Saving soil and financial feasibility. A model to support public-private partnerships in the regeneration of abandoned areas.

Land Use Policy 73 (2018) 40-48
https://doi.org/10.1016/j.landusepol.2018.01.036

Saving soil and financial feasibility. A model to support the public-private partnerships in the regeneration of abandoned areas

Pierluigi Morano, Francesco Tajani*

Department of Science of Civil Engineering and Architecture, Polytechnic of Bari (Italy), Via Orabona 4, 70125 Bari, Italy

* Corresponding author.
E-mail addresses: pierluigi.morano@poliba.it (P. Morano), francescotajani@yahoo.it (F. Tajani).

Highlights

1. A model to support Public Administration decisions in the planning of urban redevelopment initiatives on abandoned areas has been developed.

2. The model constitutes a valid contribution to the the current global policies aimed at limiting soil sealing.

3. Taking into account the convenience for public and private operators, the model determines a range of combinations of urban parameters that defines an effective reference for the negotiation phases between the parties involved in the initiatives.

Abstract. The European Union aims at the zeroing of the soil consumption by 2050. Among the short-term strategies outlined by the member States of the European Commission, the highest potentialities concern the recovery of existing building assets, and in particular of abandoned areas. The regeneration of these properties, however, involves considerable costs and high risks, and therefore almost always requires the activation of a public-private partnership as well as the negotiation of the solutions to be implemented. Borrowing the theory and algorithms of operational research, the model outlined and tested in this paper aims to determine a range of combinations of urban planning parameters, to be attributed to abandoned areas, capable of reflecting the fair distribution of the burdens and financial conveniences, that constitute the basis reference for the bargaining between public and private subjects. The model is applied to a real case study, concerning the urban regeneration of an abandoned area located in a city in Southern Italy. Obtained by simulating various possible goals of the Public Administration, the outputs confirm the potentialities and flexibility of the proposed model.

Keywords: saving soil, abandoned areas, urban regeneration, operational research, financial feasibility, public-private partnership.

1 Introduction

For several years in Europe, there has been a debate on the saving soil, i.e. the need to limit the increase in the artificial land cover mainly due to urban expansion and territorial infrastructures (Torre et al., 2017). According to the estimates of the European Commission (2011), every year in Europe an area of approximately 1,000 km^2, equal to the area of the city of Berlin, is definitively waterproofed as a result of the construction of buildings, infrastructure and road networks. The issue is particularly important in countries characterized by high population density (e.g. the Netherlands, Belgium, Luxembourg, Italy, Germany, the United Kingdom, Denmark, Portugal, France), which show worrying growth, especially in urban peripheries, as well as coastal and central areas affected by a high housing demand (European Commission, 2012; ISPRA, 2017).

The objectives of the European Union for the member States aim at the zeroing of the soil consumption by 2050, avoiding the waterproofing of natural areas and compensating the "non-avoidable" component through the re-naturalization of areas of at least equal extension, which could produce the same eco-systemic effects that were provided by the compromised soils (European Commission, 2016).

Among the short-term strategies set out by the European Commission, the greatest potentialities concern the regeneration of existing building assets, in particular abandoned areas. This term specifies a wide range of urban properties that includes areas, individual artifacts or entire compendiums, characterized by different dimensions, intended uses and intensity of degradation. In many cases, these are properties contaminated by their previous uses. The

European Environment Agency estimates that in Europe there are 250,000 contaminated sites and three million potentially contaminated sites, for which more investigations are needed to determine whether reclamation is necessary (European Environment Agency, 2007).

In Italy, a recent and systematic survey of the abandoned areas is missing. The latest data available are provided by the National Statistical Institute in the report of the "IX General Survey of Industry and Services", which reported that the degraded areas represent 3% of the Italian territory, with an area of approximately 9,000 km^2, equal to the surface of the Umbria region, of which at least 30% is located in urban areas and to be reclaimed (Italian Institute of Statistics, 2012).

The regeneration of abandoned areas, however, involves considerable costs and high risks (European Court of Auditors, Special Report No. 23/2012). In recent years, with the goal of improving the measures for urban requalification, there has been a development of several tools focused on involving the private investors through different types of partnerships (Sagalyn, 2007; Bourguignon, 2013). The public-private partnership (PPP) is a form of cooperation between public authorities and private operators aimed at financing, building and managing public infrastructures or providing public utilities (Ng et al., 2012). This form of cooperation allows the Public Administration to attract resources and skills that are not available within its system (Grimsey & Lewis, 2002; Bing et al., 2005; Clifton & Duffield, 2006). In these types of initiative, the public-private relationship must be based on the use of operational models that meet the requirements of flexibility, transparency and easy understanding for the parties, through which it is possible to reach mediated solutions among the interests involved, while also guaranteeing mutual financial conveniences.

In the planning of the transformation of the abandoned areas, the determination of the urban parameters of the project to be attributed to the areas (building index, intended uses, coverage ratio, incidence of roads, maximum height, green space rate, etc.) is among the main issues. The definition of these parameters depends on a number of factors that must be respected, in relation to these kinds of boundaries: i) urbanistic-design aspects, since these parameters influence the type of settlement to be implemented; ii) environmental limits, since they define the burdens connected to the users of the new functions and the soil consumption; iii) legal restrictions, since the setting of these parameters must be carried out in compliance with the current regulations; iv) financial constraints, since, if the private investor is involved in the initiative, he will decide to participate after having compared the revenues and costs.

Furthermore, in the current economic contingency, it may happen that the Public Administration, in order to lighten its balance sheets and to share the burden of the initiatives, intends to base its relationship with the private investor on the negotiation, by allowing the entrepreneur to build additional volumes, in exchange for the disposal and the reclamation of areas for public use or other kinds of public resources (Morano & Tajani, 2013). In this case, the bargaining concerns the measure of the urban planning parameters to be attributed to the area to be regenerated, capable of ensuring the distribution of the public and private conveniences.

2 Aim

With regard to the draft scenario, this research aims to develop and test a model to support Public Administration decisions in the planning of urban redevelopment initiatives, characterized by the involvement of private investors and therefore by the negotiation of the solutions to be implemented.

Through marginal-type compensatory mechanisms and taking into account the objectives pursued by the Public Administration, the model allows to determine a range of combinations of urban parameters to be assigned to the areas to be regenerated and upon which the negotiation between the parties involved should be set. These parameters, in particular, should be capable of reflecting a fair allocation of the burdens and of the financial conveniences between the public and private subjects. The aim is not only to ensure efficiency and transparency in the decision-making process, but also to encourage forms of rewarding, such as an increase in the building index, the availability of the private investor to realize substantial rates of the public spaces, especially in cases where the costs for the purchase and reclamation of the areas are particularly significant.

Public Administrations rarely have appropriate expertise to set the best intervention modality (Zhou et al., 2016). As a consequence, either the initiatives fail or the private investors' profits are so high that the PPP initiatives must be verified by a public inspection entity (e.g. the judiciary), determining the interruption of the initiatives and the resulting negative effects on the image of the current Public Administration (Gan et al., 2015; Buckley et al., 2016).

The proposed model allows to determine: the building index to be attributed to the areas to be recovered; the extension of the surface upon which the private buildings permitted by the building index will have to be concentrated; the measure of the private green spaces; the surface of the private parking spaces; the surface for public roads; the surface of public spaces; the public area share that the private operator will have to buy, reclaim and free transfer to the Public Administration. Due to the conditions and perspectives of the local real estate market, the economic parameters and environmental objectives, the model will have to simulate the relationship between the public and private subjects, as well as determine the values of urban planning parameters that reflect the fair distribution of the burdens and the benefits of the initiative, ensuring the mutual financial conveniences.

The model can be used in the initial stages of the urban redevelopment initiatives, where there is the need to define the synthetic sizing of the investment and identify the limits of the negotiation among the parties, as well as in the verification of initiatives already approved by technical-policy decisions, that did not take into account the conditions of the property market and the redevelopment costs.

In this work, the model is defined and tested with reference to Italy, where the regeneration of abandoned areas constitutes a highly perceived issue, but the purchase of these properties is particularly expensive, since they are generally located in central areas, with consequent effects on the market values due to urban rent phenomenon.

The experimentation of the model is developed with reference to the initial stages of the investment. The lack of a detailed project, that is a circumstance that typically occurs in these phases, has led to defining a model that operates in an "automatic" way, reaching the sizing of the public spaces such as to guarantee at least the minimum share of public areas established by the national regulations (D.M. No. 1444/1968 and L. No.122/1989).

Borrowing the principles of the Operational Research, the model implements the simplex algorithm through the Linear Interactive Discrete Optimizer software (LINDO). An urban planning problem is characterized by strong analogies with the general problem of the Operational Research, since it concerns the determination of the optimal use of scarce resources that can be used in alternative modalities. In the model proposed: i) the resource available in limited quantities is represented by the area to be recovered; ii) the alternative uses are identified by the different public and private intended uses; iii) the constraints are obtained from the mathematical translation of the legal regulations, of the urban planning and environmental decisions of the Public Administration about the land use and the morphological organization of the spaces of the initiative and from the financial balance sheets of the public and private operators, through which it is possible to evaluate the mutual benefits; iv) the return function varies in relation to the goals which, in the various cases, may be pursued by the Public Administration.

The paper is structured as follows. In section 3, the main studies in current literature in which the goal programming has been applied are recalled. In section 4, the hypotheses of the model are introduced. In section 5, the variables, the constraints of the model and the possible objective functions of the Public Administration are described. In section 6, the model is implemented to a real case, concerning the urban regeneration of an area in disuse, located in the city of Salerno (Italy). In section 7, the conclusions of the work are discussed.

3 Background

In the academic literature of the last decades, there has been a renewed attention regarding the development of models that borrow goal programming logic, as a method to solve effectively complex decision-making systems, characterized by high uncertainties related to their multiplicity of objectives, number of variables and constraints (Walker, 2001; Linares & Romero, 2002). The need to obtain valid solutions for conflicting goals - e.g. economic, environmental and social targets generated by the current econonomic instability and climate and welfare policies - has led to identifying goal programming as one of the most widely used multicriteria decision-making techniques (Caballero et al., 2009).

In the business-decision environment, there are numerous applications of goal programming, which is implemented as a flexible tool capable of taking into account, simultaneously, not compatible objectives: Wheeler and Russell (1977) have used it in farm planning; Welling (1977) has developed a goal programming model for planning the use of interacting human resources by firms; Puelz and Puelz (1991) have elaborated a goal programming model integrated by the Analytic Hierarchy Process for defining the best personal financial planning, identified according to the individual's disposable wealth and his consumption preferences; Oglethorpe (2010) has proposed a goal programming method for improving the food supply chain strategies; Aznar et al. (2011) have combined the Analytic Hierarchy Process and goal programming for multicriteria agriculture valuation; Mehrbod et al. (2012) have defined an interactive fuzzy goal programming for the optimization of company logistics.

Several studies concern the use of the goal programming approach for environmental targets: Porterfield (1976) has implemented this methodology for the optimization in the tree improvement programs; Chang and Buongiorno (1981) have used the goal programming filtered by the input-output analysis to determine the best public forest management; Hrubes and Rensi (1981) have analyzed the goal programming utility for the forest resource allocation; Chen and Chang (1998) have used a multiobjective fuzzy genetic algorithm for optimal water quality control.

Various authors have studied the benefits of the goal programming method for the selection of the most performing investments on the territory, regarding the maximization of the social welfare function (Ben et al., 1969; Lee, 1973; Lee & Keown, 1979), the revitalization strategies of historic centers (Chang et al., 2009), the population settlements in the metropolitan areas (Courtney et al., 1972), the allocation of public road funds (Taplin et al., 1995), the sustainability of social housing initiatives (Tajani & Morano, 2015), the enhancement of public buildings (Tajani & Morano, 2017), the resource allocation for the urban redevelopment (Nesticò & Sica, 2017).

With reference to the real estate sector, interesting applications of the goal programming technique concern the elaboration of property valuation models (Adolphson et al. 1989; Kettani et al., 1998; Kettani & Khelifi, 2001; Estellita Lins et al., 2005; Gomes and Rangel, 2009) and the implementation of optimization algorithms for property investments (Bowlin, 1987; Schniederjans et al., 1995; Anderson et al., 1998; Wang 2005; Tan et al., 2008; Min et al., 2009).

In the property finance sector, the goal programming tecnique has also been characterized by a wide use (Byrne and Lee, 1994; Anderson et al., 2004; Hin et al., 2006; Shi & Yang, 2006; Byrne and Lee, 2011). In particular, the approach has shown a high utility for the definition of flexible methodologies aimed at effective property risk management (Findlay et al., 1979; Byrne & Lee, 1997; Zhou & Li, 2008; Shevchenko et al., 2008; Estrada, 2008; Kroencke & Schindler, 2010).

4 Assumptions of the model

The elaboration of the model requires the preliminary definition of:

a) the theoretical hypotheses;

b) the modalities through which the relationship between the public and private subjects must be schematized;

c) the type of benefits to be considered and the tools for their measurement and comparison;

d) the criteria to be followed for the determination of the balance between the public and private financial conveniences.

4.1 The theoretical hypotheses

The complexity of the initiatives of the redevelopment of abandoned areas, given the large number of variables to be managed (location of the areas, accessibility, property structure, current legislation, local housing market, etc.), has required the preliminary formulation of some hypotheses, in order to simplify the definition and experimentation of the model. In particular:

- the only effects of the urban redevelopment initiative that can be translated into monetary terms are considered. Therefore, the intangible effects that would require the use and assessment of qualitative variables are not taken into account;

- the area affected by the redevelopment initiative is assumed "isolated" with respect to the remaining urban context. This means the "overflow" effects that could be generated by the redevelopment initiative on the adjacent areas are neglected;

- the actors involved in the initiative are schematized in a public entity (the Public Administration) and a private operator (a generic real estate developer). The initiative could be implemented by different profile subjects (cooperatives, joint stock companies, public-private joint ventures, etc.);

- the allowed intended uses and the relative impact on the total realizable volumes are known, since they are identified through a market survey.

4.2 The relationship between public and private subjects

The relationship between the Public Administration and the private investor is outlined taking into account the Guidelines for Urban Redevelopment Programs (Italian Public Works Ministry, 1992). According to these documents, the relationship between public and private subjects in urban regeneration initiatives should be regulated by a special urban planning negotiating agreement (Art. 8, L. No. 765/67). The typical agreement can be illustrated as follows:

- through the definition of the building index (I_t), the Public Administration grants the private investor the development rights to be realized through the initiative;

- considering to ideally divide the area to be recovered (S_t) into a private (S_{priv}) and public surface (S_{pub}), the development rights should be calculated by applying the building index (I_t) to the total surface (S_t) of the area, but they will then be located on only the private surface (S_{priv});

- the private operator realizes the building volumes allowed by the building index (I_t) and sells them at the market prices;

- the private operator is obliged to pay to the Public Administration the primary, secondary and construction urbanization charges, on the basis of the quantities and intended uses of the initiative (L. No. 10/1977);

- if the financial conveniences of the initiative are verified, the private operator may be required to purchase, reclaim and free transfer to the Public Administration a share or the total area for the primary (roads, lighting, network works, etc.) and secondary urbanization works (schools, worship buildings, etc.), to free transfer other buildings for public uses and/or realize public works.

The public-private negotiation relationship can thus be outlined: as the housing market's demand grows, the requests of the Public Administration to the private investor for areas and public works may increase, that should be compensated by an increase in the building index. However, these requests should be carefully calibrated, assessing the areas purchase and reclamation costs, since these amounts could have a significant impact on the private investor's balance sheet, so that his participation in the redevelopment initiative could be not convenient. Furthermore, the hypothesis to compensate these costs through an excessive increase of the building index does not make sense, as both the soil consumption increases and the absorption capacity of the local market establishes the limit beyond which the volumes realized cannot be sold.

4.3 Assessment of the public and private conveniences

The assessment of the public and private conveniences is carried out in accordance with the criteria and the procedures set by the Italian Law No. 179/1992 and the the Guidelines for Urban Redevelopment Programs (Italian Public Works Ministry, 1992).

In particular:

a) for both the public and the private subjects, the conveniences of the initiative must be assessed only in financial terms. This approach reflects the need to employ a "common language" between the public and private parties in the evaluation of their benefits;

b) the conveniences for the private subject must be calculated by comparing: as revenues, the amounts generated by the sale of the permitted building units with the urban planning parameters determined by the bargaining; as costs, the total amounts that the private investor will have to incur in order to realize the private buildings of the initiative and the public works at his expenses;

c) the conveniences of the public subject are to be computed by comparing the realization cost of the public works with the monetary value of the resources and the properties free transferred by the private operator;

d) the measure of the public and private conveniences is to be developed through the cost-revenue analysis, that is an instrument ordinarily used to assess the financial feasibility of an investment or to compare alternative solutions.

For both the public and private balance sheets, the cost-revenue analysis is carried out "instantly", i.e. by comparing the costs and the revenues of the initiative, without considering their temporal distribution. It is, therefore, assumed that both the outputs and inputs occur at the same time, coinciding with the evaluation moment. This operational modality is suitable for the initial stages of the initiative, when synthetic indications about the financial sustainability of the initiative are required.

Since the "time" variable for the distribution of the costs and the revenues is not considered, the cash flows are assumed to be concentrated at the moment of valuation, the construction and the selling times are canceled and the absorption capacity of the private building units from the local real estate market is transferred at the same time.

In the "instant" comparison, the Net Value (NV) as an indicator of the financial viability of the investment is determined, both for the public and private balance sheets, through the difference between the arithmetic total of the revenues and the costs. The investment is feasible if the NV is higher than or equal to zero:

$$NV = \Sigma i\ Ri \ - \Sigma i\ Ci \qquad (1)$$

where Ri and Ci represent the revenues and costs of the i-th balance sheet item.

Both for the public and private subjects, the balance sheet must be constructed by comparing the costs and revenues of the "*without urban planning negotiating agreement*" situation with the respective economic parameters of the "*with urban planning negotiating agreement*" situation.

In the analysis, the financial charges are calculated by considering the entire amount required for the realization of the initiative as a loan capital. The taxes are not included in the balance sheets: the aim is to achieve results that are independent of the legal-tax profile of the subjects involved in the initiative, which would influence the convenience of the initiative.

4.4 The balance of the public and private conveniences

A necessary condition for the participation of the private operator in urban redevelopment initiatives is that his financial balance sheet is positive: in other words, the revenues generated by the sale of the building units allowed by the urban planning parameters will have to exceed, or at least equalize, the costs that the private operator has to incur for the realization of the private buildings and the public works that have been charged.

Among the cost items of the private operator, the "ordinary profit" is included, i.e. the expected compensation for the generic investor - in a specific area and for a specific typology of the initiative -, considering the activities of production coordination and the burden of the risk investment. Thus, the condition of minimal financial viability for the private investor is identified by the urban planning parameters for which the financial balance is equal to zero, ensuring at least the ordinary profit. Upper urban planning parameters values will generate an "extra" profit for the private operator.

Land Use Policy 73 (2018) 40-48
https://doi.org/10.1016/j.landusepol.2018.01.036

For the public subject, the financial conveniences are satisfied when the costs of the public works of the initiative are covered by the monetary values of the resources provided by the private operator. This condition identifies the least financial convenience of the initiative for the Public Administration. In the public balance sheet, the ordinary profit is not included, since the public subject aims for the "break-even point" of the balance sheet and the effective management of the public system.

5 Description of the model: the variables, the constraints and the objective function

The model should allow to determine: 1) the building index I_t [m^2 of gross floor surface (*GFS*) per m^2 of total land surface (S_t)] which, respecting the political, urban and environmental decisions of the Public Administration and the local property market conditions, guarantees the public and private financial conveniences; 2) the surface S_e [m^2] of the private land surface (S_{priv}) upon which the private buildings units allowed by I_t must be located; 3) the surface S_v [m^2] of the private land surface (S_{priv}), upon which the private green spaces will be realized; 4) the surface S_p [m^2] of the private land surface (S_{priv}), upon which the private parkings will be built; 5) the surface S_{stand} [m^2] of the public land surface (S_{pub}) upon which the public works (green spaces, parkings, schools, churches, etc.) will be realized; 6) the surface S_{road} [m^2] of the public land surface (S_{pub}) for the construction of the public roads; 7) the surface S_c [m^2] of the public land surface (S_{pub}) that the private operator will be able to purchase, reclaim and free transfer to the Public Administration.

In particular, the model is structured so that the surface S_c that the private investor is required to purchase, reclaim and free transfer to the Public Administration corresponds to the area that ensures his financial conveniences and at the same time allows for the effective urban planning organization of the redevelopment initiative. In theory, this surface should be at least equal to the spaces that the public entity should expropriate, in order to realize the primary and the secondary urbanization works (Art. 8 of Law No.765/1967), which in the model represents the sum of the public road surfaces (S_{road}) and the surface for the "standard" public works (S_{stand}). However, it may happen that the negative economic situation of the real estate market or the high costs for the purchasing and reclaimation limit the private conveniences so that the entrepreneur can buy only a share of the S_{pub} (a share that is equal to zero in the worst condition).

In practice, the building index I_t and the surface S_c identify the main variables of the problem around which the bargaining among the public and private subjects takes place. The remaining variables allow to define the constraints of the initiative and contribute to delineating the morphological organization of the initiative and corresponding soil consumption.

The constraints of the model can be schematized as follows.

Physical constraints. The first boundary condition concerns the subdivision of the total land surface S_t in the different surfaces described above:

$$S_t = S_e + S_v + S_p + S_{stand} + S_{road} \qquad (2).$$

In particular, the total land surface S_t can also be articulated as follows:

$$S_{priv} = S_e + S_v + S_p \qquad (3)$$
$$S_{pub} = S_{stand} + S_{road} \qquad (4).$$

Another physical constraint concerns the division of the total gross floor surface (GFS_{tot}) allowed by the building index I_t ($GFS_{tot} = I_t \cdot S_t$) in the shares corresponding to the intended uses provided by the redevelopment initiative. In this research, it is assumed - as an example - that the mix of the intended uses identified by a market survey includes residential (*res*), commercial (*com*) and tertiary (*off*) units, according to the subdivision indicated in Eq. (6).

$$GFS_{tot} = GFS_{res} + GFS_{com} + GFS_{off} \qquad (5)$$

$$\begin{aligned} GFS_{res} &= 0.7 \cdot GFS_{tot} \\ GFS_{com} &= 0.2 \cdot GFS_{tot} \\ GFS_{off} &= 0.1 \cdot GFS_{tot} \end{aligned} \qquad (6).$$

The last physical constraint concerns the extension of the surface S_c that the private investor is required to purchase, reclaim and free transfer to the Public Administration, which must be:

$$S_c \leq S_{pub} \qquad (7).$$

Project constraints. The realization of the gross floor surface in the S_e requires the verification of some rules that define the soil use intended to be allowed. Using R_c to indicate the coverage ratio of the total land surface S_t, in order to contain the soil sealing, the project hypothesis requires that:

$$S_e \leq R_c \cdot S_t \quad (8).$$

The number of floors (N_f) of the buildings, on the other hand, must respect the condition:

$$GFS_{tot} / S_e \leq N_{f,max} \quad (9)$$

where $N_{f,max}$ represents the maximum eligible number of floors.

The surface S_v is intended for the private green spaces. The hypothesis is that the project choices provide that:

$$S_v \geq a \cdot S_{priv} \quad (10)$$

according to which the private green surface S_v must be at least equal to the "*a*" share of the private land surface S_{priv}.

Assuming that the surface for the public roads has been already fixed by project choices, the hypothesis is that S_{road} is equal to a "*b*" share of the total territorial surface:

$$S_{road} = b \cdot S_t \quad (11).$$

Urban planning constraints. The public works (green spaces, public parkings, schools, churches, etc.) must be located in the surface S_{stand}. With reference to the Italian context, the surface for the public works must be determined for each eligible intended use according to Italian Ministerial Decree No. 1444/1968.

For the residential intended use, at least 18 m^2 of the total land surface S_t must be provided for each inhabitant of the new residential buildings. The number of inhabitants (n_{inhabs}) can be calculated taking into account the minimum *GFS* per inhabitant, that Italian Ministerial Decree No. 1444/1968 establishes as 25 m^2. Therefore:

$$S_{stand,res} = n_{inhab} \cdot 18 = (GFS_{res}/25) \cdot 18 \quad (12).$$

For the commercial and tertiary intended uses, Italian Ministerial Decree No. 1444/1968 establishes that for every 100 m^2 of new GFS, 80 m^2 of the total land surface S_t must be intended for public works. Hence:

$$S_{stand,com} = 0.8 \cdot GFS_{com}$$
$$S_{stand,off} = 0.8 \cdot GFS_{off} \quad (13).$$

Overall:

$$S_{stand} = S_{stand,res} + S_{stand,com} + S_{stand,off} \quad (14).$$

Private parking must be located on the surface S_p. The minimum size of S_p is fixed by the total building volume (Vol_{tot}), i.e. with reference to Italian Law No. 122/1989, for which 1 m^2 of parking per each 10 m^3 of new construction is to be ensured. Assuming an average height of three meters for each floor:

$$S_p = Vol_{tot} / 10 = (GFS_{tot} \cdot 3) / 10 \quad (15).$$

Public and private financial convenience constraints. The convenience functions for the public and private subjects are obtained from the respective financial balance sheets, according to the criteria outlined in paragraph 4.3. The economic items in each balance sheet vary depending on the agreements between the parties during the bargaining, in relation to the type of the initiative, the objectives of the Public Administration and the economic situation crossed by the real estate market.

The private balance sheet is built by comparing the costs and revenues that occur in situations "*with*" and "*without*" urban planning negotiating agreement. In the "*without agreement*" situation, the private operator realizes the transformation of only the private land surface S_{priv}. The private investor buys the surface S_{priv} and carries out all the operations required by the redevelopment initiative, recording the related economic items in his financial balance sheet. In particular, the economic items to be considered are: a) *Costs*: purchase of the surface S_{priv}; property transfer expenses (tax register and notary fees); payment of the primary, secondary and construction urbanization charges; reclamation of the area; construction of the new gross floor surfaces to be sold (residential, commercial, tertiary, private parkings, private green spaces); expenses associated with the construction costs (management and technical costs); marketing expenses; financial charges; the ordinary profit of the private investor; b) *Revenues*: sale of the realizable gross floor surfaces (residential units, shops, offices, parkings). On the other hand, in the "*with agreement*" situation, the commitments made by the private investor towards the Public Administration should be considered, i.e. the purchase and reclamation of the areas (S_c) to be free transfer to the public subject. This item is to be added to the costs of the private balance sheet, since it represents an additional burden for the private investor.

Regarding costs and revenues, the economic parameters of the private investor's balance sheet can be schematized as follows (Table 1).

The purchase price of the area (K_{area}). Determined the unit market price (in €/m^2) of the building areas (c_{area}), this item is expressed by Eq. (16) in Table 1.

Property transfer (K_{sell}). It assumes equal to a percentage of 10% of the total purchasing price of the areas - Eq. (17) in Table 1.

Primary, secondary and construction urbanization charges ($K_{urbanization}$). Established by Art. 3 Law No. 10/1977, the primary and secondary urbanization charges should be calculated by applying to the new gross floor surfaces the values in €/m^2 reported in the specific municipal tables, according to the intended uses and type of the initiative to be realized. The construction cost charges are instead calculated for each intended use, as a percentage of the relative construction cost. In this case, these economic items are summarized in Eq. (18) in Table 1, applying an average parameter cost ($c_{urbanization}$) per square meter of gross floor surface.

Reclamation ($K_{reclamation}$). The unit reclamation cost ($c_{reclamation}$), in €/m^2, varies depending on the conditions of the sites, the soil characteristics and type of the reclamation required. The mathematical expression for determining this economic item is reported in Eq. (19) of Table 1.

Construction of the buildings (K_{build}). The measurement of this item is determined (in €/m^2) on a parametric basis (c_{build}), according to the specific intended uses - Eq. (20) in Table 1.

Construction of private parkings (K_p) and of private green spaces (K_v). The unit costs (€/m^2) for the realization of private car parks (c_p) and private green areas (c_v) can be derived from the cost of similar works or from the price lists published by public Entities and/or institutional associations - Eq. (21) in Table 1.

Technical expenses (K_{tech}). This item constitutes the remunerations for the technicians' activities. They are calcultated as a percentage of 5% of the sum of the total construction costs of the initiative ($K_{constr} = K_{reclamation} + K_{build} + K_p + K_v$). Therefore, the technical expenses are obtained by Eq. (22) in Table 1.

Management expenses ($K_{management}$). They represent the expenses for the management activities of the initiative and are computed as a percentage of 4% of the sum of the total construction costs (K_{constr}). The management expenses are calculated using Eq. (23) in Table 1.

Marketing expenses ($K_{marketing}$). This item is the cost for the commercialization activities of the realized units. The marketing expenses are determined as a percentage of 2% on the estimated revenues (R_{tot}) from the initiative - Eq. (24) in Table 1.

Financial charges (K_{loan}). They identify the interest on the loan capital for the redevelopment initiative. Assuming that the entire transformation is realized through a loan capital, the financial charges can be determined through Eq. (25) in Table 1, i.e. in percentage of 6% of the total cost items that affect the entire transformation process ($K_{transf} = K_{constr} + K_{area} + K_{sell} + K_{urbanization} + K_{tech} + K_{management} + K_{marketing}$).

Ordinary profit of the private entrepreneur (K_{profit}). This item constitutes the compensation of the private investor for the organization of the production factors and the risk investment of the initiative. In this case, an average rate of 20% of the expected revenues is assumed - Eq. (26) in Table 1.

Revenues (R_{tot}). This item includes the revenues generated by the sale of the gross floor surfaces obtained through the transformation process. The unit sale prices (in €/m^2) are to be estimated according to the values of the local real estate market, depending on the intended uses and the finishings provided by the project. For a redevelopment initiative that includes residential, commercial and tertiary units and the related parking areas, indicating the respective unit market prices with r_{res}, r_{com}, r_{off} and r_p, the revenues are derived from Eq. (27) in Table 1.

Table 1.- Economic parameters of the private investor's balance sheet

Costs	
$K_{area} = c_{area} \cdot (S_{priv} + S_c)$	(16)
$K_{sell} = 0.10 \cdot K_{area}$	(17)
$K_{urbanization} = c_{urbanization} \cdot GFS_{tot}$	(18)
$K_{reclamation} = c_{reclamation} \cdot (S_{priv} + Sc)$	(19)
$K_{build,res} = c_{build,res} \cdot GFS_{res}$ $K_{build,com} = c_{build,com} \cdot GFS_{com}$ $K_{build,off} = c_{build,off} \cdot GFS_{off}$	(20)

$K_p = c_p \cdot S_p$ $K_v = c_v \cdot S_v$	(21)
$K_{tech} = 0.05 \cdot K_{constr}$	(22)
$K_{management} = 0.04 \cdot K_{constr}$	(23)
$K_{marketing} = 0.02 \cdot R_{tot}$	(24)
$K_{loan} = 0.06 \cdot K_{transf}$	(25)
$K_{profit} = 0.20 \cdot R_{tot}$	(26)
Revenues	
$R_{res} = r_{res} \cdot GFS_{res}$ $R_{com} = r_{com} \cdot GFS_{com}$ $R_{off} = r_{off} \cdot GFS_{off}$ $R_p = r_p \cdot S_p$	(27)

Even for the public balance sheet, as for the private investor, the costs and revenues that occur in the situation "*without agreement*" and "*with agreement*" must be compared.

In the situation "*without agreement*", the following items are to be considered: a) *Costs*: the expropriation and reclamation of the public land surface (S_{pub}); b) *Revenues*: the primary, secondary, and construction urbanization costs paid by the private investor for the intended uses and the gross floor surfaces provided by the redevelopment initiative.

In the situation "*with agreement*", the commitments made by the private investor must be taken into account, i.e. the free transfer and reclamation of the areas (S_c) that constitute a share (or the total) of the surface upon which the public services (S_{pub}) must be located. This item must be included in the revenues of the public subject.

The economic parameters of the public subject's balance sheet are schematized as follows (Table 2).

Purchase price and reclamation of the areas ($K_{area} + K_{reclamation}$) for the public works provided by the redevelopment initiative. These items are the amounts for the purchase and the reclamation of the public land surface (S_{pub}), estimated using the unit price (c_{area}) and the unit reclamation cost ($c_{reclamation}$) found on the local market - Eq. (28) in Table 2.

Primary, secondary and construction urbanization charges ($K_{urbanization}$). This item corresponds to the amount paid by the private operator for the primary, secondary and construction urbanization costs, that for the Public Administration represents a revenue. It is quantified by applying the average unit cost ($c_{urbanization}$) to the total gross floor surface (GFS_{tot}) to be realized - Eq. (29) in Table 2.

Missed costs (K_{missed}) of the Public Administration. They identify the value of the areas (S_c) that the private investor is required to purchase, reclaim and free transfer to the Public Administration, evaluated by applying the unit market value (c_{area}) and the unit reclamation cost ($c_{reclamation}$) found on the local market - Eq. (30) in Table 2.

Table 2.- Economic parameters of the Public Administration's balance sheet

Costs	
$K_{area} + K_{reclamation} = (c_{area} + c_{reclamation}) \cdot (S_{pub})$	(28)
Revenues	
$K_{urbanization} = c_{urbanization} \cdot GFS_{tot}$	(29)
$K_{missed} = (c_{area} + c_{reclamation}) \cdot S_c$	(30)

Ultimately, the financial viability constraints for the public and private operators are obtained from the respective balance sheets, by imposing the condition of non-negativity of their performance indicators:

$$NV_{priv} \geq 0$$
$$NV_{pub} \geq 0 \qquad (31).$$

Objective function. This is the translation into mathematical expressions of the goals that the Public Administration intends to pursue through the redevelopment initiative. These objectives may vary. They can be "simple" objectives, such as:

i) the minimization of soil sealing. In this case, the objective is to identify the lowest value of the building index which, respecting the physical, urban and legal constraints defined for the initiative, ensures the public and private financial conveniences. This objective function will be:

$$Min!\ I_t \qquad (32);$$

ii) the maximization of the public surfaces that can be required to the private investor. This case may arise if there is the need for the Public Administration to obtain the highest possible share of public land surface. The goal is to search for the highest value of S_c, that is at the same time compatible with the constraints of the initiative. The objective function becomes:

$$Max!\ S_c \qquad (33).$$

Finally, there may also be "complex" objectives, resulting from the combination of "simple" objectives, with weights that represent the respective priorities. For example, if the goal is to maximize the surface S_c, trying, at the same time, to reduce the value of the building index I_t, the objective function will be a linear combination of Eq. (32) and Eq. (33) with weights α and β:

$$Max!\ (\alpha \cdot S_c - \beta \cdot I_t) \qquad (34).$$

6 Application of the model

The case study concerns the redevelopment of a former industrial complex located in the city of Salerno, in the South of Italy. The area covers 25,500 m^2 of surface and needs some reclamation interventions.

Table 3 summarizes the essential data for the application of the model. The urban data are derived from the local regulations.

Table 3.- Parameter values of the model application

Physical-urban data	
S_t	25.500 m^2
$N_{f,max}$	6
R_c	0.4
a	0.1
b	0.1
Economic data	
c_{area}	210 €/m^2
$c_{reclamation}$	50 €/m^2
$c_{urbanization}$	115 €/m^2
$c_{build,res}$	1.100 €/m^2
$c_{build,com}$	1.000 €/m^2
$c_{build,off}$	1.050 €/m^2
c_p	45 €/m^2
c_v	45 €/m^2
r_{res}	2.200 €/m^2
r_{com}	3.000 €/m^2
r_{off}	2.300 €/m^2
r_p	1.000 €/m^2

In this case, it is assumed that the "*a*" and "*b*" coefficients are fixed by the project of the redevelopment initiative.

The data for the construction of the public and private financial balance sheets have been found by crossing the prices reported in the official territorial lists with the evidence collected through a local analysis.

Four different objective functions are considered:

1) the minization of soil sealing ($Min!\ I_t$);

2) the maximization of the surfaces purchased, reclaimed and free transferred by the private investor ($Max!\ S_c$);

3) the combination, with the same priority, of the two previous objectives [$Max!\ (S_c - I_t)$]

4) the minimization of soil sealing for a fixed value of the surface S_c [$Min!\ (I_t, S_c = cost)$].

The model structure for the case study considered is reported in Table 4.

Land Use Policy 73 (2018) 40-48
https://doi.org/10.1016/j.landusepol.2018.01.036

Table 4.- The model structure

variables	I_t, S_e, S_v, S_c	
constraints	$S_e + S_v + 26{,}622 \cdot I_t + 2{,}550 = 25{,}500$	(I)
	$S_e \leq 10{,}200$	(II)
	$25{,}500 \cdot I_t - 6 \cdot S_e \leq 0$	(III)
	$0.9 \cdot S_v - 0.1 \cdot S_e - 765 \cdot I_t \geq 0$	(IV)
	$S_c \leq 2{,}550 + 18{,}972 \cdot I_t$	(V)
	$16{,}091{,}722 \cdot I_t - 5{,}301{,}450 - (58 \cdot S_e + 110 \cdot S_v + 303 \cdot S_c) \geq 0$	(VI)
	$-2{,}000{,}220 \cdot I_t - 663{,}000 + 260 \cdot S_c \geq 0$	(VII)
objective function	*Min!* I_t; *Max!* S_c; *Max!* $(S_c - I_t)$; *Min!*$(I_t, S_c{=}cost)$	

The definition of the constraints allows to reduce the number of the variables to four (I_t, S_e, S_v and S_c). Since the algorithm of the model has been set up, the surfaces intended for parking (S_p) and public services (S_{stand}) functionally depend on the building index (I_t), whereas the public surface intended for public roads (S_{road}) is immediately determined, as it has been fixed equal to 10% of the total land surface (b = 0.1).

For the effective definition of the setting of the possible solutions, the non-negativity constraints of the variables should also be added. However, the LINDO software automatically takes into account these boundaries, therefore they are not formalized in the algorithm of the model.

Table 5 summarizes the results obtained for the objective functions considered.

Table 5.- Outputs of the model application

	I_t	S_c	S_e	S_v	S_p	S_{stand}	S_{road}
Min!I_t	0.488498	6,308	8,577	1,368	3,737	9,268	2,550
Max!S_c	0.712861	16,074	3,030	943	5,453	13,524	2,550
Max!$(S_c - I_t)$	0.712861	16,074	3,030	943	5,453	13,524	2,550
Min!$(I_t, S_c{=}cost)$	0.551576	10,000	7,017	1,248	4,220	10,465	2,550

In the first case, the objective pursued by the Public Administration (*Min!* I_t) concerns the minimization of the building index, in order to limit soil sealing, while also ensuring a better quality of the urban spaces and best "liveability" of the new settlements. The model returns a bulding index equal to 0.488498 m^2/m^2.

The private and public land surfaces are:

$$S_{priv} = S_e + S_p + S_v = 8{,}577 + 3{,}737 + 1{,}368 = 13{,}682\ m^2$$
$$S_{pub} = S_{stand} + S_{road} = 9{,}268 + 2{,}550 = 11{,}818\ m^2,$$

which in percentage terms correspond respectively to 54% - for S_{priv} - and 46% - for S_{pub} - of the total land surface S_t. In this case, the surface S_c assumes a value of 6,308 m^2, that is 53% of the public land surface S_{pub}. In the situation described, the constraint (VI) in Table 4 is close to zero, so the private investor can only earn the ordinary profit from the redevelopment initiative, equal to 5,904,475 €. The free transfer and reclamation of additional areas - i.e. in addition to the surface S_c calculated by the model - are subject to the attribution of a building index higher than that determined by the model.

The equation of the public balance sheet is also satisfied, with a value close to zero. The surface S_e is within the boundary fixed by the constraint (II), whereas the surface S_v coincides with the area imposed by the constraint (IV).

The second objective function (*Max!* S_c) pursues the maximization of the surface S_c that the private investor is required to purchase, to reclaim and free transfer to the Public Administration. The model returns a value of the surface S_c equal to 16,074 m^2, which corresponds to the entire public land surface S_{pub}. Compared with the previous case, the bulding index increases (= 0.712861 m^2/m^2), whereas the sizes of the private land surface S_{priv} and public land surface S_{pub} are:

$$S_{priv} = S_e + S_p + S_v = 3{,}030 + 5{,}453 + 943 = 9{,}426\ m^2$$
$$S_{pub} = S_{stand} + S_{road} = 13{,}524 + 2{,}550 = 16{,}074\ m^2,$$

which correspond respectively to 37% - for S_{priv} - and 63% - for S_{pub} - of the total land surface S_t. The surface for the private green spaces S_v is equal to the value fixed by the constraint (IV). In this case, solving the public financial constraint (VII), the model provides a public benefic equal to 2,090,361 €, whereas the private financial constraint (VI) is widely satisfied, with an extra-profit for the private investor equal to 1,019,819 €.

It is interesting to note how the same results of the second objective (*Max!* S_c) are obtained by considering the complex objective function *Max!* $(S_c - I_t)$, i.e. the pursuit, with the same weights, of the maximization of the surface that can be purchased, reclaimed and free transferred by the private investor and the minimization of soil sealing. As in the previous case, adding the extra-profit of 1,019,819 € to the ordinary profit of the private investor, equal to 8,616,350 €, the total profit of the private investor is equal to 9,636,169 €, that is 22.37% of the total revenues generated by the redevelopment initiative.

Another objective could be to find the lowest value of the building index I_t at a fixed value of the surface S_c [*Min!* $(I_t, S_c = cost)$]. For example, a minimum surface S_c = 10,000 m^2 is assumed, that the private investor is required to purchase, reclaim and free transfer to the public subject. The resulting values are shown in the fifth row of Table 5. The building index is equal to 0.551576 m^2/m^2. The private and public land surfaces are:

$$S_{priv} = S_e + S_p + S_v = 7{,}017 + 4{,}220 + 1{,}248 = 12{,}485\ m^2$$
$$S_{pub} = S_{stand} + S_{road} = 10{,}465 + 2{,}550 = 13{,}015\ m^2,$$

that are respectively equal to 49% - for S_{priv} - and 51% - for S_{pub} - of the total land surface S_t. The surface upon which the private building units will be located (S_e) verifies the constraint (II), whereas the surface S_v is equal to the minimum value, i.e. 10% of the private land surface S_{priv}. The private financial constraint (VI) in Table 4 returns a value close to zero (= 91.65 €), so the model exclusively admits an ordinary profit of the private investor (= 6,666,900 €). Finally, the public financial constraint (VII) results widely satisfied (= 833,727 €).

7 Conclusions

With reference to the initiatives of regeneration of the abandoned areas, the model developed and tested in this research attempts to define a valid contribute to the objective set by the European Union to progressively limit soil sealing. Furthermore, taking into account the needs deriving from the current economic situation, the model can ensure the financial conveniences of the public and private operators involved in the redevlopment initiatives, through the fair distribution of the burdens and risks of the investments. In this sense, this research seeks to fill the lack of evaluation models for the determination of the financial sustainability of renewal investments to be implemented in public-private partnership (PPP), through the development of an easily repeatable methodology, characterized by high transparency and effectiveness.

The urban planning parameters to be attributed to the abandoned areas that must be recovered and the extent of the public surfaces that the private investor will have to purchase, reclaim and free transfer to the public subject, constitute a fundamental starting point for the negotiation among the PPP actors. Through the model defined, these surfaces are generated taking into account both the objectives of the Public Administration as well as the verification of the physical, projectual, legal, environmental and market factors that characterize the redevelopment initiative.

Concerning the practical use, the model can be used by both the public and private operators, as a tool for verifying and improving the redevelopment initiatives on the territory. Therefore, the use of the model aims at i) systematising the analysis of the project proposals, ii) rationalizing the selection process by improving its transparency, iii) disseminating the practice of the financial feasibility evaluations from the public and private subjects, by increasing their awareness of the agreements reached and the impacts that, on the basis of the conditions of the local market, they will have on their respective financial balance sheets.

The possibility of applying the model to different territorial contexts derives from the flexibility conferred to its structure by the Operational Research, which allows for i) the adjustment of the constraint system to the specific situation in analysis, ii) the modification of the economic items of the public and the private balance sheets, iii) the translation into mathematical expressions of the projectual choices, of the urban planning regulations and of the objectives of the Public Administration. In the final result, therefore, all the elements that can guarantee the mutual financial viability of the public and private parties are considered.

Although it has been presented in this research with reference to initiatives that provide for the requalification of the areas in disuse, the model can be also used for the evaluations that concern existent buildings that must be restored, maintaining the original conformation of their volumes (e.g. architectural emergencies, industrial archeology buildings, etc.).

Further insights of the model may result from the removal of some hypotheses, e.g. the assumption that provides the abandoned area "isolated" respect to the urban context, as well as the hypothesis that concerns the exclusive examination of the effects translatable in monetary terms. Finally, more improvements may involve the implementation of the cost-revenue analysis, by considering the distribution of the cash flows over time.

Note: The paper is to be attributed in equal parts to the authors.

References

1. D.L. Adolphson, G.C. Cornia, L.C. Walters: Railroad property valuation using Data Envelopment Analysis, Interfaces 19(3) (1989) 18-26.
2. R.I. Anderson, C.M. Brockman, C. Giannikos, R. McLeod: A non-parametric examination of real estate mutual fund efficiency, International Journal of Business and Economics 3(3) (2004) 225-238.
3. R.I. Anderson, R. Fok, L. Zumpano, H. Elder: Measuring the efficiency of residential real estate brokerage firms, Journal of Real Estate Research 16(2) (1998) 139-158.
4. J. Aznar, F. Guijarro, J.M. Moreno-Jimenez: Mixed valuation methods: a combined AHP-GP procedure for individual and group multicriteria agricultural valuation, Annals of Operations Research 190(1) (2011) 221-238.
5. H. Ben-Shahar, A. Mazor, D. Pines: Town planning and welfare maximization: a methodological approach, Regional Studies 3(2) (1969) 105-113.
6. L. Bing, A. Akintoye, P.J. Edwards, C. Hardcastle: The allocation of risk in PPP/PFI construction projects in the UK, International Journal of Project Management 23 (2005) 25–35.
7. C. Bourguignon: Leases, concessions, and authorizations: Searching for an alternative to the privatization of federal domain in Brazil, Land Use Policy 33 (2013) 100–110.
8. W.F. Bowlin: Evaluating the efficiency of US Air Force real-property maintenance activities, The Journal of the Operational Research Society 38(2) (1987) 127-135.
9. R.M. Buckley, A. Kallergis, L. Wainer: The emergence of large-scale housing programs: Beyond a public finance perspective, Habitat International 54(3) (2016) 199–209.
10. P. Byrne, S. Lee: Computing Markowitz Efficient Frontiers using a spreadsheet optimizer, Journal of Property Finance 5(1) (1994) 58-66.
11. P. Byrne, S. Lee: Sector, region or function? A MAD reassessment of real estate diversification in Great Britain, Journal of Property Investment & Finance 29(2) (2011) 167-189.
12. P. Byrne, S. Lee: Real estate portfolio analysis under conditions of non-normality: the case of NCREIF, Journal of Real Estate Portfolio Management 3(1) (1997) 37-46.
13. R. Caballero, T. Gomez, F. Ruiz: Goal programming: realistic targets for the near future, Journal of Multi-Criteria Decision Analysis 16(3-4) (2009) 79-110.
14. S.J. Chang, J. Buongiorno: A programming model for multiple use forestry, Journal of Environmental Management 13(1) (1981) 45-58.
15. Y.H. Chang, W.M. Wey, H.Y. Tseng: Using ANP priorities with goal programming for revitalization strategies in historic transport: a case study of the Alishan Forest Raiway, Expert Systems with Applications 36(4) (2009) 8682-8690.
16. H.W. Chen, N.B. Chang: Water pollution control in the river basin by fuzzy genetic algorithm-based multiobjective programming modeling, Water Science and Technology 37(8) (1998) 55-63.
17. C. Clifton, C.F. Duffield: Improved PFI/PPP service outcomes through the integration of Alliance principles, International Journal of Project Management 24(7) (2006) 573-586.
18. J.F. Courtney Jr, T.D. Klastorin, T.W. Ruefli: A goal programming approach to urban-suburban location preferences, Management Science 18(6) (1972) B-258.
19. M.P. Estellita Lins, L.F. De Lyra Novaes, L.F. Loureiro Legey: Real Estate Appraisal: a double perspective data envelopment analysis approach, Annals of Operations Research 138(1) (2005) 79-96.
20. J. Estrada: Mean-semivariance optimization: a heuristic approach, Journal of Applied Finance 18(1) (2008) 57-72.
21. European Commission (2011). *Tabella di marcia verso un'Europa efficiente nell'impiego delle risorse*. Bruxelles: https://ec.europa.eu.
22. European Commission (2012). *The state of the soil in Europe*. Luxembourg: Publication Office of the European Union, https://ec.europa.eu.
23. European Commission (2016). *Future Brief: No net land take by 2050?*. Issue 14. Bruxelles: https://ec.europa.eu.
24. European Environment Agency (2007). *Progress in management of contaminated sites (CSI 015)*. Italy: https://www.eea.europa.eu/it.
25. European Court of Auditors (2013). *Special Report No. 23/2012*. Luxemburg: Ufficio delle pubblicazioni dell'Unione europea, https://europa.eu/european-union/about-eu/institutions-bodies/european-court-auditors_it.
26. M.C. Findlay, C.W. Hamilton, S.D. Messner, J.S. Yormark: Optimal real estate portfolios, Real Estate Economics 7(3) (1979) 298-317.

27. X. Gan, J. Zuo, K. Ye, M. Skitmore, B. Xiong: Why sustainable construction? Why not? An owner's perspective, Habitat International 47 (2015) 61–68.
28. L.F.A.M. Gomes, L.A.D. Rangel: Determining the utility functions of criteria used in the evaluation of real estate, International Journal of Production Economics 117(2) (2009) 420-426.
29. D. Grimsey, M.K. Lewis: Evaluating the risks of public private partnerships for infrastructure projects, International Journal of Project Management 20 (2002) 107–118.
30. K. Hin, D. Ho, S. Eng Ong, T.F. Sing: Asset allocation. International real estate investment strategy under a workable analytic hierarchy process (AHP), Journal of Property Investment & Finance 24(4) (2006) 324-342.
31. R.J. Hubres, G. Rensi: Implications of goal programming in forest resource allocation: some comments, Forest Science 27(3) (1981) 454-459.
32. ISPRA (2017). *Consumo di suolo, dinamiche territoriali e servizi ecosistemici*. Rapporti 266/2016, http://www.isprambiente.gov.it/it.
33. Italian Institute of Statistics (2012). *IX Censimento dell'industria e dei servizi*. www.istat.it.
34. O. Kettani, K. Khelifi: PariTOP: a goal programming-based software for real estate assessment, European Journal of Operational Research 133(2) (2001) 362-376.
35. O. Kettani, M. Oral, Y. Siskos: A multiple criteria analysis model for real estate valuation, Journal of Global Optimization 12(2) (1998) 197-214.
36. T.A. Kroencke, F. Schindler: Downside risk optimization in securitized real estate markets, Journal of Property Investment & Finance 28(6) (2010) 434-453.
37. C. Lee (1973). *Models in Planning*. Oxford: Pergamon Press.
38. S.M. Lee, A.J. Keown: Integer goal programming model for urban renewal planning, Urban Systems 4(1) (1979) 17-26.
39. P. Linares, C. Romero: Aggregation of preferences in an environmental economics context: a goal-programming approach, Omega 30(2) (2002) 89-95.
40. M. Mehrbod, N. Tu, L. Miao, D. Wenjing: Interactive fuzzy goal programming for a multi-objective closed-loop logistics network, Annals of Operations Research 201(1) (2012) 367-381.
41. H. Min, H. Min, S.J. Joo, J. Kim: Evaluating the financial performances of Korean luxury hotels using Data Envelopment Analysis, The Service Industries Journal 29(6) (2009) 835-845.
42. Italian Public Works Ministry (1992). *Guida ai Programmi di Riqualificazione Urbana ex art.2, comma 2, Legge 179/92*. Italy: http://www.mit.gov.it.
43. P. Morano, F. Tajani: The transfer of development rights for the regeneration of brownfield sites, Applied Mechanics and Materials 409-410 (2013) 971-978.
44. A. Nesticò, F. Sica: The sustainability of urban renewal projects: a model for economic multi-criteria analysis, Journal of Property Investment & Finance 35(4) (2017) 397-409.
45. S.T. Ng, Y.M.W. Wong, J.M.W. Wong: Factors influencing the success of PPP at feasibility stage. A tripartite comparison study in Hong Kong, Habitat International 36(4) (2012) 423–432.
46. D. Oglethorpe: Optimising economic, environmental, and social objectives: a goal-programming approach in the food sector, Environmental and Planning A 42(5) (2010) 1239-1254.
47. R.L. Porterfield: A goal programming model to guide and evaluate tree improvement programs, Forest Science 22(4) (1976) 417-430.
48. A.V. Puelz, R. Puelz: Personal financial planning and the allocation of disposable wealth, Financial Services Review 1(2) (1991) 87-99.
49. L.B. Sagalyn: Public/private development, Journal of the American Planning Association 73(1) (2007) 7–22.
50. M.J. Schniederjans, J.J. Hoffman, G.S. Sirmans: Using goal programming and the analytic hierarchy process in house selection, The Journal of Real Estate Finance and Economics 11(2) (1995) 167-176.
51. G. Shevchenko, L. Ustinovichius, A. Andruškevičius: Multi-attribute analysis of investments risk alternatives in construction, Technological and Economic Development of Economy 14(3) (2008) 428-443.
52. J.L. Shi, J. Yang: Performance evaluation of listed real estate companies with Data Envelopment Analysis, Journal of Shangai University (Natural Science Edition) 3(022) (2006).
53. F. Tajani, P. Morano: An evaluation model of the financial feasibility of social housing in urban redevelopment, Property Management 33(2), (2015) 133-151.
54. F. Tajani, P. Morano: Evaluation of vacant and redundant public properties and risk control. A model for the definition of the optimal mix of eligible functions, Journal of Property Investment & Finance 35(1) (2017) 75-100.
55. J.H. Taplin, M. Qiu, Z. Zhang: Allocation of public road funds by goal programming on multiple criteria, Austrialian Journal fo Public Administration 54(1) (1995) 58-64.
56. C.M. Torre, P. Morano, F. Tajani: Saving soil for sustainable land use, Sustainability 9(3) (2017) 1-35.
57. Y. Tan, L. Shen, W. Lu, Q. Shen: Multiple-objective bidding strategy using goal programming technique, Management Decision 46(4) (2008) 656-672.
58. R.C. Walker (2001). *Introduction to Mathematical Programming*. Prentice-Hall.
59. W.K. Wang: A knowledge-based decision support system for measuring the performance of government real estate investment, Expert Systems with Applications 29(4) (2005) 901-912.
60. P. Welling: A goal programming model for human resource accounting in a CPA firm, Accounting, Organizations and Society 2(4) (1977) 307-316.
61. B.M. Wheeler, J.R.M. Russell: Goal programming and agricultural planning, Journal of the Operational Research Society 28(1) (1977) 21-32.

62. S.J. Zhou, Y.C. Li (2008): *Research of real estate investment risk evaluation based on Fuzzy Data Envelopment Analysis method*. In: The 2008 International Conference on Risk Management & Engineering Management (444-448). IEEE.
63. G. Zhou, C. Li, M. Li, J. Zhang, Y. Liu: Agglomeration and diffusion of urban functions: An approach based on urban land use conversion, Habitat International 56 (2016) 20–30.