

Article

Valuation Standards and Estimation Accuracy in the Appraisal of a Building Housing Vertical Farming

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Abstract: The possibility of carrying out the cultivation of numerous plant species in vertical farming highlights the need for policy makers to determine the cadastral value of the buildings in which these production activities are carried out. In this regard, estimates of buildings intended to host vertical farming are illustrated according to the procedure established by Italian cadastral legislation, which establishes that the fiscal value of buildings intended for vertical farming must be estimated through their market value. Appraisals are carried out using the direct capitalization method but follow two different approaches. One approach is based on the expertise of the appraiser, who acts by making assessments through subjective and arbitrary choices. The other approach is based on the use of best practices, as indicated by international evaluation standards that follow appropriate methodologies. Our comparison between the two approaches focuses on determining the capitalization rate, which determines the estimated value. The market value estimated using the procedures recognized by the valuation standards appears to be more valid methodologically and more reliable. This is demonstrated by applying yield capitalization to the same income cash flow in both formulations. Additionally, through the identification of the conversion cash flow, useful details on financial flow can be obtained and used to determine the value. The obtained results may be useful for public operators for the purposes of determining the value of assets for tax purposes. More generally, they are also useful from a methodological and application point of view in real estate valuation and support the development of tools for making efficient investment choices.



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1. Introduction

In recent years, the diffusion of the real estate valuation standard in Italy has experienced significant growth due to several factors, including the increased availability of comparative real estate data and an increase in the functionality of access to public and private databases due to the greater efficiency of information technologies [1,2].

The opportunity to perform real estate appraisals following valuation standards in a context different from the one in which they were conceived and widely used, like in the UK and the USA, has encouraged further interest among Italian appraisers and certification bodies involved in the process leading to the acquisition of certification for appraisers [3–5]. These dynamics have also affected the prevalent approaches in Italian estimation practices [6], where the use of standardized evaluation practices is less widespread. Instead, synthetic and analytic estimate methods have remained deeply rooted, mainly due to the contributions made to the discipline by studies carried out during the last century by various authors [7–11].

The opportunity to access efficient and universally recognized valuation methods, considered as “best practice” references, has brought about considerable research from

scholars, professionals, and real estate operators, who have attempted to introduce valuation standard rules in real estate appraisals [12–15].

Although the proposed methodological content is not different from that found in the estimation literature, these best practices, subject to periodic review, indicate that the followed procedures are performed in a manner that is consistent with the estimation principles that are used internationally [16]. In this context, one of the fundamental principles of this approach is the application of intelligible and replicable methods, which is required to take place on the basis of objective economic-estimative elements and through the detection of quantitative and qualitative characteristics. Unsurprisingly, the estimation procedures recognized in [16,17], codified on the basis of the contents of the International Valuation Standard (IVS) and the European Valuation Standard (EVS), have already been described in some estimation manuals [18,19].

However, the use of procedures that do not meet the principles adopted by IVS continues to be non-negligible in the Italian context [20,21]. In this context, there is still the possibility that estimations of the market value of real estate are performed by more or less explicitly resorting to an appraiser's expertise.

In real estate, expertise indicates the judgment formulated by an appraisal in a subjective way, without the possibility of being submitted to demonstration, as it is derived by omitting the use of "intelligible and replicable methods (. . .) that are instead essential in the scientific approach that underlies valuation standards" and the substance of estimates [16].

The use of intelligible and replicable methods is the basis for the application of valuation standards that recall the need to develop property estimates on the basis of objective comparable factors, based on the recognition of the specific characteristics of the asset to be estimated [16,22,23].

With reference to a market-oriented approach, a typical example of an appraisal technique carried out by the use of an appraiser's expertise is the monoparametric method [21]. In this method, the market value of the asset is carried out solely according to a single characteristic (usually the surface area), neglecting the possibility that other characteristics could influence the value of the asset. Beyond that, however, the average reference price used to make the comparison (e.g., EUR/m²) is often set arbitrarily by the appraiser without specifying the data used to derive it [2,24,25].

Therefore, by relying on the personal and subjective judgment of the appraiser, the estimate made based on expertise lacks the requirements of reliability and replicability which are present in international standards. This is a problematic issue, because neglecting the basic requirements recognized by valuation standards can negatively and significantly affect the appraisal value [26,27].

The use of appraiser expertise, however, also results in distorting effects in the application of income capitalization estimates. The major pitfalls are related to the nature and complexity of the operations required to identify the capitalization rate, especially when the appraiser relies on arbitrary judgments, with negative consequences in terms of the replicability, transparency, and reliability of the estimated rate and appraised value [16,19,28]. The aim of this paper is to verify the efficacy of using the estimation procedures recognized by the valuation standards with reference to the income capitalization method versus the use of real estate expertise. Verification is carried out by comparing the estimates of a building intended to house vertical farming using the income approach.

More precisely, this paper provides a methodological and applicable contribution that is useful for addressing the issue of determining the tax value of a building intended to host vertical farming.

In fact, this type of building, i.e., with special usage characteristics, falls into the category of properties for which the Italian cadastral system does not establish a unique and common cadastral tariff variable based on surface area, but requires an estimate of the market value to be carried out on a case by case basis for this category of buildings.

This topic is of particular interest, because vertical farming constitutes an agricultural production context that seems likely to have prospects for diffusion in many urban

contexts. In addition, this topic could bring to the attention of appraisers an appropriate methodological approach to be used for valuing this kind of building.

The analysis was conducted in an Italian context but is applicable to other estimating contexts, i.e., with reference to other countries that have other cadastral systems, and for the determination of the market value of real estate intended for other uses or for purposes related to real estate investments. The examined topic also deals specifically with the estimative aspects involved in determining market value which are useful not only for cadastral aspects but also for the investors and other operators involved in real estate, such as banks, technicians etc.

The analysis was carried out by applying two capitalization methods: direct capitalization and yield capitalization. The analysis was characterized by some distinctive features that are innovative in some ways. Although, in fact, with reference to the estimation of real estate conducted with market-oriented methods, some authors have highlighted the usefulness of resorting to the IVS best practices [2,29], to the best of my knowledge, there is a lack of similar analyses with respect to the use of best practice of standard valuation applying the income approach. In addition to highlighting the reliability of the estimated market value achievable using standards-based estimation methods, some innovative insights related to the use of cash flow conversion also emerged from the examined case study. In particular, the procedure appears to be useful for operating effectively and reliably in the auditing of the results of appraisals already made and both in estimating the market value of a property and in the financial analysis of the investment, contributing to providing effective choice support to investors [12]. Other possible applications may relate to aspects of estimative analyses carried out using spatial econometric approaches [30,31] or focusing on fiscal or social aspects [32,33].

The article is structured as follows: after a brief description of the estimation context, the methodology is described. The case study is shown with an analysis and a discussion of the main results. Some brief concluding remarks close the paper, highlighting some limitations of the study, with the hope that further applications and research of the subject may follow.

2. Vertical Farming and Estimative Analysis

Vertical farming (VF) can be described as an agricultural practice carried out in urban and confined environments, mostly consisting of buildings or greenhouses [34]. In such environments, temperature, water, humidity, and light are artificially controlled through the use of sophisticated technologies [35] which are capable of ensuring suitable conditions for plant development and growth with limited labor input and without pesticide interventions [36]. The cultivation techniques used consist of those that can be used in a confined environment, such as hydroponics, aeroponics, and aquaponics [37]. The achievable benefits mainly consist of soil savings, which is a particularly useful aspect in an urban environment, raw material savings, the absence of pesticide interventions, and the ability to supply consumer markets by reducing climate-change gas emissions due to reduced transport of harvested productions [38]. The water volumes used for cultivation are also reduced [36]. The absence of pesticide residues also provides assurance in terms of food safety [39].

As a result of these peculiarities, interest is being directed toward vertical farming by various economic players including, in addition to agribusinesses, companies active in technological innovations, real estate investors, and consumers [40]. The capacity to compete in the supply of food near or within urban centers, coupled with the ability to curb the waste of limited resources and help limit greenhouse gas emissions, give the VF considerable potential for growth in view of the product, process, and organizational and management innovations that can be fostered as technological innovations occur [41]. These characteristics also make VF particularly suitable for several of the aims of the 2030 Agenda for Sustainable Development adopted by the United Nations [42], with beneficial effects for the environment but also for communities, consistent with the pervasive logic

of sustainable development [43]. The estimative analysis proposed here concerns the determination of the value of buildings in which vertical farming will be established [44].

The purpose of the appraisal which is the case study below, however, is not to determine the value of the productive activity but the estimation of that of the building in which vertical agriculture will be established. The valuation, therefore, does not take into account the revenues, costs, and income of the cultivation activity, which may differ according to the cultivated species, the techniques used, etc.

It should also be considered that these assessments are influenced by the market opening for these innovative cultivation methods and the degree of integration they can achieve compared to traditional agricultural settings. In this respect, a comparison between short and traditional food chains showed a limited degree of substitutability [45], from which it was concluded that these niche markets tend to coexist with conventional systems rather than replace them. Applying this framework to vertical agriculture, it is possible to assume that it too may remain a niche market in the near future, especially in environments where infrastructure, consumer preferences, and regulatory support favor traditional agriculture. However, this can be helpful from a methodological as well as an application point of view for appraisers and investors that are interested in start-up vertical farming activities. With reference to the first aspect, the analysis makes it possible to arrive at an appraisal value of a property but also to determine the return on investment, offering an innovative path for determining the internal rate of return (IRR). From the second point of view, the proposed analysis is also characterized by an application profile of possible interest to any investors potentially interested in making investments in such a business; to professionals involved in this kind of valuation; and to policy makers, public decision makers, and administrators, who, in light of the increasing spread of VF production facilities, are called upon to define, from a legal and fiscal point of view, the most appropriate profile of such activities [46].

The proposed analysis can be further enriched and expanded in a way that is functional for broad estimation objectives such as those, for example, of estimating business activities as a whole [47]. What is outlined in the paper is therefore not intended to be exhaustive with respect to the addressed topic, but it is believed that it can nonetheless constitute a contribution to analysis techniques in the context of a modern, know-how-intensive line of business with a great need for innovation, such as VF. In this regard, other valuation issues that should be taken into account are those related to the need to consider environmental, social, and governance (ESG) factors and their effects on the market value of real estate [48].

3. Materials and Methods

The present case study illustrates the determination of the market value of a building intended to house vertical farming by using the income-capitalization method. As pointed out previously, the aim is to contribute, through a concrete case, to the determination of the value of the cadastral tariff of a property intended to host a VF.

The building considered was deemed adequate to host a VF in relation to its location in an urban context, as it is easily connected to the main communication routes. It is located near the railway station and the city harbor. It is also well connected to the motorway junction for the road transport of the harvested products intended for sale in the agri-food distribution chain. Also, from a functional and structural point of view, it shows characteristics making it suitable to host VF as, in the past, it has been used for the wholesale sale of ornamental plants. VF activities can be inserted into urban contexts, as in the case described here, and can be designed and undertaken even in “normal” buildings that do not require particular characteristics [49]. They can also be undertaken in buildings without windows or can be adapted to structures that present particular external constraints, such as historic buildings or those with valuable architecture [50,51].

Since it is possible to respect the entire external infrastructure of a building that houses cultivation, VFs can also contribute to the redevelopment and recovery of disused industrial structures, abandoned buildings, and unused warehouses [52].

In the examined case, this aspect is of particular relevance, since, from the point of view of the Italian cadastral regulations, the value of the property, being characterized by its location, is separate from the economic yield of the production activities carried out within it [53].

From this point of view, agricultural cultivation carried out within buildings is included within the categories of special-purpose buildings, i.e., in the category D/10—buildings for production functions related to agricultural activities.

For real estate in this category (Group D) and for those that manifest singularities in terms of their characteristics (Group E), cadastral value is determined by direct estimation of the market value for each individual unit [53]. In this regard, the value of the real estate consists of the market value that can be determined using one of three estimation approaches: income approach; market approach and cost approach.

In the case study analyzed here, the appraisal was carried out using the direct capitalization and the yield capitalization methods. Cash flow conversion was also applied to ascertain the return on investment (Figure 1).

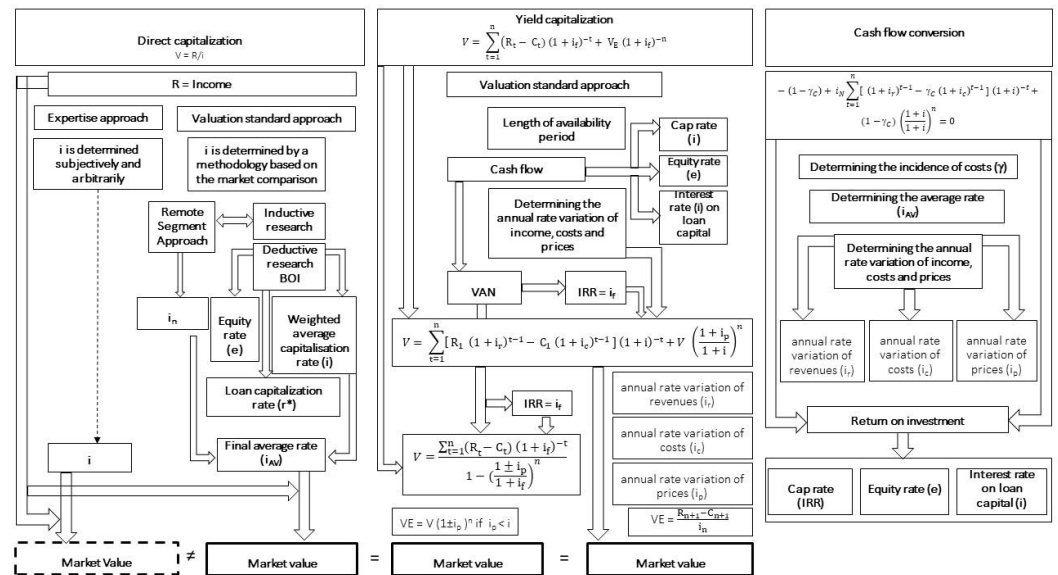


Figure 1. Methodological path.

Two different approaches have been applied in the direct capitalization method. The first is represented by direct capitalization with determination of the rate in a subjective and a priori way by an appraiser, based on his expertise. The second one was developed following the methodology recognized in the valuation standards literature [28,54], carrying out research of the rate using the inductive and deductive method. The determination of market value by yield capitalization is also illustrated. In this method, also the internal rate of return of the investment, represented by the purchase of the property, has been estimated. In this regard, it was considered that the purchase of the property was done partly with the buyer’s capital (on equity) and partly by resorting to bank credit through a mortgage contract with constant, annual, and deferred payments (loan to value). To ensure the consistency of the results obtained using the two different approaches and to verify the reliability attributable to those results, the same income to be capitalized was used in both methods. The capitalization rate, equity rate, and interest rate were also calculated by a different approach, i.e., cash flow conversion, without determining the income of the property.

The direct capitalization procedure used assumes that the annual income that the property is capable of delivering is continuous and constant, so the value was obtained by dividing the income over the capitalization rate as follows [55]:

$$V = \frac{R}{i} \quad (1)$$

where V denotes the market value of the property to be estimated, R the net annual income (Euro/year), and i is the annual capitalization rate. Since i corresponds to the inverse of the gross rent multiplier (GRM) [19], the value can also be derived as follows:

$$V = R \times \text{GRM} \quad (2)$$

For the determination of the income to be capitalized, the procedure followed was that provided by the Agenzia delle Entrate [53,56], using data collected on the market with the help of technicians and professionals in the field. For the determination of costs, official data [57], as well as direct surveys from real estate operators operating in the local market, were used.

The direct procedure assumes that the cadastral rent is obtained from the ordinary gross income, retraceable by deducting expenses and any losses. Ordinary gross income is the rent from which ordinary maintenance expenses incurred by the tenant and expenses incurred by the landlord are deducted [53].

More precisely, the income to be capitalized is obtained through an average annual estimated budget as the difference between annual operating revenues and costs. Revenues are represented by the average annual rent found in the local market for a property with similar characteristics to the one to be estimated. The costs taken into account were those related to the ordinary operation of that type of property and consisted of maintenance and repairs, insurance, management, utilities and services, vacancy, and unpaid rent. Prices were taken from the local market for properties with similar characteristics to the one to be studied.

Direct capitalization was applied in two ways. In the first mode, the capitalization rate was considered to have been subjectively established by the appraiser, based on his own beliefs and thus on his own expertise. The value obtained in this way was compared with a second estimate carried out using the same method (direct capitalization) but following the best practices of valuation standards. Given the uniformity of the property's income, in this second appraisal, the analysis focused on the determination of the capitalization rate. In this regard, the inductive method, based on the Remote Segments Approaches (RSA) [28,58–60], and the deductive method, based on the use of the band of investment (BOI), were used [16,48,54]. Both RSA and BOI allow compliance with the logic of valuation standards, which require adherence to certain basic and self-evident principles regarding the reliability of the achievable estimation result in terms of objectivity and transparency [16,22,23].

Using the inductive method based on segment comparison, in the absence of similar properties, the capitalization rate was determined by comparing price and income, in reference to different properties, belonging to a market segment different from the one of the property being estimated.

The market segment constitutes the non-further separable elementary unit of the real estate market. Properties with common technical and economic characteristics are identified within the same segment, and each market segment is distinguishable from the others [16].

In general terms, given two properties (A and B) for which the corresponding prices and incomes have been detected (respectively, P_A and R_A , and P_B and R_B), the price/income

ratio of the market segment (ρ_{seg}) is derived as the expected value by which the respective incomes occur:

$$\rho_{\text{seg}} = \rho_A \frac{R_A}{R_A + R_B} + \rho_B \frac{R_B}{R_A + R_B} = \frac{P_A + P_B}{R_A + R_B} = \frac{P_{\text{seg}}}{R_{\text{seg}}} \quad (3)$$

where $\rho_A = \frac{P_A}{R_A}$, $\rho_B = \frac{P_B}{R_B}$, P_{seg} and R_{seg} represent average values (e.g., EUR/m²; EUR/m² per year) [20].

If prices and incomes refer to different properties belonging to the same market segment, the sought relationship can be derived from average unit prices and incomes, even with different data. In this context, Equation (1) assumes the following formulation:

$$\frac{\frac{P_C + P_D}{S_C + S_D}}{\frac{R_X + R_Y + R_W}{S_X + S_Y + S_W}} = \frac{P_{\text{seg}}}{R_{\text{seg}}} \quad (4)$$

where:

- P_C and P_D represent prices of C and D properties, respectively;
- R_X , R_Y , and R_W represent, respectively, the incomes of properties X, Y, and W;
- S_C and S_D represent, respectively, the surfaces area in properties C and D;
- S_X , S_Y , and S_W represent, respectively, the measurement of surface area in buildings X, Y, and W.

As the sample size increases, the price/income ratio can be inferred from the respective average values:

$$\rho_{\text{seg}} = \frac{\text{Prices average}}{\text{Incomes average}} \quad (5)$$

When price and income data were not available in the same market segment in which the asset being valued fell, as presented here, according to the best practice of standard valuation [16], the price/income ratio was estimated using the RSA [28,57,58].

This procedure makes a comparison between the market segment of the asset being estimated and one or more similar market segments. The purpose of the method lies in estimating the GRM (and subsequently the capitalization rate) in the segment to which the asset to be estimated belongs. From the ratio of prices and incomes found in other market segments, the RSA, by some adjustments on these quantities, derives the rate to be used to develop an estimate of the value of the asset based on income capitalization.

Therefore, the determination of the capitalization rate is done through the inductive method, following the logic of remote search for the rate and making comparisons with market segments for which prices and incomes are available [28,54]. Prices and incomes being measured in different market segments, they are subjected to systematic adjustments with reference to the marginal values of the characteristics for which they differ. These adjustments can be expressed in percentage and value terms [28,54].

The choice of comparison characteristics concerns those for which differences occur between the subject segment and the comparison segment.

In this aspect, too, the evaluation standards are very detailed, as they indicate the characteristics to be taken into account in the comparison. In particular, the following are stated: the location, the type of contract, the location, the property type, the building type, the size, the demand and supply characteristics, the market form, the price level, and the number of exchanges [16,28]. Consistent with the principles of comparison, characteristics with the same intensity are not useful for estimative comparisons and were therefore not taken into account. For each characteristic, moreover, adequate identification is provided by means of the appropriate nomenclator and related technical and economic measures.

The purpose of this step is to be able to determine, with all else being equal, the extent to which the market price level of the comparable segment differs from the price level of the segment in which the property being estimated belongs.

The achieved result is represented by the value that the prices and incomes of properties belonging to a comparable segment would have if they belonged to the segment in which the estimated asset lies [28].

With reference to two segments (H) and (K), the RSA predicts that marginal price $\Delta_H^{\text{par } j}$ of generic character j , expressed in percentage terms, and marginal income $\delta_H^{\text{par } j}$ of a generic character j , also expressed in percentage terms, can be derived through the following expressions, respectively [28]:

$$\Delta_H^{\text{par } k} = \frac{P_K^{\text{par } j} - P_H^{\text{par } j}}{P_H^{\text{par } j}} \quad (6)$$

$$\delta_H^{\text{par } j} = \frac{R_K^{\text{par } j} - R_H^{\text{par } j}}{R_H^{\text{par } j}} \quad (7)$$

The market price and income corrected for all the characteristics of the market segment of the property to be appraised can thus be determined based on the following relationship, by which we identify the prices [$P_K(H)$] and incomes [$R_B(H)$] which properties belonging to a comparable segment (H) would have if they fell into segment (K), in which the property to be estimated belongs to (8) and (9) [28,58]:

$$P_K(H) = P_H \left(1 + \Delta_H^{\text{localization}} + \Delta_H^{\text{location}} + \Delta_H^{\text{typology}} + \Delta_H^{\text{dimension}} + \dots \right) \quad (8)$$

$$R_B(H) = R_H \left(1 + \delta_H^{\text{localization}} + \delta_H^{\text{location}} + \delta_H^{\text{typology}} + \delta_H^{\text{dimension}} + \dots \right) \quad (9)$$

Price–income ratio $\rho_K(H)$ of the segment of the property to be valued is then equal to:

$$\rho_K(H) = \frac{P_K(H)}{R_K(H)} \quad (10)$$

where $P_K(H)$ and $R_K(H)$ are the adjusted average unit prices and rents.

The characteristics taken into consideration for the application of the RSA were location and building type, with reference to both the rental and price segments. This is because, with regard to the other relevant characteristics for market segmentation, no differences were found. The comparison segment (Segment A) includes buildings with commercial uses, such as showrooms, hospitality and cultural events such as exhibitions and celebratory ceremonies, and period of construction, i.e., around the middle of the 20th century. A comparison of average annual values (Euro/m² per year for rent; Euro/m², for prices) was carried out with the values of average market quotes collected from local real estate operators related to the segment to which the property to be estimated belongs. The market segment to which the property to be estimated belongs consisted of buildings in which service and tertiary production activities are carried out, with modern period of construction.

The relative differences measured with respect to the characteristics considered in the comparison of the available values in the examined segments made it possible to determine the fitting coefficients to be taken into account in the application of the RSA.

Since the property to be appraised was purchased by resorting to a bank loan, a deductive search for the capitalization rate was conducted by employing the BOI, which estimates the capitalization rate by decomposing the property to be appraised into its financial components. Capitalization rate i of a property to be valued is derived from the weighted average of the rates of the financial parts of the investment property consisting of the capital invested by the owner and the capital borrowed from a lending institution.

The formula used to derive the capitalization ratio via the BOI can be written as follows [19,28,48]:

$$i = M r^* + (1 - M) e \quad (11)$$

where M is the ratio of the sum borrowed to the market value of the property, also referred to as Loan to Value;

r^* is the capitalization rate of the loan;

e is the direct profitability rate on the self-financed portion (equity rate).

The profitability rate expresses the measure of the profitability of the investor's equity used for the purchase of a property and may be expressed by the ratio of net income to the purchase price, or by the capitalization rate.

For the purpose of determining the profitability rate, therefore, net income R_N of the property, obtained by subtracting expenses other than the cost of the loan instalment, is divided between debt service B and the part allocated to the owner, referred to as equity (E) [16,19]:

$$RN = B + E \quad (12)$$

In this relationship, B is the capital borrowed by the investor through a bank credit transaction, and E represents the investor's equity used in the investment. From the ratio between the equity used for the purchase (equity) and the part financed by bank credit, we derived the measure of the profitability of the property for the investor. If M denotes the ratio between the amount borrowed (borrowed) and the market value of the property, the rate of direct profitability and of the self-financed part of the investment (equity rate) can be derived from the ratio between equity and the self-financed percentage $(1 - M)$ of market value V of the property in the following way:

$$e = \frac{E}{(1 - M) \times V} \quad (13)$$

Mortgage capitalization rate r^* (mortgage capitalization rate), given in Equation (13), is derived from the following relationship:

$$r^* = \frac{B}{M \times V} = \frac{r}{1 - (1 + r)^{-n}} \quad (14)$$

as:

$$B = M \times V \times \frac{r}{1 - (1 + r)^{-n}} \quad (15)$$

where r is the interest rate of the loan;

n is the loan length in years;

B is the debt service, which is equal to the amortization rate of the borrowed percentage of the value of the property.

If the purchase of the property is totally self-financed without recourse to a mortgage ($M = 0$), capitalization rate i is equal to profitability rate e (equity rate).

The capitalization rate of the loan r^* is thus equal to the amortization rate of the capital unit with the periodicity and maturity of the loan payment referring to the year.

Applying the BOI technique, the capitalization rate is therefore equal to the weighted average of the capitalization rate of the loan for the loaned portion (loan to value, LTV) and the profitability rate (equity rate, e) of the property for the remaining self-financed portion (13).

In our deductive search for the rate, the incidence of the depreciation rate on the income was also calculated, according to the following relationship [28]:

$$\mu = \frac{Q_D}{R_N} = \frac{LTV r^*}{i_N} \quad (16)$$

where Q_D is the annual rate of the loan redemption;

R_N is the annual net income;

LTV is loan-to-value, also referred to as M ;

r^* is the capitalization rate of the loan, equal to $\frac{r}{1 - (1 + r)^{-n}}$;

i_N is the capitalization rate.

Equity rate (e) was calculated according to the following relationship:

$$e = \frac{LTV}{1 - LTV} \frac{1 - \mu}{\mu} r^* \quad (17)$$

where the symbols used have the meanings already indicated and from which (13) was arrived at by using value r^* for the borrowed amount, provided that M represents LTV.

The capitalization rate used to estimate the property was obtained as final average rate i_{av} and is equivalent to the average value of net rate i_N , determined by the inductive method, and the weighted average rate, obtained by the BOI deductive search, according to the following relationship:

$$i_{av} = \frac{i_N + i}{2} \quad (18)$$

A valuation of the property was also carried out by yield capitalization, which envisages an initial cost equal to the purchase price of the property, a series of variable annual incomes, and a final income consisting of the resale value of the property at the end of the availability period. This is a different and more realistic assumption than the one underlying direct capitalization, which assumes a constant and unlimited return on the property over time. Yield capitalization can be represented according to the following general formulation [19,28,48]:

$$V = \sum_{t=1}^n (R_t - C_t) (1 + i_f)^{-t} + V_E (1 + i_f)^{-n} \quad (19)$$

where:

R_t and C_t represent, respectively, the annual deferred income of the property during the availability period;

V_E represents the final resale value of the property at the end of the availability period;

n denotes the duration of the availability period of the property;

t denotes a generic year within the availability period of the property;

i_f represents the net annual capitalization rate.

Depending on the different ways in which the value of V_E can be determined, (19) can be formulated in different ways.

If V_E is determined by capitalizing the income of the year following the availability period, (19) becomes the following:

$$V = \sum_{t=1}^n (R_t) (1 + i_f)^{-t} + \frac{R_{n+1}}{i_n} (1 + i_f)^{-n} \quad (20)$$

If, on the other hand, V_E is determined on the basis of the depreciation or revaluation of the current market value of the property during the availability period [13], (19) may be configured as follows:

$$V = \frac{\sum_{t=1}^n (R_t - C_t) (1 + i_f)^{-t}}{1 - \left(\frac{1 + i_p}{1 + i_f}\right)^n} \quad (21)$$

where:

i_f represents the net annual capitalization rate

i_p denotes the annual rate of price change;

n denotes the period of availability of the property in years;

t denotes a generic year within the availability period of the property.

Deductive searches for the rate can be applied in financial capitalization through two distinct steps. The first involves the application of the BOI for the determination of the direct capitalization rate (i_N); the second is based on the conversion of this into the financial

capitalization rate [28]. Having previously applied the BOI (13), with regard to the second step, the procedure was carried out by determining the conversion cash flow of the rate obtained from the formulation of the financial capitalization cash flow expressed as follows:

$$V = \sum_{t=1}^n [R_1(1 + i_r)^{t-1} - C_1(1 + i_c)^{t-1}](1 + i)^{-t} + V \left(\frac{1 + i_p}{1 + i} \right)^n \quad (22)$$

where:

- i_r is the annual rate of income variation;
- i_c is the annual rate of cost variation;
- i_p denotes the annual rate of price variation;
- n is the length of property availability in years;
- t is a generic year in the property availability period;
- i is the annual capitalization rate according to the yield capitalization method

With reference to annual variation rate, i_r was determined taking into account the annual change in contractual salaries provided by the Italian Institute National of Statistics [61]; i_c was defined taking into account the average planned inflation rate, calculated by the Italian Treasury Department [62]; and i_p was determined taking into account the price index of existing buildings [63].

Capitalization rate i_N in the direct capitalization method can be expressed by the following relationship:

$$i_N = \frac{R_1 - C_1}{V} \quad (23)$$

where R_1 is the property's revenues in the first year, C_1 is the property's operating costs in the first year, and V is the property's market value.

Assuming that costs (C_1) and revenues (R_1) are related in the following way:

$$\gamma_C = \frac{C_1}{R_1} \quad (24)$$

direct capitalization rate i_N can be written in the following way:

$$i_N = \frac{R_1 - (1 - \gamma_C)}{V} \quad (25)$$

Therefore, by setting (23) equal to zero and substituting the ratio γ_C for C_1 , the same expression can be written in the following way:

$$-V + R_1 \sum_{t=1}^n [(1 + i_r)^{t-1} - \gamma_C(1 + i_c)^{t-1}](1 + i)^{-t} + V \left(\frac{1 + i}{1 + i} \right)^n = 0 \quad (26)$$

From which multiplying by arbitrary factor $\frac{(1-\gamma_C)}{V}$ and substituting in (23) gives:

$$-(1 - \gamma_C) + \frac{R_1(1 - \gamma_C)}{V} \sum_{t=1}^n [(1 + i_r)^{t-1} - \gamma_C(1 + i_c)^{t-1}](1 + i)^{-t} + (1 - \gamma_C) \left(\frac{1 + i}{1 + i} \right)^n = 0 \quad (27)$$

which is equivalent to the following expression:

$$-(1 - \gamma_C) + i_N \sum_{t=1}^n [(1 + i_r)^{t-1} - \gamma_C(1 + i_c)^{t-1}](1 + i)^{-t} + (1 - \gamma_C) \left(\frac{1 + i}{1 + i} \right)^n = 0 \quad (28)$$

With this formulation, identifiable as conversion cash flow, known as direct capitalization rate i_N , financial capitalization rate i represents the internal rate of return on the financial investment.

The notation that follows is that the calculation of the capitalization rate can be done without determining the income of the property [28].

Using the same procedure, the values of the equity rate and the interest rate were also calculated as a function, respectively, of the cash flows of the equity used by the investor and of the capital borrowed and repaid through payments of the annual redemption of the loan.

4. The Appraisal of the Building to Be Used for Vertical Farming

The asset to be estimated consisted of a building that can be used for vertical farming activities, located in the center of Catania (Sicily, southern Italy), in an area of the city where there are buildings intended for residential and office use of modern real estate typology, as well as buildings that host commercial activities for the sale of consumer products and other buildings intended for activities such as hosting cultural events, exhibitions, etc., as well as ancient real estate typologies.

The building to be estimate, having been built around 2010, can be considered to be of modern construction. Given the absence of data of similar properties bought and sold recently, an estimation by market comparison methods was not applicable. Therefore, to estimate the market value of the building, the income approach was used. Direct capitalization was initially applied in two different ways. The first was based on the use of the appraiser's expertise. The second was based on the use of best practice valuation standards.

The results obtained, although derived from the application of the same method, were different because of the different levels of accuracy followed, especially with regard to the capitalization rate.

The income to be capitalized, by using an economic balance sheet for estimation purposes, was obtained from the values of operating revenues and costs, including the annual payment for of the amortization fee paid to pay off the capital, which was considered to be borrowed (Table 1). As mentioned previously, the data used referred to the general operation of the building and did not include the flow of cultivation activities carried out within it. This was because the aim of the appraisal was to estimate the market value of the building itself.

Table 1. Revenues, costs, and income of the building to be estimated (Euro/Year).

	(Euro/Year)
Revenues (annual rent)	266,000
Costs	113,700
- Loan payment	26,600
- Maintenance and repairs	18,500
- Insurance	12,000
- Management	13,300
- Utilities and services	30,000
- Vacancy and uncollectibility	13,300
Income	152,300

To proceed with direct capitalization, once the determination of income had been made, the capitalization rate to be used had to be identified.

The first application using the direct capitalization method (Equation (1)) was based on the use of the appraiser's expertise and involved a rate that was determined subjectively and arbitrarily.

Following this procedure, the valuer took into account the return on other financial investments, which the appraiser adapted to the estimate context through variations that were deemed suitable in the appraiser's own judgement on the basis of his own personal opinions.

With reference to the examined case, the government bond yield taken as a reference was that of index-linked treasury certificates (Ccteu), which, at the time the estimate was made (July 2024), stood at 5.04% [64]. These are variable-rate bonds with a duration of between 3 and 7 years, indexed to the 6-month Euribor rate. In consideration of his experience in the local real estate market and in relation to the dynamics of the local real estate market and other indications that could be considered valid to justify the choice he felt to be most appropriate, the appraiser opted to modify the base rate taken as reference (5%) by increasing it by one percentage point. Using the appraiser's expertise, the capitalization rate to be used was established to be equal to 0.06. This was based on subjective perceptions and assessments, undertaken in an arbitrary and opaque way, which basically and explicitly manifests the use of expertise.

Even if these limitations exist, comparing the annual income of the property (Euro 152,300, considered continuous and constant, using Equation (1)), it was possible to obtain a market value of Euro 2,538,333. However, the question to be asked is whether this value really corresponds to the market value attributable to the asset.

The method followed by the appraiser, although advantageous for the limited commitment required in terms of the time and resources used, led to an estimate that was probably not entirely reliable. The obtained result was also free from the transparency and veracity requirements common to valuation standards [16,22,23].

To verify the reliability of the value estimated by using the appraiser's expertise, verification, carried out by making a second estimate of the same asset, was applied. This verification was carried out by the same method, i.e., direct capitalization, but by identifying the capitalization rate following a different path. The aim was to verify whether and what differences occurred by using an approach that was more in line with the guidelines of the valuation standards.

The verification focused on the possibility of determining the capitalization rate following a transparent and replicable procedure. It was adapted to the fundamental principles established by the valuation standards and using methods recognized by best practices of property valuations that are shared nationally and internationally [16,22,23].

In particular, the method used to determine the capitalization rate differed from that based on appraiser's expertise, in that, rather than being determined subjectively, an inductive and deductive search of the capitalization rate was performed by comparing it with real estate data collected on the market [16,28,48,54]. The rate to be used in direct capitalization was derived from the average value of the rate obtained by inductive research conducted with RSA and the rate obtained by deductive research, i.e., by the application of the BOI.

The capitalization rate, not being a quantity expressed by the market, cannot be defined a priori by the appraiser. Derived from original quantities (prices and income) that can be found on the market, its size depends on the values assumed by these quantities. Therefore, the corresponding values must be surveyed in the segment of the asset to be estimated or in segments close to it [54].

The market segment to which the asset to be estimated belongs consisted of buildings dedicated to tertiary activities and advanced services with a modern building typology.

As a market survey did not yield real estate data for similar assets, in order to determine prices and incomes, it was necessary to extend our analysis to other market segments. Market surveys provide useful data for the induction search of capitalization rates, by comparing different segments (8 and 9). In particular, some data were available for properties belonging to a different market segment (Segment A) that was close to that of the property segment to be evaluated. Segment A includes buildings constructed in the 1950s but with commercial use, such as showrooms, hospitality, etc. that can be assumed to be quite compatible with the market segment of the property to be valued.

In the comparison with segment A, the annual rents of three buildings (property 1, property 2, and property 3) were surveyed, from which the average annual rent (Euro/m²

per year) was derived, and two sales prices (those of property 4 and property 5) we obtained, from which the average unit price (Euro/m²) was determined (Table 2).

Table 2. Determination of the capitalization rate by the inductive approach.

Properties	Annual Rent	Surface	Annual Average Unit Value	GRM	Capitalization Rate
	€/year	m ²	€/m ² × year		
Property 1	252,000	752.4	334.93		
Property 2	312,000	615.6	506.82		
Property 3	189,600	848.31	223.51		
Average	251,200	738.77	340.02		
Property 4	665,000	225.3	2951.62		
Property 5	745,000	294.7	2527.99		
Average	665,000	225.30	2951.62		
GRM				7.97	
i_L					0.1254
i_N^*					0.0718

* The incidence of expenses is equal to 0.43.

The unit average values are equal to Euro 340.03/m² year and Euro 2711.54/m² respectively. The corresponding GRM is 7.97, with a gross capitalization rate of 0.1254. Taking into account that the incidence of expenses on the income of the property is equal to 0.43, the net rate to be taken into account for the purposes of determining the capitalization rate, however, is equal to Euro 194.68/m² year. Therefore, the net capitalization rate i_N would be 0.0718.

Since the values are surveyed in a market segment different from that of the property to be estimated, the estimation analysis for determining the rate therefore continues through the use of RSA. This method, although prices and income are surveyed in a different market segment, through some adjustments on the characteristics for which the market segments differ, allows to identify the values that prices and revenues would have if they belonged to the same segment of the property to be estimated. After making the necessary adjustments, from the incomes and prices it is possible to derive the capitalization rate sought in the market segment to which the property to be estimated belongs.

The relevant characteristics taken into account for the application of the RSA were the location and typology of building, both with reference to the segment of rents and prices. This is because no differences were found in the other relevant characteristics between the market segments.

The annual average values for comparison segment A (Euro/m² × year for fees; Euro/m², for prices), were then compared with the values of the average market quotations relative to the segment belonging to the property to be estimated (segment subject) and collected from local operators in the real estate sector (Table 3).

Table 3. Coefficients of variation in market segments for the application of the RSA.

Relevant Characteristics	Rent (Euro/m ² Anno)			Prices (Euro/m ²)		
	Subject	Comparable Segment	Coeff. Var %	Subject	Comparable Segment	Var %
Location	374.03	340.03	0.10	3118.27	2711.54	0.15
Typology of building	357.03	340.03	0.05	2982.69	2711.54	0.10

In the examined case, the adjustments in question showed a positive relative variation (%) in the average annual rent to be made in segment A, equal to 10% for the location and 5% for the typology. With reference to the average price, the corresponding relative variations (%) were 15% and 10%, respectively.

In light of the differences found in terms of the characteristics for which the comparison segment differed from the segment of the property to be estimated, the average unit values of rent and prices recorded in the comparison segment could be compared to the segment to which the property belonged (Table 4).

Table 4. Determination of capitalization rate for direct capitalization by the RSA.

Variables	Values
Average annual rent in the comparable segment A (Euro/m ² × year)	340.03
- Location (variation coefficient %)	0.10
- Typology of building (variation coefficient %)	0.05
Gross annual rent estimated (Euro/m ² × year)	391.03
Incidence of expenses	0.43
Annual net rent (Euro/m ² × year)	223.89
Average price in the comparable segment (A) (Euro/m ²)	2711.54
Location (variation coefficient %)	0.15
Typology of building (variation coefficient %)	0.10
Price estimated (Euro/m ²)	3389.42
GRM	8.67
i_L	0.1154
i_N	0.0655

The two average values were equal to Euro 391.03/ m² year and Euro 3389.42/m². The corresponding GRM was 8.67, with a gross capitalization rate of i_L equal to 0.11537. Taking into account that the incidence of expenses on the income was equal to 0.43, the net rent to be taken into account for determining the capitalization rate was 223.89 Euro/m² year. Thus, applying an inductive search of the assay using the RSA the net capitalization assay, i_N was equal to 0.0655.

For deductive research of the capitalization rate, considering that the purchase of the property to be estimated was partially financed through a mortgage, following the best practice of the valuation standards, we applied the BOI. This procedure determines the value of the capitalization rate (i) according to its financial components (11). In this way, considering the effect of the capital that the buyer could borrow (Loan to Value), the interest rate with which to determine the amount of the loan instalment, and the duration of the loan used to settle the debt contracted, it is possible to determine the capitalization rate of the mortgage (r^*) and the rate of direct profitability of the self-financed part (e) (Table 5).

Table 5. Determination of weighted average capitalization rate.

Variables	Values
Loan to value	0.25
Interest rate (r)	0.0450
Length (years)	20
Loan capitalization rate (r^*)	0.0769
Incidence of loan annual payment on income (μ)	0.2937
Equity rate	0.0616
Weighted average capitalization rate (i)	0.0655

In particular, on the basis of a Loan to Value of 0.25, an interest rate of 0.0450, and a loan length of 20 years, the incidence of loan instalment on income (μ) was calculated, and, applying Equation (16), equaled 0.2937. The equity rate, applying Equation (17), was equal to 0.0616.

Assuming LTV of 0.25, the weighted average capitalization rate, determined by applying a deductive search of BOI Equation (13), was equal to 0.0655.

The expected capitalization rate, useful for estimating the property to be valued by direct capitalization (Equation (1)), then corresponded to the final average rate (i_{av}), equivalent to the mean value between the net rate i_N , determined by the inductive method ($i_N = 0.06605$) and the weighted average rate, obtained by a deductive search of the BOI ($i = 0.06545$):

$$i_{av} = \frac{0.0661 + 0.0655}{2} = 0.0657 \quad (29)$$

Applying this rate in the direct capitalization of continuous annual income (Euro 152,300), the value of the property (Equation (3)) was therefore equal to Euro 2,316,345, although using the same capitalization method, this result differed from the previous one (Euro 2,538,333). This variation, which was about 10%, since the capitalization concerned the same income (Euro 152,300), was caused by the use of different capitalization rates, i.e., 0.0600 in the first case, where the rate was obtained by using the appraiser's own expertise, and 0.0655 in the second case, when best practice of valuation standards were used.

The point to be made, however, is that using the procedure followed by the valuation standards can lead to a more accurate and reliable results, because it is not conditioned by subjective value attributions, which the appraiser relies on, deciding the most appropriate rate to carry out the capitalization on the basis of personal assessments and own judgment (expertise).

The procedure followed in the second application, being compliant with the standards of real estate valuation [16], was also transparent and verifiable, and therefore appeared more reliable and functional. Consistent with the best practices of modern real estate valuation, the opportunity to develop the estimate following a codified and replicable methodological path also allows an effective procedure to operate in similar estimation contexts. The verification procedure also allows for functional operation in any activity to verify the obtained results including for the purposes of reviewing real estate relationships [16,22,23].

Since direct capitalization (Equation (1)) requires the income to be capitalized to be constant and permanent, the estimate by capitalization of income was made using the yield capitalization method (Equation (19)). This method instead considers a well-defined period of availability that, in the present case, was 12 years and appeared to be more suitable, also in relation to the effects that innovations may generate on production technologies that can be used in assets intended to be used for VF [65].

In order to further verify the effectiveness of the valuation standards against the use of the appraiser's expertise, the yield capitalization method was applied in both ways; the final resale value of the asset could then be determined (Equations (20) and (21)).

This method converts the income series of the property to be estimated into its present value considering a period of time defined in years of availability of the property and its final value determined at the end of that period. These values are discounted at the present time through a capitalization rate.

Although the general formulation of the yield capitalization method can be formalized as in (19), for the aim of the analysis developed here, it was considered in the same way as reported in (20) and (21).

The cash flow of the property to be considered for the capitalization was determined taking into account the annual variation rates in revenue (i_r), cost (i_c), and price (i_p) (Table 6 and Equation (22)).

Table 6. Annual variation rate.

Annual variation rate of income	0.013
Annual variation rate of expenses	0.015
Annual variation rate of price	0.010

Subsequently, the cash flow of the property was prepared for capitalization purposes, distinguishing between revenues and costs indexed by their annual variation rates, as previously described (Table 7). The length of the period taken into account (12 years) corresponded to the duration of the property's availability period. This duration is equivalent to a contract for rental of an urban property intended for non-residential use (equal to 6 years, renewable to another 6), as regulated by the general Italian law on rentals.

Table 7. Property income cash flow for income capitalization—Euro thous./year.

Revenue, Costs and Income	Years											
	1	2	3	4	5	6	7	8	9	10	11	12
Annual rent	266.00	269.46	272.96	276.51	280.10	283.75	287.43	291.17	294.96	298.79	302.67	306.61
Costs	113.70	115.41	117.14	118.89	120.68	122.49	124.32	126.19	128.08	130.00	131.95	133.93
- Loan payment	26.60	27.00	27.40	27.82	28.23	28.66	29.09	29.52	29.96	30.41	30.87	31.33
- Maintenance and repairs	18.50	18.78	19.06	19.35	19.64	19.93	20.23	20.53	20.84	21.15	21.47	21.79
- Insurance	12.00	12.18	12.36	12.55	12.74	12.93	13.12	13.32	13.52	13.72	13.93	14.14
- Management	13.30	13.50	13.70	13.91	14.12	14.33	14.54	14.76	14.98	15.21	15.44	15.67
- Utilities and services	30.00	30.45	30.91	31.37	31.84	32.32	32.80	33.30	33.79	34.30	34.82	35.34
- Vacancy and uncollectibility	13.30	13.50	13.70	13.91	14.12	14.33	14.54	14.76	14.98	15.21	15.44	15.67
Income	152.30	154.05	155.82	157.62	159.43	161.26	163.11	164.98	166.87	168.79	170.72	172.68

The cash flow values were used for the capitalization rate search (Table 8). The annual equity capital and the annual interest rates of the LTV were also determined. This was represented by the mortgage annual payment for a loan term of 20 years, i.e., greater than the availability period of the property. The mortgage annual payment, equal to Euro 44,517.93/year, was calculated using the r^* capitalization rate of the loan previously determined (0.7688) by means of the coefficient $\frac{r}{1-(1+r)^{-n}}$, where r is equal 0.045 (Table 5).

Since in the yield capitalization method, the rate is represented by the IRR of the investment constituted by the purchase of the asset, the annual variable income, and the final revenue equal to the resale price of the asset at the end of the availability period, the determination of the capitalization rate equals the IRR [28,54,66].

Therefore, we determined the following: the initial cost as the purchase price of the asset estimated by direct capitalization (Euro 2,316,345); the annual cash flow as previously determined (Table 8); and the final resale value of the property equivalent to Euro 2,782,793. This value was obtained by taking into account the net income of the last year and the initial value of the property revalued with the annual variation rate of price, equal to 0.01, at the end of the availability period.

This procedure was performed both to determine the final capitalization rate to be used in yield capitalization and to determine the equity rate and interest rate. The IRR corresponding to the cash flow thus constructed corresponded to the capitalization rate of yield capitalization and was equal to 0.07621 (Table 8). The equity rate was derived by determining the annual cash flow IRR of the equity value corresponding to net income values and was equal to 0.08395. The interest rate on the borrowed capital (loan to value), calculated in the same way, taking into account the cost of the mortgage, was instead equal to 0.045.

Table 8. Capitalization rate, equity rate, and interest rate based on income cash flow.

Year	Income	Capital on Equity	Capital on Loan
0	−2,316,345	−1,737,259	−579,086
1	152,300	107,782	44,517
2	154,052	109,534	44,517
3	155,824	111,306	44,517
4	157,615	113,097	44,517
5	159,427	114,909	44,517
6	161,258	116,740	44,517
7	163,109	118,591	44,517
8	164,981	120,463	44,517
9	166,873	122,355	44,517
10	168,786	124,269	44,517
11	170,721	126,203	44,517
12	2,782,792	2,444,639	44,517
13	−	−	44,517
14	−	−	44,517
15	−	−	44,517
16	−	−	44,517
17	−	−	44,517
18	−	−	44,517
19	−	−	44,517
20	−	−	44,517
Cap rate	0.07621		
Equity rate		0.08395	
Interest rate			0.04500

Applying the yield capitalization (21), replacing the values determined and reported in Tables 7 and 8 also with this method, the estimated value of the asset was equal to Euro 2,316,345.

$$\frac{\sum_{t=1}^{12} (\text{Euro } 1,235,210.90) (1 + 0.07621)^{-12}}{1 - \left(\frac{1 + 0.10}{1 + 0.07621}\right)^n} = \text{Euro } 2,316,345 \tag{30}$$

The same result was obtained by applying yield capitalization considering the alternative which involved determining the final value of the property by capitalizing the income of the year following the end of the availability period, by using the final rate in (20).

In this case (20), the estimation result was obtained according to the following expression:

$$\sum_{t=1}^n (\text{Euro } 1,235,210.90) (1 + 0.07621)^{-12} + \frac{\text{Euro } 172,676.66}{0.06616} (1 + 0.07621)^{-12} = \text{Euro } 2,316,345 \tag{31}$$

where i_n equals 0.06616 and is the final capitalization rate obtained from this ratio:

$$i_n = \frac{\text{Euro } 172,676.66}{\text{Euro } 2,316,345.49 (1 + 0.01)^{12}} \tag{32}$$

Applying both formulations of the yield capitalization, the result of the estimate obtained was therefore the same, i.e., Euro 2,316,345. In addition, results ((20) and (21)) were equal to the estimated value obtained by direct capitalization using the final average rate derived from the mean of the RSA-estimated rate and the weighted average rate (18). The equality of the estimation result obtained through our tests, according to the indications of the estimation standards, indicated the possibility of achieving more reliable values in a transparent way. The obtained results also allowed us to concretely verify the possibility of containing the possible consequences of an excessive use of the appraiser’s expertise following the best practices of the standard valuation.

It should also be noted that the difference between the estimation values obtained by using expertise and the use of methods recognized by the valuation standards could have been greater if the “established” rate by the expert had been subjectively significantly different from that shown here ($i = 0.06$).

The application of yield capitalization, however, brought out other points for reflection; further insights would be useful from a methodological and application point of view. By using the determination of the cash flow conversion (28) solving the expression with the values of the case study (Table 9), it was possible to determine the IRR of the investment corresponding to the purchase of the asset considered. This value, equal to 0.07621, represented the rate (cap rate) suitable for the yield capitalization:

$$-(1 - 0.43) + 0.6575 \sum_{t=1}^{12} [(1 + 0.013)^{t-1} - 0.43 (1 + 0.015)^{t-1}] (1 + i)^{-t} + (1 - 0.43) \left(\frac{1 + 0.01}{1 + i} \right)^n = 0 \quad (33)$$

Table 9. Capitalization rate, equity rate, and interest rate by the cash flow conversion.

Years	i	E	r
0	-0.5726	-0.4294	-0.1875
1	0.0376	0.0266	0.0144
2	0.0381	0.0271	0.0144
3	0.0385	0.0275	0.0144
4	0.0390	0.0280	0.0144
5	0.0394	0.0284	0.0144
6	0.0399	0.0289	0.0144
7	0.0403	0.0293	0.0144
8	0.0408	0.0298	0.0144
9	0.0412	0.0302	0.0144
10	0.0417	0.0307	0.0144
11	0.0422	0.0312	0.0144
12	0.6879	0.6043	0.0144
13			0.0144
14			0.0144
15			0.0144
16			0.0144
17			0.0144
18			0.0144
19			0.0144
20			0.0144
Cap rate	0.07621		
Equity rate		0.08395	
Interest rate			0.04500

With (28), known as the direct capitalization i_N rate, we obtained rate i of the yield capitalization, which represented the IRR of the investment.

The sensitivity analysis method used One-At a Time (OAT) [67,68]. This was applied by varying only one parameter each time, leaving all others unchanged and keeping the cash flow capitalization rate (IRR) constant. The parameters considered were the annual rate of change in income (i_r), the annual rate of change in costs (i_c), and the annual rate of change in price (i_p). In direct capitalization (Figure 2), the sensitivity analysis showed the decrease in the estimated value as the capitalization rate increased.

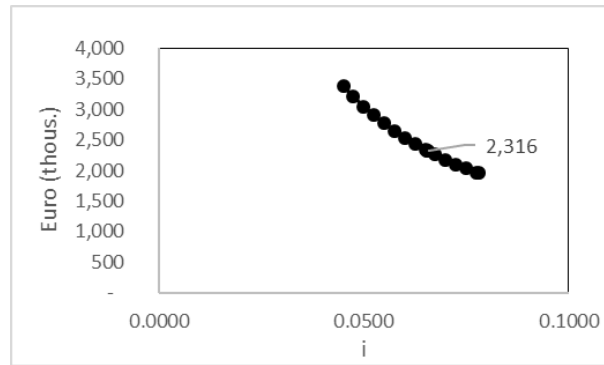


Figure 2. Sensitivity analysis of direct capitalization.

In the yield capitalization (Figure 3) as i_r increased, the estimated value grew in both applications (Equations (20) and (21)). The effect was most prominent in the application conducted with Equation (20).

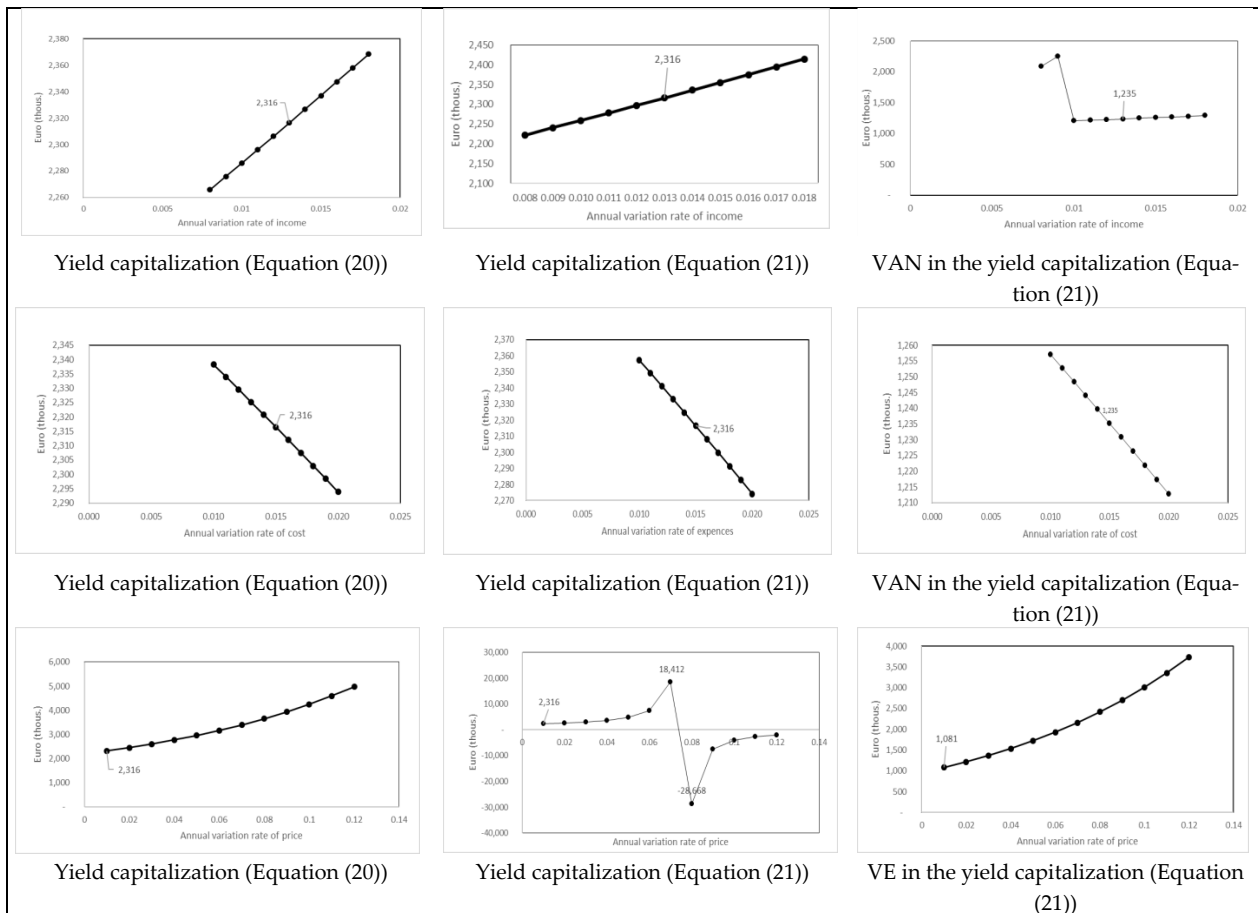


Figure 3. Sensitivity analysis of the yield capitalization.

The positive change in i_c caused a decrease in estimated value in both paths followed in yield capitalization (Equations (20) and (21)), with the effect being more prominent in the estimation performed with Equation (20). Increasing i_p also resulted in a growth in estimated value (Equation (20)).

In the yield capitalization carried out in the mode followed in Equation (21), if the parameter i_p increased beyond the value of the capitalization rate (0.07621), the estimate value took on a negative value. In order for the estimate value not to fall outside the domain, the condition that $i_p < i_r$ or $1 - \left(\frac{1+i_p}{1+i_r}\right)^n > 0$ had to be imposed. NPV is positively affected by an increase in i_r , but it is negatively affected by an increase in i_c . Both of these parameters do not affect the VE, determined as in Equation (20). VE increased as the annual rate of change in price (i_p) rose.

5. Discussion

The results lead to some interesting conclusions. First of all, it is possible to observe that the methodological approach proposed by valuation standards appears to have been adequate to deal with the valuation case in question. The results appear more reliable and objective than those obtainable by resorting to appraiser's expertise.

It is also clear that even in the income capitalization, the use of valuation standards can reduce the risk and approximation inevitably associated with the use of expert knowledge [56]. Of course, the determination of the income to be capitalized must also take place through the preparation of an appropriate economic, preventive, and regular balance sheet, i.e., average, annual, etc.

The results also show that the capitalization test is based on a reliable and verifiable procedure; direct capitalization may also be able to solve the estimation question effectively. In this sense, our analysis showed the possibility of acting consistently with the principles of the valuation standards, even in the absence of comparison data belonging to the same segment of the property to be estimated.

Furthermore, the opportunity to use a procedure for determining the standard and uniform capitalization rate is brought to the attention of real estate operators for two main reasons: the possibility of achieving a reliable estimate value; and to promote awareness of the existence of a valid and effective estimation tool to determine the value of real estate without resorting to approximations or modifications deemed more reliable by the appraiser than best practices shared by valuation standards at national and international level.

Professional ability, preparation, and knowledge of the market by the appraiser remain indispensable and decisive for carrying out reliable real estate estimates [69]. In the absence of these factors, the value estimated by the appraiser's expertise remains exposed to numerous possible causes of alteration, with obvious negative consequences for all operators in the real estate sector.

The methodology used can be replicated in other appraisal contexts and to determine the market value of different assets. From what has been possible to verify, however, it does not appear that any appraisal applications aimed at determining the value of a property intended for vertical farming have been proposed, at least in relation to the urban context taken into consideration. As already highlighted, the illustrated estimative analysis referred to the determination of the value of the building and not to the production activity located therein, in our case represented by the VF. However, with respect to this aspect, other limitations are highlighted which should be adequately investigated, for example, the structure of the market segment and the extent to which vertical farming could be a substitute or complement to conventional methods. The dynamics of market penetration, infrastructure development, and political incentives are extremely important factors that cannot be overlooked. Just like short food supply chains that operate within certain constraints, vertical farming may encounter similar limitations, which are capable of influencing the growth potential of VFs [45].

However, it should be noted that the case presented here was necessarily limited to the objective of the estimate which concerned the possibility of determining the market value

of a property based on its special intended use (cadastral category D/10), i.e., different from that of other properties used for production purposes.

Although this consideration represents a limitation of the illustrated application, it is also appropriate to highlight another aspect that concerns the determination of the capitalization rate. Its determination, in fact, being carried out through a procedure based on the detection of the quantities from which it derives (income and prices), implicitly expresses a component of risk or uncertainty, perceived and expressed by the real estate market. Although it is not explicitly manifested in the case of the procedure followed by operating according to another methodology of identification of the rate, as in the case of the build-up approach [19], the risk or uncertainty component acts together with other variables which are capable of conditioning the performance of the economic activity on the capitalization rate. Moreover, the method we followed is capable of returning a more realistic and objective value than can happen by resorting to the expertise of the expert.

It is also worth adding that the determination of the market value, carried out according to the methodology recognized by the valuation standards, did not allow for the consideration of other variables that could influence market values. It was based on the detection of prices and incomes of properties present on the market and on the effects of dynamics and variables that are capable of stimulating real estate values with different intensities in different segments.

Another aspect of our results concerns the use of the cash flow conversion. This also allowed us to determine the equity and interest rate on the capital borrowed in the context of the bank credit operations that could be used by the buyer to purchase an asset (Table 9). The resulting notations are double: the values of IRR, equity rate, and interest rate calculated through the conversion cash flow are equal to the corresponding values determined by the analysis of the income cash flow (Tables 8 and 9); the calculation of the capitalization rate of financial capitalization can be performed without determining the income flow of the property but by determining the variables of the conversion flow (28) [28].

This evidence provides interesting and innovative perspectives for the use of income capitalization methods. The first piece of evidence is the possibility of applying the income capitalization without necessarily knowing the income cash flow of the asset. To calculate the yield capitalization rate (i) rather than the equity rate (e), and the borrowing rate (loan to value) (r^*) by defining the incidence of expenses on the income (γ_c) and determining the direct capitalization rate (i_{av}), it is sufficient to determine the annual variation rate of income (i_r), the annual variation rate of cost (i_c), the annual variation rate of price (i_p), and the length of the period of availability of the asset (n). This procedure is therefore effective for a rapid determination of the IRR, facilitating not only the estimation evaluations but also decision-makers' choices among possible alternatives.

The use of conversion cash flow also increases the credibility and reliability of the valuation standards that recognize the use of yield capitalization by limiting the use of expert judgement. Another aspect to be highlighted concerns the possibility of using the conversion flow to carry out verifications and controls of the estimated values proposed by other operators in judicial, extrajudicial, and credit and financial activities [70,71]. More generally, in the presence of partially certain and reliable real estate data, which could alter the estimation judgment developed with market-oriented procedures, the use of the conversion flow may bring about more efficient and transparent operations through income capitalization. If the estimated value of the property obtained with direct capitalization and with financial capitalization is equal, it is clear that both methods can be considered equivalent.

While this may lead one to believe that the use of direct capitalization to estimate the value of a property is plausible, regardless of the variation in cash flow and the period of availability of the property, it imposes the need for further investigations.

Finally the obtained results show that the principles, criteria, and methods of real estate valuations belong to a single scientific apparatus, while professional valuations can have different characteristics from country to country and traditionally develop in national

contexts, being linked to legislative, administrative, and fiscal rules and, in general, to the economic and social situation of the place where the property to be valued is located [28].

6. Concluding Remarks

The analysis presented here was conducted by considering the estimation of a property intended to be used as a vertical farm. It was developed by limiting the resolution of the estimation case to the determination of the market value of the property and not of the production activities that will be carried out in it. The obtained results appear to be consistent with the estimation aims, but it is believed that they can also be useful from a methodological and application point of view. The distorting effects of the use of expertise in real estate appraisals can also manifest in the application of income capitalization. With reference to estimation by direct capitalization, the described analysis shows that it is appropriate to follow the methodological references indicated by valuation standards. Even in income capitalization estimates, if the obtained result cannot be subjected to demonstration, it is characterized by low reliability and risks being approximate and of limited usefulness.

In this regard, the verification conducted in the case study demonstrates the greater reliability of the estimated value derived by following the valuation standards. The analysis was developed with particular reference to the procedures that can be used to determine the capitalization rate and highlighted the effectiveness of an inductive and deductive search for the rate.

With reference to inductive research, both direct research mode and determination by RSA were considered. Deductive research was expressed through BOI, which, in the case of a loan for the purchase of the property, determines the capitalization rate through the weighted average of the rates attributable to the financial components of the value.

In the absence of comparable data on the segment of the property to be estimated, both procedures used to determine the essay were performed with reference to market segments close to that of the property to be estimated.

The reasons why the capitalization rate to be used in determining the value of a property cannot be derived from investments of another nature, such as through the yield on debt securities, are well known [54,72]. Despite the presence of such evidence, the procedure often preferred by appraisers continues to be based on their expertise, taking into consideration exchange markets for economic assets of a nature other than real estate.

Thus, remote research of the capitalization rate is omitted, which requires the proper market survey to be extended to segments close to that of the asset to be estimated.

In the most glaring cases, it is precisely the absence of purchases and sales of assets similar to the asset being estimated that is emphasized to motivate the use of a determination of the rate by means of the appraiser's expertise, with the consequences previously mentioned in terms of the applicability and reliability of the appraisal result.

Further verification of the validity of the estimation result obtained by income capitalization following the best practices of valuation standards was obtained by applying the yield capitalization. The estimation value obtained by this method turned out to be the same for both formulations (30) and (31) and also coincided with that obtained by direct capitalization, in which the rate was derived by procedures consistent with valuation standards (1 and 18). To the best of my knowledge, this is an innovative result, on which further verification and investigation is certainly worthwhile.

Using the yield capitalization, however, it also emerged that by applying the resolving logic of determining the IRR of the conversion cash flow, it is possible to derive the values of the capitalization rate, the equity rate, and the interest rate on the borrowed capital without first proceeding to determine the income cash flow. Again, this is a result to consider for possible further verification and investigation; it nonetheless highlights useful implications. For example, the possibility of providing a convenient decision support tool among alternatives to facilitate the choices of public or private investors. The ability to prepare and use the conversion cash flow without determining the annual income flow

can also facilitate the use of income capitalization in determining the market value of a property without having to resort to subjective and unreliable approximations of real estate expertise. Other issues that were not taken into account in this analysis can be addressed in further research, including the role played by ESG criteria [73] in the value of real estate used for productive purposes and, in particular, their influence on the capitalization rate.

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