

# THE BUILT ENVIRONMENT OF FARM WINERIES: AN ANALYSIS METHODOLOGY FOR DEFINING META-DESIGN REQUIREMENTS

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## 1. Introduction

The study represents the first step of a broader research aimed at defining specific building and landscape design criteria for small to medium-sized wine farms, to which the most common standards of industrial wineries cannot be applied. The scientific literature includes several specific studies about the design of industrial wineries [Ayuga 1999; Bailey 2002] and technical and functional features of equipment and facilities necessary for the production process [Jacquet 2007; Fuller 2004], whilst no systematic framework of design references for farm wineries is available.

Methodological frameworks regarding the broader theme of building design for agroindustrial facilities have been proposed by several authors [Fichera 1995], who recognized the meta-design as a crucial phase for the definition of a correct decision process [van der Voordt 2005]. Meta-design allows to achieve a virtuous interaction between choices regarding building aspects and needs of the transformation process, as it properly links production functional requirements and built spaces performances.

With reference to the above-mentioned farm typologies and the wine-growing and producing sector of the Emilia-Romagna region (Italy), the study aims at identifying the main knowledge references for the formulation of meta-design requirements. In particular, this goal is organized into the following specific objectives:

- identification of a significant study area, as for both potential and actual production;
- analysis of the wine-growing and producing sector in the study area and the main production features of the farms under study;

- formulation of a preliminary framework of the main building code provisions for the spatial units of wineries.

## 2. Materials and methods

First the research focused on the identification of a study area representative in terms of wine-growing and wine production within the considered regional context. Processing the most recent production data available referred to 2007 [Emilia-Romagna Region 2008] allowed us to identify a representative provincial territory on the basis of the least overall deviation of the main production parameters (vineyard area, quantities of produced grape and wine) from average regional values.

Then, in the considered province, we analysed vineyard sizes based on data surveyed in each municipality for the most recent census of agriculture [Istat 2000], thus identifying a super-municipal area which proved representative as for the ratio of vineyard area to total land area, indicative of the wine-growing attitude. A GIS analysis allowed us to perform a geo-morphological characterization of vineyard parcels, derived from the “vineyard cadastre” vector geodatabase provided by the competent bureau of the provincial government.

We studied in depth the features of the wine-growing and producing sector through the analysis of the available data collected by the institutions in charge of licences, verifications and inspections of the agro-food processing activities and wine producers’ associations. In particular the local Department of Public Health (AUSL) provided us with the database of all the wineries authorized or registered under the Law by Decree 193/07 [Italian Republic 2007]. Processing such a database allowed us to characterize the sector in terms of distribution of annual production capacities and thus to identify the most frequent production classes in the study area, in order to focus on these the subsequent analyses of the production process.

Such analyses called for the creation of a highly detailed database founded upon specific parameters, to be surveyed on a representative sample of farms

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and processed on the basis of an inferential approach. To this end, within the identified classes of production size, we selected a sample of farms whose frequency distribution of wine production quantities basically reproduced the whole population's one, checking the availability of necessary information. This selection was supported by the Regional Prevention Environment Agency (ARPA) and farmers associations. In particular ARPA provided data concerning wine-growing (vineyard size, quantities of grapes produced, acquired, sold) and wine production (quantities of grapes processed and wine produced, divided into the main categories, and the kind of commercialisation, loose or bottled), quantities of drawn and waste waters, waste management systems, and presence of agritourism. Then we prepared a specific questionnaire and administered it to farmers, with the support of farmers associations, to get further information about vine cultivars, tank capacities and main marketing strategies. Sampled data were organized into a geodatabase and integrated with those derived from vineyard maps and cadastral data. Finally we analysed the local technical regulations for winery design in order to identify a framework of the main building requirements and work out a table of the corresponding indicative parameters. The analysis was performed with the collaboration of the Public Health Department and the Municipal technical services of the study area, and involved the compared analysis of Decree 380/2001, Laws by Decree 152/2006, 193/2007, 4/2008, 81/2008 [Italian Republic 2001, 2006, 2007, 2008a, 2008b], as well as the municipal building and hygiene codes.

### 3. Results and discussion

#### 3.1 Definition of a study area

Grape production in Emilia-Romagna in 2007 was 738, 714 tons, and involved 56, 496 ha of vineyards. In the same year the regional wine production was  $5757 \times 10^6$  hl, 34% of which being table wine, 40% IGT (Typical Geographic Indication), and 26%

VQPRD (Quality Wines Produced in Certain Regions, i.e. Controlled Denomination of Origin, DOC, and Controlled and Guaranteed Denomination of Origin, DOCG). Data about production and surface area referred to each province of the considered region are broadly diversified (Fig. 1), being those of the Bologna province the closest to the regional average: differences are +11% for vineyard surface areas, +16% for grape production, -3% for wine production; whilst product division into table wines and brand products matches regional rates. The analyses have shown that, in this province, 55% of vineyards surface area and 95% of IGT and 75% of DOC wine production are concentrated in the New District of Imola (NCI), a super-municipal 787 km<sup>2</sup> area covering 21% of the province, thus chosen as the study area. It represents an association of municipalities, to which certain provincial and regional administrative functions are delegated, that is currently formulating its inter-municipal land-use plan (defined Structural Plan by Regional Law 20/2000, [Emilia-Romagna Region 2000]) and the relative town planning and building code. Since the authors are members of the work-group supporting this process, this study also contributes to a broader work aimed at the knowledge of the features of the various agricultural sectors, including food processing, functional to the development of the above planning and technical regulation tools.

#### 3.2 Characters of the wine-growing and producing sector in the study area

The study area shows heterogeneous geo-morphological characters, which may be synthetically represented (Fig. 2) through the identification of suitable altimetry classes and land suitability classes for agricultural and forestry use (hereafter shortened to land suitability). We have defined three altitude thresholds [Tassinari 2007] corresponding to 50 m, 300 m, 600 m above sea level. They subdivide the territory respectively into fully plain areas (below 50 m, representing the 46% of the study area), hill-foot areas (between 50 m and 300 m; 38%), fully hilly areas (between 300 m and 600 m; 15%) and piedmont areas

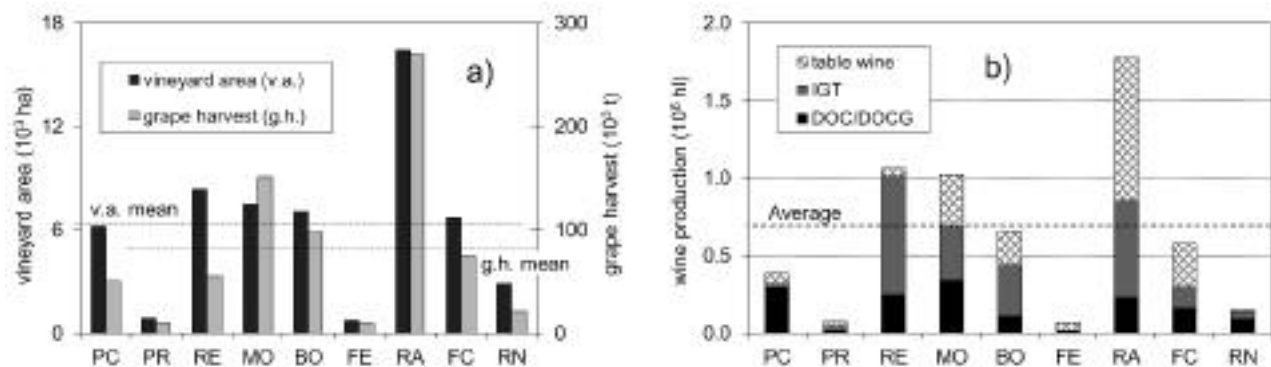


Fig. 1 - Vineyard surface areas and quantities of grapes harvested (a) and wine production (b) in the various provinces of the Emilia-Romagna region in 2007.

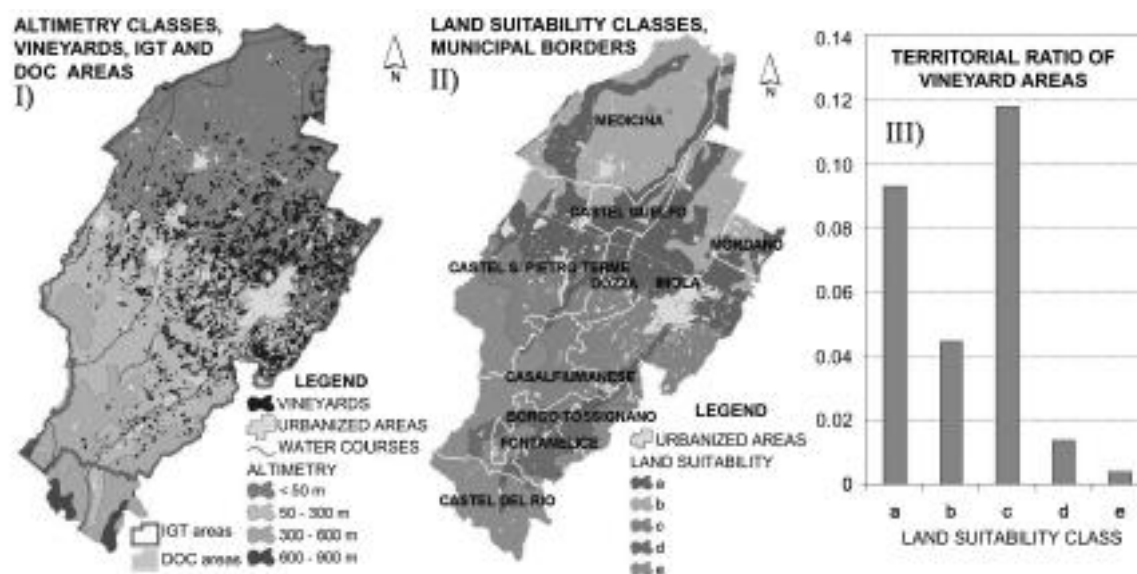


Fig. 2 - Characterization of the study area: I) vineyards distribution and altimetry classes; II) municipalities and land suitability classes; III) vineyard areas incidences in the various land suitability classes.

(above 600 m; 1%). The land suitability classes, defined on the basis of a combined analysis of land capability, elevation and morphology, are:

*a*) level land well suited for agricultural use (32% of the study area);

*b*) level land less suited for agricultural use than class *a* areas (24%);

*c*) hill-foot and hilly regions with an intermediate suitability for agricultural use (22%);

*d*) hilly regions moderately suitable for agricultural use (4%);

*e*) areas with low suitability for agricultural use (18%).

Analyses of cultivated land performed in the GIS environment (Fig. 2-I) have pointed out that 46% of vineyards are located in plain land and the remaining ones in hill foot areas, and that almost all vineyard parcels are within IGT production districts, and 95% within DOC districts too. On the basis of the land suitability classification (Fig. 2-II, III), *c* class lands show the overall highest incidence of vineyards surface area (corresponding to 38% of total vineyards), whilst 44% of vineyards of the study area are located in *a* class lands and only 16% in *b* class ones. These data highlight that vineyard locations greatly depend on land suitability, and that a territorial analysis solely based on altimetry classes is not enough to identify the landscapes mostly characterized by viticulture.

The analysis of wine production data allowed to identify 146 wineries, whose production capacities vary from 14 hl to 290 000 hl per year, and in most cases (90%) do not exceed 5000 hl per year. Consistently with the study aims, we focused on these wineries, which are likely to be farms mainly processing their own grapes.

The data analyzed have been represented in the histogram of Figure 3, where each rectangle is erected

over a production interval with an area equal to the relative frequency of the observations. Such a diagram clearly shows that year production of most farm wineries (76%) is under 1000 hl, exceeding 2500 hl in few cases (4%).

According to the procedures described in section 2, we selected a sample of 46 farm wineries within those whose annual production did not exceed 5000 hl (Fig. 4.a), corresponding to a 35% sampling ratio. With reference to the above-mentioned altimetry classes, 2/3 of the sampled farms are located in hill-foot areas and cover 2/3 of the total wine production of the sample, whilst the remaining farms are located in plain areas. As regards land suitability classes, 60% of wine is produced by wineries located in *c* class areas, 39% by those located in *a* class, and remaining 1% in *e* class areas.

Average size of wine farms in terms of total farmland is 30 ha, whereas the mean vineyard area is 15 ha. Frequency distribution of wine farms in function of their overall size appears quite irregular, whilst

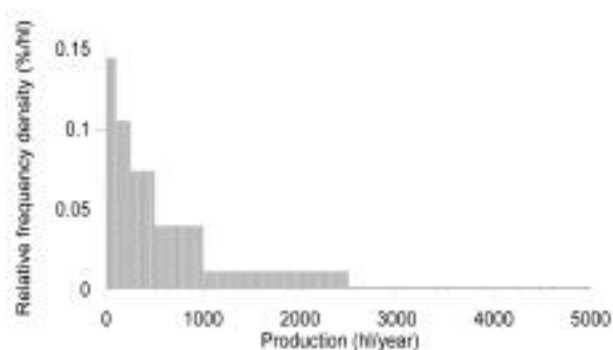


Fig. 3 - Histogram of yearly wine production quantities for the wineries in the study area.

their frequency distribution in function of vineyard surface areas shows a clear peak corresponding to 5-10 ha and 10-20 ha classes (Fig. 4.b), which together represent 54% of farms, their separating value (10 ha) also being the median of the distribution. Farm distributions based on quantities of produced and processed grape are reported in Figure 4.c. Average annual quantities of grapes produced and processed amount to 165.2 tons and 189.6 tons respectively. Therefore these farms acquire on an average 15% of processed grape by other farms. We also investigated grape harvesting modalities, given their well known implications in the wine-making process. It resulted that almost half of the farms (46%) uses only manual harvesting; in all other cases mechanized and manual harvesting are adopted jointly.

The farms under study grow manifold cultivars: Trebbiano romagnolo (45% of total vineyard areas), Sangiovese (19%) Albana (10%), Pignoletto (8%), Cabernet Sauvignon (4%), Chardonnay (4%), Malvasia Bianca di Candia (4%), Merlot (2%), Barbera (1%), Uva Longanesi (1%), Pinot bianco (1%), and others (1%). Such variety reveals the trend of farms towards profiting from niche markets. The allocation of produced wines into the above-mentioned categories reflects the regional one, as a further confirmation of the sample representativeness. As for the wine-making process, all the sampled farms produce both white and red wines. White wines represent 60% of the whole production (25% table wine, 23% IGT, and 12% VQPRD) and red wines the remaining part (9% table wines, 16% IGT and 15% VQPRD). The mean overall capacity of wine tanks of each farm is 1800 hl

and the values distribution (Fig. 5.a) shows that in 69% of wineries overall capacity is not greater than 2000 hl.

The average quantity of drawn water, essentially used for washing winery spaces, tanks, equipments, and bottles, results equal to 155 m<sup>3</sup>/year (Fig. 5.b). No clear correlation is recognizable between production quantities and volumes of used water (ratios of used water to produced wine volumes vary from 0.2 to 4.5, 1.3 on an average), as the latter strongly depends on the size of bottling activities, which require great water volumes in case non sterile bottles are used.

Nevertheless, data about wastewater volumes for the sampled wineries, besides being comparable to drawn water volumes, proved fundamentally consistent with those reported in scientific literature [Farolfi 1995; Berta 2003]. Wastewaters of the considered wineries are classified according to national law in force (Legislative Decree 152/2006 [Italian Republic 2006]) as industrial assimilated to domestic, as far as they produce at least 2/3 of processed grapes. According to the provisions of Deliberation 1053/2003 by the Regional Government [Emilia-Romagna Region 2003], the treatment system generally adopted consists in an oil-water separator, an Imhoff tank, and one of the following systems: a rotating biological contactor, a trickling filter, a total oxidation plant, or a phytodepuration system. ARPA generally suggests the adoption of an Imhoff tank and a sub-irrigation system when wastewater volumes do not exceed 10 equivalent inhabitants.

Only 15% of farms, with 2700 hl average annual production, bottle their wine on their own; wineries

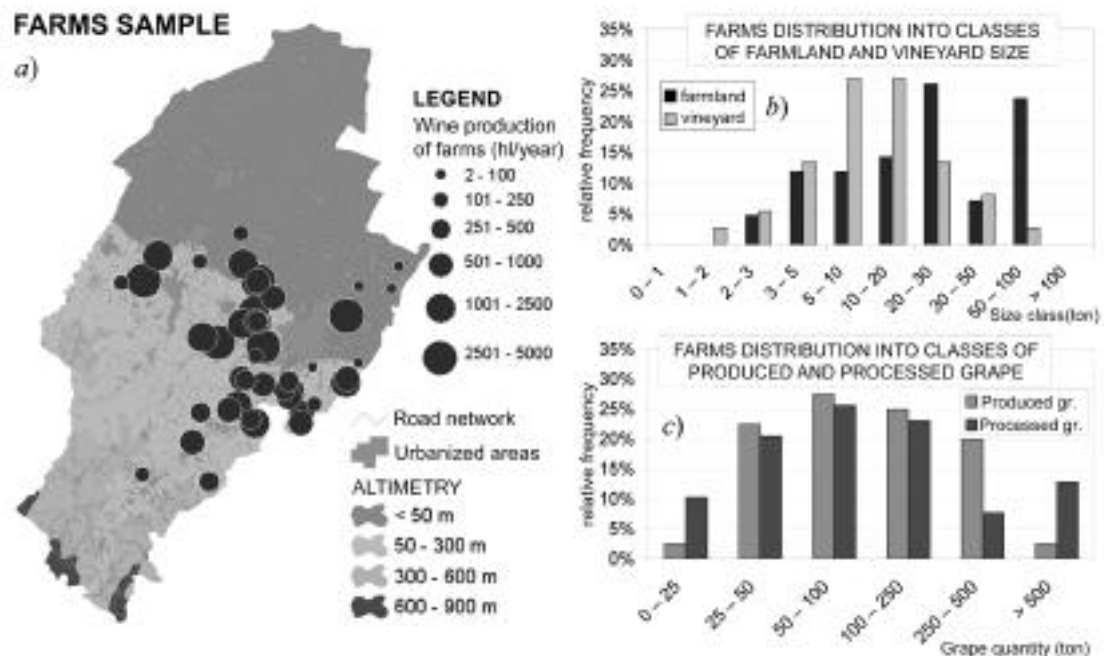


Fig. 4 - a) Location of the sampled farms and their wine production. b) Distribution of the sampled farms based on overall size and vineyard size classes, according to intervals defined by the Italian Statistic Board [Istat 2000]. c) Distribution of the sampled farms based on quantities of grape produced and processed.

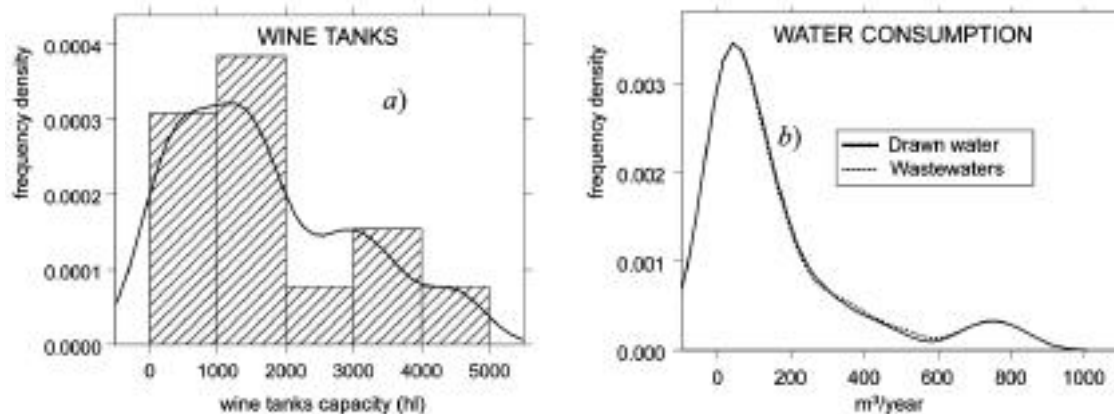


Fig. 5 - a) Histogram and equalized histogram of wine tanks capacity of the sampled wineries. b) Equalized histograms of the volumes of drawn water and wastewaters of the wineries.

with no bottling equipment have a definitely smaller production size (860 hl/year on an average). All the sampled farms provide tasting services and direct selling, and have a visitor car parking area for this purpose.

Farms providing also agritourism service are 13% and have a mean vineyard area and an average wine production of 10 ha and 670 hl/year respectively, therefore remarkably smaller than those of the remaining farms, which are 14 ha and 1200 hl/year respectively. Conversely, agritourism farm wineries are characterized by a greater average overall farm size (38 ha vs. 29 ha). The marketing trends of these farms appear therefore more broadly diversified, also outside the wine sector.

### 3.3 Building requirements for farm wineries

The analyses referred to building technical regulations, developed as described in section 2, have led to the identification of the main spatial units that, according to code provisions currently in force, have to be included when planning the spatial layout of a winery, both in the design of new buildings and transfor-

mation of existing ones. Such units are summarized in the scheme of Figure 6 and are referred to according to the numeration reported in the scheme itself.

In case grapes are not poured directly inside the winery, an outdoor sheltered drivable space is required for the grape receipt area (1). Within the building, proper development of the wine-making process and the disposition of the necessary equipments call for at least one room (2) to be planned, organized into two distinct sectors, dedicated to must production and the arrangement of wine tanks respectively. A further room (3) is required to contain the oenological products (additives and technological adjuvants); an alternative is to use a washable and disinfected properly-sized cabinet. Moreover at least one toilet (4) for the workers has to be planned, including one washbasin every ten workers and an access area, a changing room (5), and a shower room (6), with a shower every ten workers. In wineries producing bottled wine, in case bottling activities are not performed using temporary equipments, a dedicated room or suitable area of the wine-making room has to be planned for bottling and packaging (7), equipped with at least one

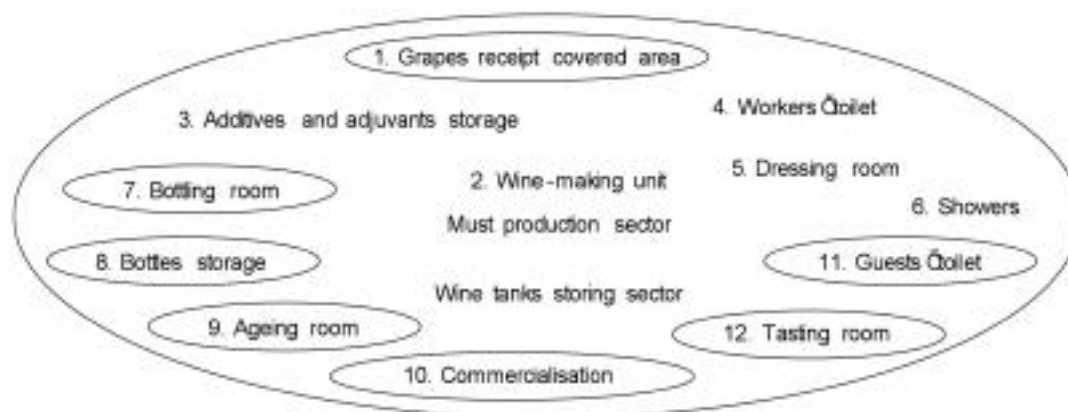


Fig. 6 - Conceptual scheme of the spatial units of a winery. Broken contour lines indicates rooms that may not be present, depending on process features and marketing choices.

	SU	REQUIREMENTS AND PARAMETERS
<b>H</b>	2	3 m
	3, 8, 9	2.40 m; 2,70 m if any work position is hosted
	5; 6; 10	2.70 m
	4; 11	2.40 m
<b>S</b>	4	1.2 m <sup>2</sup> per WC
	5	1.2 m <sup>2</sup> / worker; $\geq 2$ m <sup>2</sup>
<b>L</b>	2, 5, 7, 10, 12	1/8
	3, 8, 9	1/8; not required in rooms only occasionally used
	4, 11	1/8; $\geq 0.60$ m <sup>2</sup>
<b>V</b>	2, 5, 7, 10, 12	1/16
	3, 8, 9	1/16; not required in rooms only occasionally used
	4, 11	1/16; $\geq 0.60$ m <sup>2</sup>
<b>P</b>	1	drivable concrete paving
	2, 7, 8,	washable paving with draining system
	4, 5, 6, 11	tiled floor
<b>W</b>	2, 7, 8	tiling or plaster with washable anti-mould painting. For stone facing walls: painting with transparent washable anti-dust resins. At least up to tanks height or storing height, however $\geq 2$ m
	4, 5, 6, 11	full height walls, tiling at least up to 2 m

TABLE 1 - Main requirements and relative indicative parameters for the spatial units (SU) of wineries, in terms of minimum height (H), minimum surface area (S), minimum ratio of natural lighting surface area to room area (L), minimum ratio of natural ventilation surface area to room area (V), paving features (P) and wall requirements (W).

sink. If direct selling to the public is provided, a suitable room or area for commercialisation (10) is required. For tasting activities it is necessary that the winery includes a toilet for guests (11), accessible for disabled persons, and a tasting room (12).

We have performed a detailed synthesis of building requirements provided for wineries and relative design parameters, reported in Table 1. These parameters are meant as quali-quantitative indications of minimum reference standards, to be compared and integrated with the provisions of building and hygiene codes in force in each municipality.

In many existing wineries located in old rural buildings, the above parameters often result inapplicable, due to structural constraints. Although meeting the described requirements would assure the best functionality and safety conditions, the trend shared by technical officers of the various public institutions of the study area is to allow specific derogations for family-run farm wineries which do not perform bottling operations. In particular, in those cases it is provided that workers may use the toilet and the bathroom of farmers' homes, the minimum height for all the spatial units is 2.40 m, and minimum natural lighting and ventilation ratios are not considered as compulsory.

#### 4. Conclusions

The study has led to the identification of the main basic elements useful for the definition of meta-de-

sign requirements for small to medium-sized farm wineries, with reference to a study area in the Emilia-Romagna region (Italy). The results allowed to outline a preliminary framework of design references, related both to the main quali-quantitative characteristics of the production processes typical of the case study, and current law requirements of the considered sector.

In particular, the results regarding the sizes of the wine-growing and producing activities, the categories of wine produced and the modalities of bottling and packaging, and product presentation and commercialisation have pointed out the distinctive features of the considered farm typologies, for which few outcomes of specific studies were available. Moreover, the results of integrated analyses of code provisions and indications of the various regulation fields involved in the design process have led to define the main spatial units of wineries and the respective functional requirements and dimensional parameters. These have a fundamental importance to translate the functional needs of the investigated production processes into preliminary design solutions.

This study is part of a research project aimed at the combined reading of the above results and further outcomes of on-site surveys on a sample of wine farms, that will be the subject of future work, in order to analyse performance requirements of existing wineries. Based on the results of such analyses, we aim to identify the main design issues of the sector, and define a framework of proper technical and architectural solutions.

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## SUMMARY

The study represents the first step of a broader research aimed at outlining specific building and landscape design criteria for small to medium-sized farm wineries. With reference to a study area of the Emilia-Romagna region (Italy) representative of the regional wine-growing and producing sector, the specific aims of the study are the identification and quantification of the main production parameters, and the formulation of a preliminary framework of dimensional and functional requirements of wineries. We acquired, georeferenced, and analysed the available databases about wine farm production and sizes. We analysed a representative sample of such farms and the national and local codes about building design for that sector. The study has led to the definition of the main characters of the production process and a layout of the main parameters influencing the design process.

**Keywords:** farm wineries, functional needs, building design.

