working structure of the study is presented in Figure 5.

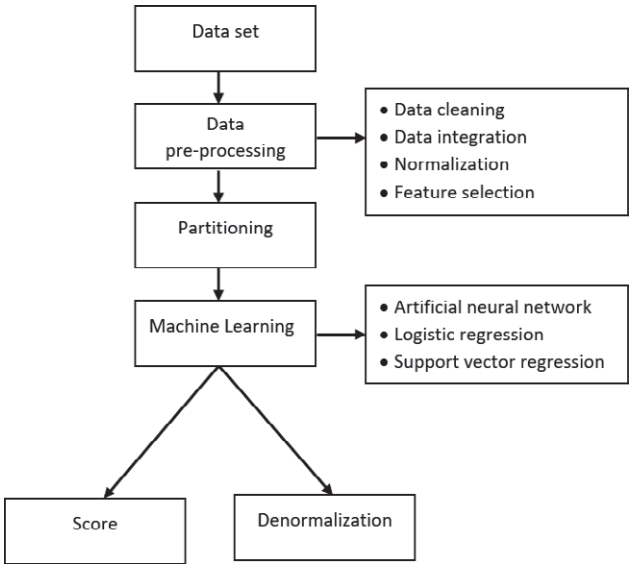

Figure 5. Main working structure of the study.

As can be seen in Figure 5, first process to be done after the dataset is created is the preprocessing stage on the dataset. The first step of this stage is data removal. Inconsistent and erroneous data in the dataset are called noise. For removing the noise in the data, the records with missing values may be excluded, missing values can be replaced with a constant value, this value can be written instead of the missing data by calculating the average of the other data, and it can be used instead of missing data by making an appropriate estimation of the data.

The second stage is the data integration stage. It is the process of converting different types of data into a single type so that the data obtained from different datasets or data sources can be evaluated together. While the price information in our dataset contains numerical information, whether it is included on the site contains yes/no information, that is, textual information. At this stage, all information in the dataset has been converted to numerical format.

The third stage of data pre-processing consists of the normalization stage. The size and value ranges of the data in the dataset may vary. Thus, numerical features of different scales may reduce the performance of the model by affecting the model applied in the learning process in an unbalanced way. The distribution of numerical features can be standardized by observing certain limit values according to the characteristics of the problem to be solved. In this study, the data were linearly normalized using the Min-Max method. It is the normalization of all values in a group of data according to the largest and smallest value in this group. While the minimum is the lowest value that a data can take, the maximum refers to the highest value that the data can take. The values to be generated here will be between 0-1. Min-Max normalization formula:

$$x' = \frac{x_i - x_{min}}{x_{max} - x_{min}} \quad (9)$$

where, x_i represents the normalized data, x_i represents the input value, x_{min} represents the smallest number in the input set, x_{max} represents the largest number in the input set.

Various methods have been developed for variable selection. These methods are examined in two groups according to calculation techniques: classical methods and stepwise methods. If stepwise methods are (Alpar, 2003):

1) Forward selection method
2) Backward selection method
3) Stepwise selection method

In the forward selection method, it is desired to find the most appropriate regression model by adding one independent variable each time. In the backward selection method, the opposite is the case with the forward selection method. The model starts with all independent variables. In the stepwise selection method, both the forward selection method and the backward selection method are used simultaneously (Çakır Zeytinoğlu, 2007; Kayaalp et al., 2015). The forward selection method was used in this study.

Another stage of the study was dividing the data into two as training and testing. It is the stage where the ideal parameters for the machine learning chosen during the training phase are determined and the error is reduced to the minimum level. In the test phase, the parameters determined during the training phase are tested on the data that have not been used before in the dataset and are statistically evaluated. In the literature, it is accepted to divide the dataset into 70% Training, 30% Test or 80% Training, and 20% Test data. While doing this application, when the dataset was divided into 70% Training and 30% Test data, our current dataset included 630 Training and 270 Test data. Different methods are used to divide the data into two as training and testing. Take from top, linear sampling and draw randomly are some of the data selection methods that can be used. In the study, the linear sampling method was preferred in data selection to compare the results of the two models.

R^2 (Coefficient of determination), MSE (Mean Squared Error) and MAPE (Root Mean Square Error) techniques were used to analyze and interpret the results of the study.

R^2 is the coefficient of determination, which is the measure of how much the independent variable x explains the dependent variable y with the regression model. R^2 takes values between 0 and 1 ($0<R^2<1$). The fact that R^2 value approaches 1 when there is a linear relationship between the variables indicates that most of the variation in the dependent variable is explained by the independent variables. R^2 describes the extent to which the variance of one variable explains the variance of the second variable. R^2 formula is presented in Equation 10:

$$R^2 = 1 - \frac{\text{Unexplained Variation}}{\text{Total Variation}} \tag{10}$$

MSE refers to how close a regression curve is to a set of points. MSE measures the performance of a machine learning model, estimator, and is always positive. It can be said that estimators with an MSE value close to zero perform better. MSE gives an absolute number of how much your predicted results differ from the actual number. MSE formula is presented in Equation 11:

$$\text{MSE} = \frac{1}{n}\sum_{j=1}^{n} e_j^2 \tag{11}$$

Here, n is the number of data and e is the error value.

The MAPE statistic eliminates the disadvantages that may arise in the comparison of models with different unit values. Among the listed criteria, the fact that MAPE has a meaning on its own as it expresses the prediction errors as a percentage is considered as its superiority over other criteria. While the models with MAPE <10% are classified as "very good", the models with 10% < MAPE < 20% are classified as "good", the models with 20% < MAPE < 50% are classified as "acceptable", and the models above 50%<MAPE are classified as "false and faulty". MAPE formula is presented in Equation 12:

$$\text{MAPE} = \frac{100}{n}\sum_{j}^{n} \frac{|e_j|}{|A_j|} \tag{12}$$

Three different machine learning techniques were used in the study. They were neural networks, support vector regression and multiple linear regression.

A feedback model consisting of seven inputs and one output neuron was developed for the artificial neural network method. The number of hidden layers in the model and the number of neurons in the hidden layer were determined by trial-and-error method. As a result of the study, it was seen that the structure with two hidden layers and two neurons in each layer produced more successful results since it gave the most successful result. The structure of the developed model is presented in Figure 6.

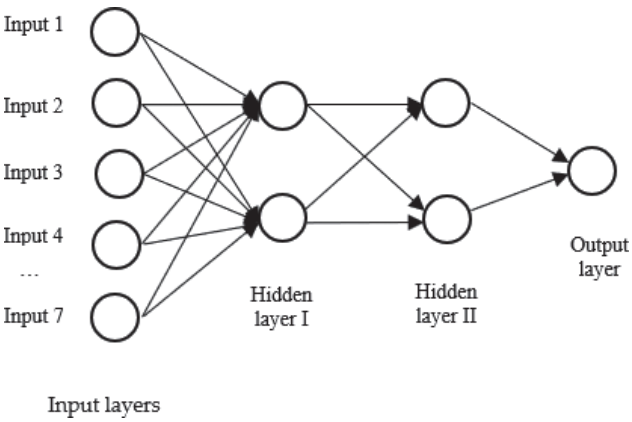

Figure 6. ANN model designed.

The sigmoid function was used after testing various functions for the Activation Function. Back-propagation algorithm was preferred as the learning algorithm, and its parameters were determined automatically through the software. 1.000 iterations were performed to get the best results in the model.

Nonlinear SVR was used for support vector regression, which was another machine learning method used in the study. Polynomial, hyper tangent, radial basis function (RBF) was tested for the kernel function and RBF was preferred in the study since it was determined as the most successful model. Other parameters of the model were chosen as overlapping penalty value of 100 and RBF sigma value of 0.1.

A significance value was first determined to measure the effects of variables on the system in multiple linear regression. The variable with the current highest p-value (probability value) now was determined and if P>SL, the variable was removed from the system. The model was established again and then this step was repeated. The elimination was terminated when it was P<SL for all variables. Since there were no independent values below 0.05 for p values in the designed model, the model was found to be significant.

The success and error values of the models according to the ANN, SVR and MLR methods are presented in Table 4.

An R^2 value of 1, which indicates how well the data fit a linear curve, indicates that the test data have provided a linear curve. As a result of the study, the R^2 value was 82.7% for ANN, 72.1% for MLR, 74.9% for SVR and it was seen to be very close to the ideal value. MSE measures the performance of a machine learning model, estimator, it is always positive, and it can be said that estimators with MSE value close to zero perform better. Therefore, the MSE value is desired to be close to zero. In the study, it was observed that the MSE value was 0.006 for ANN, 0.008 for MLR and 0.027 for SVR, which was close to the ideal value. The models with a MAPE of less than 10 percent are considered very well. In the study, it was observed to be 4.86 for ANN, 6.69 for MLR and 6.69 for SVR. It was considered that the MAPE value was very good in all three models. Considering the error and success values, it was observed that the most successful and least error models were ANN, SVR and MLR, respectively.

Table 4. Comparison of success and error of the models.

	Artificial neural network	Multiple linear regression	Support vector regression
R^2	0.827	0.721	0.749
MSE	0.006	0.027	0.008
MAPE	0.486	0.669	0.567

Since the results of the study were normalized, they are shown between 0 and 1. Denormalization is performed to adapt the results to real values and make sense of them. Thus, users reach the real values.

5. CONCLUSION

Housing is the basic need of households. The basic features of the house in the living areas are decisive in meeting these needs. These features are the value and other physical characteristics of the house. Therefore, households prefer and seek houses that are suitable for their income and meet their needs. The location, size, number of rooms, age, floor, independent property or whether it is in a site, which we call as the micro-variables of the house, were used to predict the price of the house in this study. Artificial neural networks, multiple linear regression, and support vector regression techniques, which are among the machine learning methods were used for this prediction.

The success and error analyses of machine learning methods were statistically performed based on the R^2, MSE and RMSE criteria. The most successful and least erroneous models used in the study were neural networks, support vector regression and multiple linear regression, respectively. The models are considered acceptable value according to the R^2 value. It was observed that the change in the independent variables used in the model affected the dependent variable in all three methods. According to the MSE and RMSE criteria, they are considered as the methods that predict with low error coefficient, in other words, with less error. These results of the study are like the studies of Cechin et al. (2000), Mora-Esperanza and Gallego (2004), and Varma et al (2018) that revealed the features the house as variables and uses ANN and multiple linear techniques in the literature.

With this study, institutions that supply housing and mediate their sales will make the price fluctuations as stable as possible and prevent speculative movements in the market by accurately estimating the prices of subjects with similar features. Housing suppliers will supply houses according to the preferences and price expectations of the households. Institutions that act as an intermediary for those seeking housing will work more effectively in finding houses according to the budget of households. They will be able to help their customers in making the right decision by using the artificial neural

networks machine learning technique. Financial institutions involved in housing finance will have more accurate appraisal results by using this model. Thus, it will reduce capital costs by providing the right number of financial resources to house demanders.

REFERENCES

Abut, F., Akay, M. F., & George, J. (2016). Developing new VO_2max prediction models from maximal, submaximal and questionnaire variables using support vector machines combined with feature selection. *Computers in Biology and Medicine*, 79, 182–192.

Abraham, A. (2005). Artificial neural networks. In Sydenham, P. H.,& Thorn, R. (Eds.). *Handbook of measuring system design*. London, John Wiley and Sons, 901–908.

Alpar, R. (2003). Introduction to Applied Multivariate Statistical Methods-1. Ankara, Turkey, Nobel Publication.

Bahçecitapar, M., & Aktaş, S. (2017). Use of linear mixed model in multicollinearity and an application. *Sakarya University Journal of Science*, 21(6), 1349–1359.

Bhagat, N., Mohokar, A., & Mane, S. (2016). House price forecasting using data mining. *International Journal of Computer Applications*, 152(2), 23–26.

Bircan, H. (2004). Studies of the Logistic Regression Analysis and its application on the medical data. *Kocaeli University Journal of Social Sciences*, 8, 185–208.

Cechin, A., Antonio, S., & Gonzales, M. A. (2000). Real estate value at Porto Alegre City using Artificial Neural Networks. In *Proceedings, Vol. 1, Sixth Brazilian Symposium on IEEE on Neural Networks, November 2000*. 237–242.

Çakır Zeytinoğlu, F. (2007). The effects of current assets of companies on sales: selection of the best regression equation and sectoral comparison. *Marmara University Journal of Economic and Administrative Sciences*, 23(2), 331–349.

Çoban, F., & Demir, L. (2021). Demand forecasting with Artificial Neural Networks and Support Vector Regression: an application in a food company. *Dokuz Eylul University Faculty of Engineering Journal of Science and Engineering*, 23(67), 327–338.

Demir L., Akkaş S. (2018). A comparison of sales forecasting methods for a feed company: a case study. *Pamukkale Üniversitesi Mühendislik Bilimleri Dergisi*, 24(4), 705–712.

Drucker, H., Burges, C. J. C., Kaufman, L., Smola, A., & Vapnik, V. (1997). Support vector regression machines. In Moser, M., Jordan, J., & Petsche, T. (Eds.). *Neural information processing systems*, Vol. 9. Cambridge, MA, USA, MIT Press, 155–161.

Eberly, L. E. (2007). Multiple linear regression. In Ambrosius, W. T. (Ed.). *Methods in Molecular Biology, vol. 404: Topics in Biostatistics*. Totowa, NJ, USA, Humana Press, 165–187.

Mora-Esperanza, J. G., & Gallego, J. (2004). Artificial intelligence applied to real estate valuation an example fort he appraisal of Madrid. *Catastro*, 1, 255–265.

Feggella, D. (2019). What is machine learning? Available at: https://emerj.com/ai-glossaryterms/what-is-machine-learning/ (Accessed 11 April 2022)

Hassoun, M. H. (1995). *Fundamentals of artificial neural networks*. Cambridge, MA, USA, MIT press.

Jain, A. K., Mao, J., & Mohiuddin, K. M. (1996). Artificial neural networks: a tutorial. *Computer*, 29(3), 31–44.

Iacoviello, M. (2000). House prices and the macroeconomy in Europe: results from a Structural VAR Analysis. ECB Working Paper No. 18.

Kayaalp, G. T., Güney, M. Ç., & Cebeci, Z. (2015). Variable selection in Multiple Regression Model application of animal science. *Çukurova University Journal of the Faculty of Agriculture*, 30(1), 1–8.

Kayakuş, M., & Terzioğlu, M. (2021). The prediction of pension fund net asset values using Artificial Neural Networks and Multiple Linear Regression methods. *Journal of Information Technologies*, 14(1), 95–103.

Kayakuş, M. (2022). Estimating the changes in the number of visitors on the websites of the tourism agencies in the COVID-19 process by Machine Learning Methods. *Sosyoekonomi*, 30(53), 11–26.

Kayakuş, M., Terzioğlu, M., & Yetiz, F. (2022). Forecasting housing prices in Turkey by machine learning methods. *Aestimum*, 80, 33-44.

Kim, K., & Park, J. (2005). Segmentation of the housing market and its determinants: Seoul and its neighbouring new towns in Korea. *Australian Geographer*, 36(2), 221–232.

Koktashev, V., Makee, V., Shchepin, E., Peresunko, P., & Tynchenko, V. V. (2019). Pricing modeling in the housing market with urban infrastructure effect. *Journal of Physics*. Conference Series, 1353(12139), 1–6.

Krogh, A. (2008). What are artificial neural networks? *Nature Biotechnology*, 26(2), 195–197.

Ngiam, K. Y., & Khor, I. W. (2019). Big data and machine learning algorithms for health-care delivery. *The Lancet Oncology*, 20(5), 262–273.

Olive, D. J. (2017). Multiple linear regression. In Olive, D. J. (Ed.). *Linear regression*. Cham, Switzerland, Springer, 17–83.

Park, B. H., & Bae, J. K. (2015). Using machine learning algorithms for housing price prediction: the case of Fairfax County, Virginia housing data. *Expert Systems with Applications*, 42(6), 2928–2934.

Rafiei, M. H., & Adeli, H. (2016). A novel machine learning model for estimation of sale prices of real estate units. *Journal of Construction Engineering and Management*, 142(2), 04015066.

Shiller, R. J. (2007). Understanding recent trends in house prices and home ownership. National Bureau of Economic Research, Working Paper 13553.

Thamarai, M., & Malarvizhi, S. P. (2020). House price prediction modeling using machine learning. *International Journal of Information Engineering & Electronic Business*, 12(2), 15–20.

Tranmer, M., & Elliot, M. (2008). Multiple linear regression. The Cathie Marsh Centre for Census and Survey Research (CCSR), 5(5), 1–5.

Wang, C. C., & Wu, H. (2018). A new machine learning approach to house price estimation. *New Trends in Mathematical Sciences*, 6(4), 165–171.

Vapnik, V. (1995). *The Nature of Statistical Learning Theory*. New York, USA, Springer.

Varma, A., Sarma, A., Doshi, S., & Nair, R. (2018). House price prediction using machine learning and neural networks. 2. In *Proceedings of the 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT), April 20–21, 2018, Coimbatore, India.* 1936–1939. IEEE.

Yamane, T. (1969). *Statistics: an introductory analysis*. New York, USA, Harper & Row.

Yu, H., & Wu., J. (2016). Real estate price prediction with regression and classification CS 229 Autumn 2016 Project Final Report 1–5. Available at: http://cs229.stanford.edu/proj2016/report/WuYu_HousingPrice_report.pdf (Accessed 6 July 2022)

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Circular, Cultural and Creative City Index: a Comparison of Indicators-based Methods with a Machine-Learning Approach

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Abstract. Culture, creativity and circularity are driving forces for the transition of cities towards sustainable development models. This contribution proposes a data-driven quantitative methodology to compute cultural performance indices of cities (C4 Index) and thus compare results derived by subjective and objective assessment methods within the case study of the Metropolitan City of Naples. After data processing with Machine-Learning (ML) algorithms, two methods for weighting the indicators were compared: principal component analysis (PCA) and geographically weighted linear combination (WLC) with budget allocation. The results highlight similar trends among higher performance in seaside cities and lower levels in the inner areas, although some divergences between rankings. The proposed methodology was addressed to fill the research gap in comparing results obtained with different aggregation methods, allowing a choice consistent with the decision-making environment.

Keywords: Benchmarking cultural cities, Composite indicator(s), Machine learning, Urban monitoring.
JEL codes: O21, C44, C52.

1. INTRODUCTION

1.1 Conceptual background

Cultural and creative cities deliver spatial, economic, and social benefits to their citizens by reinforcing the physical and digital environment, human capital, social networks, institutions, and regulatory frameworks. They host Cultural and Creative Industries (CCIs,) which contribute to 3% of the global GDP. However, it has been estimated that higher-income cities do not necessarily correlate with the higher number of people employed in cultural jobs, as opposed to lower-GDP cities, whereas about 10% of people are employed in creative and cultural sectors (Solutions for Youth Employment (S4YE), 2020, p.4). UNESCO and World Bank (2021) defined creative cities as the "*places where culture, arts, cultural and creative industries (CCIs), diverse expressions, and imagination flourish and contribute to sustainable urban*

development and inclusive growth" (UNESCO and World Bank, 2021, p. 8). These cities are also rich in intrinsic values (Fusco Girard et al., 2019; Cerreta et al., 2022) and cultural capital, which embraces all the *"Cultural goods serving as capital assets that, in combination with other inputs, contribute to the production of other cultural goods and services, jobs, and overall well-being of local communities"* (UNESCO and World Bank, 2021, p. 8).

The Circular Economy (CE) model, based on the principle that nothing can be considered 'waste' in nature, and everything can become a 'resource', aims to make sustainable development principles operative. The United Nations introduced into the New Urban Agenda (United Nations, 2016), the final document of the Habitat III conference, the notion of CE as a general development model that impacts natural and social contexts while generating new economic wealth. This stimulates an indefinite extension of the resources' life and the values of their use and promotes cooperation circuits among stakeholders. CE can be recognized as a general development model, capable of transforming linear urban metabolism into a new circular urban metabolism in which input and output flows are 'closed'. Therefore, the concept of circular processes can be applied not only to the flows of matter and nature (zero-waste approach), but also to broader issues, such as economic models of investment/ re-investment, or political systems of multi-level participatory governance. CE can and must be considered the engine of strategic planning development policies, as highlighted by strategies and measures adopted by the European Commission to stimulate the European path towards the CE (European Commission, 2015). The sectoral approach of waste cycle management with which the CE is associated must therefore be considered an approach to the global organization of the city, its economy, its social system, and its governance to improve urban productivity.

The Circular City Model incorporates the principles of the CE, establishing a regenerative and accessible urban system. The closure of the cycles is, in fact, a fundamental concept at the basis of this model (Ellen MacArthur Foundation, 2015a). In addition, flexibility in the design of the built environment, collaborative/cooperative behaviour, integration and recycling, and digital technology support for the circularization of processes are key concepts of the Circular City (Ellen MacArthur Foundation, 2015b; World Economic Forum, 2018).

The European Circular City Models are focusing their strategies and actions mainly on the sectors where the flows of materials are more consistent. Circular city models and, in particular, the experiences of European circular cities have highlighted the need to focus on "immaterial" flows relating to the human and cultural dimension (Fusco Girard and Nocca, 2019). The relationship between the CE and job creation is a key factor, highlighting the contribution of this model to improving the quality of life. Employment is also a key word linked to the concept of well-being: it contributes to making people 'feel good', not only for the economic aspects, but because it allows people to be in relationships with each other. Therefore, the challenge is to consider the cultural 'waste' as potential resources to favour new approaches to sustainable urban regeneration and thus to encourage autopoietic systems, which is capable of self-regenerating. In particular, the cultural challenges for the transition to the circular city model concern norms, ideas, customs, and social behaviour of people (Williams, 2019).

In this perspective, there is the need to determine evaluation approaches and tools, with particular concern on indicators, which represent one of the relevant tools for structuring an evaluation approach, allowing both to analyse existing phenomena and to evaluate impacts. Indicators assessing the circular economy's benefits are necessary to support the transition and implementation towards this new urban development model, demonstrate the multidimensional benefits of the circular economy and convince policymakers, communities, businesses, etc., that investing in the CE is worthwhile. Indicators-based frameworks, together with institutional change, can be the driving forces for transitions to unfold in cities. Indeed, the former helps circular cities to evidence advancements towards urban sustainability, while the latter guarantee the operational level of transitions (Cerreta et al., 2021; Ehnert et al., 2018; Paoli et al., 2022).

This article focuses on monitoring and evaluating specific urban sustainability indicators linked to culture, creativity, and circularity. Multiple worldwide institutions have recognised the importance of indicators as tools to investigate different facets of culture, especially those linked to the social-economic development of cities (UNESCO, 2014). Nevertheless, to the best of our knowledge, culture has not been formally recognised as crucial for urban economic development up to 2009, when UNESCO released the Framework for Cultural Statistics (FCS) with a corpus of 460 indicators selected by previous international classifications – e.g. the Harmonised Commodity Description (HS) and Coding System, the Central Product Classification (CPC), the International Standard Industrial Classification (ISIC) – aimed to measure the economic dimension of cultural activities and products (Ortega-Villa and Ley-Garcia, 2017). In 2015, the Sustainable Development Goals (SDGs) highlighted the culture's contribution to sustainable development by attaching the cultural issue

to education (target 4.7), the promotion of local culture through sustainable forms of tourism (target 8.9), and the safeguarding of cultural heritage (target 11.4). The SDGs contain a set of 231 performance indicators to measure the progress in achieving targets (United Nations, 2015). However, these indicators are not always available for all the world countries and, for this reason, knowledge tools for data disaggregation (Asian Development Bank, 2021) and guidelines for indicators proxy identification (Economic and Social Council, 2019) have been recently emerging.

The need to measure material and non-material factors enabling a cultural and creative city, by means of variables and indicators, was stressed by the international scientific literature, global organisations like UNESCO and the World Bank, European research centres, i.e. JRC, and, at the local level, Italian Institutes for National Statistics (ISTAT) and the National Council for Economy and Labour (CNEL). The Organisation for Economic Co-operation and Development (OECD, 2008) designed methodological guidelines for constructing indicators and composite indicators concerned with the quality of information and rigorous procedures to check data consistency and affordability. This methodology was followed by many data analysts, practitioners, and researchers to support policy-makers and institutions at the European level. In particular, composite indicators express the complexity of different phenomena by assessing multidimensional issues at once, thus providing cross-cutting indications and a "big picture" (Galli et al., 2018, p. 161). Through the global creativity index, Florida et al. (2015) aimed to rank worldwide nations according to the three main variables of economic development: technology, talent, and tolerance. To derive their index, these authors have aggregated different qualitative metrics and quantitative indicators which explore, i.e.: the number of patents per capita, GDP invested in R&D sectors, the share of adults with higher levels of education, and people's perceptions about the level of liveability and tolerance against minorities. Furthermore, Florida et al. (2013) have analysed the role of human capital in citizens' well-being by aggregating statistics at the metropolitan level and using variables as proxies to forecast economic performance and community fulfilment (Florida, 2013, p. 614). However, in their investigation, the authors do not explicitly mention the concept of culture, but indeed they consider it as a positive externality produced by the human capital in terms of better education, more spending on cultural amenities, and higher openness and tolerance in a community (Florida, 2013, p. 624). In Italy, creativity – recognised as economic innovation – has been internalised into BES (Istat, 2015), a monitoring tool of Italian cities which collects performance indicators related to 12 domains of well-being at national levels. Nevertheless, the cultural issues analysed in this tool relate only to cultural heritage physical features, and culture is conceived as an education facet.

One of the relevant aims linking most of these studies and projects has been to benchmark cities' cultural performance for tailoring fit-for-purpose policies or monitoring. The most frequently used approaches to point out this goal include descriptive statistics and mathematics, i.e.: Linear regressions and explanatory variables models, data envelopment analysis (DEA), principal components analysis (PCA), and participatory methods such as the multi-criteria decision analysis (MCDA). To select the fit-for-purpose assessment method, indeed, particular attention must be paid to the choice of the indicators weighting system and aggregation procedures (Garcia-Bernabeu et al., 2020), which can be substantially based on the upper two mentioned categories: statistical aggregation rules or participatory approaches (Nardo et al., 2005). By way of example, the Cultural and Creative City Monitor (CCCM) is a monitoring tool of 155 European cities – selected for their active engagement in the promotion of culture and creativity (Van Puyenbroeck et al., 2021, p.584) – with the ambition of a more informed and strategic decision-making process toward the management of cultural and creative assets of cities. CCCM experimented with Equal Weighting (EW) assigned by experts to measure the degree of relevance of each dimension and domain in which cultural and creative facets have been clustered (Montalto et al., 2019). On the contrary, De Jorge-Moreno and De Jorge-Huertas (2020) proposed an alternative approach to the equal weighting of CCCM's variables by implementing DEA with a metafrontiers analysis to measure the impact of each variable in the determination of a cultural and creative efficiency index (IEC3) at the level of cities and groups of cities (De Jorge-Moreno and De Jorge-Huertas, 2020).

In the field of Operative Research and MCDA, among several experimentations to derive composite indicators that rank cities in terms of urban sustainability (Carli et al., 2018; Della Spina, 2019; Giffinger et al., 2007; Munda, 2016; Munda and Saisana, 2010; Phillis et al., 2017; Torre et al., 2017; Zhang et al., 2016), culture has been not included or, often, categorised as an economics or well-being sub-domain. In these studies, the most recurring indicators to measure Country or City cultural level – and creativity conceived as innovation – relate to GDP invested for R&D or education, technological patents, high-education expenditure, and people with education higher than a master's degree. In par-

ticular, Corrente et al. (2021) implemented a Stochastic Multi-Criteria Acceptability Analysis (SMAA) combined with the PROMETHEE method to rank 20 European cities in the 2012-2015 timespan. Although this contribution was particularly innovative for different reasons – i.e. the methodological accuracy, robust recommendations concerning the adopted sustainability criteria, the possibility to rank-order the cities concurrently at a comprehensive level and according to each macro-criterion – the authors adopted 9 elementary criteria in their analysis by including the amount of waste as a unique indicator of Circular Economy and excluding cultural issues (Corrente et al., 2021). With a different approach, Ferrara and Nisticò (2015) calculated a composite index of well-being at the city and regional scale with PCA by representing the results in spatial GIS maps. Also, in this study, the cultural issue has been analysed as a sub-domain of well-being by means of a regression-based decomposition method to measure the contribution of each partial indicator (Ferrara and Nisticò, 2015, p. 377).

This contribution was addressed to fill conceptual and methodological gaps detected in the literature. On the one hand, culture, creativity, and circularity have been considered comprehensive domains – and not as sub-domains of well-being, education, social dimension, or economy – by exploring the dimensions in which they can be declined, and the variables needed to understand each dimension. On the other hand, the comparison of cultural indices, derived by different aggregation procedures and methods, has been explored to identify a suitable methodological approach and fill a gap found in scientific literature.

The innovative contributions of the proposed methodology are aimed at: (i) the inclusion of small and medium-sized cities (with a population above 50,000 inhabitants) within the scoreboard, unlike other monitoring tools that generally only estimate large European cities; (ii) the selection of CE indicators to enrich the analysis framework, in the belief that cultural 'waste' can become a resource if managed correctly; (iii) the use of open-source data and ML techniques that can be easily replicated in other contexts; (iv) the balance of subjective and objective weightings of indicators which, in this study, represent the proxy variables for measuring indeterminate concepts such as circularity, culture and creativity.

1.2 Research questions and purposes

Considering the identified gaps, the main research questions were addressed: (RQ1) How to expand the methodology for assessing composite indicators to benchmark cities in circular, cultural, and creative terms?; (RQ2) How to effectively produce performance indices through subjective and objective assessment methods to better inform decision-making?

The purpose of this work is not to guide users and policy-makers to choose the best benchmarking method, but rather to open a debate on the potential of comparisons between subjective and objective weighting to scoreboard the cities, exploring the reason why the results change depending on the method used, and how they can be implemented in the monitoring of fit-for-purpose policies and recommendations for cultural cities policies and strategies. Therefore, the primary aim of this work is to understand the meaning of the differences between subjective and objective dimensions of policy-making to guide decision-makers toward more informed and aware choices. To do so, a data-driven quantitative methodology was designed to compute cultural performance indices of cities and, thus, to compare results derived by subjective and objective assessment methods.

The Metropolitan City of Naples (Italy) was chosen as a testing area because it featured by large, small, and medium-sized cities that differ significantly in social-economic conditions, cultural features, and morphological characteristics.

2. MATERIALS AND METHODS

Starting from the declared goal, the proposed data-driven methodology enforced two methods for weighting indicators, which made it possible to create composite indices and compare them in the last methodological step. A method based on principal components analysis (PCA) allowed objective weights to be determined through statistical and mathematical aggregation procedures. The other assessment method based on the joint application of a geographically weighted linear combination (WLC) with a budget allocation method has allowed experts' preferences to be transferred from literature and cultural composite indicators to be implemented. Henceforth, we refer to the former as the *PCA-driven* method and the latter as the *Expert-driven* method.

The proposed methodology was tested on the Metropolitan City of Naples' 92 urban districts – referred to as municipalities and corresponding to the NUTS3 classification (Eurostat, 2015) – and it can be summarised into 5 main steps (Figure 1):

- Step 1. *Theoretical and operative background*;
- Step 2. *Knowledge model*;
- Step 3. *Data processing methods*;

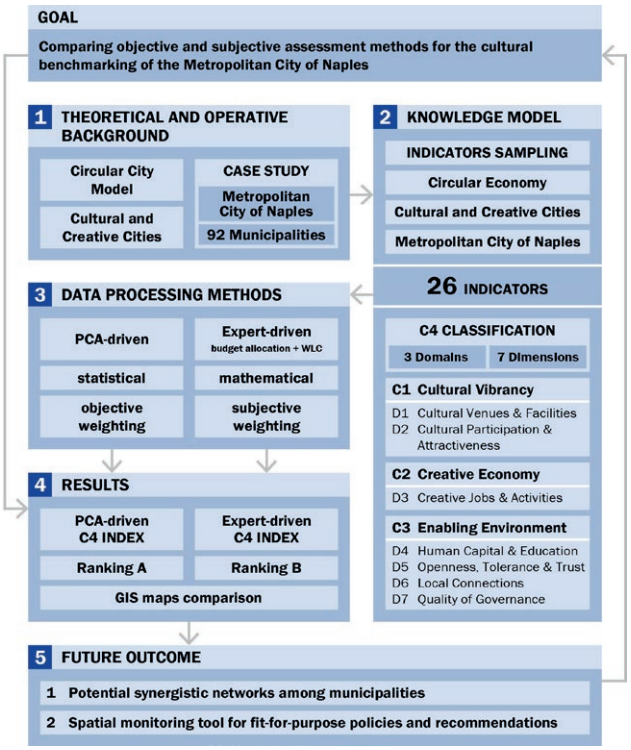

Figure 1. Graphical abstract with the 5-steps data-driven methodology.

- Step 4. *Results*;
- Step 5. *Future outcome*.

In Step 1, the conceptual framework to determine the criteria for indicator selection has been reviewed from the scientific literature. The results of this step revealed that culture had been generally considered a sub-domain of well-being, economy, education, or social category. However, except for the CCCM, few studies have treated culture as a comprehensive category. At the same, the authors have mostly intended creativity as innovation in technology transfer and research (Dubickis and Gaile-Sarkane, 2015); while circularity has been expressing a variable to measure the transition towards a Circular Economy (Cheshire, 2021; Ellen MacArthur Foundation, 2015b), particularly focussed on waste management and closing the loop in technological processes (Bridgens et al., 2019).

In Step 2, a set of 26 variables with related indicators has been selected, considering the former as the key concept to be explored to give consistency to the output, and the latter as the way the variables were measured, including the indicator's direction[1].

[1] For the sake of brevity, the unscaled and standardised datasets are not shown, but they are available from the authors on request at this link: https://bit.ly/3AZYSDY.

In Step 3, statistical procedures for data harmonisation and methods for data comparison have been elaborated. Some correlation analyses were useful in reducing data dimensionality passing from a starting dataset of 70 variables to 26 selected ones. At the same time, the KMO test allowed us to choose the most appropriate method to process the dataset between PCA and Factor Analysis. This study implemented an ML algorithm to perform statistical tests, data harmonisation, and Principal Components Analysis (PCA). Regarding the computational steps, the authors have manipulated, and adjusted to their objectives, part of the python code released by Bucherie et al. (2022) to produce a multidimensional index of vulnerability to flooding (Bucherie et al., 2022, *supplementary materials*). These preparatory steps allowed the implementation of the *Expert-driven* and *PCA-driven* methods to provide the cities' indices.

Step 4 allowed us to interpret the results of the comparison between the two experimented methods understanding the similarities and differences within the obtained results. Furthermore, the spatial visualisation of results in a GIS environment allowed the indices to be represented by choropleth maps and the indices' differences for each city to be better highlighted.

Step 5 concerned the research outcomes and further pathways of development.

The article remainder proceeds as follows: Subsections 2.1-2.4 focus on the knowledge model (step 2) related to criteria for indicators selection, and data processing methods (step 3) referring to data harmonisation, *Expert-driven* method, and *PCA-driven* method; Section 3 highlights the threefold results obtained by the application of the proposed methodology to a case study (step 4); in particular, Sub-section 3.1 shows Expert-driven method results, while Sub-section 3.2 presents the results from the application of PCA-driven method, and Sub-section 3.3 highlights the comparison of city rankings obtained from two above mentioned methods; Section 4 discusses results while Section 5 draws conclusions about the research innovative contribution and follow-ups (step 5).

2.1 Knowledge model: an Operative framework for the selection and processing of cultural indicators for the Metropolitan City of Naples

The indicators selection analyses the intersection and comparison between Circular Cities indicators and Cultural and Creative Cities indicators identified by the JRC Monitor, combining them with the available indicators of the Metropolitan City of Naples (Figure 2). In this way, a set of 70 indicators was generated, capable of

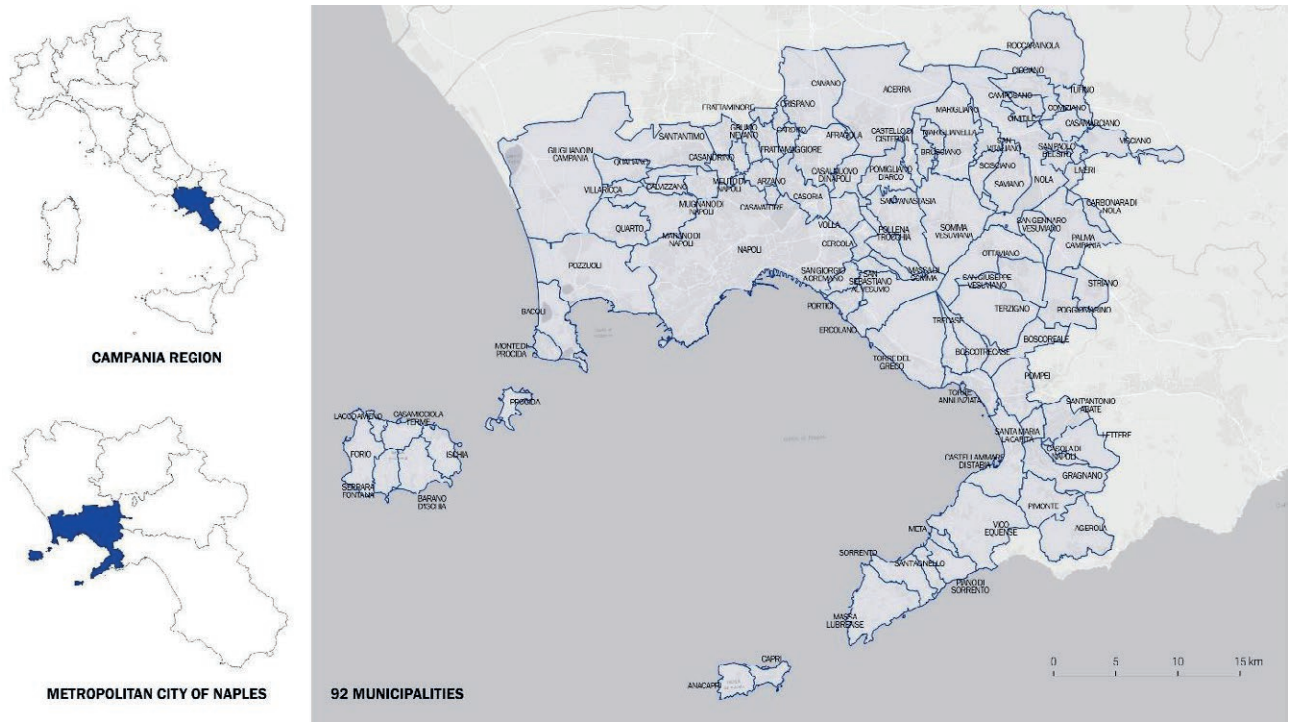

Figure 2. The study area.

describing the cultural specificities of 92 municipalities according to the three main categories of Sustainability: environmental indicators, economic indicators, and social indicators.

The criteria for selecting the indicators included, with reference to the data set construction manuals: relevance, analytical soundness, timeliness and accessibility.

Since there are multiple combinations of reliable indicators, the data selection process might be extremely subjective (OECD, 2008, p. 23). The core-set of 26 indicators was thus assembled through a series of statistical tests and, specifically, multivariate analysis (i.e. Cronbach Coefficient Alpha) performed on different combinations of indicators. The selection considered the indicators identified by the mentioned sector studies on the cultural benchmarking of cities (see 1.1), according to the identified selection criteria. The final set, shown in Table 1, is the result of the elimination of indicators that show too high co-dependencies between each other or that are not relevant to the context according to a critical choice from literature and used sources.

Therefore, it was possible to develop a spatial database of the municipalities, visualising it in a GIS environment, a geographic information system capable of spatially localising and returning information relating to the territory.

The proposed classification framework represents a reinterpretation of the CCCM one, including the 3 main domains and 7 dimensions. The 3 domains are:

- C1. Cultural Vibrancy: culture expressed in terms of places and participation;
- C2. Creative Economy: employment in the cultural and creative economic sector;
- C3. Enabling Environment: the resources that make cities fertile ground for triggering cultural processes.

The 7 dimensions are the following:

- D1. Cultural Venues & Facilities: the presence of places and infrastructures linked to culture;
- D2. Cultural Participation & Attractiveness: the ability of cities to attract people into their cultural life;
- D3. Creative Jobs & Activities: businesses and non-profit organizations in the cultural and creative sector;
- D4. Human Capital & Education: the number of young graduates and, in contrast, early school leaving;
- D5. Openness, Tolerance & Trust: the presence of different cultures and social participation;
- D6. Local Connections: the public and private mobility system;
- D7. Quality of Governance: the investments of municipalities in culture.

Table 1. The indicators set.

Domains	Dimensions	Indicators (i)	ID	Source	U.M.	KMO
Cultural Vibrancy	Cultural Venues & Facilities	Museums, monuments and archaeological areas	01	ISTAT	n	0.81
		Architectural heritage	02	ISTAT	n	0.87
		Archaeological heritage	03	ISTAT	n	0.60
		Libraries	04	Campania Region	n	0.56
		Theaters	05	teatri.it	n	0.81
		Cinema screens	06	SIAE	n	0.48
		Entertainment and cinema organizations	07	Campania Region	n	0.69
		Parishes	08	italia.indettaglio.it	n	0.56
	Cultural Participation & Attractiveness	Visitors to museums, monuments and archaeological areas	09	ISTAT	n	0.45
		Entrances to cinemas	10	SIAE	n	0.30
		Cultural events	11	Authors' processing of MiBACT and Campania Region data	n	0.63
		Hotel accommodation rate	12	Authors' processing of ISTAT data	n	0.69
		Non-hotel accommodation rate	13	Authors' processing of ISTAT data	n	0.66
Creative Economy	Creative Jobs & Activities	Incidence of cultural and creative enterprises	14	ISTAT	%	0.80
		Incidence of employees of cultural and creative enterprises	15	ISTAT	%	0.67
		Incidence of cultural and creative non-profit organizations	16	ISTAT	%	0.76
Enabling Environment	Human Capital & Education	Incidence of young people with university education	17	ISTAT	%	0.65
		Early exit from the education and training system	18	ISTAT	%	0.76
	Openness, Tolerance & Trust	Social participation index	19	ISTAT	%	0.71
		Incidence of foreign residents	20	ISTAT	%	0.45
	Local Connections	Railway stations density index	21	Authors' processing of OpenStreetMap data	n	0.67
		Bus stop density index	22	OpenStreetMap	n	0.43
		Vehicle fleet density index	23	comuni-italiani.it	n	0.75
	Quality of Governance	Per capita expenditure for the enhancement of cultural heritage and activities	24	openpolis	€	0.61
		Per capita expenditure on tourism	25	openpolis	€	0.72
		Per capita expenditure on sports and leisure activities	26	openpolis	€	0.66

All indicators have been recalculated as the expression of a ratio: indicators 01-13 and 23 as the ratio on the total resident population, per 1000 inhabitants; indicators 14-18 as the percentage ratio on the total of the reference entity of the indicator; indicators 19-20 as the percentage ratio on the total resident population; indicators 21-22 as the ratio on the municipal area per 100 sq. km of the area; indicator 24-26 as the ratio on the total resident population.

This method allowed the cultural performance of cities to be expressed in per capita terms and municipalities which are different in terms of surface area and population to be compared according to equal parameters. Therefore, if the CCCM allows the comparison among large European cities, the proposed framework aims to investigate the comparison in cultural terms among cities belonging to the same territorial body, which therefore have close geographical, but also social and, therefore, cultural ties.

Data for this study were extracted entirely by open-source databases in the chronological range 2015-2019, and they refer to: ISTAT, Campania Region, SIAE, Italian statistics (italiaindettaglio.it and openpolis), OpenStreetMap for geographical crowdsourced data, and MiBACT (now MIC).

2.2 Statistical tests and data harmonisation

Data cleaning and standardisation are essential operations that must be performed to reduce statistical errors in calculations and make data comparable. This was done by applying ML algorithms to data processing. ML is a type of artificial intelligence (AI) that uses algorithms to analyse data and make predictions based on the patterns it finds. It enables practitioners to automate complex data processing tasks and make more accurate decisions faster. ML can take advantage of larger datasets with more variables than traditional econometric models, allowing for more complex relationships to be explored. In this study, it has been used to detect anomalies in data that may be difficult to detect using traditional methods.

The indicators listed in Table 1 were normalised and transformed to establish the same preferred direction in terms of indicator values, and then standardised to a set of z-values with a mean of zero and a standard deviation of one. Such standardisation makes the variables observable and comparable and removes the dependencies on the measurement scale (Wang, 2009, p. 1).

Two statistical tests helped us choose the best-fit approach to construct the composite index of cities: the correlation analysis and the Kaiser-Meyer-Olkin (KMO) test. First, the correlation analysis helped us to determine the dependencies between the data, while the KMO test allowed us to determine whether the factor analysis was appropriate (Dziuban and Shirkey, 1974).

Correlation analysis aims to calculate correlation coefficients, representing the relationships among variables in a dataset ranging from -1 to 1. At the extremes, the coefficient expresses a completely negative or positive linear relationship, while the value 0 excludes relationships among variables (Dodge, 2008, p. 115). Figure 3 shows a symmetrical and square matrix – referred to as the correlogram – with the 26 standardised indicators on the axes and the correlation coefficients on the cross. The lighter the colour of the cell, the stronger the positive correlation and vice versa. It highlights that, although most indicators show a positive correlation, the overall values are not very high (Figure 3). An exception is the coefficient of 0.81, which indicates the correlation between i03 (Archaeological heritage) and i09 (Visitors to museums, monuments, and archaeological areas). In general, i25 (Per capita expenditure on tourism) has a correlation of up to 0.6 with all other variables six times, namely: i01 (Museums, monuments and archaeological areas) with 0.71; i02 (Architectural heritage) with 0.61; i05 (Theatres) with 0.64; i11 (Cultural events); i12 (Hotel accommodation rate) with 0.73; i13 (Non-hotel accommodation rate) with 0.74.

The indicators listed with the highest correlation are all related to resources and facilities associated with tourism expenditure by cities. It is also noticeable that i18 (Early exit from the education and training system) is negatively correlated with all the other indicators, as is i23 (Vehicle fleet density index). However, the correlation coefficients are not relevant, except for the record value of 0.68, which is the correlation between i18 and i17 (Incidence of young people with university education).

The KMO is a statistical test to measure sampling adequacy for factor analysis (Kaiser, 1970, p. 404) by determining it using a semantic rating scale from *unacceptable* to *marvellous* (Kaiser and Rice, 1974, p. 112) about a threshold that should be above 0.8 to be acceptable in a standardised range of 0-1. However, as can be seen in Table 2, the KMO results indicate that the factor analysis cannot be justified, as only four indicators with scores up to 0.8 are classified as *meritorious*, while five indicators with scores up to 0.7 are classified as *middling*. Furthermore, the mean value of the entire data set is 0.67, which is considered *mediocre* on the KMO scale.

Therefore, we decided to exclude factor analysis to weigh the indicators to derive the final index in favour of PCA.

2.3 Principal Component Analysis (PCA)

PCA is commonly used to reduce the complexity of large datasets and has the twofold objective of eliminating correlation among variables and identifying the variables with the highest eigenvalues, i.e. those with high informational relevance. Unlike factor analysis, PCA is not used for data reduction and preserves the information because the number of components is the same as that of the original variables (Wang, 2009, p. 2).

Table 3 shows the results of PCA using three metrics: the percentage of explained variance, the percentage of cumulative explained variance, and the eigenvalues of the 26 principal components. The same results are represented through a graph in Figure 4. The generalized equation to produce the aggregated final index follows:

$$PCAdriven\ index = \sum_{i=1}^{n} (\eta^2 \times PC_{ki}) \quad (1)$$

in which η^2 is the explained variance belonging to the variables of the dataset, while PC_{ki} the eigenvalues attached to the Principal Components. In this analysis, the final index has been calculated using the eigenvalue $k = 1$ only since it shows the highest score compared to the other components with a relevant deviation

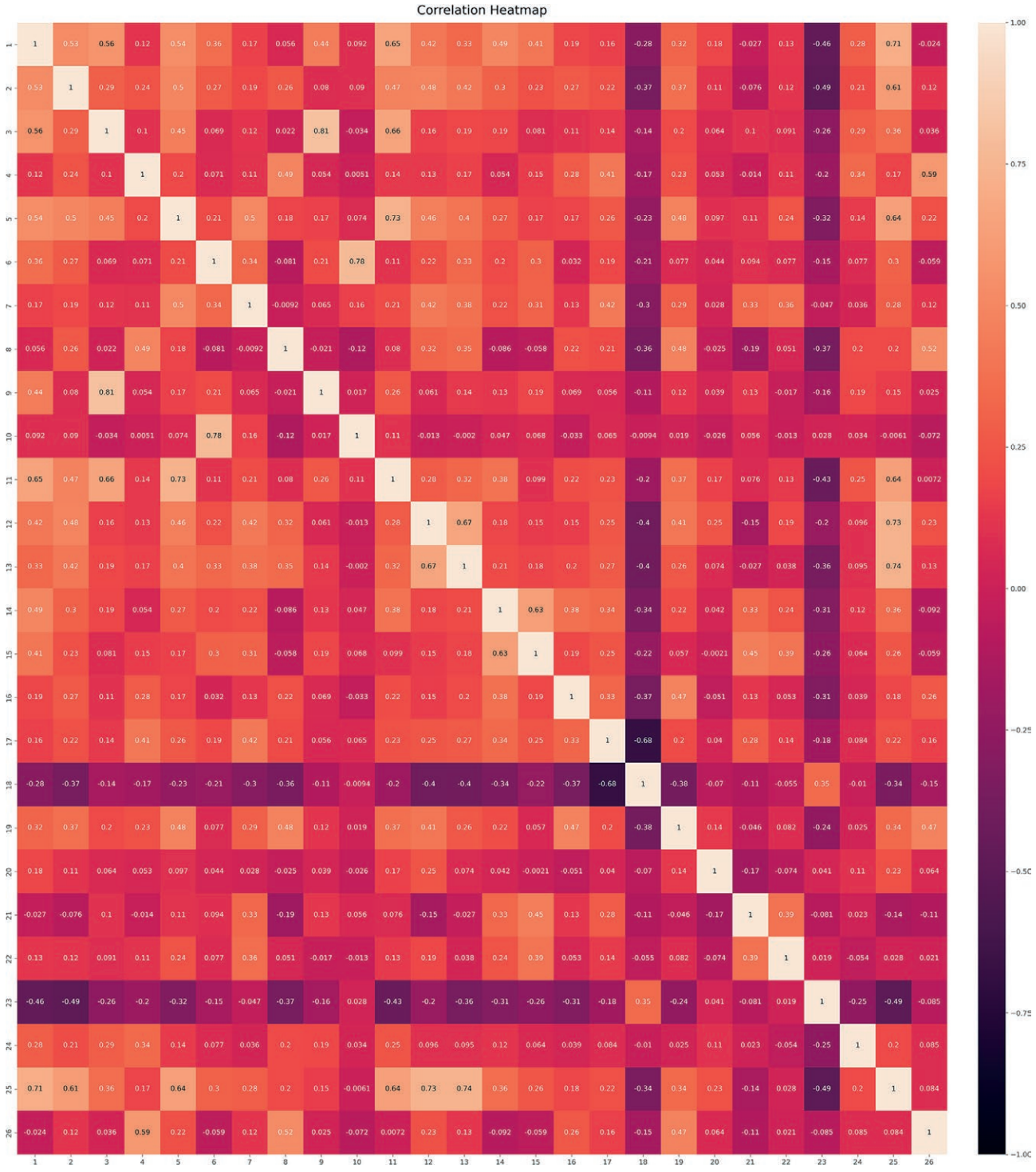

Figure 3. The correlogram – or matrix of correlation coefficients – represents the co-dependencies among the variables in a range between -1 and 1.

between the first (6.948451) and the second (2.732930) components.

The results obtained in this way are an alternative to equal weighting and they can be compared with the out-

Table 2. The Kaiser-Meyer-Olkin (KMO) scores.

ID	KMO	ID	KMO	ID	KMO
01	0.81	10	0.30	19	0.71
02	0.87	11	0.63	20	0.45
03	0.60	12	0.69	21	0.67
04	0.56	13	0.66	22	0.43
05	0.81	14	0.80	23	0.75
06	0.48	15	0.67	24	0.61
07	0.69	16	0.76	25	0.72
08	0.56	17	0.65	26	0.66
09	0.45	18	0.76	**Mean**	**0.67**

put of the *Expert-driven* method, which is shown in the next section (2.4).

2.4 Budget Allocation and Weighted Linear Combination (WLC)

It was required to give each indicator, dimension and domain a weight in order to build the scores achieved by the municipalities that define the partial, aggregated, and global indices. Therefore, the weights created for the framework created by the JRC were considered. Table 4 shows the weights determined using the Budget Allocation Method, in which a group of experts were given a sum of n points to allocate among the dimensions and domains, giving more points to those whose significance was intended to be stressed.

The scores that each municipality earned for dimensions, domains and globally were computed starting with the weights allocated to the indicators in an arithmetic manner. The Weighted Linear Combination, a spatial Multi-Criteria approach, was thus used to calculate the indices. This algorithm is provided in the QGIS software through the *geoWeightedSum* algorithm. The values obtained through the weighted sum algorithm allow drawing a map that returns the geography of the scores on a chromatic scale. Lastly, the indicators have been suitably maximized or minimized (i.e. i18 and i23) according to the resilience or the vulnerability expressed by them.

$$Experdriven\ index = \sum_{j=1}^{n} w_j \times v(x_{kj}) \quad (2)$$

Where k is used to indicate the municipality; $v(x_{kj})$ is the value of the kth alternative with respect to the jth attribute (indicator) and w_j is the expert weight.

Table 3. Percentage of Explained variance, Cumulative percentage of variance and eigenvalues attached to the 26 Principal Components (PC).

PC	% Explained variance (η^2)	Cumulative explained variance (%)	Eigenvalues
1	0.264343	0.264343	6.948451
2	0.103970	0.368313	2.732930
3	0.089567	0.457880	2.354336
4	0.072339	0.530219	1.901484
5	0.060189	0.590409	1.582129
6	0.054612	0.645022	1.435540
7	0.045660	0.690682	1.200219
8	0.043227	0.733910	1.136270
9	0.041040	0.774951	1.078787
10	0.036272	0.811223	0.953437
11	0.027007	0.838231	0.709913
12	0.024615	0.862846	0.647033
13	0.022799	0.885645	0.599293
14	0.019811	0.905456	0.520751
15	0.018428	0.923885	0.484399
16	0.014292	0.938178	0.375701
17	0.012237	0.950416	0.321684
18	0.010589	0.961005	0.278349
19	0.008324	0.969329	0.218803
20	0.007902	0.977232	0.207723
21	0.006571	0.983803	0.172724
22	0.005501	0.989305	0.144622
23	0.005374	0.994679	0.141269
24	0.002197	0.996877	0.057773
25	0.001603	0.998480	0.042152
26	0.001519	1.000000	0.039928

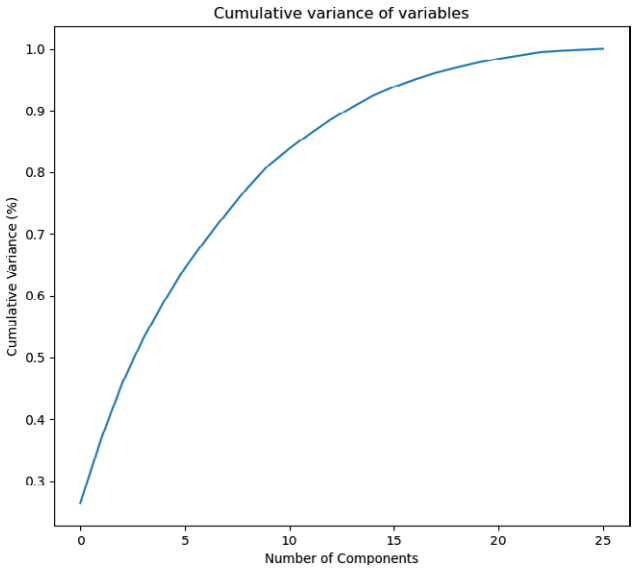

Figure 4. The cumulative variance of variables.

Table 4. Weights matrix.

Domains		Weights	Dimensions		Weights	Indicators	Weights	MAX/MIN
C1	Cultural Vibrancy	40,00%	D1	Cultural Venues & Facilities	50,00%	01	12,50%	MAX
						02	12,50%	MAX
						03	12,50%	MAX
						04	12,50%	MAX
						05	12,50%	MAX
						06	12,50%	MAX
						07	12,50%	MAX
						08	12,50%	MAX
			D2	Cultural Participation & Attractiveness	50,00%	09	20,00%	MAX
						10	20,00%	MAX
						11	20,00%	MAX
						12	20,00%	MAX
						13	20,00%	MAX
C2	Creative Economy	40,00%	D3	Creative Jobs & Activities	100,00%	14	33,33%	MAX
						15	33,33%	MAX
						16	33,33%	MAX
C3	Enabling Environment	20,00%	D4	Human Capital & Education	40,00%	17	50,00%	MAX
						18	50,00%	MIN
			D5	Openness, Tolerance & Trust	40,00%	19	50,00%	MAX
						20	50,00%	MAX
			D6	Local Connections	15,00%	21	33,33%	MAX
						22	33,33%	MAX
						23	33,33%	MIN
			D7	Quality of Governance	5,00%	24	33,33%	MAX
						25	33,33%	MAX
						26	33,33%	MAX

3. RESULTS

3.1 PCA-driven index

Table 5 highlights the partial results of PCA that show the variance explained by each indicator on the first nine principal components (PC), which were reported since their eigenvalues score with values up to 1, following the approach proposed by Filmer and Pritchett (2001) and replicated by Bucherie et al. (2022).

It can be noticed that i25 (Per capita expenditure on tourism) shows the highest absolute load on the first principal component, confirming its relevance within the entire dataset. Furthermore, all the loadings factors on the first component have the same positive direction, except for i23 (Vehicle fleet density index), which does not seem to correlate with all the other variables. In the second and third positions, the most relevant variables on the same principal components are i01 (Museums, monuments and archaeological areas) and i05 (Theatres), scoring respectively 0.286 and 0.281, which are close to the values of i02 (Architectural heritage) and i11 (Cultural events). The above-mentioned are the variables that most contributed to the final PCA-driven ranking. It can be confirmed by comparing these results with table 4, where Capri and Sorrento take first place for tourism, architecture, and cultural events. They are followed by Anacapri and Pompei, which, although at different levels, supply museums and very relevant archaeological areas.

3.2 Expert-driven index

Starting from the scores of Dimensions and Domains, it was possible to derive the Circular, Cultural and Creative City Index (C4I), specifically obtained as a weighted average of the aggregate indices of the 3 Domains. In this average, Cultural Vibrancy and Creative Economy have double the weight of Enabling Envi-

Table 5. Loading factors of indicators associated with each principal component, showing the first nine components with the first three highest variables per each component (in bold).

Indicators	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
i01	**0.286**	-0.161	-0.239	0.039	-0.008	-0.099	0.068	-0.032	0.109
i02	0.266	0.051	-0.086	-0.097	-0.039	-0.156	0.145	-0.162	-0.014
i03	0.201	-0.137	-0.318	**0.331**	0.122	0.218	-0.217	0.095	-0.114
i04	0.146	**0.267**	0.170	0.184	**0.335**	0.040	**0.309**	0.141	0.092
i05	**0.281**	-0.020	-0.083	-0.025	-0.072	0.324	0.039	-0.251	-0.012
i06	0.149	-0.240	0.064	-0.387	**0.444**	-0.079	-0.024	-0.032	-0.038
i07	0.187	-0.126	0.266	-0.172	-0.036	**0.393**	-0.054	0.082	-0.079
i08	0.141	**0.431**	0.092	0.073	0.101	-0.051	0.103	-0.008	-0.225
i09	0.131	-0.172	-0.238	**0.301**	0.251	0.131	-0.307	0.246	-0.144
i10	0.041	-0.208	0.057	-0.354	**0.546**	-0.034	-0.046	-0.253	0.070
i11	0.268	-0.093	-0.245	0.115	-0.050	0.110	-0.020	-0.232	0.095
i12	0.252	0.134	-0.021	-0.308	-0.207	0.142	0.034	0.182	-0.062
i13	0.249	0.088	-0.013	-0.258	-0.124	-0.040	-0.018	0.212	-0.344
i14	0.204	-0.252	0.150	0.134	-0.168	-0.270	0.049	-0.058	**0.272**
i15	0.163	-0.292	0.250	0.097	-0.070	-0.154	0.275	0.092	0.083
i16	0.165	0.112	0.208	0.201	-0.012	-0.236	-0.250	-0.283	0.184
i17	0.192	0.017	**0.333**	0.051	0.069	-0.048	-0.246	**0.332**	0.061
i18	0.220	0.085	0.229	-0.034	-0.053	-0.222	-0.391	0.244	-0.028
i19	0.220	0.231	0.067	0.031	-0.005	0.140	-0.239	-0.358	0.210
i20	0.066	0.058	-0.163	-0.146	-0.062	0.098	0.030	**0.345**	**0.705**
i21	0.048	-0.318	**0.332**	**0.251**	-0.017	0.113	0.028	0.014	-0.110
i22	0.092	-0.168	**0.271**	0.086	-0.160	**0.356**	**0.321**	-0.101	-0.070
i23	-0.223	-0.042	0.071	-0.130	0.015	**0.397**	-0.121	0.139	**0.244**
i24	0.114	0.033	-0.151	0.187	0.287	-0.085	**0.418**	**0.261**	0.036
i25	**0.310**	0.023	-0.199	-0.203	-0.188	-0.067	0.104	0.052	-0.053
i26	0.102	**0.395**	0.144	0.111	0.218	0.233	0.052	-0.080	0.102

ronment. The combined ranking thus obtained shows that the island of Capri, for its two respective municipalities, gained the best scores in terms of culture and creativity. Among the top 10 municipalities, 40% are municipalities of the islands (Capri, Anacapri, Forio, Procida), 40% are municipalities of the coastal area (Portici, Sorrento, Meta, Naples), 20% are municipalities of inland areas (Scisciano, Cimitile).

Specifically, the municipality of Capri gains the first position in both partial rankings relating to the Cultural Vibrancy and Enabling Environment domains, thanks to the high number of theatres and cultural events and the largest per capita expenditure on tourism. The municipality of Scisciano, thanks to a strong incidence of cultural and creative enterprises, obtains the first position in the partial ranking of the Creative Economy domain. Lastly, the municipality of Naples obtained the tenth score, contrary to what would have emerged if the data had been expressed in absolute terms and not in per capita ones.

3.3 The comparison of PCA-driven and Expert-driven indices: a composite index of the percentage difference

As shown in Table 6, the composite indices derived from *PCA-driven* and *Expert-driven* methods highlight similar trends toward higher performance in the coastal cities and islands and lower levels in the inner areas.

However, the comparison of the two indices, represented with GIS maps in Figure 5, reveals some significant divergences. The percentage difference between the *Expert-driven* index compared to the *PCA-driven* index for each city was derived from Equation (3), showing the extent of this divergence.

$$\text{Percentage difference} = \frac{(PCA\ index - Expert\ index) \times 100}{(PCA\ index + Expert\ index) \div 2} \quad (3)$$

First, it can be noticed a concordance between the two methods in relation to the top ranking which is placed by Capri for both indices. In addition, it can be

Table 6. The comparison of PCA and WLC rankings.

Municipalities	C4I values (PCA)	PCA ranking	C4I values (WLC)	WLC ranking	Municipalities	C4I values (PCA)	PCA ranking	C4I values (WLC)	WLC ranking
Capri	1.000	1	1.000	1	Palma Campania	0.130	47	0.227	42
Sorrento	0.729	2	0.721	4	Boscotrecase	0.127	48	0.168	58
Anacapri	0.551	3	0.817	2	San Paolo Bel Sito	0.126	49	0.143	67
Pompei	0.476	4	0.490	12	Cicciano	0.124	50	0.167	59
Procida	0.453	5	0.555	8	Roccarainola	0.122	51	0.218	43
Serrara Fontana	0.448	6	0.442	15	Pimonte	0.122	52	0.106	72
Ischia	0.409	7	0.482	13	Brusciano	0.122	53	0.201	49
Portici	0.379	8	0.789	3	Frattamaggiore	0.121	54	0.193	51
Forio	0.348	9	0.622	7	Poggiomarino	0.119	55	0.162	62
Meta	0.342	10	0.660	6	Mariglianella	0.118	56	0.229	39
Piano di Sorrento	0.335	11	0.368	19	San Giuseppe Vesuviano	0.118	57	0.190	54
Napoli	0.333	12	0.514	10	Casoria	0.116	58	0.177	55
Sant'Agnello	0.330	13	0.498	11	Acerra	0.114	59	0.141	68
Bacoli	0.327	14	0.410	17	San Vitaliano	0.113	60	0.170	56
Cimitile	0.300	15	0.545	9	Villaricca	0.110	61	0.192	53
Agerola	0.289	16	0.356	22	Casalnuovo di Napoli	0.109	62	0.163	61
Nola	0.288	17	0.434	16	Afragola	0.109	63	0.210	46
Vico Equense	0.280	18	0.359	21	Camposano	0.108	64	0.123	69
Scisciano	0.276	19	0.702	5	Grumo Nevano	0.101	65	0.151	65
Liveri	0.275	20	0.289	30	Marano di Napoli	0.098	66	0.198	50
Casamicciola Terme	0.255	21	0.334	25	Sant'Antonio Abate	0.098	67	0.108	71
Massa Lubrense	0.234	22	0.241	37	Quarto	0.098	68	0.158	64
Pozzuoli	0.229	23	0.340	23	Tufino	0.091	69	0.100	76
Lacco Ameno	0.228	24	0.203	47	Ottaviano	0.091	70	0.105	74
Castellammare di Stabia	0.224	25	0.318	27	Castello di Cisterna	0.090	71	0.192	52
San Sebastiano al Vesuvio	0.216	26	0.366	20	Casavatore	0.089	72	0.166	60
Ercolano	0.209	27	0.227	41	San Gennaro Vesuviano	0.085	73	0.105	73
Casamarciano	0.205	28	0.233	38	Striano	0.085	74	0.201	48
Trecase	0.198	29	0.373	18	Giugliano in Campania	0.084	75	0.169	57
Torre del Greco	0.189	30	0.315	28	Arzano	0.081	76	0.080	78
San Giorgio a Cremano	0.189	31	0.335	24	Cercola	0.081	77	0.104	75
Massa di Somma	0.184	32	0.146	66	Casola di Napoli	0.076	78	0.069	82
Barano d'Ischia	0.182	33	0.322	26	Caivano	0.072	79	0.095	77
Torre Annunziata	0.182	34	0.228	40	Visciano	0.069	80	0.073	81
Comiziano	0.177	35	0.247	36	Carbonara di Nola	0.068	81	0.038	87
Somma Vesuviana	0.177	36	0.300	29	Terzigno	0.067	82	0.109	70
Sant'Anastasia	0.172	37	0.216	44	Mugnano di Napoli	0.054	83	0.052	84
Pomigliano d'Arco	0.169	38	0.275	33	Frattaminore	0.052	84	0.000	92
Monte di Procida	0.161	39	0.287	31	Cardito	0.049	85	0.041	86
Pollena Trocchia	0.158	40	0.445	14	Melito di Napoli	0.048	86	0.067	83
Gragnano	0.153	41	0.247	34	Volla	0.043	87	0.032	89
Saviano	0.151	42	0.247	35	Calvizzano	0.038	88	0.021	91
Lettere	0.148	43	0.074	80	Casandrino	0.036	89	0.037	88
Marigliano	0.146	44	0.284	32	Sant'Antimo	0.024	90	0.044	85
Santa Maria la Carità	0.137	45	0.159	63	Crispano	0.019	91	0.026	90
Boscoreale	0.133	46	0.213	45	Qualiano	0.000	92	0.079	79

highlighted a lower dispersion in *PCA-driven* C4I values where the data mean is equal to 0.18 and the standard deviation is 0.15; while the *Expert-driven* index shows a mean of 0.25 and a standard deviation of 0.19. Furthermore, the *PCA-driven* index scores lower values overall, and the deviation between the first position (corresponding to 1 with Capri) and the second position – corresponding to 0.729 with Sorrento – is upper than the *Expert-driven* index, in which the second-ranking position scores 0.817 with Anacapri. A further consideration in relation to the indices difference involves the data intervals. According to the *PCA-driven* index, only three cities exceed the threshold value of 0.50, while the *Expert-driven* index includes ten cities with a score up to 0.50.

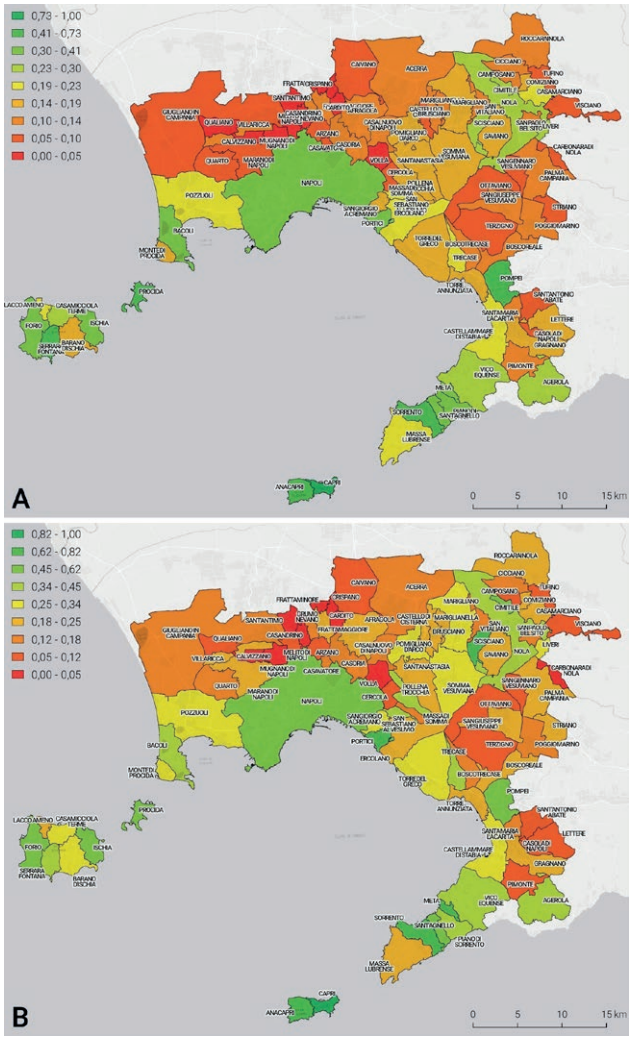

Figure 5. The comparison of spatial indices. At the top, C4I with the Expert-driven method (A), and at the bottom, C4I with the PCA-driven weighting procedure (B).

In Figure 6, the choropleth map shows the deviation of indices for each municipality as coloured values from red to green, where red colours indicate the assessment of the composite index using the *Expert-driven* method is lower than using the *PCA-driven* one, and vice-versa. These spatial maps are substantial to underline urban districts with an increased index sensitivity which depends on the methods used. It remarks on the most relevant research's purpose, which is inherent to estimating the sensitivity of results when different methods are applied and, particularly, the likely uncertainty linked to the cultural indices assessment and cities benchmarking.

In particular, the *Expert-driven* index for the seven municipalities of Portici, Qualiano, Marano di Napoli, Giugliano in Campania, Cercola, Pollena Trocchia, Scisciano and Striano ranks above the *PCA-driven* index with the most marked differences. In contrast, the PCA-driven index ranks the municipalities of Crispano, Calvizzano, San Sebastiano al Vesuvio, Lettere, and Carbonara di Nola below the Expert-driven index. Some differences can be noticed for Portici and Frattaminore, which reverse the ranking from 0.379 (PCA) to 0.789 (Expert) with a gap of five positions for the former, and from 0.052 (PCA) to 0 (Expert) with a gap of six positions for the latter. Despite these deviations, both cities remain in the top and bottom ten. Although the cities of Pompei, Serrara Fontana and Ischia, on the other hand, lose their top-ten position when switching from objective to subjective evaluation methods, the index of discordance is not very high. It means that the sensitivity of methods does not affect the first and last ten ranking

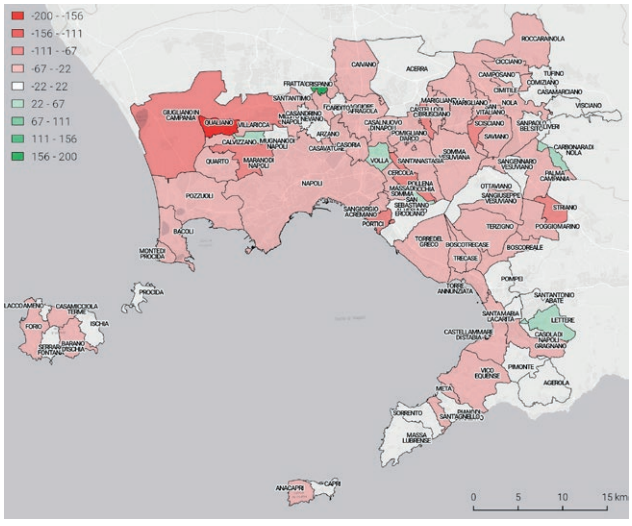

Figure 6. Percentage difference between PCA-driven/Expert-driven methods with the deviation of the rankings.

places. Ultimately, while there are significant deviations in terms of positions between the two rankings, the difference between the values of the indices obtained with the two methods is limited.

4. DISCUSSION

This contribution aimed at benchmarking cities in terms of culture, creativity, and circularity through a data-driven quantitative methodology, thus comparing results obtained by subjective and objective assessment methods. Starting from the declared goal, the structured methodological process for the Metropolitan City of Naples represents an experimental context to highlight the cultural, creative and circular potential of a homogeneous territorial system. A critical concern on the meaningfulness of fit-for-purpose indicators was part of the knowledge phase of this study, which has been further implemented with an ML algorithm to derive indicators with higher information content. Among the multiple purposes, indicators are useful for – i.e. improving communication and awareness, engaging stakeholders, co-designing visions of the future, evaluating pathways for social and institutional changes, or supporting policy evaluation – Lehtonen et al. (2016) have mentioned the monitoring and assessment of performance to support policymakers in detecting signals to decide whether or not to act (Lehtonen et al., 2016, p. 2). In this perspective, as decision-making tools, indicators and composite indicators should not only measure but also accelerate the multidimensional transitions of cities (Köhler et al., 2019, p. 44). However, it is necessary to pay particular attention to the ways in which composite indicators have been processed, as different methods may lead to completely different results (Greco et al., 2018), so it is useful to focus not only on the intrinsic quality of the information used to analyse the issues (Lehtonen et al., 2016, p. 1) but also on comparing the results obtained with different aggregation methods, making a choice with respect to the decision-making environment and the objectives set at an early stage (De Montis et al., 2004). The data-driven methodology was addressed to fill these research gaps.

In particular, the proposed approach has been addressed to answer RQ1, which concerns the expansion of the methodology for evaluating composite indicators for benchmarking cities. From a conceptual point of view, the findings outlined how culture can and should be considered as a comprehensive domain, and not only as an education-related positive externality or as an economic or well-being sub-domain. This is set in the perspective of considering, measuring with appropriate metrics, and evaluating cultural issues in their entirety, including those related to cultural 'waste', appropriately considered as a potential resource according to the principles of CE. The circular, cultural and creative approach can ultimately contribute to sustainable urban development and inclusive growth. From a procedural point of view, it has been shown how ML accelerates the process of harmonisation and comparison of numerous variables with different typological data characteristics, thus expanding the possibilities of data manipulation according to procedures already tested in the literature but not appropriately compared.

A core-set of 26 significant indicators was produced and analysed in response to RQ2 – which focused on the capability of providing performance indices using subjective and objective assessment methods – by testing the research hypothesis through the case study. Following the proposal of a classification framework based on the JRC Cultural and Creative City Monitor (CCCM), it was possible to implement *Expert-driven* and *PCA-driven* methods for weighting indicators and thus computing the C4 composite indices of the 92 municipalities. As a result, comparing the implemented assessment methods to compute composite indices allowed the sensitivity of the proposed model to be evaluated when weighting procedures change, by consistently identifying a concordance of indices between the highest and lowest performing cities. The critical analysis of the results makes it possible to think in multi-dimensional terms, compensating the subjectivity linked to the weighing methods of the indicators with the objectivity linked to their performance values.

5. CONCLUSION

The discussion of the results highlighted the innovative contribution of this research, which aimed to advance knowledge in the field of econometric approaches and spatial decision-making systems, as well as the main potential provided by the proposed methodological approach and the limitations encountered.

Therefore, the main limitations of the methodology concern the snapshot data, which were useful to test, on a preliminary basis, the functioning of the operational steps by providing a "big picture" but were not useful to assess the sensitivity of the indicators to the transformation of cities or to policy impacts. Time-series data are better suited to fully understand these dynamics and effectively measure policy impacts. Furthermore, ML techniques, while reducing the computation time for data processing, can produce a "black box" effect by generating logical

processes that are unclear to humans (Traub and Pianykh, 2022). Furthermore, the budget allocation method used in phase 3 should be implemented with local stakeholders to assess the stability of the ranking when new priority preferences emerge. Finally, the WLC method was well adapted to the representation of GIS data, but allowed for compensation between indicators that should be approved as a decision rule before data processing.

As for the potentials, C4I can support decision-makers, practitioners and researchers by highlighting different forms of knowledge related to the cultural dimensions of cities, namely: comparing the cultural performance through different sources and thus deciding whether to improve or maintain the *status quo* of the cultural resource in question, also taking into account the geographical location at the city and regional levels; to make decisions regarding a cultural policy both subjectively and objectively through the combined application of the two identified methods; measure the impact before and after the implementation of policies or regulations related to the use of cultural resources according to the city's performance; provide a comprehensive picture of a city's overall performance to facilitate understanding by non-experts.

This contribution tried to make a step forward in the benchmark analysis of the cities' cultural and creative performances by using objective and subjective assessment methods on the same dataset to compare the results. The ambition relates to data downscaling on the NUTS-3 level to make operational a methodological tool for policy-makers and users addressed to regional planning.

As a future research pathway, the objective is to critically assess the cultural opportunities of the selected case study, identifying, through appropriate MCDA methods, potential coalitions and synergistic networks among municipalities according to their specific cultural vocations. This assessment shall highlight the vulnerability and resilience factors from which to set territorial strategies and thus provide a useful tool for policy-makers of strategic planning.

A further step to be pursued is implementing a spatial monitoring tool for fit-for-purpose policies and recommendations to better inform decision-makers, exploiting the potential of combining GIS, MCDA and ML tools in real-time simulation scenarios.

REFERENCES

Asian Development Bank. (2021). *A practical guidebook on data disaggregation for the sustainable development goals*. Asian Development Bank.

Bridgens, B., Hobson, K., Lilley, D., Lee, J., Scott, J. L., & Wilson, G. T. (2019). Closing the loop on e-waste: a multidisciplinary perspective. *Journal of Industrial Ecology*, 23(1), 169–181. https://doi.org/https://doi.org/10.1111/jiec.12645

Bucherie, A., Hultquist, C., Adamo, S., Neely, C., Ayala, F., Bazo, J., & Kruczkiewicz, A. (2022). A comparison of social vulnerability indices specific to flooding in Ecuador: principal component analysis (PCA) and expert knowledge. *International Journal of Disaster Risk Reduction*, 73, 102897. https://doi.org/10.1016/j.ijdrr.2022.102897

Carli, R., Dotoli, M., & Pellegrino, R. (2018). Multi-criteria decision-making for sustainable metropolitan cities assessment. *Journal of Environmental Management*, 226, 46–61. https://doi.org/10.1016/j.jenvman.2018.07.075

Cerreta, M., La Rocca, L., & Micelli, E. (2022). Impact assessment for culture-based regeneration projects: a methodological proposal of ex-post co-evaluation. In Calabrò, F., Della Spina, L., Piñeira Mantiñán, M.J. (Eds). *New Metropolitan Perspectives*. NMP 2022. Lecture Notes in Networks and Systems, vol 482. Cham, Springer (pp. 501–511). http://dx.doi.org/10.1007/978-3-031-06825-6_47

Cerreta, M., Muccio, E., Poli, G., Regalbuto, S., & Romano, F. (2021). A multidimensional evaluation for regenerative strategies: towards a circular city-port model implementation. *Smart Innovation, Systems and Technologies*, 178, 1067–1077, 4th International Symposium on New Metropolitan Perspectives, NMP, Reggio Calabria, 26-28 May 2020. https://doi.org/10.1007/978-3-030-48279-4_100

Cheshire, D. (2021). What is a Circular Economy? In Cheshire, D. (Ed.). *The Handbook to Building a Circular Economy*. London, RIBA Publishing. (pp. 4–13). http://dx.doi.org/10.4324/9781003212775-2

Commissione Europea, Centro comune di ricerca, Langedijk, S., Saisana, M., Montalto, V., & Jorge Tacao Moura, C. (2018). *The cultural and creative cities monitor: 2017 edition*. Publications Office.

Corrente, S., Greco, S., Leonardi, F., & Słowiński, R. (2021). The hierarchical SMAA-PROMETHEE method applied to assess the sustainability of European cities. *Applied Intelligence*, 51(9), 6430–6448. https://doi.org/10.1007/s10489-021-02384-5

De Jorge-Moreno, J., & De Jorge-Huertas, V. (2020). Measuring European cultural and creative cities efficiency: a metafrontier DEA approach. *Journal of Economic Studies*, 47(4), 891–909. https://doi.org/10.1108/jes-06-2019-0265

De Montis, A., De Toro, P., Droste-Franke, B., Omann, I., & Stagl, S. (2004). Assessing the quality of different

MCDA methods. In Getzner, M., Spash, C., & Stagl, S. (Eds.). *Alternatives for Environmental Valuation*. London, Routledge.

Della Spina, L. (2019). Multidimensional assessment for "culture-led" and "community-driven" urban regeneration as driver for trigger economic vitality in urban historic centers. *Sustainability*, 11(24), 7237. https://doi.org/10.3390/su11247237

Dodge, Y. (2008). *The Concise Encyclopedia of Statistics*. New York, Springer Science & Business Media.

Dubickis, M., & Gaile-Sarkane, E. (2015). Perspectives on innovation and technology transfer. *20th International Scientific Conference "Economics and Management 2015 (ICEM-2015)"*, 213, 965–970. https://doi.org/https://doi.org/10.1016/j.sbspro.2015.11.512

Dziuban, C. D., & Shirkey, E. C. (1974). When is a correlation matrix appropriate for factor analysis? Some decision rules. *Psychological Bulletin*, 81(6), 358–361. https://doi.org/10.1037/h0036316

Economic and Social Council (2019). *Report of the Inter-Agency and Expert Group on Sustainable Development Goal Indicators*. United Nation. Available at: https://unstats.un.org/unsd/statcom/50th-session/documents/2019-2-IAEG-SDG-E.pdf (Accessed 9 Agoust 2022).

Ehnert, F., Kern, F., Borgström, S., Gorissen, L., Maschmeyer, S., & Egermann, M. (2018). Urban sustainability transitions in a context of multi-level governance: a comparison of four European states. *Environmental Innovation and Societal Transitions*, 26, 101–116. https://doi.org/10.1016/j.eist.2017.05.002

Ellen MacArthur Foundation. (2015a). *Delivering the circular economy: A toolkit for policymakers*. Available at: https://ellenmacarthurfoundation.org/a-toolkit-for-policymakers (Accessed 9 Agoust 2022).

Ellen MacArthur Foundation. (2015b). *Growth within: A circular economy vision for a competitive Europe*. Report. Available at: https://ellenmacarthurfoundation.org/growth-within-a-circular-economy-vision-for-a-competitive-europe (Accessed 9 Agoust 2022).

European Commission Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. (2015). *Closing the loop – An EU action plan for the Circular Economy 2015*.

Eurostat (2015). *Regions in the European Union: Nomenclature of territorial units for statistics: NUTS 2013/EU-28*. European Union.

Ferrara, A. R., & Nisticò, R. (2015). Regional well-being indicators and dispersion from a multidimensional perspective: evidence from Italy. *Annals of Regional Science*, 55(2–3), 373–420. https://doi.org/10.1007/s00168-015-0704-y

Filmer, D., & Pritchett, L. H. (2001). Estimating wealth effects without expenditure data—or tears: an application to educational enrollments in states of India. *Demography*, 38(1), 115–132. https://doi.org/10.1353/dem.2001.0003

Florida, R., Mellander, C., & King, K. (2015). *The Global Creativity Index 2015*. Toronto, Martin Prosperity Institute.

Florida, R., Mellander, C., & Rentfrow, P. J. (2013). The happiness of cities. *Regional Studies*, 47(4), 613–627. https://doi.org/10.1080/00343404.2011.589830

Fusco Girard, L., & Nocca, F. (2019). Moving towards the circular economy/city model: which tools for operationalizing this model? *Sustainability*, 11(22), 6253. https://doi.org/10.3390/su11226253

Fusco Girard, L., Nocca, F., & Gravagnuolo, A. (2019). Matera: city of nature, city of culture, city of regeneration. Towards a landscape-based and culture-based urban circular economy. *Aestimum*, 74, 5–42. https://doi.org/10.13128/aestim-7007

Galli, A., Đurović, G., Hanscom, L., & Knežević, J. (2018). Think globally, act locally: implementing the sustainable development goals in Montenegro. *Environmental Science & Policy*, 84, 159–169. https://doi.org/10.1016/j.envsci.2018.03.012

Garcia-Bernabeu, A., Cabello, J. M., & Ruiz, F. (2020). A multi-criteria reference point based approach for assessing regional innovation performance in Spain. *Mathematics*, 8(5), 797. https://doi.org/10.3390/math8050797

Giffinger, R., Fertner, C., Kramar, H., & Meijers, E. (2007). *City-ranking of European Medium-Sized Cities. Centre of Regional Science. Vienna, UT*, 9(1), 1–12.

Greco, S., Ishizaka, A., Tasiou, M., & Torrisi, G. (2018). On the methodological framework of composite indices: a review of the issues of weighting, aggregation, and robustness. *Social Indicators Research*, 141(1), 61–94. https://doi.org/10.1007/s11205-017-1832-9

Grossi, E., Tavano Blessi, G., Sacco, P. L., & Buscema, M. (2011). The interaction between culture, health and psychological well-being: data mining from the Italian culture and well-being project. *Journal of Happiness Studies*, 13(1), 129–148. https://doi.org/10.1007/s10902-011-9254-x

Istat (2015), Rapporto Bes 2015. Available at: https://www.istat.it/it/files//2015/12/Rapporto_BES_2015.pdf (Accessed 9 August 2022)

Kaiser, H. F. (1970). A second generation little jiffy. *Psychometrika*, 35(4), 401–415. https://doi.org/10.1007/bf02291817

Kaiser, H. F., & Rice, J. (1974). Little Jiffy, Mark Iv. *Educational and Psychological Measurement*, 34(1), 111–117. https://doi.org/10.1177/001316447403400115

Köhler, J., Geels, F. W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M. S., Nykvist, B., Pel, B., Raven, R., Rohracher, H., Sandén, B., Schot, J., Sovacool, B., Turnheim, B., Welch, D., & Wells, P. (2019). An agenda for sustainability transitions research: state of the art and future directions. *Environmental Innovation and Societal Transitions*, 31, 1–32. https://doi.org/10.1016/j.eist.2019.01.004

Lehtonen, M., Sébastien, L., & Bauler, T. (2016). The multiple roles of sustainability indicators in informational governance: between intended use and unanticipated influence. *Sustainability Governance and Transformation 2016: Informational Governance and Environmental Sustainability*, 18, 1–9. https://doi.org/https://doi.org/10.1016/j.cosust.2015.05.009

Montalto, V., Moura, C. J. T., Panella F., Alberti, V., WE,, B., & Saisana, M. (2019). *The Cultural and Creative Cities Monitor: 2019 Edition*. Publications Office of the European Union.

Munda, G. (2016). Multiple criteria decision analysis and sustainable development. In Greco, S., Ehrgott, M., & Figueira, J. (Eds.). *Multiple Criteria Decision Analysis*. International Series in Operations Research & Management Science, vol 233. New York, Springer. (pp. 1235–1267). http://dx.doi.org/10.1007/978-1-4939-3094-4_27

Munda, G., & Saisana, M. (2010). Methodological considerations on regional sustainability assessment based on multicriteria and sensitivity analysis. *Regional Studies*, 45(2), 261–276. https://doi.org/10.1080/00343401003713316

Nardo, M., Saisana, M., Saltelli, A., & Tarantola, S. (2005). *Tools for Composite Indicators Building*. Joint Research Centre (European Commission).

OECD, Union, E., & Commission, J. R. C. E. (2008). *Handbook on constructing composite indicators: Methodology and user guide*. OECD Publishing.

Ortega-Villa, L. M., & Ley-Garcia, J. (2017). Analysis of cultural indicators: a comparison of their conceptual basis and dimensions. *Social Indicators Research*, 137(2), 413–439. https://doi.org/10.1007/s11205-017-1588-2

Paoli, F., Pirlone, F., & Spadaro, I. (2022). Indicators for the circular city: a review and a proposal. *Sustainability*, 14(19), 11848. https://doi.org/10.3390/su141911848

Phillis, Y. A., Kouikoglou, V. S., & Verdugo, C. (2017). Urban sustainability assessment and ranking of cities. *Computers, Environment and Urban Systems*, 64, 254–265. https://doi.org/10.1016/j.compenvurbsys.2017.03.002

Solutions for Youth Employment (S4YE) (2020). *Orange economy: As a driver of jobs for youth*. Solutions For Youth Employment. Available at: https://www.s4ye.org/node/3725 (Accessed 1 September 2022).

Torre, C. M., Morano, P., & Tajani, F. (2017). Saving soil for sustainable land use. *Sustainability*, 9*(3), 350,* https://doi.org/10.3390/su9030350

Traub, S., & Pianykh, O. S. (2022). Correction: an alternative to the black box: Strategy learning. *PLOS ONE*, 17(6), e0270441. https://doi.org/10.1371/journal.pone.0270441

UNESCO (2014). *UNESCO culture for development indicators: Methodology manual*. UNESCO Publishing.

UNESCO, & World Bank (2021). *Cities, Culture and Creativity: Leveraging culture and creativity for sustainable urban development and inclusive growth*. UNESCO Publishing.

United Nations (2015). *Transforming Our World: The 2030 agenda for sustainable development : A/RES/70/1*.

United Nations (2016). *Draft outcome document of the United Nations Conference on Housing and Sustainable Urban Development (Habitat III)*.

Van Puyenbroeck, T., Montalto, V., & Saisana, M. (2021). Benchmarking culture in Europe: a data envelopment analysis approach to identify city-specific strengths. *European Journal of Operational Research*, 288(2), 584–597. https://doi.org/10.1016/j.ejor.2020.05.058

Wang, F. (2009). Factor analysis and principal-components analysis. *International Encyclopedia of Human Geography* (pp. 1–7). Elsevier. http://dx.doi.org/10.1016/b978-0-08-102295-5.10377-4

Williams, J. (2019). Circular cities: challenges to implementing looping actions. *Sustainability*, 11(2), 423. https://doi.org/10.3390/su11020423

World Economic Forum. (2018). *Circular economy in cities: evolving the model for a sustainable urban future*.

Zhang, L., Xu, Y., Yeh, C. H., Liu, Y., & Zhou, D. (2016). City sustainability evaluation using multi-criteria decision making with objective weights of interdependent criteria. *Journal of Cleaner Production*, 131, 491–499. https://doi.org/10.1016/j.jclepro.2016.04.153

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Evaluation of the quality of participatory landscape perception in neighborhoods of cultural landscape to achieve social sustainability

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Abstract. Citizen communication creates the foundation for sustainable development by adopting the notions of social life, space and human behavior. Furthermore, the perceptions of the cultural landscape, and the social sustainability of the neighborhoods are assessed through the participation of the citizens. As such, to gain a more in-depth understanding of the issues, the passage of the Fil Bazaar in Eshagh Beig neighborhood and Haj Zainal passage in Sang-e Siah neighborhood in the historical context of Shiraz has been selected. This research used a mixed-methodology. Due to necessity, using the questionnaire method and the Likert scale, with the help of architectural and urban planning specialists, a survey was conducted. Lastly, the collected data were analyzed using MAXQDA-software and using the Halprin-cycle, criteria were analyzed and assessed. With the aid of the Halprin-cycle, it is established that factors, correlation, Communication, and social life will impact the social stability.

Keywords: Urban landscape perception, Citizen communication, Participatory landscape, Social sustainability, The cultural landscape of Shiraz.
JEL code: O18.

1. INTRODUCTION

Focusing on neighborhoods sustainability is one of the novel approaches to make decisions concerning. Neighborhoods On the other hand, the urban landscape has goals that have in its context the principles of sustainability This study also aims at building a connection between sustainability and urban landscape perception, such that it can be productive on a neighborhoods scale. “Neighborhood” is not a new word in the global urban planning literature, particularly in Iran. The primary form of this notion can be seen centuries ago, when the first central governments of Iran settled, in the form of “*Kohan Dezh*” (meaning old fortress) and “*Shaarestan*” (meaning city). The

word is so inherent in Iranian culture that it is extensively used even in popular literature, and its meaning is understandable to people. But when it comes to defining and proving its meaning, the same familiar, simple phrase molds in a twisted and variable form such that both ordinary people and the specialists in this domain are unable to specify it precisely. In defining the neighborhood, each distinct scientific area has detailed and applied it according to their particular theoretical disciplines and their perspective on the idea of the neighborhood. Historical neighborhoods are of particular significance because of their historical value and features. The *Baazarche-ye-Fil* passage in Es'hagh Beig neighborhood from the fabric of Shiraz (Case A) is chosen as the case study. This historical passage (the route from *Baazarche-ye-Fil* to Es'hagh Beig neighborhood of Shiraz) has its own spatial and unique values. Accordingly, this area must be protected from instability and its consequences and decline in the quality of landscape perception. Landscape perception and communication are some of the constructive layers of the urban landscape in neighborhoods with a Cultural Landscape that will influence social sustainability and promote the perceived quality of the environment in the perceptions of the people. Citizen communication is the connection between urban landscape perception and neighborhood social sustainability. The absence of dynamism in neighborhoods of the Cultural Landscape has prompted social instability in these neighborhoods. Particularly in the neighborhoods of the Cultural Landscape of Shiraz. High levels of social indifference and lack of vibrance in the historical context neighborhoods led to the social instability of the neighborhoods, particularly those within the historical context. To this end, the present study seeks to offer a response to the following research question:

> What are the key elements in promoting social sustainability through cultural landscape perception in historical sites?

The final goal of the research is the strategies and policies extracted from the interaction of environmental perception with the cultural landscape in the two historical transitions of Bazarche Fil and Haj Zainel in the old context of Shiraz, which is considered one of the research strategies with the help of the foundational data theory, through which theorizing based on the main concepts obtained It is formed from the data in the field. After analysis using the content analysis method, some certain codes were obtained. Based on those codes, the elements that determine the perceived quality of landscapes with Cultural Landscape s from the perspective of experts and residents were determined.

2. LITERATURE REVIEW

Research within the expanding knowledge of landscape architecture is not only as important as research in other domains, but also because of the need to know more clearly the limits of this knowledge, it is classed as one of the paramount components needs to be addressed. The urban landscape has always been one of the principal issues of civil design, architecture, and landscape architecture, as reflected in previous research. During the past two decades and based on fundamental studies of researchers, the quantitative and qualitative assessment of the landscape has developed. Consequently, landscape can be measured in the form of landscape architecture knowledge, based on the research of its processes and patterns, and a distinct image of it can be perceived. In the 1980s, attempts were made to apply research techniques in the social sciences to use in landscape architecture, the most significant of which was the Seta Love practices at the University of Pennsylvania (Low, 1981). Economic and social notions have changed over the past four decades. However, the idea of communication has always been part of the development process and has gained increasing significance. The 1960s, known as the Decade of Development, was characterized by the development process with the excitement over approaches to decolonization and the political independence of Third World countries, the weight of popular movements, the impact of human contributions, and the presence of the people in society.

Describing people's actual perceptions of space has a lengthy history in the literature, starting with Kevin Lynch in 1960. Residents' communication in the living conditions of their neighborhood is an essential indicator of urban quality of life. This view, first put forward by Turner and Fichter (1972) and Turner (1977), is welcomed once again today. In particular, the communication of citizens in designing household areas to access more humane settings has been addressed in the West. But for modern urbanists, such as Krier and Porphyrios (1984), Duany and Plater-Zyberk (1991), although the idea of the neighborhoods symbolic, it is seen as crucial to set a connection between a "place" and an "activity".

2.1 The concept of the urban landscape and social performance

Activities in common areas can improve the quality and add to the number of people encouraged to stay and interact in these spaces. Public spaces present a platform for a broad range of activities, from daily activities to recurrent, personal and social, active, and inactive celebra-

Table1. Human and the urban landscape.

No.	Author	Research scope	Details
1	Crow et al. (2006)	The concept of the urban landscape	The urban landscape is perceivably the result of the level of contact between a man and the city, and respectively, a man not only influences the structure of the visual landscape of the city through his deed but also the behavior and mental perception of men area affected by the city (Crow et al., 2006, p. 282).
2	Gehl (1987)	The relationship between daily human activities and urban landscape	Jan Gehl argues that the growth of selective activities and, consequently, social activities are directly related to the quality of these spaces and their sense of hospitality. (Gehl, 1987, p. 68).
3	Lindholm (2011), according to Jacobs (1961)	The relationship between human activity and urban landscape	Similarly, Jane Jacobs considers the establishment of daily activities in the streets to attract others (Lindholm, 2011, p. 7). Like Gehl (1987), she argues that low-intensity forms of social communication are the main precursors to the vibrancy of the urban space, stating that cities will perish as soon as interesting, useful, and meaningful interactions between citizens are reduced to private relationships.
4	Cullen (1995)	The concept of the urban landscape	The urban landscape of any city is a response to human behaviors, climate, safety factors, and in other words, skillful interventions in line with the enhancement of the capabilities of the environment (Cullen, 1995).
5	Black and Street (2014)	The elements of urban space	Elements in the urban landscape lead to semantic associations, that is, evoke memories, including natural and artificial elements, urban spaces, people's perceptions of space, events and incidents, chronology, identity, culture, history, sacredness, signs, as well as physical and environmental elements, that can be directly perceived by the human senses (Black and Street, 2014).

tions. Activities like looking, listening and experiencing others, and active and passive communication in the place, enliven it (Gehl, 1987). Yet the activity dimension of public areas is directly related to the applications and functions around the environment. The greater the amount of charming and diverse functions in urban spaces, the more variety and diversity of activities will take place (Loukaitou-Sideris et al., 1998). Diversity in the planning of public areas can create opportunities for the presence of various individuals and groups in the place Table 1.

Social activities cover those that are most reliant on the presence of others in society. These include children's games, meetings, and brief conversations, various kinds of group activities, and ultimately, the most comprehensive model of social activities, passive communication including simply looking at or listening to people (Gehl, 1987). The passive communication is a pleasure that one sometimes achieves from looking at people's vibrant scenes of everyday life. On the other hand, active communication or active interaction implies the direct experience of an area and the people inside it. The pillar of this conflict is communication in activities. Just as some people enjoy watching others, others take an interest in direct contact with them, whether they are strangers or members of a group (Carr et al., 1992).

Jan Gehl regards the growth of selective and, therefore, social activities as directly linked to the quality of these spaces and their charm. According to him, when the open-air space is not of satisfying quality, only the essential activities are carried out, and people immediately return to their homes. In such a circumstance, people do not prefer not to hang around in the urban place. He states that individual activities never have a chance to thrive, develop, and become significant, and therefore will not encourage other events (Gehl, 1987, p. 68).

Jane Jacobs further regards the existence of everyday activities on the streets as a method of attracting others. She declares states that the activity of all those who go shopping, or those gathered only to drink or eat somewhere, is in itself a method of drawing others to a place (Lindholm, 2012). She indicates that the city will die as soon as interesting, beneficial, and significant synergies between citizens and private relationships decrease. She considers the quality of urban spaces to be effective in shaping such connections and emphasizes the diversity and practical appeal of the place. She also notes that a thriving urban space depends on a location that is linked to human activities (Lai et al., 2013). In terms of performance, spaces must satisfy basic requirements, like an active engagement with the setting and the possibility of discovering the environment. The installation of fountains, the creation of appropriate views, the use of components of public art, and the holding of various exhibitions create the opportunity for passive communication with the space. Because of this arranging various elements, benches, telephone booths, water fountains, statues, and sales booths can, to a small extent, bear social communication (Carmona et al., 2010).

2.2 Perception of the urban landscape in the interaction between human and the environment

The landscape is an objective, subjective, dynamic, and relative phenomenon that is the outcome of human interaction with the environment and society with history (Mansouri, 2005). Landscapes can be understood in the context of human activities, perceptions, and actions (Norman, 2011). Overall, the perspective may involve the study of anything relevant to appearance or the manifestation and experience of an environment or fabric (Hutchinson et al., 2012). Elements in the urban landscape, such as natural elements, artifacts, urban spaces, people's perception and mentality of space, events and happenings, time, identity, culture, history, sacredness, signs, as well as physical and environmental elements that can be perceived directly by the human senses (Black et al., 2014) and evoke memories. One of the aspects of urban landscapes is their objectivity, which is because of the quality of the introduction of physical factors in the environment. But gradually, due to the presence of historical conditions and repetition for the group of human beings who perceive it, this dimension obtains a sort of mental existence and becomes the joint element that joins the people of the society (Golkar, 2006).

2.3 Cultural landscape

The landscape is defined as the container of intangible values. The notions of the cultural landscape have been developed to scrutinize the interaction and evolution between biological and cultural diversity (Hill, 2011). Landscape embodies history and epitomizes intangible aspects of urban culture (Türkyılmaz, 2016). Therefore, tangible and intangible identities, given their attribution to the characteristics of the surrounding world and human experiences, are closely affiliated to the concept of place, hence its significance to human beings. The cultural landscape has become one of the most sought-after academic notions in world heritage and even beyond. In general, it represents the level of contact between culture and nature, tangible and intangible identities, and biological and cultural diversity, thereby reflecting a close affiliation of a network of affairs, identities, and cultures (Rössler, 2006). Since 1972, the UNESCO World Heritage Convention has been the first international body to recognize the notion of cultural landscape (UNESCO, 1972). UNESCO does not provide standards for a cultural landscape management plan, but some of the proposed elements of the cultural landscape, where the use of land reflects a combination of the proposed element as a module (UNESCO, 2008). The cultural landscape is where land application reflects a combination of environmental opportunities and human endeavors (Azari-Dehkordi, 2011). To understand the cultural landscape, the examination of cultural and natural components is of paramount importance. In general, UNESCO has divided the cultural landscape into three categories, namely:

1. Man-made landscapes (parks, recreational gardens, plazas, squares, cemeteries, promenades, and courtyards, among others)
2. Landscapes that have evolved naturally (organic landscapes)
3. Semantically associative cultural landscape: concerning religious, cultural, and natural components (Carreno, 2006).

Using the Historic Landscape approach increase the people perception of the local inhabitants where many difficulties conflict with the sustainable development of the town. The Intangible urban heritage values lead to the protection of cultural sustainability (Prabowo, 2020). Theories related to the urban landscape are presented in Table 2.

Many challenges in urban conservation persists, however, which include the prevalent centralized heritage governance, lack of community participation, unclear land and building ownership patterns, high pov-

Table 2. Theories related to the urban landscape.

No	Author	Research scope	Comments
1	Azari-Dehkordi (2011)	Formation of unique places with distinct environments and economies	A cultural landscape can manifest itself in the combination of natural and cultural elements of terrestrial ecosystems (Azari-Dehkordi, 2011)
2	Kaya and Weber (2003)	The identity of each space as the consequence of the interaction of nature and the cultural components of the landscape over time	The cultural landscape is not confined to a specific time and place (Kaya and Weber, 2003)
3	Nohl (2001)	Cultural landscape and sustainability	The urban landscape is disturbed in terms of aesthetic quality. The better the improvement of landscape aesthetics, the better landscape improvement in economics, ecology, and culture (Nohl, 2001).

erty rate among the residents, low construction quality of buildings, and informal urban expansion in historic areas (Silva, 2019). In a highly significant article, Araoz (2008) has addressed the evolution of the notion of the value in the historic-urban landscape with an authenticity assessment approach, arguing therein that organized transition from a "historic city" to a "historic urban landscape" in the 2005 Vienna Memorandum has expanded the values of historic urban areas, and emphasizes on the dynamic historical patterns of its evolution and shifts (Araoz, 2008). He further discusses that historic urban landscape is a new avenue by which UNESCO seeks to achieve a sustainable future and that the ultimate goal of the historic urban landscape is to manage urban sustainability and the resulting alteration to preserve objective and subjective values. A comprehensive comparison of values indicates that the values of natural or artificial contexts in the form of a city or natural landscape, intangible values of perception or commemoration, and collective values developed by the people progress the heritage-related cultural values of the historic urban landscape, making it highly distinctive in the aftermath (Khorasani, 2020). Pingyao's urban morphological study reveals the historical expressiveness or historicity of its urban landscape forms as both spatial-temporal and representational creations. An approach to the historic urban landscape that includes both integrated and morphological values is fundamental to the development of historic and public urban development and preservation plans. (Wang et al., 2020).

2.4 Historical fabric

Historic sites are significant because they are meaningful to people they share cultural and historical ties (Lennon and Davis, 2020). In an important article, Araoz (2008) discussed the evolution of the concept of historical urban landscape value with the approach of authentic evaluation and believes that the exemplary transition from "historical city" to "historical urban landscape" in the 2005 Vienna note has led to the expansion of the values of historical urban areas and It focuses on the dynamic historical patterns of evolution and change. Historical fabrics refers to that, notwithstanding wear and tear, have valuable urban buildings, complexes, equipment, and facilities, or a collection of these in their span (Sharan, Consultant Engineers, 2005). The historical urban landscape is a new tool of UNESCO in order to achieve a sustainable future, and the ultimate goal of the historical urban landscape approach is to manage urban continuity and changes resulting from it in order to preserve tangible and intangible values. Traditional-Cultural Landscape are the indisputable reality of cities with historical backgrounds. These kind of fabric are part of and field of the city that have been sustained for some time and embraced the commutations and material and spiritual trading of the people of that time. In other words, the historical urban fabric is a creative and alive and allows one to understand the status of human the world and their association with the past. It is a place to modify the environment and change one's perspectives on the present and future life (Habibi, 2006). Cultural Landscape can be described in any form of built space in which the image of the organized, constant, and designed progress of human thought can be recognized in a period of the past. Thus, the Cultural Landscape of cities is a part of the memory and identity of the people of that area (Mahjoor, 2014). Cities used to possess visual unity, and with forms that increasingly gained more intricacy, they created the social bedrock of the neighborhoods (Piran, 2005).

2.5 The concept of neighborhood

The semanticization of human beings in the setting is obtained through features that can be examined in various physical, social, and process dimensions. Physical and social aspects of the environment can improve the quality of life of citizens (Moulay et.al, 2018). Neighborhood-related theories are presented in Table 3.

The notion of the local neighborhood can be studied and analyzed from four perspectives:

A) Social concept: An assortment of people with mutual interests, organization, and law. This concept is the oldest concept of the local neighborhood in sociological thought.

B) Legal-economic concept: Highlights the element of joint interests and ownership in the definition of the local neighborhood.

C) Geographical-spatial concept: Maintains the component of place in the description of the local neighborhood and covers those people who live in a specific geographical location.

D) Ecological concept: In this concept, the local neighborhood is defined as the assimilation of organisms with mutual connections with each other.

Within the skeleton of these notions, the local neighborhood can be split into two categories: local neighborhood based on shared interests and relations, and local neighborhood based on place or geography (Askari, 2005). The neighborhood is considered an example of the creation of a link between the structure and the citizens and the setting. Table 4 shows the concept of neighborhood from the social aspect from the view of experts.

Table 3. Theories related to neighborhood.

No	Author	Research scope	Comments
1	Shokoie (2007)	Neighborhood as a decisive element in organizing people's behavior	The neighborhood is a space that engages a significant share of interactions and activities of the citizens (Shokoie, 2007, p. 48).
2	Barton et al. (2003)	Local community	The concept of the local community is a network of popular communities with shared identities, interests, and theories at the local level that provide the grounds for cognition, opportunity, and mutual support for mutual interaction (Barton et al., 2003, p. 4).
3	Blummer (1985)	Organizing urban neighborhoods	The design and organization of urban neighborhoods are defined based on the development model of the social type, hence reflecting micro or macro approaches (Blummer, 1985)

Table 4. The concept of neighborhood in the social dimension from the perspective of experts (authors based on research findings).

Experts	The concept of neighborhood
(Barton, 2003)	In the social dimension, the neighborhood is a section of the city's space organization in which people's interactions happen face to face and can be described by factors such as administrative communication and social perspectives of residents of the neighborhood.
(Thomlinson, 1976)	To create an urban neighborhood three conditions are necessary: to cover a large or small geographical area of the city, to form a small community of a group of people in the city, and lastly, to have and create interdependence between social groups.
(Schoenberg, 1979)	A neighborhood is a region in which the limited territory is recognizable by its residents, there is more than one institution and organization in its space, and there are numerous nodes of mutual public spaces or social networks.
(Rapoport, 1982)	The neighborhood is viewed as a public place that is used every day by residents.
(Howard, 1957)	Neighborhood as a method to enhance the quality of life of citizens
(Krier et al., 1984)	Neighborhood social dimensions are usually interpreted socially. That is, the locality is no longer feasible or advantageous, and that modern urban life is no more a place for a sense of neighborhood.
(Keyes, 1973)	The creation of urban neighborhood, in turn, can create a powerful sense of neighborhood.

2.6 Sustainable development and sustainable community and improvement of neighborhood social capital

The link between landscape and sustainable development was established by Brandt & Tress's studies and the Roskilde International Conference in 2000 (Brandt et al., 2000). Therefore, sustainable development goals require a harmonious relationship between the needs and aspirations of a society, and achieving a good life must be consistently pursued (United Nations, 2012). The expression "sustainable development" refers to the advancement of the situation. The most prominent feature of a sustainable neighborhood is that it is presented as a "sustainable social-spatial structure" (Roca-Puig, 2019). The physical elements of living environments are an essential part of the setting of human living that provide the conditions for the environment that may increase spatial attachments and the resulting outcomes by satisfying needs (Beery et.al, 2017).

The communication of the inhabitants of the neighborhood greatly impacts the promotion of social capital according to the stated factors. Social capital exists in historical sites as a value in the subset of cultural values. Social capital reflects the various aspects of social organization such as trust, norms, and networks that can improve neighborhood efficiency by facilitating collaboration. As such, social capital provides the opportunity of achieving goals (Putnam, 2001). The elements defined by Putnam for social capital, which are trust, norms, and networks, are maintained by keeping fitting appropriate communication in the neighborhood. such as proper communication of neighbors, recognizing them from each other, and the existing respect (Poursarrajian, 2016).

2.7 Factors influencing the occurrence of social interactions in neighborhood

Four principal factors are more critical in measuring the quality of urban public spaces. These factors are access and communication, mental image and comfort, applications and activities, and social accountability

Table 5. The Impact factors on social interactions (source: authors).

Main factors	The Impact factors on social interactions
The sociability of public spaces	Social events as the enhancer of the relationship between place and the interaction of people in the community
Creating diverse spaces and landscapes	Diverse landscapes involved in the vibrancy of public spaces
Presence and social interaction of individuals	Social interaction as the element improving the security of public spaces
Comfort and convenience of people in space	Physical organization of space as an effective factor in the comfort and convenience of people in public spaces
The optimal mental image of people from space	The visual pleasure of the space as an effective factor in attracting and attending to people

(Project for Public Spaces (PPS), 2009). The influence of factors on social interactions is presented in Table 5.

Empowered by its potential, public spaces present an equal chance for all residents to build and maintain social activities (albeit frail and unstable) in the first place. In the following step, after the first coagulation of social interaction, the differences at the social, economic, and cultural levels that provide various behavioral patterns will pave the way for the establishing of coherent and sustainable social connections (Ghanbaran, 2004).

The two factors of body and anticipation and the formation of social events are prominent in the presence and social interaction of individuals, which is also effective in developing a sense of belonging to the place

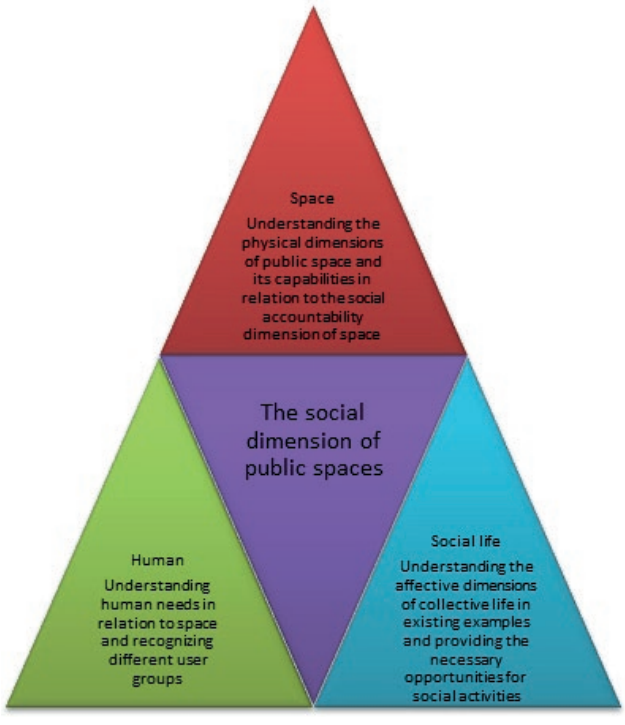


Figure 1. The social dimension triangle of public spaces (authors based on research findings).

(Lennard et.al, 1984). The tranquil atmosphere, natural factors, space privacy, and vehicle control are effective in this regard. Humanity's need for direct contact with the environment reflects the direct experience of space, people, and social activities, including interaction with acquaintances, gathering, walking, games, recreation, sports, physical activities, and the possibility of competition, which have a direct role in creating the desired mental image of people from space, dynamism, and excitement, gaining new experiences and environmental education (Whyte, 1980). Another requirement is to be able to observe and monitor others and the events that are happening, which is one of the decisive factors in the extent of responsiveness of the space (Carr et al., 1992).

Hence, social interactions are more consciously defined with the presence of objects, various kinds of accesses, different applications, and even different types of imaginations in the neighborhood. The social dimension of public places is based on a triangle of human, space, and collective life (Daneshpour et al., 2007). Responding to these dimensions demands attention to the items listed in Figure 1.

2.8 Environmental and cultural landscape perception criteria in historical fabrics

Based on the researches, the perception of the environment for the social sustainability of neighborhood levels is a reciprocating relationship in which humans and perception have a two-way relationship with each other both of which are affected by the social conditions of the society and the environmental conditions of the society, which ultimately leads to a two-way relationship between the perception of the environment and social stability. As a result, each environment has found a specific pattern based on the way people in the society relate to the physical environment and the social structure that governs the space and interacts with humans in a distinctive way. In developing countries, the affecting Factors of sustainable environmental development based

Table 6. The relationship between environmental perception and cultural landscape in historical contexts (source: authors).

	Types of the cultural landscape	Cultural landscape	
Elements	Factors affecting perception	Natural-historical	Artificial-functional
Environmental perception	Cultural values	Historical context as a part of cultural asset	Architecture and urban planning in accordance with local and indigenous values
	Social values	Promoting public participation in maintaining and improving spaces	Paying attention to sexual and age groups and other special groups, Paying attention to the mobility status and the vehicle carrying the audience, Paying attention to the observer's height, Paying attention to the observer's movement or stillness, Paying attention to citizenship or touristic intentions of the observer, Paying attention to the observer's direction, Paying attention to the instance of observation, among others
	Physical values	Use a variety of vegetation for demarcations	Physical continuity with construction in the lands between the bodies
	Identity-related values	The authentic presence of native-natural factors	Body and activity-specific and appropriate to the character of the city, elements, and monuments, etc.
	Intuitive values	Striking the perfect balance between	Hierarchy in the process of construction and activities
	Aesthetic values	Cleanness from various forms of environmental pollution	Making use of local renewable materials
	Subjective values (sensory richness)	Preservation and promotion of ecological elements, especially those with a high sensory richness	Mental disturbance of humans owing to intangible factors such as smell

on traditions, correct cultural, indigenous and natural values, are considered (Naveh, 2007). According to the topic, explaining the relationship between environmental perception and cultural landscape in historical fabrics is presented in Table 6.

When considering social factors in the neighborhood and perception of the environment and landscape, Brown and Werner (1985) associated attachment to place with three factors: 1- Group and individual characteristics of location users; 2- The degree of connection and intimacy of people in the place; and 3- communication in group activities and mass ceremonies (Brown et al., 1985). Increased satisfaction and support of informal communication and communication in social activities, and thus, the development and improved attachment of people to the place due to receiving the desired social space is essential (Erkip, 2010). Sense of belonging is associated with the negation of local and spatial self-alienation and with a sense of tranquillity and satisfaction with the setting. The existence of this sense, on the one hand, causes the individual to act progressively and dynamically in the neighborhood and the environment, and on the other hand, enables the individual to consider the society and the place (neighborhood and city) as their own and to work for its development and advancement. Having a sense of belonging constitutes a partnership, collaboration, and communication among the members of a group and neighborhood (Taghvaei et al., 2009).

Each environment finds a special pattern based on the way people in the society relate to the physical environment and the social structure that governs the space and interacts with humans in a distinct way. Since the aim of this article was to achieve a new approach of environmental perception in the historical context for the social stability of neighborhoods, according to the studies and analyzes presented in this regard, to improve the quality of neighborhood environment perception through subjective perception with the help of perception indicators. Visibility and components of social stability leads to an increase in communication with the environment and a better understanding that the practical result of these indicators and components will increase and continue the social participation of people in the neighborhoods.

3. METHODOLOGY

This research employs a mixed-method approach that includes content analysis and field survey. The theoretical framework of this research has been presented using library documents and archives and through reviewing the academic articles of the relevant literature.

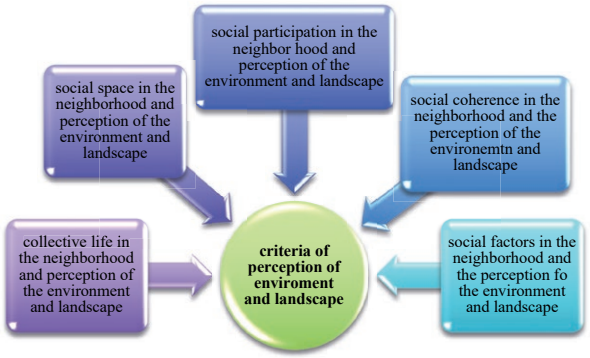


Figure 2. Criteria for perception of the environment and landscape.

It has been by using the content analysis of the shared data between the participants, the localities of the historical context have been investigated. Initially, a set of perspective factors and areas of Cultural Landscape and communication were generated. These factors were then classified in detail, and the content index parts of each were then merged. Ultimately, by analyzing the content of the data, the common data between the people communications, historical neighborhoods, and landscape perception were collected Figure 2.

According to the results achieved and, it was necessary, active experts in the field of Cultural Landscape were used. The survey was conducted employing the Likert scale-based questionnaire method in the scope of the case study (passage of the Baazarche-ye-Fil in Es'hagh Beig neighbourhood (Case A)). Twenty-five experts and 100 citizens familiar with the district were surveyed in order to answer this question. After analysis using the content analysis method, some certain codes were obtained. Based on those codes, the elements that determine the perceived quality of landscapes with Cultural Landscape s from the perspective of experts and residents were determined. Then, by attending the study neighborhood, the problems and deficiencies in the desired pass were recognized they were expressed in the form of five indicators of content analysis, including social factors, social correlation, social communication, social space, and social life. These factors were examined using MAXQDA[1] software, and then the results were assessed in the Halprin cycle (R.S.V.P.)[2]. The Halpirin cycle with the help of MAXQDA software in this article is a new and at the same time effective cognitive method that we have reached the final results with the help of extracting the effective factors in the researched area. One of the solutions is the pathology of the subject under investigation and the various theories of theorists are determined in which groups they are placed in terms of the effective factors extracted through the Halperin cycle. Halperin's cycle is an evaluation method, but so far it has not been used in landscape architecture. In this article, an attempt has been made to use this cycle to evaluate the extracted data. The expected results found their main concept in this research when the Grand Detour method of Max Kyuda software has components that are formed with the help of Halperin's basic theories. With the evaluations carried out in the Halperin cycle, the chart of the effective indicators of landscape perception in the historical context of cultural neighborhoods to achieve social stability has been obtained. This cycle was implemented in four steps: reviewing the resources available to do the job, structured scoring for description, evaluating the collected resources, and finally, assessing the performance of the resource evaluation and scoring. This was inspired by the evaluation process of Chengzhi Peng's (1994) article, "The Discovery of Participatory Design Communications: Collaboration of Architectural Modeling". Based on the appraisals, a chart of the effective indicators of landscape perception in the Cultural Landscape of neighborhoods to achieve social sustainability was created. Figure 3 displays the method and steps of the research.

3.1 Case study

Eshagh Beig neighborhood: Shiraz is one of the five largest cities in Iran and the capital of Fars province (Abdullahi, 2015). The Es'hagh Beig neighborhood: is one of the historical neighborhoods of Shiraz. In the current

[1] One of the most important and efficient tools for data analysis in this research is thematic analysis, and its tool is the use of MAXQDA qualitative data analysis software; the first version of this software was published in 1989 and currently The following programs are for qualitative data analysis around the world, which are used to create and test theoretical frameworks and draw conclusions from the analysis of various qualitative data. The application is designed for iPhone phones and was launched on the market in February 2014. In addition to being usable in a wide range of fields, this software provides users with the ability to work with text, audio, image and photo data in various formats. brings (MAXQDA, 201:online).

[2] One of the measurement and evaluation methods in landscape architecture and urban planning is the P.V.S.R model, which was formed in the 1970s. A review of the literature and experiences in this field shows that the main reasons for the emergence of this model by Lawrence Halperin are to make trends visible, establish communication and also ensure the diversity, pluralism and participation necessary for growth, change, especially in large-scale projects, as well as the ability Measurement and evaluation of all environmental events in tandem until reaching the product is through the cycle of four components. In this model, the four main components R, S, V and P are considered as the main components forming the cycle. The relationship and order between the components determines the type of process that can perform the best performance of the model.

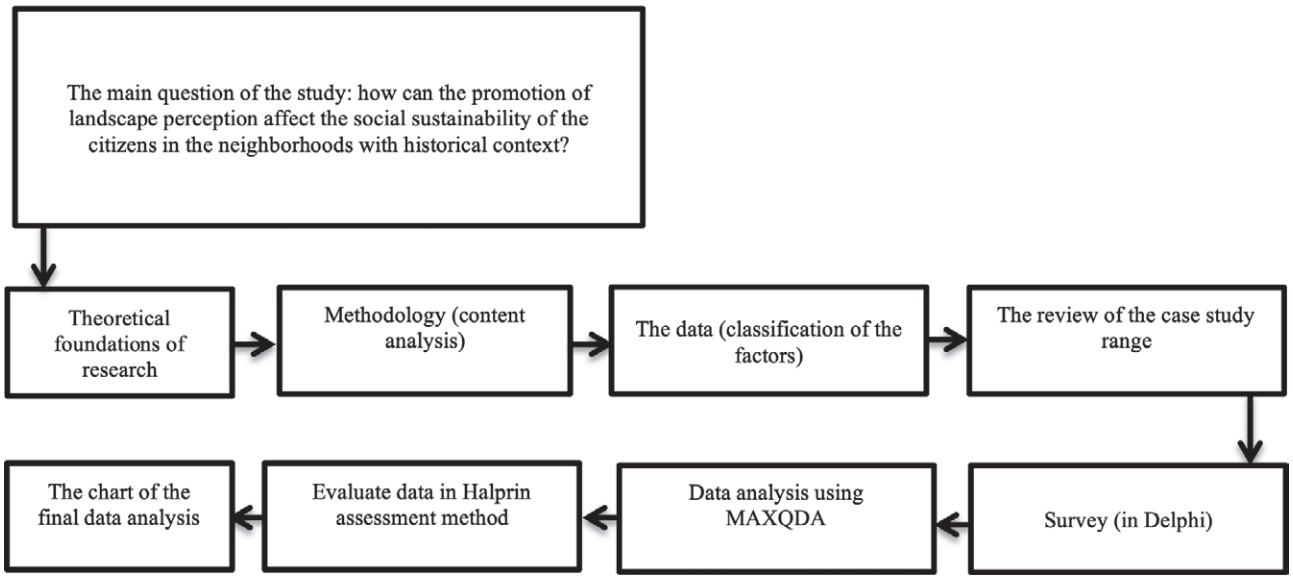


Figure 3. Research Methodology Framework (Authors).

Figure 4. The passage of the *Baazarche-ye-Fil* in Es'hagh Beig neighborhood (CaseA) and the index-oriented historical buildings (marked on the Tavassoli map).

Figure 5. The passage of the *Baazarche-ye-Fill* (Case A).

situation, this neighborhood has passages and corridors that are considered part of the physical skeleton of the historical city of Shiraz (Figure 4 and Figure 5).

One of the historical routes in the Es'hagh Beig neighborhood is the "*Baazarche-ye-Fil* passage" (Case A) (Figure 5). Along this passage, valuable historical buildings have been built, most of which are evocative of the Qajar era. According to Figure 3, each of the applications along the passage (baths, mosques, and schools), once active and sustainable social centers, have now been demolished or are governed by the Cultural Heritage organization. These applications have virtually lost their prominent role in cultural landscape perception through communication in neighborhood sustainability.

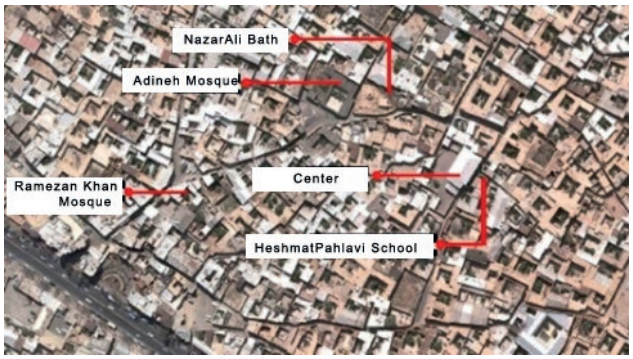


Figure 6. Active and stable social centers along the *Baazarche-ye-Fil* passage (Case A).

After surveying using the questionnaire method, different problems and issues were raised about the market, which are the products of the decline of the socio-cultural quality level of the span. The presence of addicts and criminals, the conversion of residential applications into warehouses, visual signs disturbing the environment, and the establishment of unsupervised restaurant use in the neighborhood, the conversion of active social applications to ruins, and conversion of the current route in the center of city (bazaar) into a parking lot are among the most critical problems in this area. Table 8 presents the marks of social instability on the *Fil* route (bazaar) in the Es'hagh Beig neighbourhood (Case A), together with corresponding images (Table 7 and Table 8).

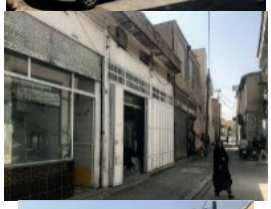
Sang-e-Siah neighborhood: In 2013, the city of Shiraz was divided into ten regions, encompassing an area of 19,322 hectares, of which the Sangeh Siah neighborhood is located in the historical context of this city (Setavand et al., 2019). Sang-e-Siah neighborhood is among the historical neighborhoods of Shiraz. Sang-e-Siah and Sardozak neighborhoods are situated in the western part of the Cultural Landscape (Figure 7 and Figure 8).

One of the historical passages, located in the eastern part of Sang-e-Siah neighborhood and the western section of Sardozak neighborhood, is acknowledged as "Haj Zeinel Passage" (Case B) (Figure 5). In fact, this passage was part of the *Alamdaar* historical passage. Alamdaar route had a religious function and was the access between the two prominent gates of the city, namely *Kazerun* Gate and *Qasbehkhaneh* Gate. After the widening of Ahmadi Street, the role of Alamdaar Passage in the area has declined and has split into two lanes. The northern part of this passage is called the "Haj Zeinel

Table 7. Signs of social instability in the historical context of Shiraz.

Fil Bazaar in the Eshagh Beig Neighborhood (Case A)		Haj Zainal passage in the Sange-e Siah and Sardazak neighborhood (Case B)	
Factors and places studied	Effective factor hindering social sustainability	Factors and places studied	Effective factor hindering social sustainability
The current center of the passage (bazaar, car park lot)	Lacking collective life	The active and functional role of mosques, reservoirs, and tombs in the past	Lack of social coherence
Connection to one of the local accesses (outdoor)	Lacking social interactions	Cars in the pedestrian passage	Diminishing social elements
Establishment of a restaurant without supervision in the neighborhood (presence of clients' cars)	Diminishing social elements	Visual cues disturbing the environment	Lack of desire for collective life to improve the environment
Nazar Ali Bath (derelict)	Loss of social space	Constructing new building incongruent with the rest of the passage in terms of height	Lack of sense belonging to the space
Visual cues disturbing the environment	Lack of desire for collective life to improve the environment	Connection to one of the local accesses (outdoor)	Lacking social interactions
Turning residential applications into warehouses	Destruction of human living space	Incomplete destruction of the old bath to disband drug seller	Loss of social space
The prominent role of Saqakhaneh in the participation and stability of the neighborhood in the past	Lack of social participation	Unused open spaces	Lack of desire for collective life to improve the environment
The active and functional role of mosques in the past	Lack of social coherence	Presence of addicts and criminals	Diminishing social elements
Presence of addicts and criminals	Diminishing social elements	*	*

Table 8. Signs of social instability in the Es'hagh Beig neighbourhood.

The current passage center (bazaar) (car park) (No collective life)	
Connection to one of the local branches (outdoor) (No social interactions)	
Establishment of unsupervised restaurant application in the neighborhood (presence of the customers' cars) (Weakness of appropriate social factors)	
Nazar Ali Bath (Ruined) (Loss of social space)	
Visual signs disturbing the environment (Lack of propensity to collective life to improve the setting)	
Conversion of residential applications into warehouses (Among social instability factors of the neighborhood)	
The prominent role of Saqakhaneh (public drinking place) in the community communication and sustainability in the past (No social communication)	
The active and functional role of mosques in the past (No social correlation)	
The presence of addicts and criminals (Weakness of proper social factors)	

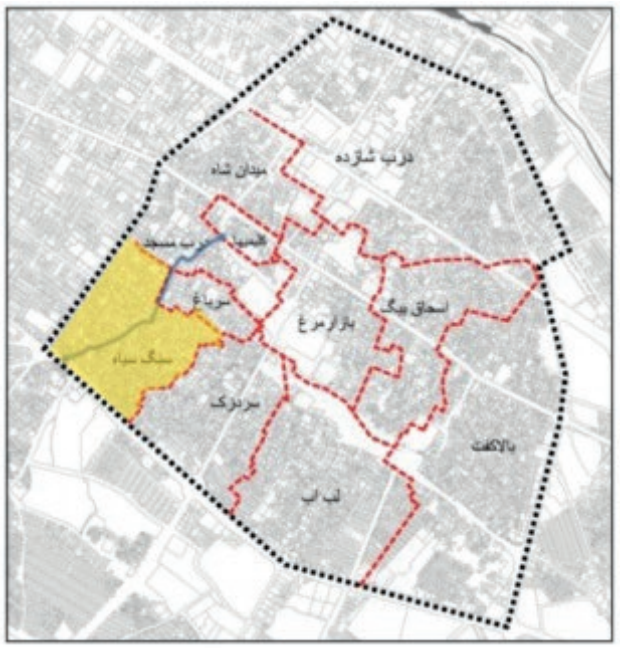


Figure 7. The span of Sang-e-Siah neighborhood in the old fabric of Shiraz (marked on the Tavassoli map).

Figure 8. Haj Zeinel's passage in Sang-e-Siah and Sardozak neighborhoods(CaseB) in the old fabric of Shiraz.

Passage" (Case B). Each of the facilities along the passage (baths, mosques, and schools), once active and sustainable social centers, have now been demolished or are governed by the Cultural Heritage organization. These applications have virtually lost their prominent role in landscape perception through communication in community sustainability (Figure 6).

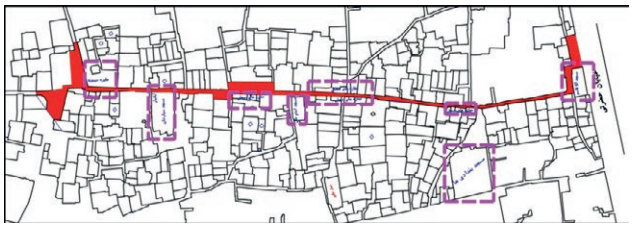


Figure 9. Active and stable social centers of the "Haj Zeinel Passage" (Case B).

Religious places have been active in the application level of the neighborhood and have kept their connection with different social strata. The most significant reasons for the activity of this passage is the existence of small commercial shops, the proximity of the residential area, and the long acquaintance with the people who attend to it. Consequently, if the neighborhood was divided up based on the mosques and commercial shops in it, the inhabitants of each area prefer to be close to the nearest mosque. But sadly, the functional and social role of mosques has declined. One of the reasons for the decline in social communications is the decline in the security function of security at the neighborhood level.

The survey using the questionnaire technique, revealed many problems and issues with the "Haj Zeinel Passage" (Case B) that is the outcome of the decline of the socio-cultural quality level of this span. The presence of addicts and criminals and visual signs disturbing the environment are the most fundamental problems of this passage. Table 9 shows the marks of social instability in the "Haj Zeinel Passage" in Sang-e-Siah neighborhood (Case B) parallel with the corresponding images (Table 9).

The following table presents strategies and policies extracted from the interaction of environmental perception in the cultural landscape in two historical passages of Haj Zainal (Case B) and Fil Bazaar (Case A) in the old texture of Shiraz to offer in-depth knowledge of the relationship between environmental perceptions and cultural landscape (Figure 7).

3.2 Analysis of Indicators of cultural landscapes of Fil Bazaar (Case A) Haj Zainal (Case B) and in the Old texture of Shiraz

According to the urban-historical view, nature, society, and culture go hand in historical cities, hence making up an intertwined layer of diverse and sometimes contradictory values that have received less attention in conservation-based approaches in the last century. Due to the disregard for heritage (cultural) landscapes, visual disturbances resulting from the absence of related laws

Table 9. Marks of social instability in the "Haj Zeinel Passage" in Sang-e-Siah and Sardozak neighborhoods (Case B).

The active and functional role of mosques, water reservoirs and tombs in the past (No social solidarity)		Connection to one of the local branches (outdoor) (No social interactions)	
The presence of cars on the sidewalk (weakness of appropriate social factors)		Unsuccessful demolition of a dilapidated bathroom to reduce the gathering place of drug dealers (Loss of social space)	
Visual signs disturbing the environment (Lack of propensity to social life to improve the setting)		Open space unused (Lack of propensity to social life to improve the setting)	
Develop a new architecture with a height inconsistent with the passage		The presence of addicts and criminals (Weakness of appropriate social factors)	

are becoming increasingly prevalent. The following table presents the main indicators for identifying the cultural landscape in the historical passage of Haj Zainal (Case B) and Fil Bazaar (Case A) in the old textures of Shiraz (Table 10).

Considering the cases stated in the factors of social sustainability through communication, by attending this historical lane ("Haj Zeinel Passage" (Case B)), Halprin's evaluation was performed. Considering the commercial application of this passage, such as supermarket, bakery, mosque, cistern, fast food, and tailor's shop, it is feasible to create beneficial behavior sitting by decorating the green space with public activities like showing movies with projectors, organizing shop signs, and turning the whole

Figure 10. Active and stable social centers of the "Haj Zeinel Passage" (Case B).

passage into commercial stores relevant to the fabric. By organizing these activities, people's communication should improve, and the environment should flourish.

3.3 Analysis of research findings

From the conclusion of quality criteria for the perception of public spaces considered by experts, a set of elements and criteria were obtained. By generalizing them to local levels, we also established criteria on a local scale and per specific perceptual characteristics at the level of neighborhoods of the Cultural Landscape in cities (Table 11). The results of theorizing about the qualitative criteria of landscape perception in neighborhoods are summarized in the Table 11.

In the present study, to discover the opinions of experts with respect to the perception of landscape in the historical neighborhood (*Baazarche-ye-Fil* route in Es'hagh Beig neighborhood of Shiraz (Case A)) with the help of communication, the survey technique was used. The type of questions is usually illustrated. It should be noted that in the questionnaire section, five components that were extracted from the literature of the subject were selected, analyzed and evaluated after the survey. These five components include social factors, social correlation, social communication, social space, and social life. This process was analyzed with the help of MAXQDA software in five steps: 1- Coding and continuous adjustment of concepts, 2- Discovering the existing relationships between categories, 3- Summarizing and concluding the interviews, 4- Breaking the codes and identifying the lanes, and 5- Re-evaluating the data within the emerging theory. Finally, the criteria of environmental perception in a cultural landscape in the neighborhoods of the historical context are presented in Figure 2. Ultimately, the degree of people's communication in social sustainability was examined by using a questionnaire with the help of MAXQDA quality software and displayed in diagram 3 and 4. Furthermore, the extent of compliance of experts in this field with the status of the *Baazarche-ye-Fil* route in Es'hagh Beig neighbourhood (Case A) and "Haj Zeinel Passage" in Sang-e-Siah

Table 10. Environmental perception of the historical passage of Haj Zeinel (Case B) and Fil Bazaar (Case A) by the observer through indicators of the cultural landscape.

Heritage-related elements of the passage (Cultural landscape indicators)	Cultural landscape Artificial/functional	Historical passage of Haj Zainal (Case B) in the old context of Shiraz	Historical passage of the Fil Bazaar (Case A) in the old context of Shiraz
Commemorative	Exhibiting the principles of local architecture in the construction	Baghdadi, Siavushun, and Imam Ali mosques	Adineh Mosque
Cultural	Architecture and urban planning in accordance with the values of traditional architectural texture	Tomb of Sibouyeh the Poet	Heshmat Pahlavi School
Social / Popular	Establishment of exhibitions and handicraft workshops	Behavioral camp and gathering of people in the bazaar of the middle of the passage	Behavioral camp and gathering of people in the bazaar of the beginning of the passage
Historical	Existence of historical monuments	Reservoir of Siavushun Mosque	Nazar Ali Bath
Physical elements	Physical continuity by reviving the abandoned building between the bodies	Variety of functions and applications in the vicinity to each other	Variety of functions and applications in the vicinity to each other
Intangible – sensory depth	The smell of old-fashioned Sangak bread and the smell of sweets from old-style confectionery workshops	The smell of old-fashioned Sangak bread	The smell of old-fashioned sweets
Memory-inducing elements		Faloodeh Shops of the bazaar of the middle of the passage	Old murals in the bazaar of the beginning of the passage

Table 11. Effective criteria in the perception of the urban landscape and historical sites in terms of social sustainability.

Theorists	Qualitative indicators	Effective criteria	Findings
Brown and Werner (1985)	Social factors	1. Group and individual features of location users. 2. The level of contact and intimacy of people in the place. 3. Communication in group activities and mass ceremonies.	1- Increased satisfaction and encouraged informal communication and communication in social activities. 2- Cause of development and improvement of attachment to place.
Alvaani and Seyed Naghavi (2003)	Social correlation	Local-scale: Individual relationships and communication networks between individuals and prevailing informal norms and values. Minor scale: Local groups and institutions such as associations, clubs and popular organizations, social and cultural characteristics of the residents of a neighborhood.	3- The extent and severity of neighborhoods, the existence of formal and informal social networks in the neighborhood, causes public communication in the neighborhood and social trust among the people of the neighborhood 2- Social cohesion is one of the main components of social capital. 3- Social capital is the driving force for moving towards sustainable development.
Carmona et al. (2003)	Social communication	Communication in the process by which a person voluntarily engages in social activity through a sense of belonging to a group and active and voluntary communication. Some experts have looked at the definition and analysis of communication from a macro perspective.	1- Active communication of individuals in political, economic and cultural life and in general all aspects of life. 2- The increasing impact of this on local levels and citizens' communication of the quality of the environment.
Carmona et al. (2003)	Social space	Social relationships can be formed in space and threatened by the shape of space.	1- Dynamic interaction, information exchange, gaining environmental experiences, the possibility of creative expression of individuals and groups. 2- Increasing the sense of social correlation and as a result more satisfaction.
Whyte (1980)	Social life	An opportunity to get rid of the stresses of everyday life, to spend leisure time, social interactions and gatherings of different individuals and groups, and a platform for presence, freedom of speech, and their tools in space.	Social interaction and communication, physical subject, one look, one conversation and communication between people.

and Sardozak neighborhood of Shiraz (Case B) regarding social sustainability was analyzed by survey with the help of MAXQDA quality software.

Next, to examine the perception of the landscape along the *Baazarche-ye-Fil* route in Es'hagh Beig neighborhood in the Cultural Landscape of Shiraz (Case A), based on the available data, the evaluation of the Halprin (R.S.V.P.) participatory model was used. This appraisal was carried out in four steps: 1- Resources (R): Means the resources available to do the job. Resources refer to data about space, time, ideas, intentions, and manpower in terms of people`s mental abilities that can be used to produce new ideas. 2- Scores (S): Means rating a framework for describing, analyzing, ranking the needs and ideas, and the outcomes of public decision-making. 3-Valuation (V): Means the process of social sustainability of urban neighborhoods dynamically in response to requirements and needs and based on preferences. This stage included analyzing the results of activities, possible choices, and decision making. 4- Performance (P): Lastly, in this step, the results gathered from resource valuation and rating were executed. Next, the operational determinants of landscape perception regarding the social sustainability of available resources were presented (Figure 13 and Figure 14).

4. CONCLUSION

By relying on the results of theoretical foundations and field studies performed on the *Baazarche-ye-Fil* route in Es'hagh Beig neighborhood in the Cultural Landscape of Shiraz (Case A), social sustainability was assessed with the aid of landscape quality evaluation. The authors considered that focusing on urban landscape perception would be useful in strengthening people's communication and thus elevating social sustainability. Employing the Halprin cycle further shows that factors such as social factors, social correlation, social communication, social space, and social life are effective in accomplish-

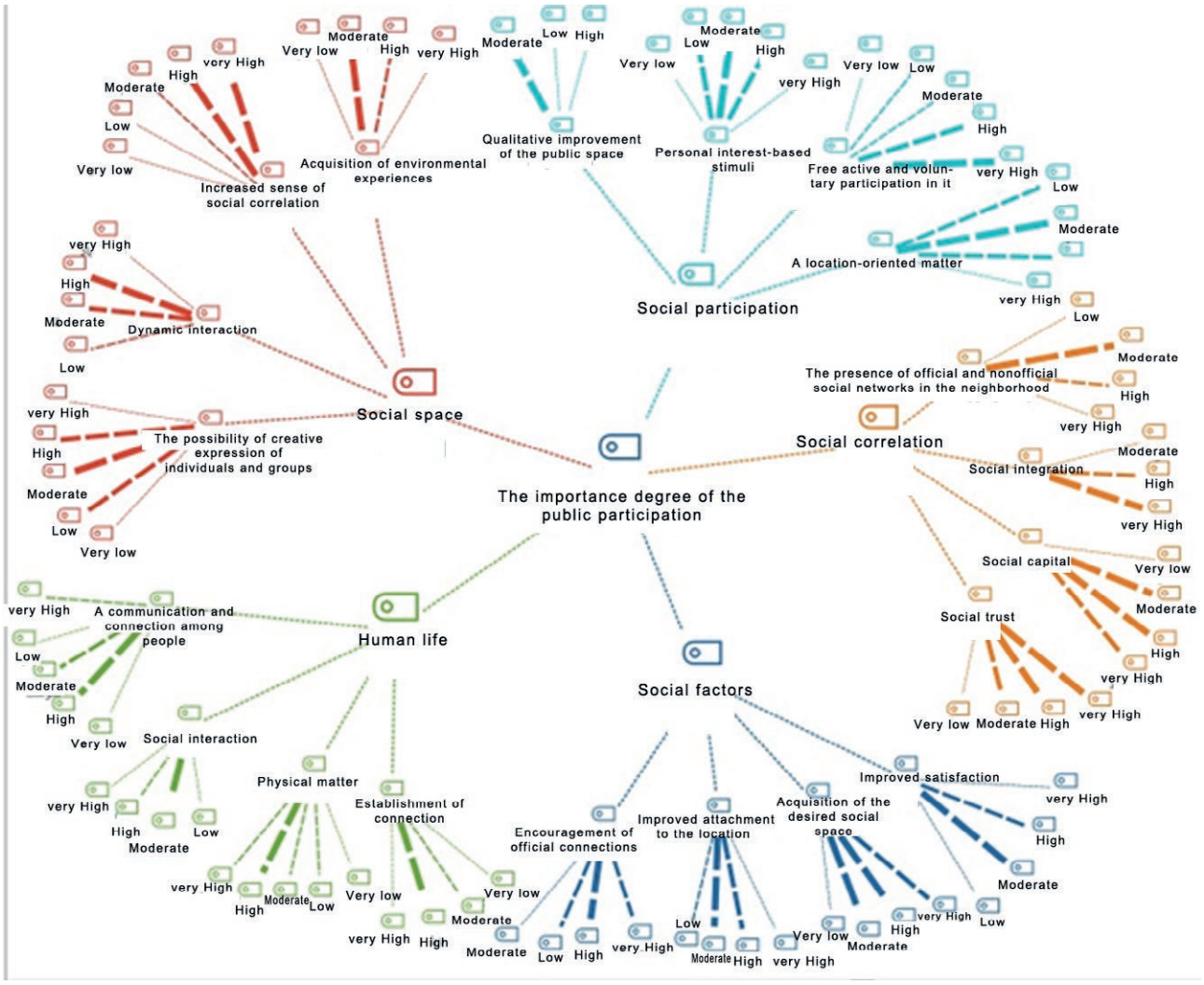


Figure 11. The degree of people's communication in social sustainability through a questionnaire and analysis with the help of MAXQDA quality software.

ing social stability. Resident communication is the tie between urban landscape perception and neighborhood social sustainability and presents sustainable development through the concepts of social life, space, socialization, and human behavior. That is, social revitalization of a neighborhood or lane in the city will lead to enhanced quality of relationships between people in that neighborhood or passage by promoting sustainability, and this will create higher communication of inhabitants. To this end, the urban landscape perception by encouraging the communication and interaction of residents improves social relations and the social stability of neighborhoods.

After examining and analyzing landscape perception in Cultural Landscape spaces, the data diagram collected from the research was plotted and presented. According to these data, qualitative indicators and urban landscape perception criteria affecting social sustainability in historical sites were identified. These indicators and criteria are divided into five parts: social factors, social correlation, social communication, social space, and social life. Based on theories of theorists, the Halprin (R.S.V.P) participatory model was adopted. After analyzing the data, the connection between Halprin's cycle evaluation model and urban landscape perception in Cultural Landscape neighborhoods in terms of social sustainability is presented in Figure 15.

Neighborhoods emerge following a particular function to respond to specific behavioral patterns.

They transform under the influence of changes in habitat and behavioral patterns and take on a new form

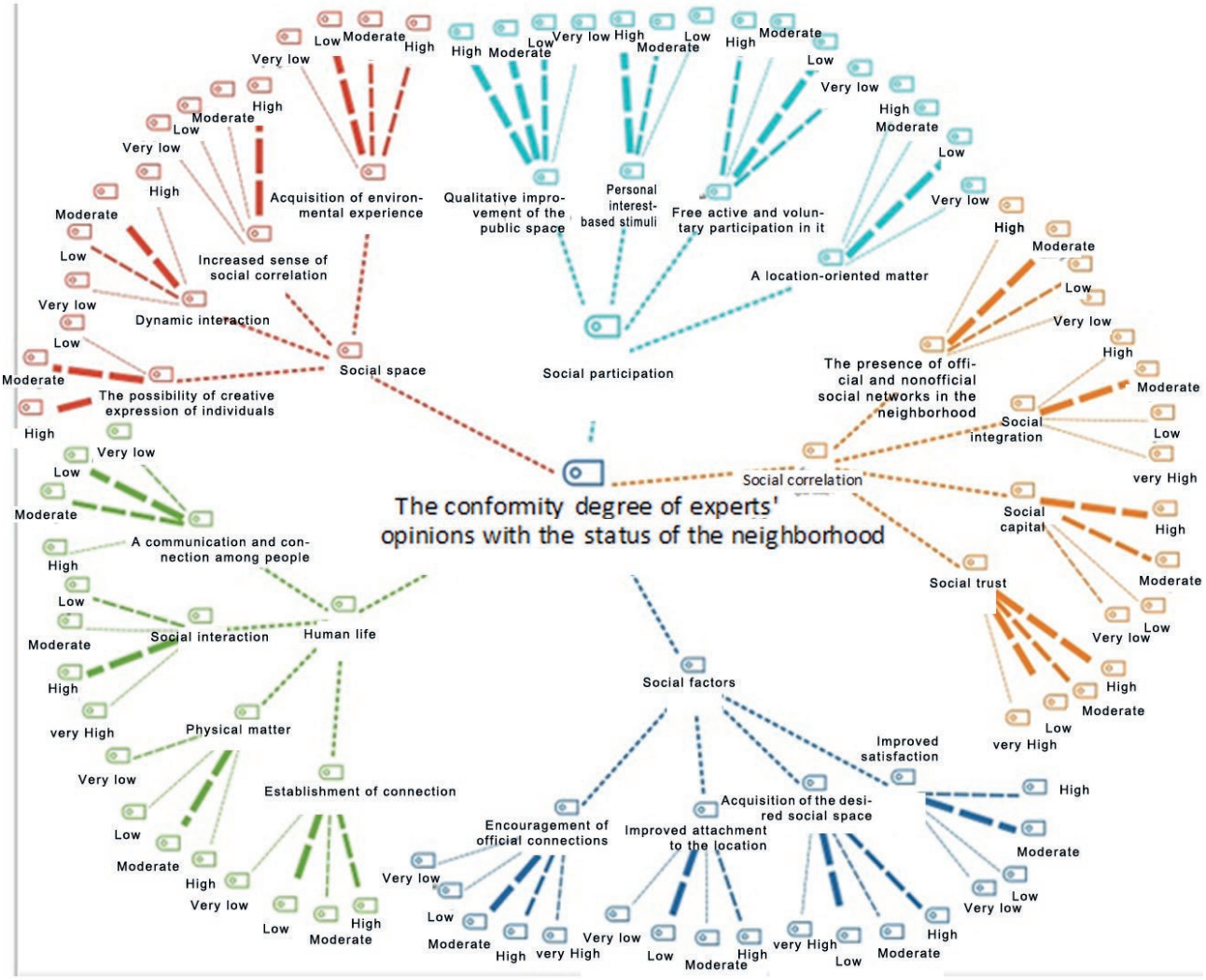
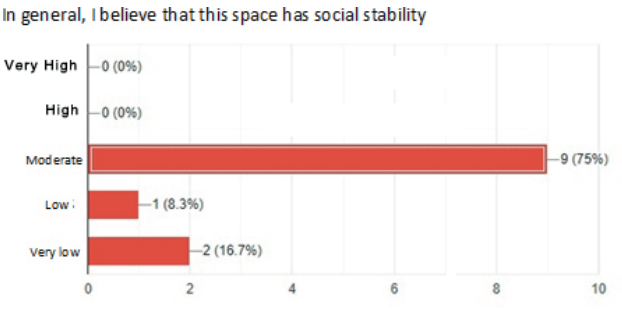


Figure 12. The extent of compliance of experts in this field with the status of the *Baazarche-ye-Fil* route in Es'hagh Beig neighbourhood (Case A) and "Haj Zeinel Passage" in Sang-e-Siah and Sardozak neighborhoods of Shiraz (Case B) regarding social sustainability was analyzed by survey with the help of MAXQDA quality software.



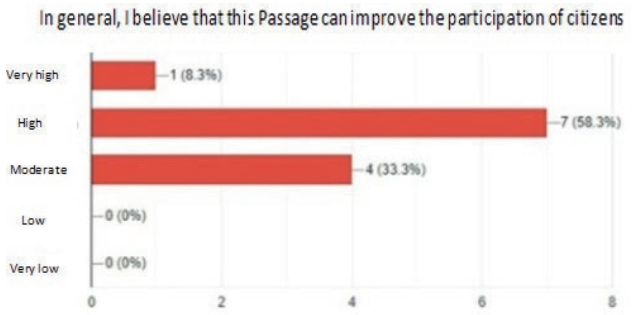


Figure 13 and **Figure 14**. The operational determinants of landscape perception regarding the social sustainability.

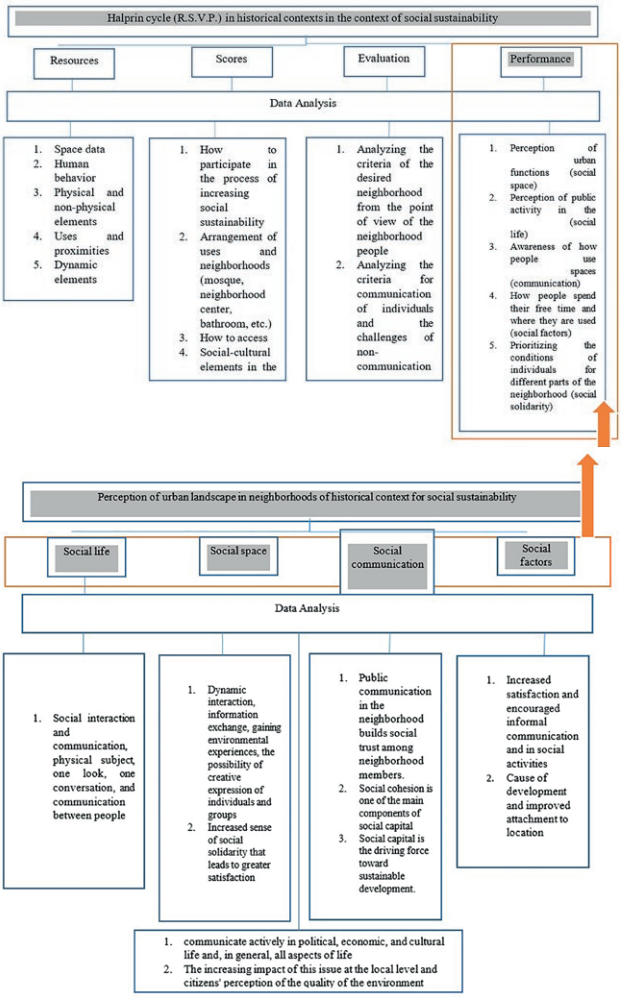


Figure 15. The connection between Halprin's cycle evaluation model and urban landscape perception in Cultural Landscape neighborhoods in terms of social sustainability.

in proportion to these changes. In this respect, the constituent elements and factors of the neighborhood should be established in such a way that they can provide the space for interaction between the masses and the space and perception of the residents. Residents must further be able to perceive a continuous flow of collective and homogeneous experiences when moving in the space between elements. Given the two-way connection that exists between perception and perspective, a linking factor is needed to obtain a two-way relationship between people and interactions. This factor is the communication of the citizens (derived from the performance of the Halprin cycle in Figure (15). Figure (16) shows Citizen communication is the connection

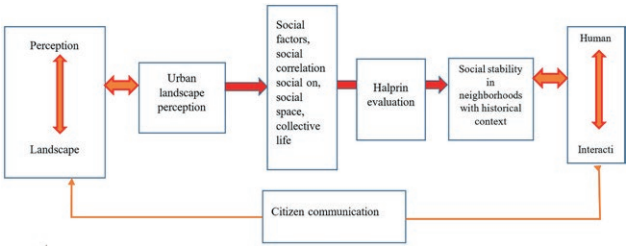


Figure 16. Citizen communication is the connection between urban landscape perception and neighborhood social sustainability.

between urban landscape perception and neighborhood social sustainability

REFERENCES

Abdullahi, A. A. (2015). Survey and evaluation of land use in 9 areas of Shiraz using LQ model in GIS environment. *Spatial Planning*, 5(1), 63–82.

Alvaani, S. M., & Seyed Naghavi, M. (2017). The balanced scorecard model: a pattern of performance management in public sectors. *Management Studies in Development and Evolution*, 10(37.38), 3–18.

Araoz, G. F. (2008). World-heritage historic urban landscapes: defining and protecting authenticity. *APT bulletin*, 39(2/3), 33–37.

Askari, A. (2005). Fundamental and identify type of local community development theory. *First Conference of Community Development Perspective of Tehran Sustainable Development*. Tehran, Municipality Publisher.

Azari-Dehkordi, F. (2011). Introducing Geo-Cultural Landscapes in Iran. In Hong, S. K., Kim, J. E., Wu, J., & Nakagoshi, N. (Eds.). *Landscape Ecology in Asian Cultures*. Ecological Research Monographs. Tokyo, Springer.

Barton, H., Grant, M., & Guise, R. (2003). *Shaping neighbourhoods: a guide for health, sustainability and vitality*. London, Routledge.

Beery, T., & Jönsson, K. I. (2017). Outdoor recreation and place attachment: exploring the potential of outdoor recreation within a UNESCO Biosphere Reserve. *Journal of Outdoor Recreation and Tourism*, 17, 54–63.

Black, P., & Street, E. (2014). The power of perceptions: exploring the role of urban design in cycling behaviours and healthy ageing. *Transportation Research Procedia*, 4, 68–79.

Blummer, M. (1985). The rejuvenation of community studies? Neighbour, networks and policy context. *The Sociological Review*, 33(3), 430–448.

Brandt, J., Tress, B., & Tress, G. (2000). Multifunctional landscapes: interdisciplinary approaches to landscape research and management. Conference Material for the International Conference on "Multifunctional Landscapes, Interdisciplinary Approaches to Landscape Research and Management," Centre for Landscape Research, University of Roskilde, Denmark, October 18–21, 2000.

Brown, B. B., & Werner, C. M. (1985). Social cohesiveness, territoriality, and holiday decorations: the influence of cul-de-sacs. *Environment and behavior,* 17(5), 539–565.

Carmona, M., Heath, T., Oc, T., & Tiestess, S. (2003). *Public place and urban space*. London, Architectural Press.

Carmona, M., Heath, T., Tiesdell, S., & Oc, T. (2010). *Public places, urban spaces: the dimensions of urban design*. New York, Routledge.

Carr, S., Francis, M., Rivlin, L. G., & Stone, A. M. (1992). *Public space*. New York, Cambridge University Press.

Carreno, M. A. (2006). Buffer zones as a tool for protecting world heritage sites: the case of the heritage routes, Paper presented at The World Heritage Convention and the Buffer Zone ICOMOS Symposium, Hiroshima, Japan.

Crow, T., Brown, T., & De Young, R. (2006). The Riverside and Berwyn experience: Contrasts in landscape structure, perceptions of the urban landscape, and their effects on people. *Landscape and Urban Planning*, 75(3-4), 282–299.

Cullen, G. (1995). *The concise townscape*. London, Routledge.

Daneshpour, A., & Charkhchyan, M. (2007). Public spaces and factors affecting collective life. *The Monthly Scientific Journal of Bagh-E Nazar*, 4(7), 19–28.

Duany, A., & Plater-Zyberk, E. (1991). Towns and town-making principles. New York, Rizzoli.

Erkip, F. (2010). Community and neighborhood relations in Ankara: an urban–suburban contrast. *Cities,* 27(2), 96–102.

Gehl, J. (1987). *Life between buildings: using public space*. New York, Van Nostrand Reinhold .

Ghanbaran, A. H. (2004). Iranischer Basar im Wandel, Stuttgart. Publication Server of the University of Stuttgart.

Golkar, K. (2006). The concept of urban landscape. *Abadi Magazine*, 38–47.

Habibi, S. M. (2006). *Az Shar ta Shahr (de la Cite a la Ville)*. Tehran, University of Tehran Press.

Hill, R., Cullen-Unsworth, L. C., Talbot, L. D., & McIntyre-Tamwoy, S. (2011). Empowering Indigenous peoples' biocultural diversity through World Heritage cultural landscapes: a case study from the Australian humid tropical forests. *International Journal of Heritage Studies*, 17(6), 571–591.

Hutchinson, F. P., & Herborn, P. J. (2012). Landscapes for peace: a case study of active learning about urban environments and the future. *Futures*, 44(1), 24–35.

Jacobs, J. (1961). The death and life of great American cities. Ney York, Randoms House.

Kaya, N., & Weber, M. J. (2003). Cross-cultural differences in the perception of crowding and privacy regulation: American and Turkish students. *Journal of Environmental Psychology*, 23(3), 301–309.

Khorasani, H. B. (2020). Indicators of Heritage Sites and Cultural Landscape in historical context – a case study of Oudlajan historical context. *Quarterly Journal of Preservation of Historical Textures*, 64, 1.

Krier, L., & Porphyrios, D. (1984). Léon Krier, houses, palaces, cities. London, Architectural Design AD Editions.

Lai, L. Y., Said, I., & Kubota, A. (2013). The roles of cultural spaces in Malaysia's historic towns: the case of Kuala Dungun and Taiping. *Procedia-Social and Behavioral Sciences*, 85, 602–625.

Lefebvre, H. (2004). *Rhythmanalysis: Space, time and everyday life*. London, Continuum.

Lennard, S. H. C., & Lennard, H. L. (1984). *Public life in urban places: social and architectural characteristics conducive to public life in European cities*. South Hampton, Gondolier Press.

Lindholm, G. (2012). Visible Gestures': On urban landscape perspectives in planning. *Planning Theory,* 11(1), 5–19.

Lynch, K. (1960). The image of the environment. *The image of the city*, 11, 1–13.

Loukaitou-Sideris, A., & Banerjee, T. (1998). *Urban design downtown: poetics and politics of form*. Berkeley, University of California Press.

Low, S. M. (1981). Social science methods in landscape architecture design. *Landscape Planning*, 8(2), 137–148.

Mahjoor, F., & Khaledian, S. (2014). Historical texture of Tehran, turning threats into opportunities. *Human Geographical Research*, 46(1), 103–124.

Mansouri, S. A. (2005). An introduction to landscape architecture identification. *The Monthly Scientific*
Journal of Bagh-e Nazar, 1(2), 69–78.

Moulay, A., Ujang, N., Maulan, S., & Ismail, S. (2018). Understanding the process of parks' attachment: interrelation between place attachment, behavioural tendencies, and the use of public place. *City, Culture and Society*, 14, 28–36.

Nohl, W. (2001). Sustainable landscape use and aesthetic perception—preliminary reflections on future land-

scape aesthetics. *Landscape and Urban Planning*, 54(1-4), 223–237.

Norman, B. (2011). Regional Environmental Governance: Interdisciplinary Perspectives, Theoretical Issues, Comparative Designs (REGov). *Procedia, Social and Behavioral Sciences,* 14, 193–202.

Pakzad, J. (2006). Theoretical foundations and urban design process. Tehran, Shahidi Publications.

Peng, C. (1994). Exploring communication in collaborative design: co-operative architectural modelling. *Design Studies*, 15(1), 19–44.

Piran, P. (2005). Identity of Cities, Chirping for a Complex Concept. *Abadi Journal*, 48, 56–92.

Poursarrajian, M. (2016). Values of historical neighborhood and criteria of change according to residents. *The Monthly Scientific Journal of Bagh-e Nazar*, 12(35), 39–52.

Prabowo, B. N. (2020). Historic urban landscape (HUL) approach in Kota Lama Semarang: mapping the layer of physical development through the chronological history. In *IOP Conference Series: Earth and Environmental Science* (Vol. 402, p. 012020). IOP Publishing.

Project for Public Spaces (PPS) (2009). What Makes a Successful Place? Available at: https://www.pps.org/article/grplacefeat (Accessed 27 May, 2020).

Putnam, R. (2001). Social capital: measurement and consequences. *Canadian Journal of Policy Research*, 2(1), 41–51.

Rapoport, A. (1982). *The meaning of the built environment*. Beverley Hills, Sage Publications.

Roca-Puig, V. (2019). The circular path of social sustainability: An empirical analysis. *Journal of Cleaner Production,* 212, 916–924.

Rössler, M. (2006). World heritage cultural landscapes: a UNESCO flagship programme 1992-2006. *Landscape Research,* 31(4), 333–353.

Schoenberg, S. P. (1979). Criteria for the evaluation of neighborhood viability in working class and low income areas in core cities. *Social Problems*, 27(1), 69–78.

Setavand, M. H., Hajizadeh, F., & Yaghfoori, H. (2019). Spatial analysis of Shiraz urban areas in terms of social justice with an emphasis on public services. *Journal of Applied Researches in Geographical Sciences*, 19(52), 171–192 .

Sharan, S. (2005). A Guide to Recognition and Intervention in Worn Worntureof Iran (case study: Isfahan, Dardasht). *Journal of Urban Management*, 31, 81–64.

Shokoie, H. (2007). New perspectives in urban geography (first volume). Tehran, Samt Organization.

Silva, K. (2019). *The Routledge Handbook on Historic Urban Landscapes in the Asia-Pacific*. New York, Routledge.

Taghvaei, A. A., & Maroufi, S. (2009). Evaluation of the role of mosques in improve the quality of urban environment; case study: Amir Mosque in Tehran. *Journal of Urban Management*, 8(25), 219–34.

Thomlinson, R. (1976). *Population dynamics: causes and consequences of world demographic change*. New York, Random House.

Türkyılmaz, Ç. C. (2016). Interrelated values of cultural landscapes of human settlements: case of Istanbul. *Procedia-Social and Behavioral Sciences,* 222, 502–509.

Turner, J. F. C. (1977). *Housing by people: towards autonomy in building environments*. New York, Pantheon.

Turner, J. F. C., & Fichter, R. (1972). *Freedom to build: dweller control of the housing process*. New York, Macmillan Company.

UNESCO (1972). Convention Concerning the Protection of the World Cultural and Natural Heritage. Adopted by the General Conference at its seventeenth session. Paris, 16 november 1972

UNESCO (2008). Operational Guidelines for the Implementation of the World Heritage Convention. UNESCO World Heritage Centre, Paris, France.

United Nations (2012). The future we want. Outcome document of the United Nations Conference on Sustainable Development. Rio de Janeiro, Brazil, 20–22 June 2012

Wang, S., & Gu, K. (2020). Pingyao: the historic urban landscape and planning for heritage-led urban changes. *Cities*, 97, 102489.

Whyte, W. H. (1980). *The social life of small urban spaces*. Washington, The Conservation Foundation.

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A CURA DI NICOLA LUCIFERO

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AGRICOLTURA

CGUE, 15/12/2022, C-23/22, *Caxamar – Comércio e Indústria de Bacalhau SA c. Autoridade Tributária e Aduaneira*
Rinvio pregiudiziale – Aiuti di Stato – Regolamento (UE) n. 651/2014 – Esenzione di alcune categorie di aiuti compatibili con il mercato interno – Orientamenti in materia di aiuti di Stato a finalità regionale – Ambito di applicazione – Esclusioni – Settore della pesca e dell'acquacultura – Settore della trasformazione e commercializzazione di prodotti agricoli – Nozione di "prodotti agricoli" – Regolamento (UE) n. 1379/2013 – Organizzazione comune dei mercati nel settore dei prodotti della pesca e dell'acquacultura – Allegato I – Attività di trasformazione di prodotti della pesca e dell'acquacultura – Merluzzo salato, congelato e dissalato
L'articolo 1 e l'articolo 2, punti 10 e 11, del regolamento (UE) n. 651/2014 della Commissione, del 17 giugno 2014. che dichiara alcune categorie di aiuti compatibili con il mercato interno in applicazione degli articoli 107 e 108 [TFUE], così come gli orientamenti in materia di aiuti di Stato a finalità regionale 2014-2020, in combinato disposto con l'articolo 2 e l'articolo 5, lettere a) e d), e con l'allegato I del regolamento (UE) n. 1379/2013, del Parlamento europeo e del Consiglio, dell'11 dicembre 2013, relativo all'organizzazione comune dei mercati nel settore dei prodotti della pesca e dell'acquacoltura, recante modifica ai regolamenti (CE) n. 1184/2006 e (CE) n. 1224/2009 del Consiglio e che abroga il regolamento (CE) n. 104/2000 del Consiglio, devono essere interpretati nel senso che un'attività di trasformazione di prodotti della pesca e dell'acquacoltura, come la produzione di merluzzo salato, merluzzo congelato e merluzzo dissalato, non costituisce un'attività di trasformazione di prodotti agricoli, che è esclusa dall'ambito di applicazione del regolamento n. 651/2014 a norma dell'articolo 1, paragrafo 3, lettera c), di tale regolamento, ma un'attività rientrante nel settore della pesca e dell'acquacoltura, che è esclusa dall'ambito di applicazione di tale regolamento a norma dell'articolo 1, paragrafo 3, lettera a), dello stesso.

CGUE, 7/7/2022, C-24/21, *PH contro Regione Autonoma Friuli Venezia Giulia, Direzione centrale risorse agroalimentari, forestali e ittiche – Servizio foreste e corpo forestale della Regione Autonoma Friuli Venezia Giulia*
Rinvio pregiudiziale – Agricoltura – Alimenti e mangimi geneticamente modificati – Regolamento (CE) n. 1829/2003 – Emissione deliberata

nell'ambiente di organismi geneticamente modificati – Direttiva 2001/18/CE – Articolo 26 bis – Possibilità per gli Stati membri di adottare le misure opportune per evitare la presenza involontaria di organismi geneticamente modificati in altri prodotti – Condizioni di applicazione – Principio di proporzionalità – Orientamenti per l'elaborazione di misure nazionali in materia di coesistenza per evitare la presenza involontaria di organismi geneticamente modificati nelle colture convenzionali e biologiche – Misura adottata da un ente infrastatale che vieta nel suo territorio la messa in coltura del mais geneticamente modificato

1) L'articolo 26 bis della direttiva 2001/18/CE del Parlamento europeo e del Consiglio, del 12 marzo 2001, sull'emissione deliberata nell'ambiente di organismi geneticamente modificati e che abroga la direttiva 90/220/CEE del Consiglio, come modificata dal regolamento (CE) n. 1829/2003 del Parlamento europeo e del Consiglio, del 22 settembre 2003, letto alla luce di tale regolamento e della raccomandazione della Commissione del 13 luglio 2010 recante orientamenti per l'elaborazione di misure nazionali in materia di coesistenza per evitare la presenza involontaria di OGM nelle colture convenzionali e biologiche, deve essere interpretato nel senso che esso non osta a una misura nazionale che vieta, al fine di evitare la presenza involontaria di organismi geneticamente modificati in altri prodotti, la coltivazione nel territorio di una regione dello Stato membro di cui trattasi di organismi geneticamente modificati autorizzati in forza del regolamento n. 1829/2003, a condizione che tale misura consenta di raggiungere l'obiettivo di garantire ai produttori e ai consumatori la scelta tra prodotti provenienti da colture geneticamente modificate e prodotti provenienti da colture biologiche o convenzionali e che, alla luce delle peculiarità di dette colture in tale territorio, la suddetta misura sia necessaria a raggiungere tale obiettivo e sia proporzionata ad esso.

2) Qualora una misura nazionale vieti, nel territorio di una regione dello Stato membro di cui trattasi, la coltivazione di organismi geneticamente modificati autorizzati in forza del regolamento n. 1829/2003, in conformità all'articolo 26 bis della direttiva 2001/18, come modificata dal regolamento n. 1829/2003, letto alla luce di tale regolamento e della raccomandazione della Commissione del 13 luglio 2010 recante orientamenti per l'elaborazione di misure nazionali in materia di coesistenza per evitare la presenza involontaria di OGM nelle colture convenzionali e biologiche, non è necessario verificare, ulteriormente e distintamente, se tale misura sia conforme agli articoli da 34 a 36 TFUE.

T.A.R. Veneto Venezia, Sez. I, 02/11/2022, n. 1672
Produzione lattiera – regolazione dell'offerta – consegne ad acquirente non riconosciuto – consegne eccedentarie.

L'art. 4, comma 2, del D.L. n. 49 del 2003 non prevede una sanzione amministrativa, ma una misura regolatoria del mercato. In particolare, il prelievo supplementare viene in considerazione esclusivamente quale misura di riequilibrio del mercato, cui deve essere assoggettato il latte conferito ad un acquirente non riconosciuto, in coerenza con la diversa ipotesi di prelievo supplementare prevista per i casi di conferimento di latte eccedente la quota assegnata.

Sia nel caso di consegne ad acquirente non riconosciuto, sia nel caso di consegne eccedentarie, si produce inesorabilmente l'effetto di porre la produzione lattiera al di fuori della filiera controllata; in entrambi i casi si tratta di comportamenti idonei ad eludere la normativa eurocomunitaria volta a ridurre lo squilibrio tra offerta e domanda di latte e prodotti lattiero caseari nonché le conseguenti eccedenze strutturali. Consegnare latte a chi non abbia più l'autorizzazione a riceverlo e sia stato estromesso dal sistema pubblico per violazioni sistematiche, equivale ad eludere il contingentamento lattiero caseario imposto a livello europeo e a scardinarne il funzionamento.

Cass. civ., Sez. V, Ordinanza, 15/09/2022, n. 27198
Agriturismo – immobili destinati a ricezione e ospitalità – ruralità dell'immobile – classificazione catastale

Ai fini della classificazione catastale delle unità immobiliari, le costruzioni destinate alla ricezione ed ospitalità, nell'ambito dell'attività di agriturismo svolta da una azienda agricola, rivestono il carattere di strumentalità all'attività agricola che giustifica il riconoscimento della ruralità, ai sensi dell'art. 9, comma 3-bis, del D.L. n. 557 del 1993, senza che ad esse possa trovare applicazione l'esclusione di cui alla lett. f) dell'art. 9, comma 3, dello stesso decreto, operante per le sole costruzioni rurali destinate ad abitazione.

Cons. giust. amm. Sicilia, 19/07/2022, n.850
Agricoltura – Attività agricola – Attività di trasformazione – Trattamento della biomassa di scarto – Inclusione.

L'attività di trasformazione di prodotti agricoli e del trattamento della biomassa di scarto e rifiuto con compostaggio è attività agricola.

ALIMENTI

CGUE, 1/12/2022, C-595/21, LSI – Germany GmbH contro Freistaat Bayern

Rinvio pregiudiziale – Tutela dei consumatori – Fornitura di informazioni sugli alimenti ai consumatori – Regolamento (UE) n. 1169/2011 – Articolo 17 e allegato VI, parte A, punto 4 – "Denominazione dell'alimento" – "Denominazione del prodotto" – Indicazioni obbligatorie sull'etichettatura degli alimenti – Componente o ingrediente utilizzato per la sostituzione completa o parziale di quello che i consumatori presumono sia normalmente utilizzato o presente in un alimento

Il combinato disposto dell'articolo 17, paragrafi 1, 4 e 5, e dell'allegato VI, parte A, punto 4, del regolamento (UE) n. 1169/2011 del Parlamento europeo e del Consiglio, del 25 ottobre 2011, relativo alla fornitura di informazioni sugli alimenti ai consumatori, che modifica i regolamenti (CE) n. 1924/2006 e (CE) n. 1925/2006 del Parlamento europeo e del Consiglio e abroga la direttiva 87/250/CEE della Commissione, la direttiva 90/496/CEE del Consiglio, la direttiva 1999/10/CE della Commissione, la direttiva 2000/13/CE del Parlamento europeo e del Consiglio, le direttive 2002/67/CE e 2008/5/CE della Commissione e il regolamento (CE) n. 608/2004 della Commissione deve essere interpretato nel senso che l'espressione «denominazione del prodotto», contenuta nell'allegato VI, parte A, punto 4, non ha un significato autonomo, diverso da quello dell'espressione «denominazione dell'alimento», ai sensi dell'articolo 17, paragrafo 1, di tale regolamento, di modo che i requisiti speciali di etichettatura previsti da detto allegato VI, parte A, punto 4, non si applicano alla «denominazione protetta come proprietà intellettuale», al «marchio di fabbrica» o alla «denominazione di fantasia» di cui all'articolo 17, paragrafo 4, di tale regolamento.

CGUE, 27/10/2022, C-418/21, Orthomol pharmazeutische Vertriebs GmbH contro Verband Sozialer Wettbewerb eV

Rinvio pregiudiziale – Sicurezza degli alimenti – Prodotti alimentari – Regolamento (UE) n. 609/2013 – Articolo 2, paragrafo 2, lettera g) – Regolamento delegato (UE) 2016/128 – Alimenti a fini medici speciali – Altre esigenze nutrizionali determinate da condizioni cliniche – Alimenti di utilità generale per il paziente – Distinzione rispetto ai medicinali

L'articolo 2, paragrafo 2, lettera g) del regolamento (UE) n. 609/2013 del Parlamento europeo e del Consiglio, del 12 giugno 2013, relativo agli alimenti destinati ai lattanti e ai bambini nella prima infanzia, agli alimenti a fini medici speciali e ai sostituti dell'intera razione alimentare giornaliera per il controllo del peso e che abroga la direttiva 92/52/CEE del Consiglio, le direttive 96/8/CE, 1999/21/CE, 2006/125/CE e 2006/141/CE della Commissione, la direttiva 2009/39/CE del Parlamento europeo e del Consiglio e i regolamenti (CE) n. 41/2009 e (CE) n. 953/2009 della Commissione, e, in particolare, la nozione di «altre esigenze nutrizionali determinate da condizioni cliniche» devono essere interpretati nel senso che un prodotto costituisce un alimento a fini medici speciali se la malattia comporta esigenze nutrizionali più elevate o specifiche che il prodotto alimentare è inteso a soddisfare, di modo che non è sufficiente, ai fini di una tale qualificazione, che il paziente tragga un beneficio generale dal consumo di tale prodotto alimentare per il fatto che le sostanze in esso contenute combattono il disturbo o ne alleviano i sintomi.

CGUE, 1/8/2022, C-319/21, *Agecontrol SpA contro ZR, Lidl Italia Srl*

Rinvio pregiudiziale – Agricoltura – Organizzazione comune dei mercati – Regolamento (CE) n. 1234/2007– Ortofrutticoli freschi imballati – Regolamento di esecuzione (UE) n. 543/2011 – Controllo di conformità – Trasporto verso un punto vendita della medesima società di commercializzazione – Documento di accompagnamento – Indicazione del paese di origine

L'articolo 5, paragrafo 4, del regolamento di esecuzione (UE) n. 543/2011 della Commissione, del 7 giugno 2011, recante modalità di applicazione del regolamento (CE) n. 1234/2007 nei settori degli ortofrutticoli freschi e degli ortofrutticoli trasformati, letto alla luce dell'articolo 8 di tale regolamento e degli articoli 113 e 113 bis del regolamento (CE) n. 1234/2007 del Consiglio, del 22 ottobre 2007, recante organizzazione comune dei mercati agricoli e disposizioni specifiche per taluni prodotti agricoli (regolamento unico OCM), come modificato dal regolamento (CE) n. 361/2008 del Consiglio, del 14 aprile 2008, deve essere interpretato nel senso che il controllo di conformità alle norme di commercializzazione di prodotti ortofrutticoli non impone al detentore di tali prodotti di emettere un documento di accompagnamento. Tuttavia, quando tale detentore emette un siffatto documento, egli deve, in tutte le fasi di commercializzazione di detti prodotti, indicare il nome e il paese di origine dei medesimi prodotti, indipendentemente dalla circostanza che le indicazioni esterne previste dal regolamento di esecuzione n. 543/2011 siano già riportate a caratteri visibili e mediante stampatura indelebile su uno dei lati degli imballaggi degli stessi, su un cartello informativo collocato in modo visibile all'interno del mezzo di trasporto con il quale sono trasportati nonché sulle fatture emesse dal fornitore di tali prodotti.

CGUE, 14/07/2022, C-159/20, *Commissione Europea c. Regno di Danimarca*

Inadempimento di uno Stato – Regolamento (UE) n. 1151/2012 – Regimi di qualità dei prodotti agricoli e alimentari – Articolo 13 – Uso della denominazione di origine protetta (DOP) "Feta" per designare formaggio prodotto in Danimarca e destinato all'esportazione verso paesi terzi – Articolo 4, paragrafo 3, TUE – Principio di leale cooperazione

Avendo omesso di prevenire e far cessare l'uso, da parte dei produttori lattiero-caseari danesi, della denominazione di origine protetta (DOP) «Feta» per designare formaggio non conforme al disciplinare di tale DOP, il Regno di Danimarca è venuto meno agli obblighi ad esso incombenti in forza dell'articolo 13, paragrafo 3, del regolamento (UE) n. 1151/2012 del Parlamento europeo e del Consiglio, del 21 novembre 2012, sui regimi di qualità dei prodotti agricoli e alimentari.

Cassazione civile sez. II, 05/12/2022, n.35685

Alimenti – Impresa alimentare – pluralità di punti vendita – responsabilità

Allorché una società commerciale di notevoli dimensioni sia articolata in molteplici punti vendita, diffusi sul territorio, dell'illecito amministrativo consumato in uno di essi (consistente, nel caso di specie, nel non consentire la tracciabilità di uno più prodotti alimentari) non può essere chiamato a rispondere il legale rappresentante della società, ma il responsabile preposto alla singola unità ove è stato commesso il fatto, il quale ne risponderà in solido con la società medesima. La mera, generica, carenza sia dei responsabili preposti alla singola unità ove è stato commesso il fatto sia della struttura che sia stata appositamente costituita per l'osservanza degli obblighi la cui violazione sia oggetto della sanzione amministrativa, non può valere a fondare una responsabilità del legale rappresentante della società quando tale carenza sia dedotta puramente e semplicemente dalla commissione dell'illecito, potendo tale responsabilità essere affermata allorquando, non solo venga verificata una specifica inadeguatezza sia dei responsabili della singola unità ove è stato commesso il fatto sia della struttura appositamente costituita, ma anche questa inadeguatezza – che non può essere desunta dalla mera commissione dell'illecito in sé ma deve trovare fondamento nella constatazione di autonome e specifiche carenze (di mezzi o di competenze) – sia riconducibile ad azioni od omissioni, parimenti determinate, del legale rappresentante della società, in violazione di altrettanto specifici obblighi di garanzia, sempre che tali azioni o omissioni abbiano fornito un contributo -pur sempre specifico – alla causazione dell'illecito (fattispecie relativa ad un'ordinanza ingiunzione a titolo di sanzione per mancato rispetto dell'obbligo di rintracciabilità dei prodotti alimentari -nel caso specifico, un formaggio -, previsto dal regolamento Ce 178/2002).

Cass. civ., Sez. II, Ordinanza, 12/07/2022, n. 21963

Produzioni di qualità – DOP e IGP – Etichettatura – disciplinare di produzione – gerarchia delle fonti.

Ai sensi dell'art. 4, comma primo, D.Lgs. n. 297 del 2004 e art. 9 del D.M. 1° febbraio 2006, per il prodotto Speck dell'Alto Adige o Speck Alto Adige (espressa in lingua italiana) e Sudtiroler Markenspeck ovvero Sudtiroler Speck (espressa in lingua tedesca), è fatto onere all'INEQ di controllare la corretta etichettatura dei prodotti a marchio IGP, così come contenuta nel disciplinare di produzione, che ha natura di fonte secondaria ed integrativa delle previsioni del decreto ministeriale dell'1.2.2006 con cui era stato approvato il predetto disciplinare di produzione. Tale disciplinare prevede che l'etichettatura Bauernspeck abbia carattere accessorio e che vada apposta sempre in abbinamento con l'etichetta IGP, che è obbligatoria per i prodotti provenienti dalla zona di produzione indicata all'art. 2 del disciplinare. Dunque tutto lo speck con denominazione Alto Adige Speck richiede l'obbligatoria apposizione dell'etichettatura IGP, alla quale può eventualmente aggiungersi quella Bauernspeck, che ha carattere accessorio ed eventuale. Solo mediante l'etichettatura IGP, infatti, è garantita la riconoscibilità dei prodotti dai consumatori e viene valorizzata la produzione della zona di provenienza identificata dall'etichettatura stessa.

T. Ancona, 21 luglio 2022.

Produzioni di qualità – DOP e IGP – ingredienti – obbligo di informazione.

Una denominazione registrata come DOP può essere menzionata all'interno della denominazione di vendita di un prodotto alimentare che incorpora prodotti che beneficiano di tale DOP se l'ingrediente in questione conferisce al prodotto alimentare in esame una caratteristica essenziale; e la quantità di tale ingrediente nella composizione del suddetto alimento costituisce un criterio importante, ma non sufficiente. Spetta dunque al giudice nazionale, di volta in volta, valutare, alla luce delle circostanze di ogni singolo caso, se un impiego del genere sia volto a sfruttare la notorietà di una DOP o meno, verificando se tale alimento abbia una caratteristica essenziale connessa a tale ingrediente.

CACCIA E PESCA

T.A.R. Basilicata Potenza, Sez. I, 19/09/2022, n. 614
Caccia – Piani faunistico venatori – bilanciamento interessi –
La L. n. 157 del 1992 delinea l'esercizio dell'attività venatoria in un regime di programmazione incentrato sull'elaborazione di piani faunistico-venatori e volto ad attuare un bilanciamento di interessi nell'ambito del quale le esigenze dei cacciatori trovano considerazione accanto a quelle di protezione della fauna selvatica ed a quelle produttive degli agricoltori, e in funzione del contemperamento di tali esigenze, è prevista l'istituzione degli Ambiti territoriali di caccia, ripartizioni del territorio provinciale rette da organi attraverso i quali si realizza la partecipazione della comunità, insediata in quel territorio, al monitoraggio delle risorse faunistiche ed ambientali ed all'attuazione del regime di caccia programmata.

T.A.R. L'Aquila, (Abruzzo) sez. I, 14/07/2022, n. 327
Caccia – Esercizio della caccia – In genere – Piano faunistico venatorio – Impugnazione – Possibilità – Unitamente ai singoli atti applicativi – In quanto atto generale avente valenza programmatoria e pianificatoria.
Il Piano faunistico venatorio, in quanto atto generale avente valenza programmatica e pianificatoria, può essere oggetto di impugnazione unitamente ai singoli atti applicativi, che possono essere individuati nei calendari venatori, i quali, partendo dalle linee guida dettate dal predetto piano, ogni anno stabiliscono in concreto il fascio e le modalità delle attività faunistico-venatorie consentite nell'intero ambito regionale, così determinando l'attualità della lesione delle situazioni giuridiche.

CONSORZI

Cons. Stato, Sez. V, 18/10/2022, n. 8866
Consorzi – natura – rapporto con consorziate.
Il consorzio ordinario, di cui agli artt. 2602 e ss. c.c., pur essendo un autonomo centro di rapporti giuridici, non comporta l'assorbimento delle aziende consorziate in un organismo unitario costituente un'impresa collettiva, né esercita autonomamente e direttamente attività imprenditoriale, ma si limita a disciplinare e coordinare, attraverso un'organizzazione comune, le azioni degli imprenditori riuniti. Nel consorzio con attività esterna la struttura organizzativa provvede all'espletamento in comune di una o alcune funzioni (ad esempio, l'acquisto di beni strumentali o di materie prime, la distribuzione, la pubblicità, etc.), ma nemmeno nella sua disciplina civilistica è dotato di una propria realtà aziendale. Ne discende che, ai fini della disciplina in materia di contratti pubblici, il consorzio ordinario è considerato un soggetto con identità plurisoggettiva, che opera in qualità di mandatario delle imprese della compagine. Esso prende necessariamente parte alla gara per tutte le consorziate e si qualifica attraverso di esse, in quanto le stesse, nell'ipotesi di aggiudicazione, eseguiranno il servizio, rimanendo esclusa la possibilità di partecipare solo per conto di alcune associate.

CONTRATTI AGRARI

Cassazione civile sez. III, 21/11/2022, n. 34196
Contratti agrari – Prelazione e riscatto – Riscatto --- Prezzo dovuto dal retraente all'acquirente – Determinazione in misura superiore a quella risultante dal contratto trascritto – Esclusione – Pattuizione di un prezzo diverso tra alienante e acquirente retrattato – Irrilevanza – Fondamento.
In tema di riscatto di fondo rustico alienato in violazione del diritto di prelazione, il retraente è tenuto a versare all'acquirente il prezzo risultante nel contratto di vendita trascritto, senza possibilità, per il retrattato, di provare che prezzo di acquisto è stato superiore a quello indicato nell'anzidetto contratto, trattandosi di circostanza rilevante esclusivamente nei rapporti tra alienante e acquirente retrattato ai fini della garanzia per evizione che sia fatta valere da quest'ultimo.

Cassazione civile sez. III, 21/11/2022, n. 34131
Contratti agrari (procedimento in materia di) – Controversie --- Controversia di competenza delle sezioni specializzate agrarie iniziata dinanzi ad altro giudice – Pronuncia di incompetenza – Riassunzione dinanzi al giudice competente – Necessità del previo esperimento del tentativo di conciliazione – Esclusione.
In materia di contratti agrari, la domanda inizialmente proposta dinanzi ad un giudice dichiaratosi incompetente (o dichiarato tale in esito a regolamento di competenza) non va preceduta dal tentativo di conciliazione in sede stragiudiziale, di cui all'art. 46 della l. n. 203 del 1982, prima della riassunzione della causa davanti alla sezione specializzata agraria.

IMPOSTE, TASSE E CONTRIBUTI

Cass. civ., Sez. V, Ordinanza, 29/09/2022, n. 28392
Piccola proprietà contadina – Agevolazioni tributarie – Acquisto di terreni agricoli – Obbligo per l'impren-

ditore di produrre l'attestazione della qualifica di coltivatore diretto – Sussistenza – Superamento del termine di decadenza per l'adempimento – Conseguenze – Perdita del beneficio – Eccezioni – Mancata produzione non addebitabile alla propria responsabilità – Limiti
In tema di agevolazioni fiscali per l'acquisto di terreni agricoli stabilite, a favore della piccola proprietà contadina, dalla l. n. 604 del 1954, ove il contribuente non adempia l'obbligo di produrre all'Ufficio il previsto certificato definitivo entro il prescritto termine decadenziale, non perde il diritto ai benefici qualora provi di aver operato con adeguata diligenza, richiedendo tempestivamente la certificazione in tempo utile, e che il superamento del predetto termine sia dovuto a colpa degli uffici competenti, avendo gli stessi indebitamente ritardato il rilascio della documentazione.

Cass. civ., Sez. V, Ordinanza, 27/09/2022, n. 28369
Contratti agrari – acquisto fondo rustico – agevolazioni – revoca.
L'agevolazione ottenuta da una società agricola per l'acquisto di un fondo rustico è revocata se il fondo viene affittato, entro un dato periodo successivo al contratto di compravendita, a uno dei soci della società acquirente, seppur dotato dei requisiti di imprenditore agricolo a titolo professionale (Iap).

Cass. civ., Sez. V, Ordinanza, 27/09/2022, n. 28169
Piccola proprietà contadina - Agevolazioni tributarie - Piccola proprietà contadina - Acquisto di terreni agricoli ad opera di una società - Scissione parziale entro cinque anni - Decadenza dalle agevolazioni - Esclusione – Condizioni
In tema di agevolazioni per la cd. piccola proprietà contadina, non costituisce causa di decadenza l'operazione di scissione parziale effettuata entro cinque anni dall'acquisto dei terreni agricoli, purché permangano, in capo alla società beneficiaria, gli altri requisiti cui risulta subordinato il trattamento agevolativo in questione, concretizzando l'operazione di scissione una vicenda meramente evolutiva del medesimo soggetto, sia pure in un nuovo assetto organizzativo.

Cass. civ., Sez. VI – 5, Ordinanza, 08/09/2022, n. 26474
Imposte – natura agricola del terreno – proprietà società di persone – socio IAP
In tema di Imposte locali sugli immobili, le agevolazioni previste dall'art. 9 del D.Lgs. 30 dicembre 1992 n. 504, consistenti nel considerare agricolo anche il terreno posseduto da una società agricola di persone si applicano – a seguito della modifica dell'art. 12 della Legge 9 maggio 1975 n. 153 da parte dell'art. 10 del D.Lgs. 18 maggio 2001 n. 228 e della sua successiva abrogazione e sostituzione con l'art. 1 del D.Lgs. 29 marzo 2004 n. 99 – qualora detta società possa essere considerata imprenditore agricolo professionale ove lo statuto preveda quale oggetto sociale l'esercizio esclusivo delle attività agricole di cui all'art. 2135 cod. civ. ed almeno un socio sia in possesso della qualifica di imprenditore agricolo ovvero abbia conoscenze e competenze professionali, ai sensi dell'art. 5 del regolamento 6 (CE) n. 1257 del 17 maggio 1999, e dedichi alle attività agricole di cui all'art. 2135 cod. civ. almeno il cinquanta per cento del proprio tempo di lavoro complessivo, ricavando da dette attività almeno il cinquanta per cento del proprio reddito globale da lavoro.

Cons. Stato, Sez. III, 20/07/2022, n. 6339
Quote latte – superamento – pluralità di allevatori – rapporti scindibili – vicende individuali.
Gli importi dovuti nel caso di superamento delle quote latte – anche quando si tratti di cartelle di pagamento – riguardano specifici rapporti di credito-debito intercorrenti tra i produttori e l'A.g.e.a., pur quando essi sono determinati tenendo conto delle posizioni degli altri allevatori e anche se vi siano stati meccanismi di calcolo, basati ad esempio sulle 'compensazioni' conseguenti al mancato utilizzo per intero delle quote spettanti ad altri allevatori. In altri termini, gli atti emessi in materia dell'A.g.e.a., nonché le cartelle di pagamento, nei confronti degli allevatori, pur quando si riferiscano a conteggi o a elenchi riguardanti altri allevatori, hanno natura di atti plurimi scindibili. I singoli rapporti giuridici tra l'A.g.e.a. e gli allevatori rilevano in sé e nei rapporti inter partes, quali rapporti di credito-debito del tutto autonomi da quelli intercorrenti tra l'A.g.e.a. e gli altri allevatori tanto che le sentenze di annullamento di atti, a tutela di posizioni individuali, non riguardano di per sé gli altri rapporti giuridici che non siano stati sottoposti all'esame del giudice.

Cons. Stato, Sez. III, 20/07/2022, n. 6334
Quote latte – impugnazioni collettive – onere di individuare le singole posizioni.
In materia di impugnazioni collettive aventi ad oggetto le quote latte, i relativi ricorsi sono inammissibili se non è dato comprendere quali siano, nello specifico, i fatti costitutivi della pretesa avanzata da ciascuna azienda, in relazione alla situazione di ciascuna di esse o se vi sia conflitto, anche solo potenziale, fra le ragioni di tali pretese, dal momento che il gravame si risolve in una reiterazione della critica 'di sistema' alla disciplina dei provvedimenti in materia di quote latte.

Cass. civ., Sez. V, Ordinanza, 15/07/2022, n. 22290
Piccola proprietà contadina - Agevolazioni tributarie - Imposta di registro e ipotecaria - Agevolazione prevista dal d.l. n. 194 del 2009 - Affitto del fondo rustico entro il quinquennio successivo al suo acquisto - Decadenza dal beneficio – Ragioni
In tema di imposta di registro e ipotecaria, con riguardo alle agevolazioni usufruite per l'atto di acquisto di terreni e relative pertinenze da parte di coltivatori diretti ed imprenditori agricoli, il comma 4 bis dell'art. 2 del d.l. n. 194 del 2009, conv. con modif. dalla l. n. 25 del 2010, espressamente contempla la decadenza da tali benefici qualora il contribuente, prima che siano trascorsi cinque anni dalla stipula dell'atto, alieni volontariamente i terreni ovvero cessi di coltivarli o di condurli direttamente; in tale ottica, il contratto di affitto assume rilevanza, quale indice sintomatico della cessazione della coltivazione diretta da parte del proprietario, in quanto sarebbe contraddittorio considerare come tuttora in coltivazione, ad opera del suo acquirente, un terreno da quest'ultimo concesso in affitto a terzi, tenuto conto che la finalità di assicurare la formazione o l'arrotondamento della piccola proprietà contadina, in relazione all'oggetto dell'atto di acquisto agevolato, implica l'effettiva coltivazione del terreno.

USI CIVICI

Cassazione civile sez. II, 23/11/2022, n.34476
Uso civico – pignoramento – legittimità – utilizzo incompatibile
Il singolo non può prendere a pretesto l'uso civico per sottrarre dal pignoramento, eseguito da un suo creditore, un bene che egli stesso utilizzi in modo incompatibile con l'esercizio collettivo.

Cassazione civile sez. II, 23/11/2022, n.34460
Uso civico – esproprio – legittimità – rimessione Sezioni Unite
Occorre rimettere gli atti al Primo Presidente affinché sottoponga alle Sezioni Unite la soluzione del contrasto giurisprudenziale sulla possibilità di esproprio o meno dei beni gravati da usi civici.

Cass. civ., Sez. Unite, Ordinanza, 04/10/2022, n. 28802
Commissari regionali - Competenza - Accertamento "incidenter tantum" della "qualitas soli" - Azioni possessorie in cui detta qualità sia stata già accertata con giudicato - Controversie - Giurisdizione del giudice ordinario - Sussistenza - Giurisdizione del commissario per la liquidazione degli usi civici - Esclusione - Ragioni
In tema di giurisdizione, spettano al giudice ordinario – e non al Commissario per la liquidazione degli usi civici – sia le controversie tra privati in cui l'accertamento sulla qualità del terreno che si assume di "uso civico" (cd. "qualitas fundi") debba essere risolto "incidenter tantum", per essere stata la relativa eccezione sollevata al solo scopo di negare l'esistenza del diritto soggettivo di cui la controparte sostenga di essere titolare, risolvendosi la stessa nella contestazione di un fatto costitutivo del diritto azionato, sia quelle in cui insorga una questione possessoria su un terreno, la cui appartenenza al demanio civico sia già stata oggetto di accertamento coperto da giudicato, non avendo essa più attinenza con la "qualitas soli", che notoriamente afferisce al petitorio.

Cassazione civile sez. un., 05/09/2022, n.26038
Usi civici – accertamento demanialità – liquidazione – competenza – commissario per la liquidazione
Una controversia che esiga la soluzione, in via principale e non meramente incidentale, della questione di demanialità, esula dalla giurisdizione del giudice ordinario e spetta alla cognizione del commissario regionale per la liquidazione degli usi civici, ai sensi dell'articolo 29 della legge n. 1766 del 1927. Deriva da quanto precede, pertanto, che la domanda di restituzione di un terreno al demanio collettivo, presupponendo necessariamente un accertamento preliminare sull'esistenza di diritti civici su tale terreno, anche in assenza di un'esplicita contestazione della relativa qualitas soli, è devoluta alla giurisdizione del Commissario regionale per la liquidazione degli usi civici.

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