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Development of a GIS methodology to evaluate informal urban green areas for inclusion in a community governance program.

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Master thesis, 30 credits, in Geographical Information Sciences

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Abstract

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Development of a GIS methodology to evaluate informal urban green space for inclusion in a community governance program.

Informal green spaces are "small green areas" which are some square meter plots along streets or in junctions, in front of public or private buildings. Informal urban green space become or remain in neglected condition due to the lack of capacity of the municipality to maintain them. Further, there is a lack of responsibility, competency and motivation of the residents to voluntarily take care of them (Rupprecht et al., 2015, Hardman et al., 2018), as is the case of the 12th district of Budapest in Hungary which is the pilot area of this research.

Municipalities can decide to cooperate with the residents to tackle this problem, but there is no information about the informal green spaces (IGS). Following an extensive search through the literature, no GIS method appears to address the analysis of informal green areas in relation to their suitability for the inclusion into a community governance program as the Stewardship Program of the 12th district. In the frame of the program, the Municipality and residents cooperate on the maintenance of IGS.

The current research intends to fill this knowledge gap by developing a methodology using GIS to identify and categorize informal urban green spaces (IGS) according to their suitability for inclusion in community management services.

As the first step, interviews and questionnaires were conducted with the leaders and the stewards (residents) of the Stewardship Program to identify IGS attributes based on which IGS can be evaluated: Ownership (areas owned by the municipality); No-man lands/green islands; Not protected area; Safeness, air and noise pollution; Original vegetation cover; Manageable size; Closeness to home; Closeness to apartment buildings; Slope steepness; Water sources available for irrigation; Not to be protected area but close to them; Along busy pedestrian area; Sunniness.

In order to measure the identified attributes, spatial indicators were established by multi-criteria analyses method applying spatial analyses tool such as distance and network analysis tool.

The final output of the analysis was a suitability map about the 12th district of Budapest which shows those areas which have high potential and those areas which have low potential to include stewardship areas. Similar maps can be created for any other districts or cities following the methodology developed in the frame of this research.

Keywords: Geography, GIS, informal urban green spaces, community governance, multi-criteria analysis

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1. Introduction

Urban green spaces provide various environmental, social and economic benefits and offer an improved quality of life as they not only provide leisure or sports facilities but make the air cleaner, reduce urban noise and even improve the urban climate (Gupta et al., 2012). Yet if the authorities being responsible for the green areas do not have the capacity to maintain them well, green areas can easily generate conflicts between inhabitants and the responsible authorities (Hardman et al., 2018). Traditional top-down approaches are often not enough or efficient to tackle such conflicts thus a new approach is needed in which green spaces could be managed smartly through cooperation between inhabitants and various authorities. The Municipality of Budapest's 12th district, also known as Hegyvidék, in Hungary has realized the necessity of such a new approach and has taken steps towards it which provided the basic idea for this research project.

Hegyvidék has a significant size and number of urban green spaces. The effective management of them calls for cooperation among all stakeholders. In addition, due to historical reasons related to the socialist period, community involvement is relatively weak in Hungary (Volunteering in the European Union 2010). Community engagement methods are not yet included in mainstream urban policies; however, they are highly needed (Social Innovation in cities 2015). All of this makes a huge challenge for the effective management of green areas for the Municipality of Hegyvidék which values its green spaces as an extraordinary asset and intends to use urban green spaces as catalysts for the promotion of pro-environmental behaviour and environmental consciousness among its residents.

In order to tackle the above explained challenges of Hegyvidék, the Municipality (Budapest 12th district) decided to participate in an Interreg Central Europe project called UGB (Urban Green Belts). In the frame of the project, the Municipality is implementing a pilot action called Stewardship Program. The program intends to create a strong community of residents who voluntarily cooperate with the municipality in taking care of "small green areas" which are some square meter plots along streets or in junctions, in front of public or private buildings being neglected due to the lack of capacity of the responsible authority to maintain them (Homepage of Stewardship Program of the Municipality of 12th district of Budapest). So far only a few small green areas were identified to be included in the Stewardship program (*Fig. 1*) which is in an initial phase, while it is expected that there are hundreds of small green areas which could be involved. However, not all small green spaces are equally valued and suitable for community management. For instance, appropriate areas must be owned by the Municipality and cannot be protected areas. In addition, they should not locate near busy roads which is not safe enough for community gardening and due to the local air and noise pollution, the work can become rather unpleasant and unhealthy. The aim of this research is to develop a methodology using Geographical Information Systems (GIS) to evaluate these "small green urban spaces" for inclusion into a community governance program similar to the Stewardship program Hegyvidék operates.

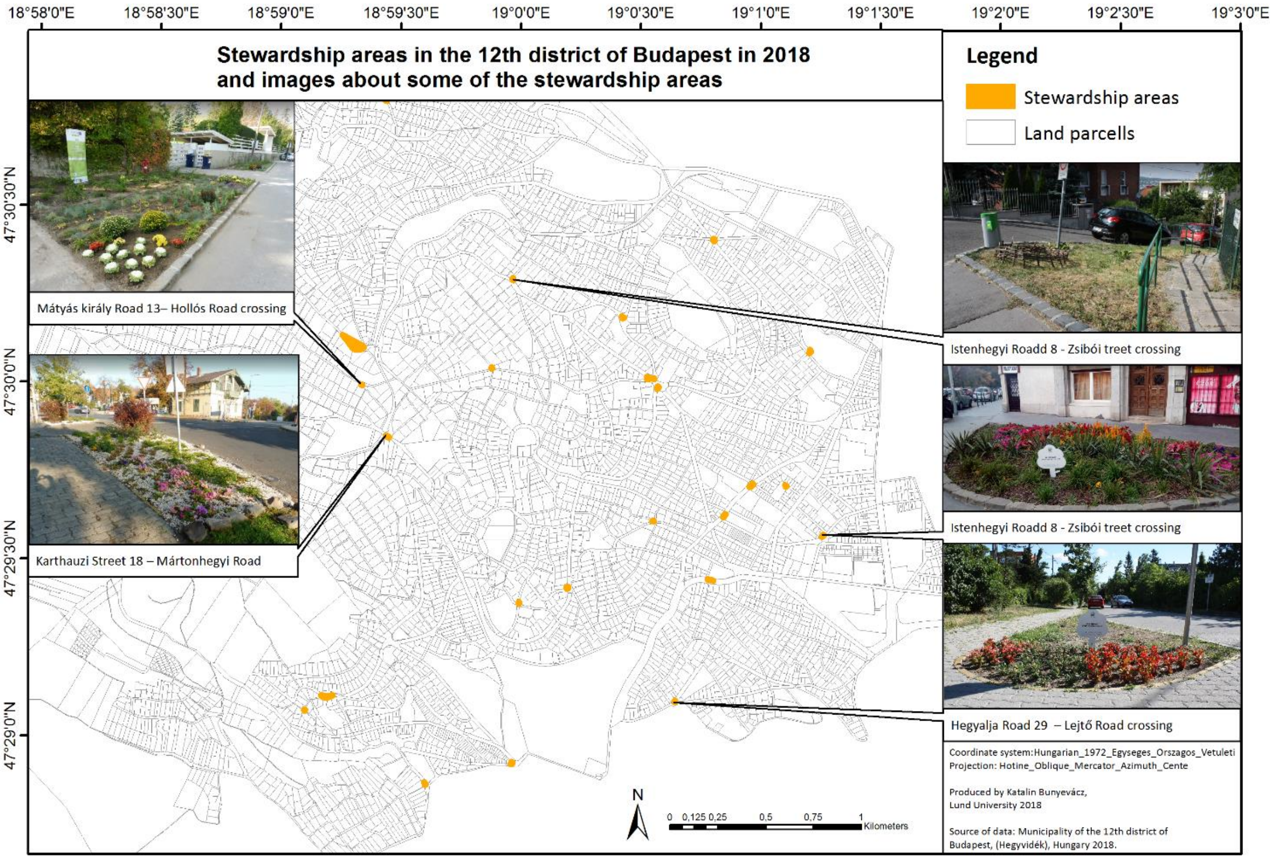


Figure 1. Stewardship areas in the 12th district of Budapest in 2018 and images about some of the stewardship areas

GIS is a system designed to capture, store, analyse and present spatial data. GIS tools allow users to analyse spatial information, edit data in maps, and present the results of these operations. In the current research GIS will be applied for combining different kinds of spatial data by performing spatial analyses and overlaying. Spatial data will be illustrated and analysed on map layers which will be overlaid on each other producing a map which summarizes the different information.

After identifying attributes and spatial indicators that are important for finding suitable green spaces a so called multi-criteria analysis will be carried out and evaluated. Multi-criteria analyses are decision support tools applied for finding the best solution – in the case of this research the most suitable area - based on different factors/criteria.

In this application, the spatial analyses will involve tools by which distances from different spatial objects (hydrants, parcels) or types of areas (protected ones) can be calculated. Distances will be calculated in different ways, for instance on the road network of the district. The analyses will also apply raster tools which make possible the combined evaluation of the data available originally in vector format.

The indicators and the multi-criteria analyses including the application of the combination of analyses tools will be tested for the 12th district of Budapest, but the proposed method is intended to be general, and therefore applicable for other urban areas, possibly after a minor customization to local circumstances (spatial data available and unique features of the city/district).

Research problem statement

Informal urban green spaces become or remain in neglected condition due to the lack of capacity of the municipality to maintain them. Further, there is a lack of responsibility, competency and motivation of the residents to voluntarily take care of them (Rupprecht et al., 2015, Hardman et al., 2018), as is the case of the 12th district of Budapest.

Municipalities can decide to cooperate with the residents to tackle this problem, but there is no information about the informal green spaces (IGS) based on which they could be evaluated for inclusion in a Stewardship Program. Following an extensive search through the literature, no GIS method appears to address the analysis of informal green areas in relation to their suitability for the inclusion into a stewardship program or similar.

Rooted in the above problems and challenges, the research problem can be identified as:

- Lack of information about the important attributes that urban residents and municipalities assign to informal green spaces for the selection and evaluation of them for the Stewardship program (or similar program).
- Lack of suitable spatial indicators for the selection and evaluation of IGS.

This research intends to fill this knowledge gap and to provide a method for other municipalities to initiate community governance in order to tackle the challenges related to informal green areas.

2. General aim and objectives

General aim:

My aim in this project is to develop a methodology using GIS to identify and categorize urban green spaces according to their suitability for their inclusion in community management services such as the Stewardship Program.

Objectives:

1) To identify attributes suitable to be used in the process of selecting informal green areas to be included in a Stewardship Program. These attributes will also be ranked according to their level of importance.
2) To propose methods on how to use multi-criteria analyses to establish spatial indicators that could be used in order to find the identified attributes for selecting informal green areas. These indicators will have the form as separate layers in a GIS.

3) To test how applicable the proposed attributes and indicators are, using the 12th district as a pilot area where the Stewardship Program is already in operation.

The first objective will be solved from interviews and questionnaires conducted with both stewards (residents) and the leaders of the Stewardship Program. The leaders of the Program are horticultural experts and works in the Green Department of the Municipality.

The second objective (to identify spatial indicators), will be produced from relevant source data as well as from spatial analyses performed in a GIS. These analyses will involve multi-criteria analyses using various combinations of overlay operations which will also contribute to reach the third objective (testing how applicable the proposed attributes and indicators).

It can be assumed that there will be some attributes determined by the Municipality which exclude significant number of IGS such as ownership or level of protection. Also, safeness, current vegetation cover and water sources availability could be important attributes. From the side of the residents the closeness to their home can be a key IGS attribute and the pleasant environment of the IGS.

It is expected that the attributes can be measured by spatial indicators for which primarily the Municipality will serve GIS data. Data can be analysed by spatial analyses tools available in ArcMap. This way such GIS methods can be developed by which further IGS of the 12th district can be selected. It is a further hypothesis that such districts or cities have high potential to apply the methodology and launch a Stewardship Program who are typically green districts/cities with areas having lot of apartment buildings with liminal gardening opportunity.

3. Background

3.1. Literature review

In the scientific literature, small green spaces are called informal green spaces (IGS) and there are only a few studies that deal with the importance and role of them in urban spaces (Pietrzyk-Kaszínska et al., 2017, Rupprecht et al., 2015). According to the study of Rupprecht et al., 2014, most of the research on urban green spaces focus on clearly demarcated and formal vegetation covers, such as urban forests and parklands while cities are fragmented landscapes being of the patchwork of built, infrastructural and green spaces. Acknowledging this state, a typology of quasi-public green spaces was created by Rupprecht et al. in their study calling these places – first in literatures - 'informal urban green space' (IGS). *Table 1* includes the developed typology. The current study focuses on the first category of the list of IGS types, on the *Street verges* as verges, roundabouts, tree rings, informal trails and footpaths.

Table 1. Informal urban greenspace typology (Rupprecht and Byrne, 2014).

IGS	Examples	Description	Management	Form
Street verges	Roadside verges, roundabouts, tree rings, informal trails and footpaths	Vegetated area within 5 m from street not in another IGS category; mostly maintained to prevent high and dense vegetation growth other than street trees; public access unrestricted, use restricted	Regular vegetation removal (≥once per month); governmental and private stewardship	Small: <100 m^2, linear
Lots	Vacant lots, abandoned lots	Vegetated lot presently not used for residential or commercial purposes; if maintained, usually vegetation removed to ground cover; public access and use restricted	Irregular veg. removal, medium to long removal intervals; private stewardship	Small–medium: <1 ha, block
Gap	Gap between walls or fences	Vegetated area between two walls, fences or at their base; maintenance can be absent or intense; public access and use often restricted	Irregular veg. removal; variable removal intervals; private stewardship	Small: <100 m^2, linear
Railway	Rail tracks, verges, stations	Vegetated area within 10 m adjacent to railway tracks not in another IGS category; usually herbicide maintenance to prevent vegetation encroachment on tracks; public access and use mostly restricted	Regular veg. removal (monthly to yearly); corporate or governmental stewardship	Medium–large: >1 ha, linear
Brownfields	Landfill, post-use factory grounds, industrial park	Vegetated area presently not used for industrial or commercial purposes; usually no or very infrequent vegetation removal and maintenance; public access and use mostly restricted	Irregular veg. removal, long removal intervals; corporate and governmental stewardship	Medium–large: >1 ha, block
Waterside	Rivers, canals, water reservoir edges	Vegetated area within 10 m of water body not in another IGS category; occasional removal of vegetation to maintain flood protection and structural integrity; public access and use often possible with some restrictions	Irregular veg. removal, long removal intervals; governmental stewardship	Small–large: >10 m^2 to >1 ha, linear

Waterside	Rivers, canals, water reservoir edges	Vegetated area within 10 m of water body not in another IGS category; occasional removal of vegetation to maintain flood protection and structural integrity; public access and use often possible with some restrictions	Irregular veg. removal, long removal intervals; governmental stewardship	Small–large: >10 m^2 to >1 ha, linear
Structural	Walls, fences, roofs, buildings	Overgrown human artifacts; often vertical; occasional removal of vegetation to maintain structural integrity; public access and use mostly restricted	Irregular veg. removal, medium to long removal intervals; varying stewardship	Small: <100 m^2, block
Microsite	Vegetation in cracks or holes	Vegetation assemblages in cracks, may develop into structural IGS; maintenance can be absent or intense	Irregular veg. removal, variable removal intervals; variable stewardship	Very small: <1 m^2, point
Power line	Power line rights of way	Vegetated corridor under and within 25 m of power lines not in another IGS category; vegetation removed periodically to prevent high growth; public access and use mostly unrestricted	Regular veg. removal (less than yearly); utility or governmental stewardship	Medium–large: >1 ha, linear

Rupprecht et al. defined 'informal green space' (IGS) as an "*explicitly socio-ecological entity, rather than solely cultural or biological"* This is a very important aspect from the point of view of the current research, as this study also focus on the evaluation of IGS from the socio-ecological point of view, therefore not purely the ecological condition of these spaces are evaluated but the socio potential to be in a community governance program. Rupprecht et al. also highlighted a very important feature of IGS: they are influenced most by the fact that they are unmanaged as they are not maintained by the responsible governing institutions or property owner. In the current study, the GIS method developed is going to help Municipalities recognize IGSs being under their responsibility and solve the maintenance of these places cooperating with residents.

Further studies addressing informal green spaces define IGS as "*areas that are not formally demarcated or have an uncertain land tenure status. Places valued for their greenness, pleasant views, uniqueness, wild character and role as natural habitats are predominantly marked outside of formal green spaces*" (Pietrzyk-Kaszínska et al., 2017). Therefore, according to this quoted definition, *informal green space* term means mainly the wild and large green areas inside or near urban places. In the current study, though, the focus will be on the rather small public *informal green spaces* which highly contribute to the overall greenness of the districts or cities but could not gain spatial attention so far in urban green space analyses. Pietrzyk-Kaszínska et al. provided a list of the most frequent type of informal green spaces (*Table 2*) in their study titled as *Eliciting non-monetary values of formal and informal urban green spaces using public participation GIS*.

Table 2. Examples of informal green spaces included in the present study. Source: Pietrzyk-Kaszínska et al., 2017

EXAMPLE OF INFORMAL GREEN SPACES	SIZE	OWNERSHIP	ACCESSIBILITY FOR THE PUBLIC
Backyards	Small	Public or private	Accessible or inaccessible
Front yards	Small	Public or private	Accessible or inaccessible
Gardens	Small	Private	Inaccessible
Unmanaged green squares	Small	Public or private	Accessible or inaccessible
Single trees or scrubs between buildings	Small	Public or private	Accessible or inaccessible
Green spaces between buildings in modern neighbourhoods	Small	Public	Accessible
Fallows, uncultivated lands	Large or small	Public or private	Accessible or inaccessible
Brownfields	Large	Public or private	Accessible or inaccessible
Fortifications and places of martyrdom	Large	Public	Accessible or inaccessible
River valleys	Large	Public	Accessible
Street greenery	Small	Public	Accessible
Green tram tracks and road medians	Small	Public	Inaccessible
Used or unused railway areas	Large	Public	Inaccessible

In the current research, the small and public informal green spaces will be investigated such as unmanaged green squares, single trees or scrubs between buildings, green spaces between buildings in modern neighbourhoods, street greenery, road medians and partly backyards and front yards. Therefore, the large and typically private areas which could not be managed by residents are excluded from the analyses such as gardens, fallows, uncultivated lands, brownfields, fortifications and places of martyrdom, river valleys and used or unused railway areas.

This literature review of Rupprecht et al. (2014) revealed that scholars know less about small IGS than for instance about vacant lots or brownfield IGS as the analysis of small IGS poses significant methodological challenge. Therefore, on the one hand there are methodological challenges of analysing these small IGSs which this study aimed to address. On the other hand, there is need for analysing these areas having lack of clear responsibility resulting in conflicts, which pose a challenge to traditional green space planning. To address this problem, Rupprecht et al. (2015) suggested the exploration of participatory management approaches. The Stewardship program of the Municipality of Hegyvidék represents exactly a participatory management approach that needs scientific support, which GIS tools and analyses could provide. Also, Pietrzyk-Kaszínska et al. (2017) emphasized, in their article, the need to identify and address informal green spaces in urban green space governance. Briefly, their study deals with the analysis of the values and important attributes that urban residents assign to green spaces. The result of this study was also considered as the identification of values and attributes (criteria), which make an informal green area attractive for residents and supported by municipalities to jointly take care of it.

To investigate multi-criteria analysis for deciding the best locations for green areas and other urban features is common in the scientific community (Balram et al., 2005, Gupta et al., 2012, Panduro et al., 2013, Neema et al., 2013, Raziyeh et al., 2017, Abebe et al., 2017). This study has a different focus compared to the former studies since it focuses on the informal green areas. The evaluation of informal green areas requires a different list of criteria compared to the formal ones. Yet, it is worth to overview the methods applied by these studies and compare to the one applied in this project.

The method applied in Raziyeh et al., 2017 and Abebe et al., 2017 follows the same logic as this project: after identifying multiple attributes and their related spatial indicators, multi-criteria analyses were carried out producing a final suitability map. The list of indicators, though, differs from the one included into this research due to the different goals set by authors of the studies.

The work of Neema et al., 2013 involves developing a new model, aiming to identify the optimum sites for green spaces as parks and open spaces (POSs). The sites were evaluated and selected based on six criteria: population, air quality, noise level, air temperature, water quality, and recreational value, including barriers for placing new POSs.

This study here resembles that of Neema et al (2013), but here more than six criteria were used, and more emphasis were given to the selection of criteria identified by the stakeholders i.e. the leader and the stewards of the Stewardship Program. Regarding the similarities, both studies include natural (air temperature) as well as human criteria (recreational value). The study of Neema et al. also used their method for a particular area, applying spatial GIS functions for analyses and representation. Even though both studies' goal is to find optimal location for urban green spaces, and similar criteria were identified, the criteria are evaluated differently. For instance, in this analysis noise polluted areas has a lower value while in the analysis of Neema at al. noise polluted areas receive higher a value as they are looking for spaces where green spaces are most needed to soften the negative urban environment effects as noise pollution. It can be concluded that green spaces evaluation criteria are relevant for any type of urban environment, though the way of evaluating and weighting them can be very different according to the goal of the analyses and the type of the city.

In addition, the method applied by Neema is definitely a more complicated method which can give more accurate result, although it can generate more source of errors. Furthermore, the application of the method requires GIS expertise which is usually not available in municipalities. The current research intends to develop such a method or at least such output maps which can be applied by urban planners and decision makers having no or minimal GIS knowledge. Also, the study of Gupta et al., 2012 highlighted the need for techniques and methods, which are easily comprehensible by urban planners and city administrators for implementation on the ground. In order to fulfil this demand, Gupta et al. developed an Urban Neighbourhood Green Index (UNGI) which aims to assess the greenness of a neighbourhood and identify intervention areas. The index included four parameters: Green

Index based on NDVI, proximity to green, built up density and height of structures. Even though the method of this project applied more than 4 parameters, it can be still considered a similarly comprehensible one as the Urban Neighbourhood Green Index.

Beside being a comprehensible method, the intention is also to develop a method which is based on information gained from local people about informal green spaces. The study of Pietrzyk-Kaszínska can be mentioned as reference in this regard, which applied data collected from residents about formal and informal GSs by an online questionnaire in which participants individually answered a series of questions, accompanied by interactive maps which provided geographical context and allow resident to indicate geographical features (Pietrzyk-Kaszínska et al. 2017). The current study also significantly relies on the information collected from local people, completed by GIS data provided by the Municipality.

This project and the work of Pietrzyk-Kaszínska et al. are considered rather unique in the regard of combining qualitative and quantitative analyses methods for analysing informal green spaces by GIS. It seems typical, based on the studies (Younis, A. et al. (2018), Rupprecht, C. et al.(2015), Gupta, K. et al. (2012), Panduro, T. E. et al. (2013), Hardman, M. et al. (2018)) discussed here, that there are studies which deal with people’s perception of informal urban green spaces and ones which deal with the evaluation of green spaces applying statistical and GIS tools. The combination of both is rare. It was also concluded by Rupprecht, C. et al. (2014) overviewing the available studies about IGSs that such method as surveys and photography are commonly used for IGS analyses, “*but participatory, GIS-augmented and mixed methods remain scarce.”*

After discussing the most relevant literatures from the point of view of the research, it can be concluded that the added value of the project compared to the previous studies is that the current research addresses informal green spaces, not the formal ones. In addition, it provides a GIS method can be applied for the maintenance and management of these places. While most of the previous studies’ goal was to assess greenness (Gupta et al., 2012, Stessens, P. et al. 2017), find intervention areas, places for new formal green spaces (Neema at al., Raziyeh et al., 2017), and categorize and analyse the impact of existing formal green spaces (Panduro et al., 2013). The method of this study is developed to support municipalities in maintaining their informal green spaces.

The purpose of the evaluation is to estimate the potential of green spots being able to be maintained by residents. In the previous studies, on the other hand, the purpose of the evaluation was to determine the value of the green areas without any parameter/criteria which would refer to the financial or management condition of the area. The work of Baycan-Levent et al., 2009 means an exception in this regard as in their study, urban green spaces of 24 European cities were evaluated from also maintenance-management point of view including such criteria as 'changes in green spaces', 'planning of urban green spaces', 'financing of urban green spaces' and 'level of performance.

In addition, as the need for community involvement in the management of urban green spaces increases, from both the municipalities and from the residents’ side, informal green spaces, having higher potential for urban voluntary gardening than the formal ones, should come also to the picture of scientific analyses.

3.2. Description of the study area

The 12th district of Budapest located on the Buda side of the River Danube mainly consists of house-holds. In 2017, the number of inhabitants reached 57 000 in the district, mainly working in the service sector. The work labour is highly educated, also the average in-come is particularly high in the district, however the immigration to abroad is quite popular among the educated youth. The 12th district is among the less populated districts of Budapest with mountainous landscape. The population continuously decreased from 1980 to 2011, however from 2011 it increases steadily. The migration balance shows a slight immigration, although the number of people having the age between 0-14 increase rapidly which leads to the rejuvenation of the district.

Budapest's biggest forests are situated in the district which determine the economic developments of Hegyvidék on the field of health and active tourism. The district has significant landscape potential being considered as the "lung of Budapest". It has green areas being part of the Buda Landscape Protection Area, green corridors (Zugligeti road - Szilágyi Erzsébet Alley - Városmajor park - Ördögárok valley) and urban green spaces having high protection level such as the Jókai garden park. The Nature 2000 areas mainly overlap with the Buda Landscape Protection Area.

The district has several public urban green spaces in the form of public parks and urban forests (Városmajor park, Kissvábhegy, Széchenyi-memorypark and the Farkasréti cemetery). The most important green area of the district is the Normafa forest park, located on the ridge of the Széchenyi and János hill, holding several fascilities, a skihouse, running paths and playgrounds being among the major attractions. This is the most popular place for active sports and leisure activities, and it is regularly visited by residents and tourists from the whole city of Budapest (Integrated Urban Development Strategy of the 12th district of Budapest, Hegyvidék, 2014 – 2022).

4. Methodological approach

Fig.2 below is constructed as a flow chart, intending to provide a general overview of the main processing steps of the analyses chronologically. In the first column, the qualitative data collection methods are included: Interviews and questionnaires were conducted with the stewards and the leaders of the Stewardship Program. Based on the information received, attributes and their importance (weight) were identified. Following it, spatial indicators were generated by which the attributes can be measured in GIS. Spatial analyses GIS tools were applied on the GIS data generating maps visualizing the spatial pattern of the indicators. Following the testing of the indicators comparing the result maps of the analyses to the map of the areas already included into the Program, a combined multi criteria map was produced identifying and visualizing the potential IGS. In the discussion chapter, the adaptability of the method developed is explained.

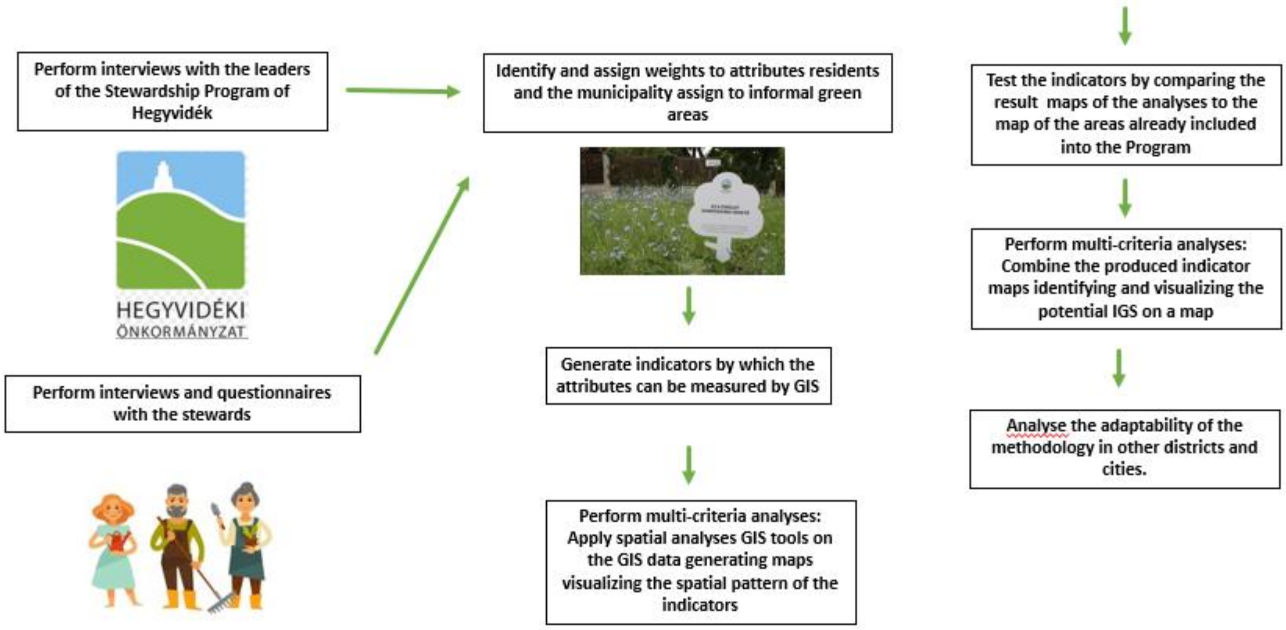


Figure 2. Overview of the combination and relation of the methods applied for the research.

5. Results

5.1. Selection of IGS attributes

Interview with the leaders of the Stewardship Program

To identify and weight attributes that citizens and municipalities use to select IGS for inclusion in a Stewardship Program, an interview was conducted with the two leaders and initiators of the Stewardship Program of the Municipality of 12th district of Budapest (Hegyvidék). In addition, two more interviews were conducted with stewards and an online questionnaire sent to all the stewards.

Regarding the first interview (with the leaders of the Stewardship Program), the goals were, first, to have a general overview about the Stewardship Program, second, to collect attributes for selecting IGS for the Stewardship Program. This information offered a strong starting point for the research, resulting in a list of attributes from which the spatial indicators could be generated. The initial involvement with the leaders provided important professional background for the research continuously during the development of a suitable methodology. For instance, they contributed to identify some sensitive indicator threshold values.

The main outcome of the interview is listed in the below table.

Table 3. Attributes identified during the interview.

ATTRIBUTES	Description
Ownership	Municipality owned areas.
No-man lands/green islands	Public areas not close to private parcels
Not protected area	Not protected areas.
Safeness, air and noise pollution	Safe, not air and noise polluted areas.
Original vegetation cover	Not grass, rather bare areas.
Manageable size	Not too big and not too small areas.
Closeness to home	Close to stewards home.
Closeness to apartment buildings	Close to apartment houses areas.
Slope steepness	Area has not too steep slope.
Water sources available for irrigation	Water sources available for irrigation in close.
Not to be protected area but close to them	Not to be protected area but close to them where native species can be plant.
Along busy pedestrian area	Slightly important
Sunny	Slightly important

The resulting attributes were agreed on using suggestions from both me and the leaders. The list of attributes included are all confirmed by the leaders. The identified attributes are the followings:

- **Safeness**: One of the most important attributes of IGSs is the safeness, which means that doing gardening activity on the area is safe, therefore the IGS is not located next to or surrounded by a busy road. Furthermore, it is accessible without taking a busy road and gardening can be done without stepping to a busy road.

- **Air and noise pollution:** Gardening is basically a healthy and relaxing activity, if the air is clean enough for physical work and quiet environment is provided. Thus, those IGS are preferred to be include into the Program whose environment has low noise and air pollution typically resulted from high traffic on close roads.

In Hegyvidék, the busy roads are basically the bus line roads which are, due to their generally high slope steepness, strongly affected by noise and air pollution. Therefore, in Hegyvidék, it is very typical that the surrounding area of bus line roads are polluted while further from them silent, clean, green and sinuous streets go.

- **Water sources available** for irrigation: So far, the municipality took care of the irrigation of the stewardship areas by using the hydrants which are managed by the fire service. Thus, for the Municipality, the closeness of hydrants means an important attribute.

- **Original vegetation cover**: The most appropriate IGSs are the neglected ones, which are aesthetically disturbing. Consequently, the residents living near these areas can be motivated to do something with it. It is better if the selected area is weedy/neglected flower bed instead of covered by grass as, if due to the Program, the grass area turns to a flower bed. If the steward at some point stop taking care of the area, the area will be in even worse condition than before when it was a grass field.

- **Ownership**: Appropriate IGSs should be owned by the municipality of Hegyvidék. However, there are also some stewardship areas which are owned by the Budapest Capital Municipality or has private owner, but the main intention is to find stewards who takes care of public urban green spaces for which the Municipality of Hegyvidék is responsible.

- **Manageable size:** The ideal size of a stewardship area is between 10 m^2 and 100 m^2.

- **Closeness to home:** One of the main attributes, stewards assign to their area, is the closeness to their home.

- **Closeness to apartment buildings**: It is likely that people living in apartment buildings have higher motivation for gardening on public green areas as they have no garden or one not big enough. Therefore, the chance of finding stewards for an area is higher if the area is located near apartment buildings.

- **No-man lands/green islands**: Taking care of green areas in front of private areas are under the responsibility of the owner(s) of the private area determined by law. Thus, these areas should not be included into the program.

- **Green for advertising**: In Hegyvidék, there are some stewards who are not persons but enterprises taking care of an area in front of their shops or office, putting their logo on a table placed on the green spot, which advertises their enterprise by this voluntary work. There is potential for such collaboration between enterprises and the municipality, thus areas which are close to shops or offices can be a high potential for long lasting maintenance by such stewards.

- **Not to be protected area but close to them**: Protected areas cannot be included in the program, however areas located next to or close to such areas can have high potential to be included. In Hegyvidék, the municipality contacted the authority responsible for the protected areas and, jointly, planted native species on the area close to the protected ones contributing to the maintenance of native species and increasing biodiversity in the district.

- **Slope steepness** is an important attribute as determines the possibility of gardening.

In addition, it turned out from the interview that some attributes were not considered relevant at selecting IGSs such as the closeness of IGS to industrial areas; public lighting close to IGS; closeness of formal green spaces (playground, park, forest); and soil type condition. Consequently, these attributes were not included into this analyse, but could have relevance in other types of districts or cities, and therefore they are still listed here.

Interviews and online questionnaire conducted with stewards

The main goal of the questionnaire and the interviews conducted with stewards was to weight the importance of each attribute relevant for residents/stewards and identify new attributes to be included into the analyses. Thus, the questionnaire was not used for developing the indicators, therefore getting to know for instance the distance which is considered close to home by residents. It was used just get to know how much it is important to have an area locating close to home.

However, it was decided to add a question to the questionnaire about the manageable size indicator asking stewards about the ideal size of an area.

It is worth to mention that not all the attributes collected from the leaders of the program were included into the questionnaire as some attributes are relevant only for the Municipality. These are the *Ownership*, the *No-man lands/green islands* and the *Not protected area* attributes.

Based on the interviews and questionnaires with the stewards, three more attributes were identified: an ideal stewardship area should be also *sunny*, *having nice view* and be located at a place where *lots of people are exposed to it*. Regarding the latter one, stewards might be more encouraged if people get to view their voluntary work. In addition, „green messages" related to an environmental consciousness can be communicated through the areas if they are placed along for instance busy pedestrian paths. The importance and relevance of the close to home, safeness, noise, air pollution and the close to apartment building was especially emphasized by the stewards answering the open-ended questions as advantages or disadvantages of their area.

The main outcome of the questionnaire and the interviews are summarized in *Table 4*, where all the identified attributes, their importance rate and the related weight applied in the GIS analyses are presented. The weights were calculated by equally considering the cumulated importance of the attributes by stewards and the leaders of the Program. Weight values were given from 1 to 0.2. 1 representing the most important and 0.2 the least important attributes. 1 value was given to the "exclusionary" attributes. Therefore, to the ones which determine whether an area can be stewardship area at all or not. These are the ownership, not protected area and no-man lands attributes. In the analyses, instead of excluding the areas which do not meet these criterion, these attributes received high weight as there are exceptional cases. For instance, it can happen that private areas or areas close to private areas become stewardship areas. 0.8 weight were given to the attributes which are important either for the leaders or the stewards, and very important either for the leaders or the stewards. Therefore, the important – very important couples received 0.8 weight. The important – important ones received 0.6 weight. The slightly important – important received 0.4. The attributes considered slightly important for both groups received 0.2 weight. *Table 4* includes the possible importance combinations and related weights. *Table 5* includes the weights produced for each of the indicators.

Table 4. Possible importance combinations and their weights

Stewards	Leaders	Weight
Very important	Very important	1
Not relevant	Very important	1
Very important	Not relevant	1
Very important	Important	0,8
Important	Very important	0,8
Very important	Slightly important	0,6
Slightly important	Very important	0,6
Not relevant	Important	0,6
Important	Not relevant	0,6
Important	Important	0,6

Slightly important	Important	0,4
Important	Slightly important	0,4
Not relevant	Slightly important	0,2
Slightly important	Not relevant	0,2
Slightly important	Slightly important	0,2

Table 5. Attributes, their importance according to the leaders of the Stewardship Program and the stewards; and the related weights defined.

Attributes	Ownership	No-man lands/green islands	Not protected area	Safeness, air and noise pollution	Original vegetation cover	Manageable size	Closeness to home	Closeness to apartment buildings	Slope steepness	Water sources available for irrigation	Not to be protected area but close to them	Pedestrian zones - noticable	Sunny
Steward 1	-	-	-	5	3	3	5	5	1	-	-	0	5
Steward 2	-	-	-	3	1	5	5	5	1	-	-	3	0
Steward 3	-	-	-	3	1	3	5	1	1	-	-	0	0
Steward 4	-	-	-	3	1	5	5	0	1	-	-	0	0
Steward 5	-	-	-	3	3	3	5	3	1	-	-	0	0
Total	-	-	-	17	9	19	25	14	5	-	-	3	5
Average value	-	-	-	3,4	1,8	3,8	5	2,8	1	-	-	0,6	1
Importance	-	-	-	Important	Slightly important	Important	Very important	Important	Slightly important	-	-	Slightly important	Slightly important
Leaders of the Stewardship Program	Very important	Very important	Very important	Very important	Important	Important	Important	Slightly important	Slightly important	Slightly important	Slightly important	Slightly important	Slightly important
WEIGHT	**1**	**1**	**1**	**0,8**	**0,4**	**0,6**	**0,8**	**0,4**	**0,2**	**0,2**	**0,2**	**0,2**	**0,2**

5.2. Generating indicators of IGS attributes

In order to generate indicators of the IGS attributes, GIS tools and analyses were applied. The flowchart of the GIS analyses is presented in *Fig. 3*. The first step of the analysis was the visualization of the listed indicators in chapter 3.3. Map layers were produced for each indicator from the data received. Each indicator layer was reclassified converting the indicator values according to the set thresholds into values from 1 to 5 and converting the vector layers into raster format. The two primary types of spatial data are vector and raster data in GIS. Raster data is made up of pixels having own value or class which are usually regularly-spaced and square. Vector data are comprised of vertices and paths. The three vector symbol types are points, lines and polygons.

The goal of converting all vector indicator layers into raster is to make the multi-criteria analyses simpler from a computability and technical point of view. Having all layers in raster, with equal spatial dimensions and resolutions, simplifies the computation, minimizes the sources of errors, and reduces storage space and above all, the time for the computer to process the data, particularly when dealing with large data sets and many indicators.

Finally, all the indicator layers are combined and all area (pixel) receive a cumulated value built up from the sum of the values of each indicator layer.

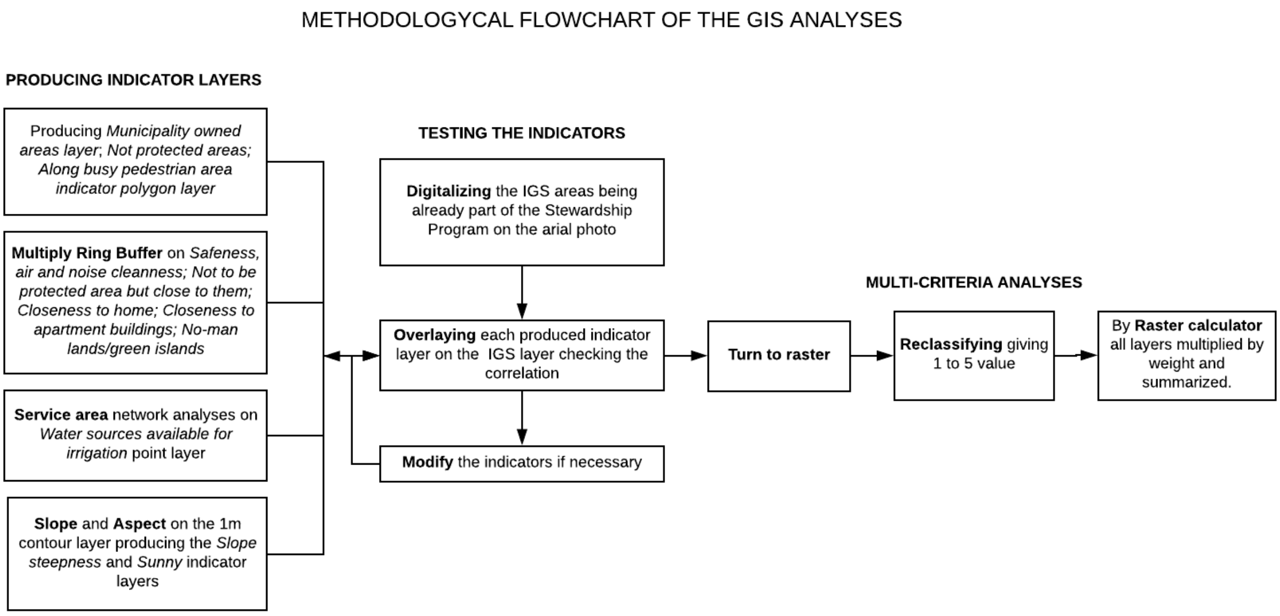


Figure 3. Flowchart of the GIS analyse

In order to measure the listed attributes in chapter 3.3, spatial indicators were developed and tested in the project.

Table 6 below includes the attributes the municipality and residents use when selecting IGS to include into a Stewardship Program. It also lists the related spatial indicators that could represent these attributes in a GIS. The thresholds were set based on the interviews, questionnaires, scientific literature or set by law.

Furthermore, the type of data that are necessary to produce the indicators and the origin of their sources are also listed in *Table 6*. Most of the data are provided by the Green Department of the Municipality of the 12th district of Budapest. They are extracted from the GIS system of the municipality called Minerva. In addition, the Institute of Geodesy Cartography and Remote Sensing (FÖMI) provided orthophotos about the district. The data about the public transport lines of Budapest was downloaded from the website of the Budapest Transport Centre.

Table 6. Attributes and the related indicators with data and data sources; Source: based on the interview and questionnaire conducted with the leaders of the Stewardship Program and stewards

Attribute	Indicator	Data needed	Source of data
Not protected area	Green spots being not protected areas.	Protected areas vector polygon layer including •National level protection areas shape layer •Budapest Capital city level protection areas shape layer •Natura 2000 areas shape layer •Buffer areas of ecological corridors shape layer •Core areas of ecological corridors shape layer	Municipality of the 12th district's GIS system, Zoning Plan 2015
Ownership	Owned by the municipality or not	Municipality owned areas vector polygon layer	Municipality of the 12th district's GIS system, 2018
Safeness, air and noise pollution	Bus line roads and additional noise polluted roads in 10m distance	Public transport lines vector polyline layer completed by additional noise polluted roads according to the Noise pollution map of Budapest	BKK- Budapest Transport Centre – document on public transport lines, 2018 Noise pollution map of Budapest, 2007
No-man lands/green islands	1m and 2m distance from parcel	Land registry base map polygon vector layer	Municipality of the 12th district's GIS system, 2018
Water sources available for irrigation	Hydrants inside 100m distance along road network	Hydrant vector point layer	Municipality of the 12th district's GIS system, 2018
Not to be protected area but close to them	Maximum 250m distance from protected areas and having border with protected areas (calculating with 5m distance)	Protected areas vector polygon layer including •National level protection areas shape layer •Budapest Capital city level protection areas shape layer •Natura 2000 areas shape layer •Buffer areas of ecological corridors shape layer •Core areas of ecological corridors shape layer	Municipality of the 12th district's GIS system, Zoning Plan 2015
Closeness to home	1m, 10m, 100m, 200m distance from inhabited areas (parcels having living	Areas having living function according to the Zoning plan of the Municipality - Vector Map of the Zoning plan	Municipality of the 12th district's GIS system, Zoning Plan 2015

	function, not industrial, recreational etc.)		
Closeness to apartment buildings	1m, 10m, 100m, 200m distance from intensive living function areas (parcels having living function, not industrial, recreational etc.)	Areas having intensive living function according to the Zoning plan of the Municipality - Vector Map of the Zoning plan	Municipality of the 12th district's GIS system, Zoning Plan 2015
Slope steepness	Slope steepness appropriate for gardening: Plain surface - <5% Slight sloping – 5-12% Moderate sloping – 12-17% Strongly sloping - 17-25 Steep slope – 25 – 45% Very steep slope – 45% <	Vector layer of contour lines (vector layer were received from the Municipality which was originally generated from raster)	Municipality of the 12th district's GIS system, 2018 1m elevation contour shape layers
Original vegetation cover	Percentage of grass cover	Vegetation cover raster delivered from ortophoto	Institute of Geodesy Cartography and Remote Sensing (FÖMI): ortophoto 2016, resolution:0,4x0,4m)
Manageable size	The size of the area is not smaller than 10 m2 but not larger than 100m2	Ortophoto	Institute of Geodesy Cartography and Remote Sensing (FÖMI): ortophoto 2016, resolution:0,4x0,4m)v
Green for advertising	…m distance from companies' headquarter and site	Address of the companies registered in the district as point vector layer	not yet identified
Sunny	Southwest and south-west facing slopes	Vector layer of contour lines	Municipality of the 12th district's GIS system, 2018 1m elevation contour shape layers
Pedestrian zones - noticeable	Pedestrian zones	Road network polyline layer Land registry base map polygon vector layer Pedestrian zones delimited in the Baseline Study of the Integrated Development Strategy of the district	Municipality of the 12th district's GIS system, Zoning Plan 2015 Baseline Study of the Integrated Development Strategy of the 12th district of Budapest 2014 - 2020

Not protected areas

A significant part of the district is under protection. There are areas having national level protection, Budapest Capital city level protection, Natura 2000 areas, buffer and core areas of ecological corridors. All these areas cannot be stewardship areas. In order to visualize all the protected areas on a single layer the input layers, namely *National level protection areas shape layer*, the *Budapest Capital city level protection areas shape layer*, *Natura 2000 areas shape layer*, *Buffer areas of ecological corridors shape layer*, *Core areas of ecological corridors shape layer* were merged into one protected areas layer. The produced protected areas layer was converted to raster giving no. 1 to the protected areas and no. 5 to the not protected ones.

Ownership

For creating a layer which includes the areas owned by the Municipality, the following input data was provided:

- Excel table listing the areas owned by the Municipality including land registry number, street name, house number, area type and size of each area.
- Land registry map shape layer including the land registry numbers of each registered area

The excel table was joined with the Land registry map's attribute table. By applying attribute search, the municipality owned areas were selected from the Land registry map. The selected features (municipality owned areas) were saved as a separated layer. It was converted to raster and reclassified as follows: areas owned by the Municipality = no. 5 and the other areas of the district = no. 1. Giving no. 1 to the areas not owned by the Municipality, it is emphasized that those areas should not supposed to be stewardship areas as the Program would like to involve residents into the maintenance of public urban green spaces, not support the maintenance of the privately owned ones.

Safeness, air and noise cleanness

The following indicator analysed was the safeness, air and noise pollution for which the road network layer was applied as input data. From the road network layer, the bus line roads, and the roads having high traffic consequently high noise pollution, were selected. All the bus line roads are noise polluted roads, and except 3 roads (Érdi, Törökbálinti and Mártonhegyi Road), all noise polluted roads are bus line roads. Those roads are considered noise polluted where the level of noise exceed the 75 dB at least one part of the road.

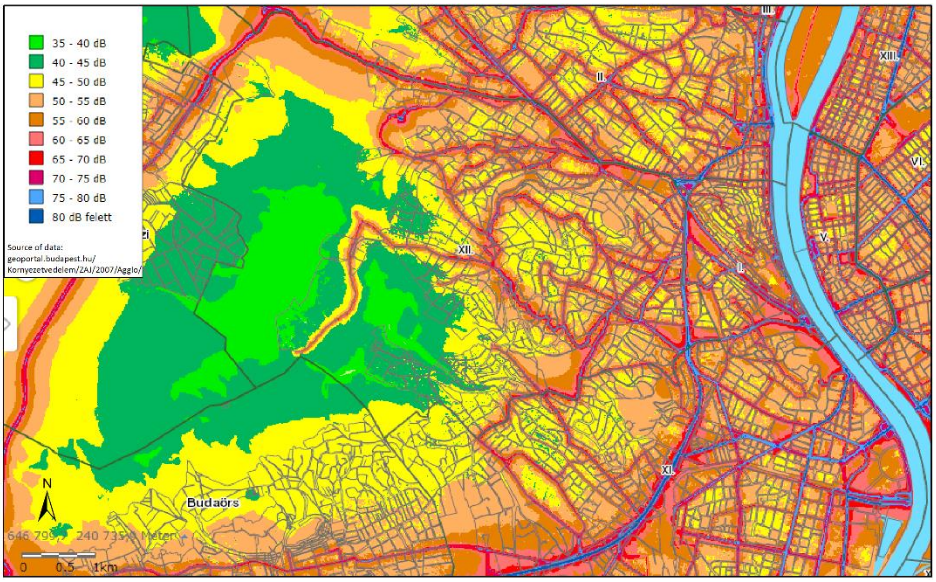


Figure 4. Noise map of Budapest. Source: Geoinformatic Portal of the Budapest Capital Municipality: https://geoportal.budapest.hu/Kornyezetvedelem/ZAJ/2007/Agglo/.

It has to be noted that *Fig. 4* was produced in 2007, however, there was no significant changes in the road transport structure of the district which is the main source of noise pollution. Therefore, the noise pollution data from 2007 is considered relevant for this less detailed analyses. Unfortunately, the map was not available in editable format to be used as raster layer in the GIS analyses, consequently, the map was applied only for identifying the noise polluted roads which were then digitalized manually.

The bus line and noise polluted roads were digitized, and buffers were produced to extract all areas within 10 m from bus line/noisy roads. The result could be illustrated in a map showing the areas along bus line/noisy roads, which are not appropriate for gardening. The 10m distance was set by overlaying the 10m buffer from bus line/noisy road polyline layer on the road network polygon layer, on which it could be seen that all the bus line/noisy roads including their surrounding areas are in maximum 10m – 10m distance from the bus line/noisy polyline. Discussing the project results with the leaders of the Program, it was reinforced that 10m distance is realistic in this environment. Areas further away than 10m, are most probably already in a private area or in another street, away from the bus line and noise polluted roads.

As air pollution data was not available, noise pollution data and information about bus line roads were applied which also provided information about the air polluted areas, as traffic is the main air pollution source in Hegyvidék. However, in the case of having air pollution data available, the indicator can be split up to two different indicators. In Hegyvidék it would not have produced significantly different result, but in other districts or cities having different function and pollution sources, it is worth to go this way.

The buffer layer was converted to raster and reclassified as follows: areas within 10 m = no.1 and areas outside 10 m = no. 5. Giving the classes no. 5 and no. 1 to the two categories is considered a quite sharp distinguish. It was decided to do this way to help map readers to recognize and raise their attention for the bus line/noisy roads on the multi-criteria analyses map where lot of indicator value will be cumulated. In addition, road networks quite sharpen the boundary of noisy or not noisy areas in urban environment. When you walk on a busy road, it is noisy and unpleasant. When you turn into a small street, immediately, the noise level decreases. It means, that road network including the buildings situated along roads creates significantly sharp boundaries how pedestrians perceive noise or air pollution. Consequently, this sharp threshold and related value is considered justified by imagining a real situation in a city.

Regarding the safeness aspect of this indicator, it can be concluded that the surrounding of all the noisy roads are not safe enough for gardening as noise pollution in the district is exclusively the result of the road vehicle traffic. Where noise pollution is high, the road traffic is also high which make the road-side green spots not safe enough for gardening.

No-man lands/green islands

The input layer of the *No-man lands/green islands indicator* is a shape layer which includes the parcels from the Zoning Plan having living function.

A buffer was applied for the Living function layer: 1m and 2m. According to the law everybody has to take care of the area being within 1 m distance from their parcel and the area locating between their parcel and the road. The latter category is usually a 2m distance in Hegyvidék. The 1 and 2m threshold was reinforced by the leaders of the Program and realistic as much as possible.

The buffer vector layer was converted to raster and reclassified as follows: areas within 1 m from living function parcels = no.1, areas 1 to 2m distance = no. 2, and no. 5 to the other areas (no data).

No. 1 was given to the 1m buffer area as it is most likely that one m from private areas, those public areas locate which has to be maintained by the owner of the private parcel. As this threshold is set by an official law, it is quite sharp. The stewards and the leaders of the Program can be more flexible in this regard involving also such areas into the Program which are inside the 1 m buffer. However, this is not the primarily intention. The focus should be on those areas which are real no-man lands.

No. 2 was given illustrating those areas which locate between private parcels and roads. Even though it is likely that within 2m distance the areas are indeed located between private parcel and the road, it cannot be stated for sure. Thus, these areas receive slightly higher value.

Out of the 2 m buffer, though, it can be stated with high likelihood that those areas are public green spaces for which resident do not feel responsibility to take care. Therefore, they are suggested to be part of the Program.

Water source available for irrigation

The input layer of the water source indicator is a shape layer including the hydrants as points. Regarding hydrants, a buffer of 100m was applied. The buffer vector layer was converted to raster and reclassified as follows: areas within 100m distance from hydrants = no.5, areas outside 100m = no. 3 as even though the Municipality cannot undertake the irrigation due to the lack of hydrants, the stewards can do. Consequently, it is not necessary to exclude these areas from the Program giving low value to them.

Beside the buffer tool, also the Service Area network analysis tool was tested for identifying the 100m service area of the hydrants on the road network of the district. By the Service Area network analysis tool, service areas can be identified around any location on a network. A network service area is a region which includes all accessible streets within a specified distance. For instance, the 10-minute service area of a point location on a network contains all the streets that can be reached within 10 minutes from that location.

The produced service area layer was converted to raster and reclassified as follows: areas within 100m distance on roads from hydrants = no. 5, areas outside 100m = no. 3.

Therefore, two types of analyses were tested to identify the areas where water from hydrants are available for irrigation. The service area analyses provided more sophisticated results as distances from hydrants were calculated on the district's road network providing a quite realistic result. Though, the buffer tool produced such result map which is able to show the areas may have not hydrants close enough as less generalization were taken place by the Buffer tool than by the Service Area Network Analyses tool.

In the case of Hegyvidék where the hydrants placed quite densely, the Service area analyses showed that almost the whole district's road network is covered. In other cities or districts, however, this picture can be more diverse. Thus, the network analyses can better highlights the anti-service areas. Therefore, this tool is suggested to be used compared to a simple Buffer one which gave sufficient results in the case of Hegyvidék.

Not to be protected area but close to them

The already produced protected areas layer was applied for the analyses of this indicator. A 250m buffer was applied around the protected areas. In addition, those parcels were selected from the Land registry map which has common border with the protected areas. Areas within 5m distance are considered border areas.

The buffer vector layer was converted to raster and reclassified as follows: areas being border areas = no. 5, areas within 250m = no. 3, areas outside 250m = no. 1.

The border areas received no. 5 as they are ideal places to be stewardship areas planting native species. The Municipality would like to encourage residents to discover and plant native species.

If an area is not a border one but close to a protected area (around 250m distance), it also makes sense to plant native species which is not completely different from the vegetation of the close protected areas which are forest areas in the case of Hegyvidék. It has to be noted that the 250m buffer is a too sharp boundary for this attribute but gives an idea to the reader of the multi-criteria map about the areas which has potential. Furthermore, it helps the Program leaders to narrow down the house blocks where this type of stewardship areas should be advertised.

The 250m and 5m threshold was set according to the suggestion and experience of Péter Mihály, horticulture expert employed by the Municipality of the 12th district.

Closeness to home

A buffer was applied on the layer extracted from the Zoning plan including only the parcels having living function. The buffer thresholds were set based on the interview with the leaders of the Stewardship Program and the stewards.

The stewards emphasized the high importance of this attribute. They stated that the most ideal if the stewardship area locates right next to their house or at least in front of the neighbouring houses. This way, they can see their nice floral garden every day.
It is also fine for them if the area is within 100m distance, though, they cannot see the area only if they go there when they water it, for instance.
It is also acceptable for them if the area is within 200m distance. Though, 200m was said as the maximum distance they can accept as they cannot go and water the area if it is too far from their house.

Consequently, the following thresholds and related values were created:
1m – right next to a resident property or apartment – no. 5
10m – on the other side of the road or in front of the neighbouring houses – no. 4
100 m – still close but not in the neighbour – no. 3
200m – maximum distance likely to be acceptable by a steward – no. 2
no buffer area: more than 200 m – no. 1

The buffer vector layer was converted to raster and reclassified.

Closeness to apartment buildings

The same method and thresholds were applied as for the Closeness to home attribute, except that the distances are calculated from the intensive living function areas.

In both indicators above, the possibility to apply network analyses calculating distances on the road network was investigated. The most suitable network analyses tool could be the *Service area* one, however, this tool calculates distances from points not from polygons. On the other hand, the Service area analyses could be a perfect tool for identifying the closest stewardship areas to the home of a specific steward. As another option, the service area of the existing stewardship areas can be calculated identifying the building blocks in close from which inhabitants could be invited to join to the work in the areas.

There is a conflict between No-man lands and Closeness indicators, as in the No-man lands indicator areas which locate 1m distance from parcels receive low value while at the Closeness indicators they receive the highest value. This conflict is due the contradictory opinion of the stewards who prefer such stewardships areas which close to their home, while the Municipality prefers such public areas which are further from residents home, not directly located next to them, areas which are under the Municipality's responsibility not the residents. Even though the two indicators eliminate each other's influence in the analyses, this is the right way of tackling the issue taken into consideration the opinion of both parties.

Slope steepness

Interpolation (*Topo to Raster*) was applied on the elevation contour layer (1m) producing a raster layer with the interpolated elevation values. Following it, the produced raster layer was reclassified giving 1 to 5 values according to the acceptability of the steepness for gardening:

- Plain surface - <5% - no. 5
- Slight sloping – 5-12% - no. 4
- Moderate sloping – 12-17% - no. 3
- Strongly sloping - 17-25% - no. 2
- Steep slope – 25 – 45% - no. 1
- Very steep slope – 45% < - no. 1

The thresholds were set according to the commonly used categories in Hungarian soil researches (Filep Gy. et al., 2010).

Sunny

As the 12th district is a typically hilly district, it is worth to calculate the sunny slopes. Sunny slopes are appropriate for planting flowering plants as honey flowers. The leaders of the Program and some stewards see high potential in planting honey flowers on the stewardship areas as honey flowers are native species which needs less care and contribute to increase biodiversity.

The sunny slopes were calculated by the Aspect tool. The produced raster was reclassified as follows:

- No. 5 = Southeast, southwest facing slopes and plain surfaces which are sunny areas but not too sunny.
- No. 4 = north slopes which is less sunny areas.
- No. 3 = south slopes which are too sunny and flowers can easily burn during summer.
- No. 2 = north east, east, northwest and west slopes which are to shadowy and cool.

The values were given according to the suggestion of Péter Mihály, horticultural expert of the Municipality.

Pedestrian zones – noticeable

According to some stewards an ideal area should be located in such places where lot of people can see it. This way their work and the whole program would be promoted encouraging other residents to participate. Also, “green messages” increasing environment consciousness at residents could be transferred by the areas locates frequently visited places. Due to the generally small size of the stewardship areas, they are noticeable rather for pedestrians, thus it is suggested to create some stewardship areas in pedestrian zones.

In the 12th district, the pedestrian traffic flows usually between the residencies and primary care institutes, and public transport stops/stations. The pedestrian traffic connected to the institutes concentrated to 3 zones: Alkotás Street - Krisztina Road; Apor Vilmos Square – Böszörményi Road – Királyhágó square (as the centre of the district); Farkasréti Cemetery. Also, the Normafa area has high pedestrian traffic being the most important recreation and touristic area of the district. However, only the road (one part of the Eötvös Road) going to

Normafa was selected in the analysis as the Normafa area itself is a protected area. Besides, the public transport crossing nodes has pedestrian traffic such as the Széll Kálmán square, Magyar Jakobinusok square and BAH square. Although, they cannot be included into the analysis due to their extremely high road traffic and the limited size of green spots available for gardening. This is also relevant for the Alkotás street - Krisztina road zone which a main road going out of the city connecting it to the M7 and M1 motorway.

The pedestrian traffic to the other districts is minimal. Exclusive pedestrian traffic is typical on the stair streets in the district which is typical due to the hilly relief. However, stairs are usually narrow, steepy, paved and shady streets. Therefore, they have low potential for gardening so they won't be included into the analyses.

Finally, the Apor Vilmos square – Böszörményi Road – Királyhágó square- Csőrsz Street, Farkasréti cemetery and the near Normafa (Eötvös út – Hegyhát út) zones were selected as potential pedestrian areas from the Land registry layer. A pedestrian area layer was created from the selected features were converted to raster and reclassified as follows: No. 5 = selected pedestrian zones and No. 1 = others (no data).

Original vegetation cover and **Manageable size**

The method and indicators related to the Original vegetation cover and Manageable size attributes will be explained in chapter 3.5.3 as their analyses would be carried out at that stage of the GIS work.

Green for advertising

The source of the data for the analyses of the Green for advertising indicator could not identified. Due to the lack of data and the low significance compared to other indicators, it is removed from the analyses.

5.3. Analyses of the indicators for IGS selection

The method applied for the analyses of the indicators for IGS selection is called multi-criteria analysis which is a popular GIS method for deciding the best locations for green areas and other urban features. Among others, the study of Balram et al., 2005, Gupta et al., 2012, Panduro et al., 2013, Neema et al., 2013 applied this method, however these studies mainly focus on formal green spaces such as parks and playgrounds. In this project, the multi-criteria analyses method is tested to apply for the identification and evaluation of informal urban green spaces.

Indicator testing

Before going to the further steps of the analyses, which will be the multi-criteria analyses of IGSs by the combination of the produced indicator layers, the indicators need to be tested whether they are able to represent the related attribute.

As the first step, the existing stewardship areas were digitalized manually on the aerial photo of the district producing a polygon shape layer. A google map interface was applied which includes the rough location of the existing stewardship areas and some pictures about them.

For the more accurate identification of the location and border of these areas, google streetview was applied.

The produced IGS layer, including the areas already part of the program, was overlaid on each indicator layer checking the correlation and analysing the % of the overlapping areas.

Ownership

It was expected that the ownership, not to be protected areas and no-man lands/green islands indicators will overlap in 100% as, according to the leaders of the Program, the Municipality selected only those areas which are owned by the Municipality, not protected ones and not in front of private parcel. In contrary, it turned out that only 12 from the 26 stewardship areas are owned by the Municipality of Hegyvidék. The rest of the areas are mainly owned by other public bodies (Budapest Capital Municipality, Budapest Transport Ltd.) but not the Municipality of the 12th district of Budapest.

The stewardship areas owned by the Municipality were selected by the *Select by Location* (*are within the source layer feature)* tool. By applying the *intersect the source layer feature,* 6 from the 26 stewardship areas selected as areas not owned by the Municipality. None of the selection method can give the complete truth but a general conclusion can be made that the ownership attribute is not an exclusionary one. Also areas not owned by the Municipality of Hegyvidék can be stewardship areas.

Not to be protected areas

By overlaying the stewardship areas layer on the protected areas layer *(Fig. 5),* it was confirmed that there is no stewardship area which is located in a protected area**.** This conclusion was made simply check it by “eyes”, and the Select by Location *are within the source layer feature* and the *intersect the source layer feature* functions was also applied.

Not be protected area but close to them

In order to test the *Not be protected area but close to them* indicator, those areas were selected from the stewardship areas layer which are within 5m and 250m distance. Only 1 area is located in 5 m from protected areas, therefore only one area locates next to a protected area. However, 10 from 26 areas are located within 250 m distance from protected areas. Even though this attribute was not considered at the selection of the existing areas, the 38% of the stewardship areas locate within 250m distance from protected areas. Therefore, the threshold set can remain as it was determined by the leaders of the Program.

In addition, it can be suggested to the stewards own areas locating within 250m distance from protected areas to plant native species contributing to the biodiversity of the district. There is a quite high potential in the district to plant native species to the stewardship areas, as 38% of the stewardship areas, and 56% of the municipality owned and not protected areas are within 250m distance from protected areas.

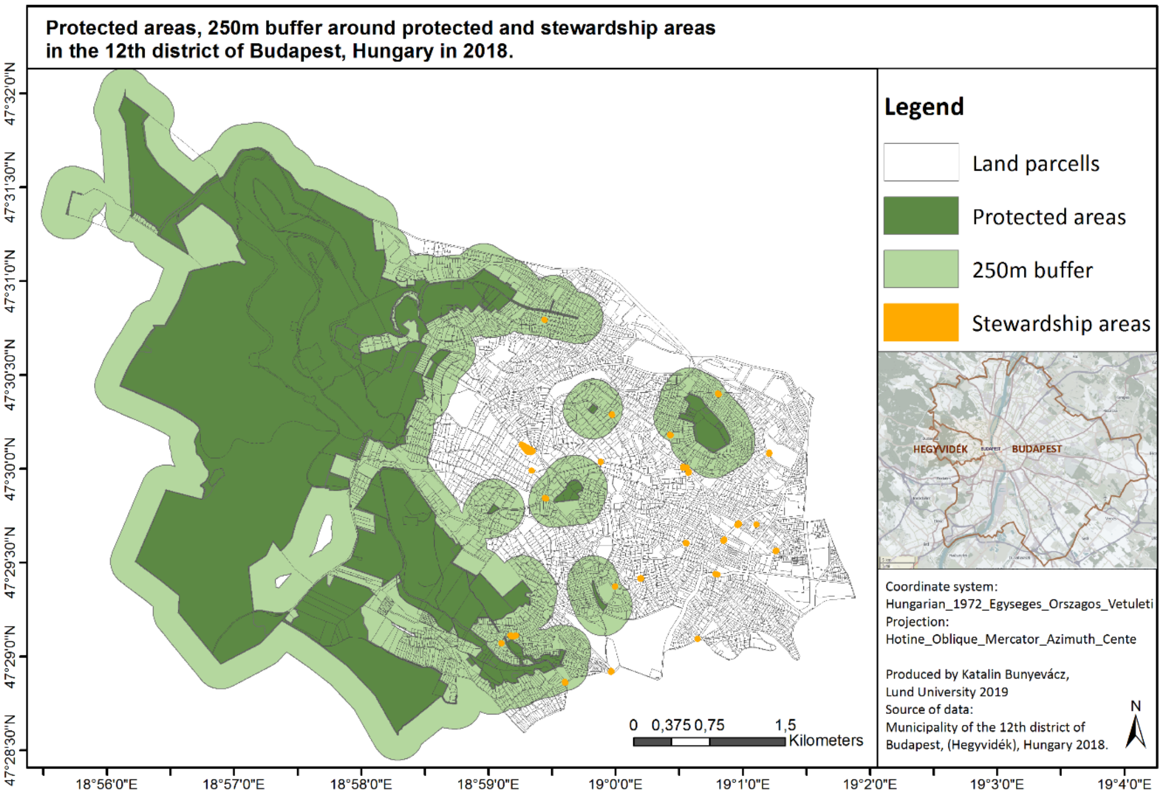


Figure 5. Map of protected areas, 250m buffer around protected and stewardship areas in the 12th district of Budapest, Hungary in 2018. Data source: Municipality of Hegyvidék.

No-man lands/green islands

By testing the no-man lands/green islands indicator *(Fig. 6),* it turned out that only 5 from the 26 stewardship areas are partly in the 1 and 2 m buffer zone. It was checked by applying the *intersect the source layer feature function* from the Select by Location tool. The *are within the source layer feature* function was also tried but there was no area which locates inside any 1 and 2 m buffer zone. Therefore, 80% of the existing stewardship areas locate more than 1 and 2m distance from privately owned parcels. It means that there is no need for modification in the threshold of this indicator.

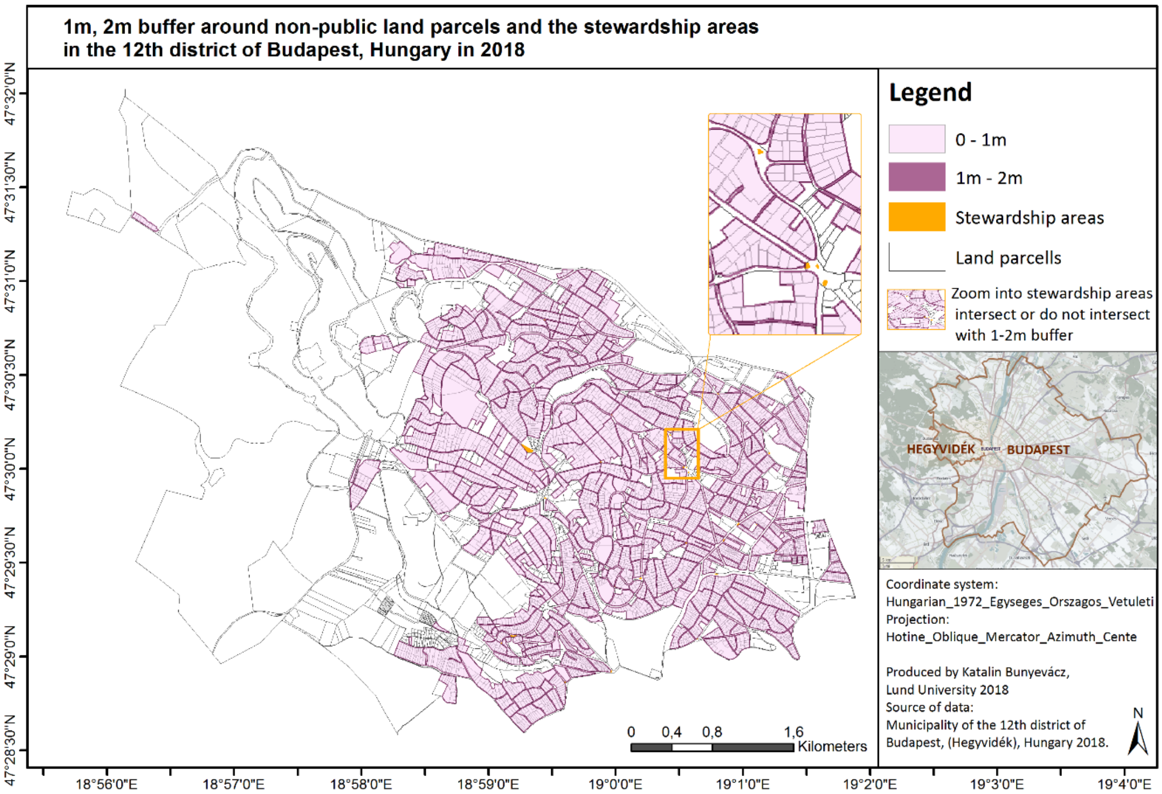


Figure 6. Map of 1, 2 m buffer around non-public and parcels and the stewardship areas in the 12th district of Budapest, Hungary in 2018. Data source: Municipality of Hegyvidék.

Testing was especially necessary at the identification of the right thresholds of the safeness, air noise pollution, not be protected area but close to them, slope steepness, water sources, original vegetation cover and manageable size indicators.

Safeness, air noise pollution

In order to test the Safeness, air noise pollution indicator *(Fig.7)*, whether the right thresholds were set, those areas were selected from the stewardship areas layer by the Select by location tool which are within10m distance. 10 from 26 areas are located within 10 m distance from bus line roads, therefore 38% of the areas which is a quite high rate compared to the low density of air-noise polluted roads in the district (in comparison with other districts of the city).

According to the leaders of the Stewardship program, it is not ideal and it was really unpleasant to do gardening at some of these areas due to the noise and air pollution resulted from the road traffic. Consequently, the threshold will not be modified, instead, it is suggested to take more attention for this indicator at the selection of further areas.

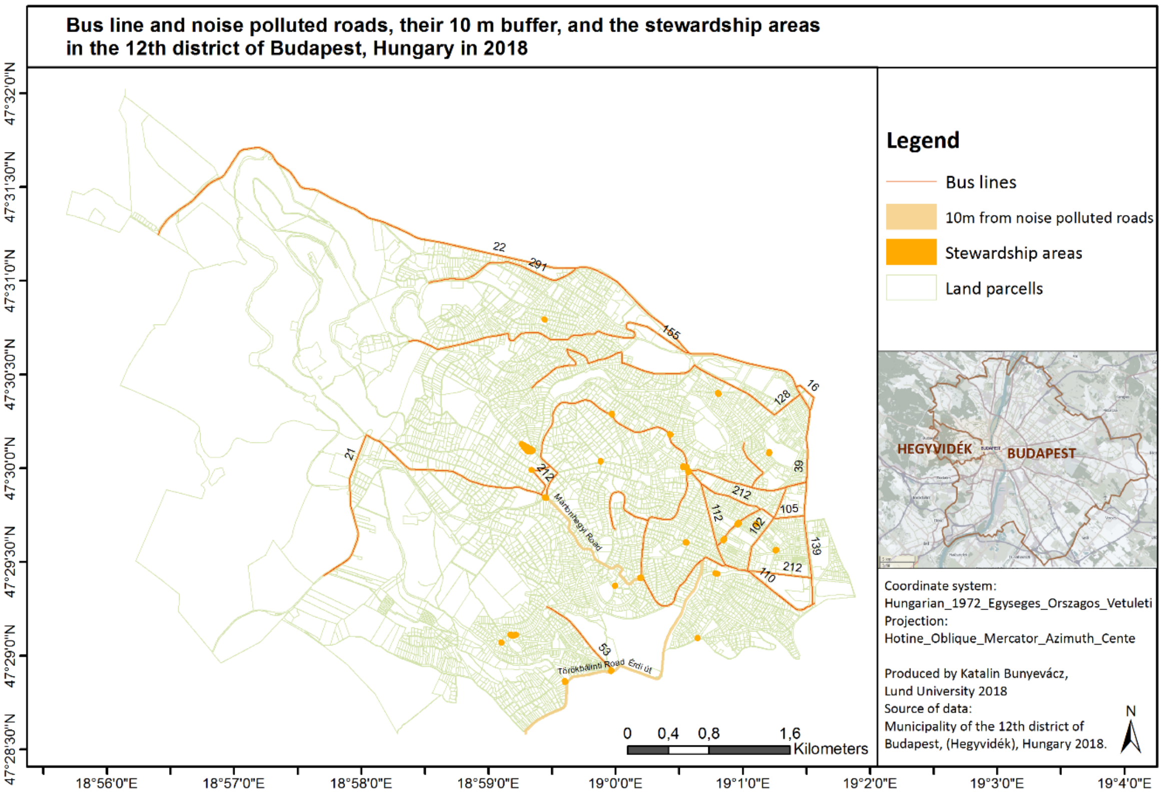


Figure 7. Map of bus line and noisy roads, their buffers and the stewardship areas in the 12th district of Budapest, Hungary in 2018. Data source: Municipality of Hegyvidék.

Slope steepness

Testing of the slope steepness indicator *(Fig. 8)* was done by applying the *Extract by mask* tool in order to extract the slope steepness values of the stewardship areas from the interpolated slope raster layer. Classes were set for the *symbology* of the produced raster layer according to the indicator thresholds. As all areas are in the first two categories, therefore all the stewardship areas have lower than 12% steepness, the set thresholds are confirmed, the most appropriate areas for gardening has plain or slight sloping surface. Consequently, there is no need for modification in this indicator.

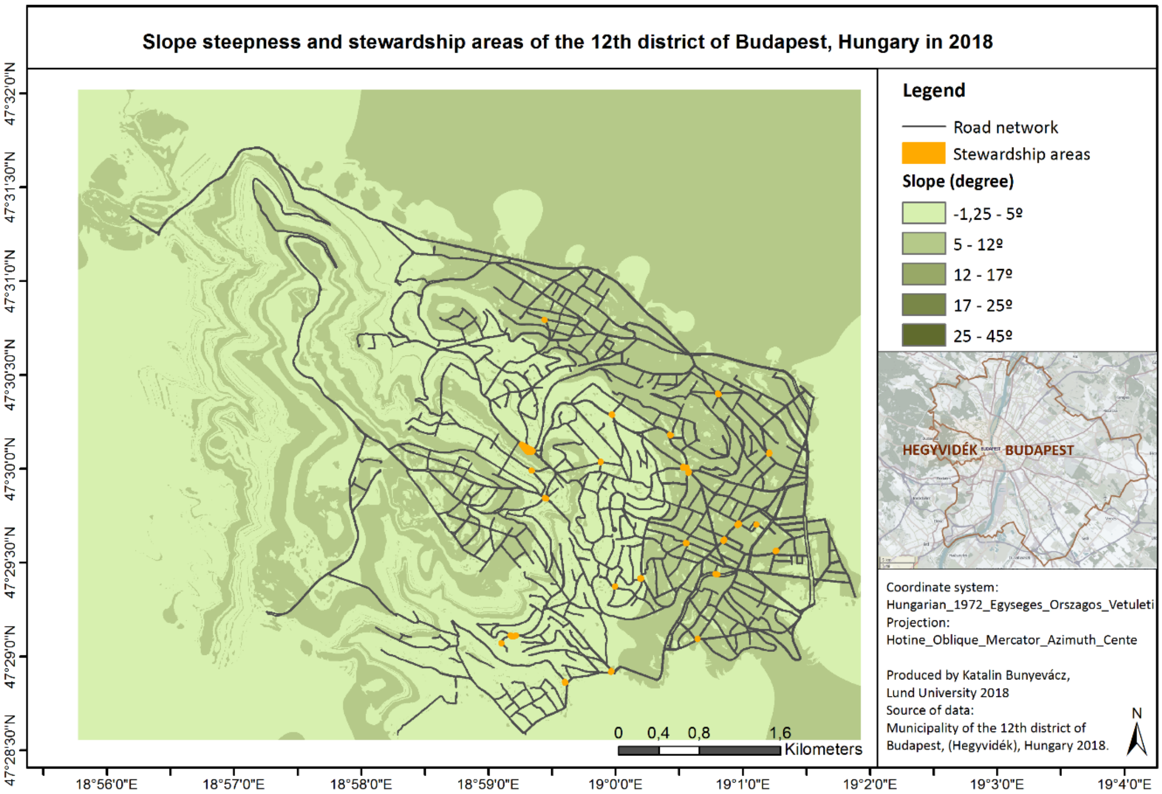


Figure 8. Map of slope steepness and the stewardship areas in the 12th district of Budapest, Hungary in 2018. Data source: Municipality of Hegyvidék.

Sunny

This indicator is not particularly tested as the thresholds are set based on the general phenomena that the southwest and southeast slopes receive ideal amount of sun shine. North slopes are also good for gardening, they are better than the very sunny south slopes where flowers can be burned easily during summer. While the west, north west, east, northeast slopes do not receive enough sun for plants *(Fig. 9).*

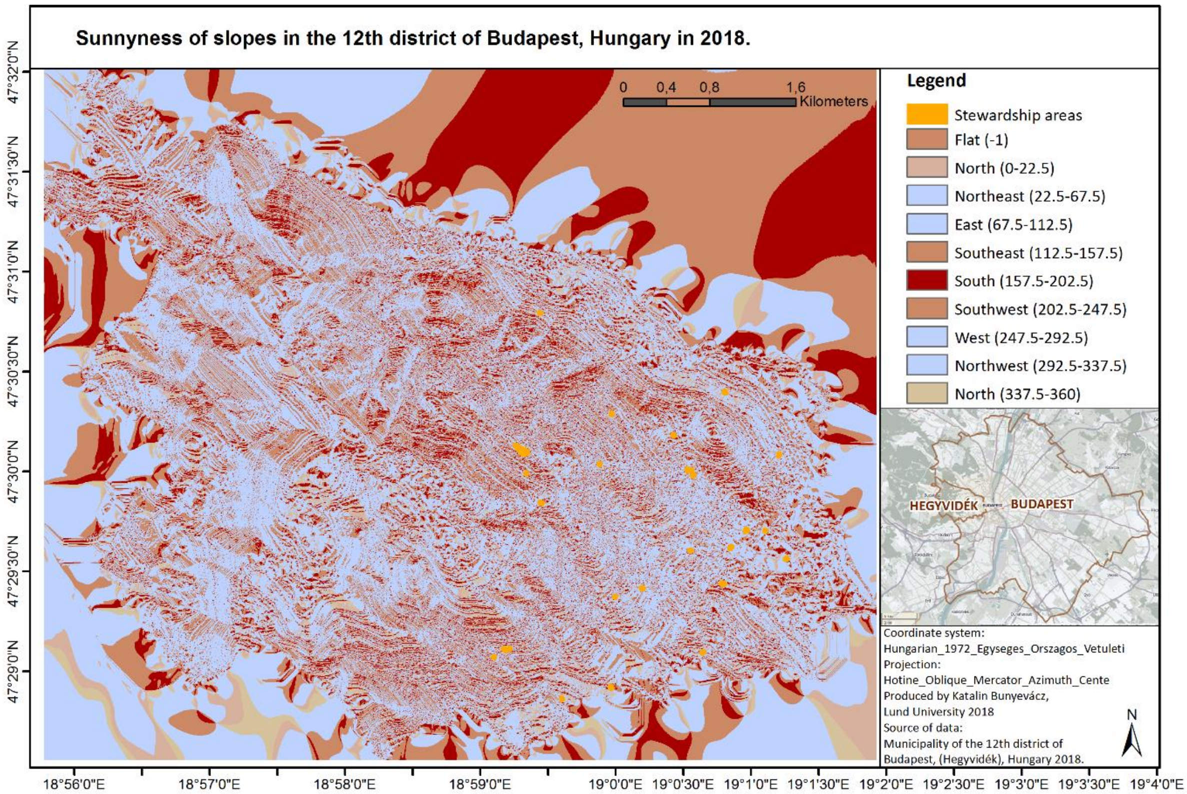


Figure 9. Map of sunniness of slopes in the 12th district of Budapest, Hungary in 2018. Data source: Municipality of Hegyvidék.

Pedestrian zones – noticeable

According to the map below *(Fig.10)*, so far there is no stewardship area which locates in pedestrian traffic zone. However, there are some areas in the close street of the Királyhágó Square – Böszörményi Road – Apor Vilmos Square region. The Municipality can consider to create stewradship areas close to the Farkasréti Cemetery and Normafa to promote the Program.

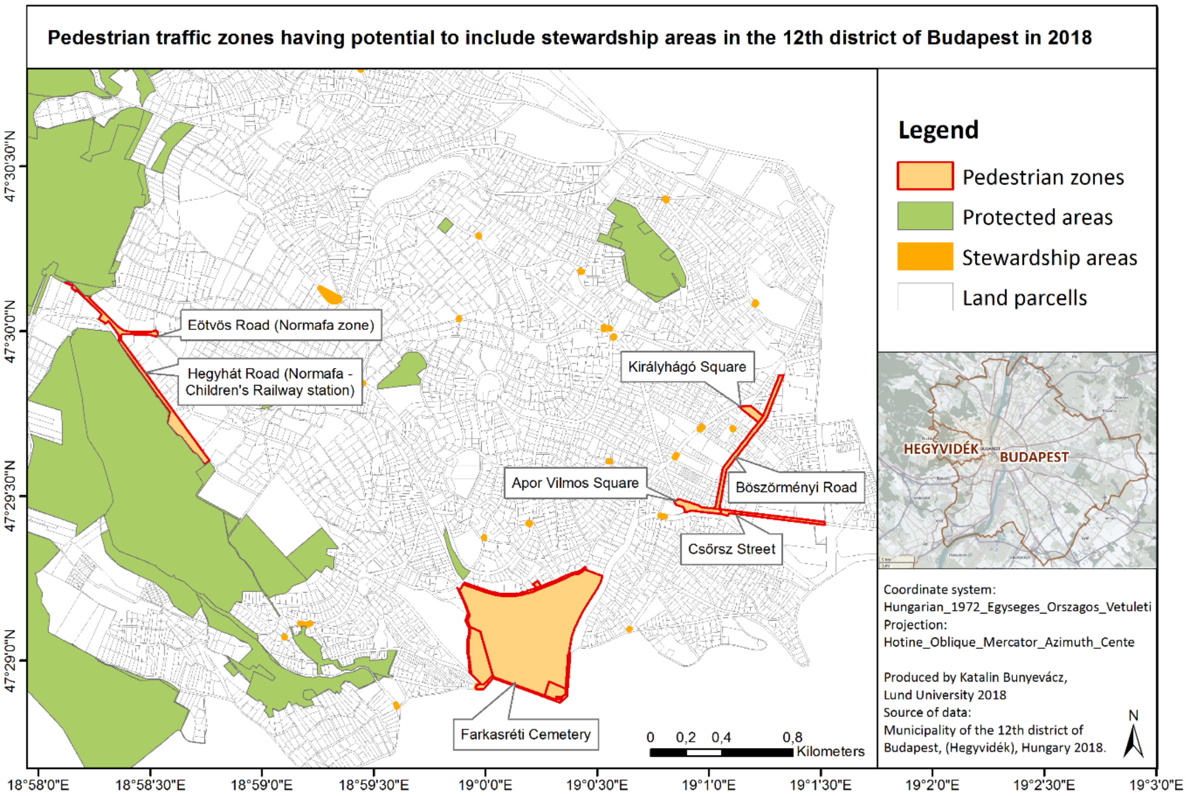


Figure 10. Map of pedestrian traffic zones having potential to include stewardship areas in the 12th district of Budapest in 2018. Data source: Municipality of Hegyvidék, Baseline Study of the Integrated Development Strategy of the 12th district of Budapest.

Water sources

In order to test the Water sources indicator *(Fig. 11)*, whether the right thresholds was set, those areas were selected from the stewardship areas layer by the Select by location tool which are 100m distance. All of the stewardship areas are within 100m distance. It was also tested for 70m where still all areas was inside the buffer, for 60m where 1 area was out of the 60m buffer, for 40m where 2, for 20m where 4 areas was out of the buffer. Even though most of the municipality owned and not protected areas (potential IGS areas for the Program) are inside the 100m buffer from hydrants, there are still a few areas out of the buffer (see zoom in map) which justify the necessity to keep this indicator in the multi-criteria analyses.

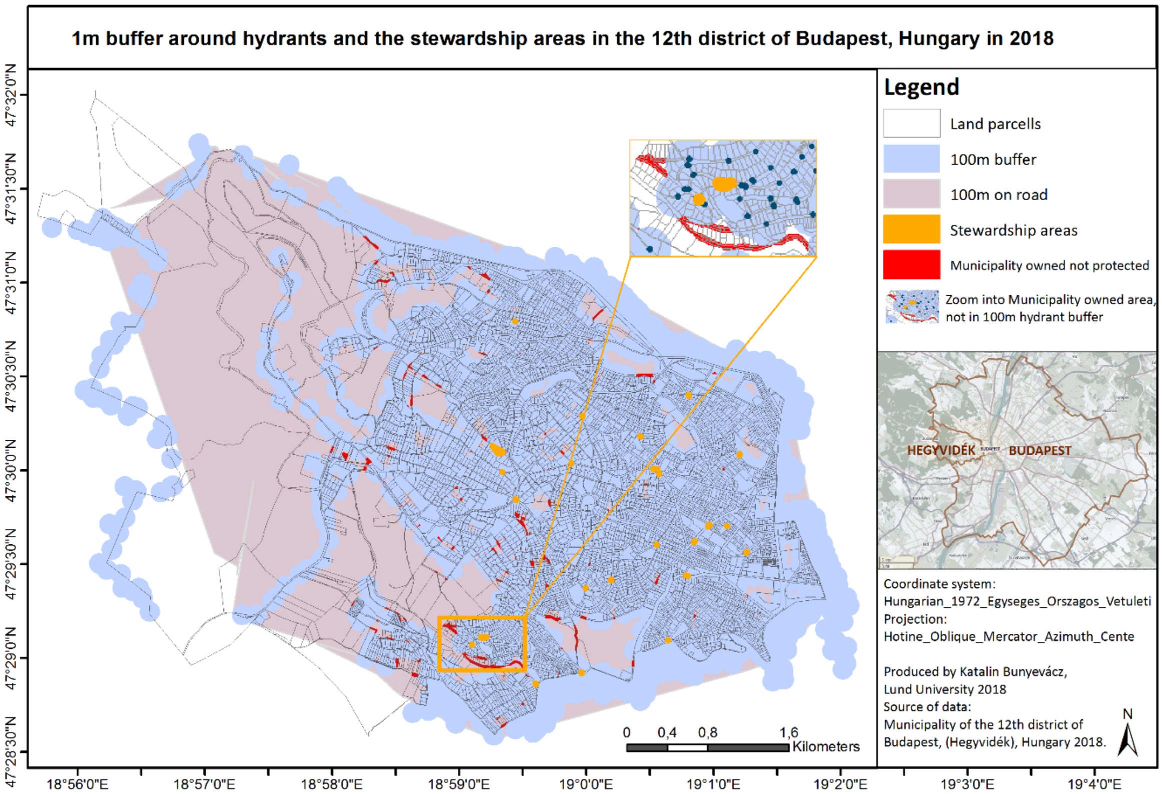


Figure 11. Map of 1m buffer around hydrants and the stewardship areas in the 12th district of Budapest, Hungary in 2018. Data source: Municipality of Hegyvidék.

Original vegetation cover

Due to the reasons will be explained in chapter 3.5.3, the testing of the vegetation cover indicator could not be carried out.

Manageable size

According to the interview conducted with the leaders of the Stewardship Program, the manageable size of a stewardship area is not smaller than 10 m2 but not larger than 100m2. However, according to the stewards the areas should be smaller than 10m2. Calculating the size of the stewardship areas in ArcMap, it turned out that the average size of the areas is 61m2, if the Devecseri Park is excluded with its atypical big size (2842 m2) from the calculation. The smallest area is 5 m2 (a rectangle under a tree). The biggest area is 354 m2 without the Devecseri Park.

In addition, 1 area from 26 has smaller size than 10m2, and only 5 areas have a size bigger than 100 m2.Therefore, 80% of the areas are inside the threshold set by the leaders of the program which was right, there is no need for modification. However, it has to be noted that stewards would prefer smaller areas than 10m2.

For the above calculations, the *Statistics* tool of the attribute table of the existing stewardship areas layer and the *Select by attributes* function were applied in ArcMap.

Closeness to home and apartment buildings

Due to the fact that the district has mainly living function areas according to the Zoning Plan, it was expected that corrections will not be needed at the closeness to home and closeness to apartment buildings indicators. However, in other urban areas or districts which has more diverse function including for instance industrial areas, these indicators play a more important role. In the case of Hegyvidék, 4 from 26 stewardship areas are within 1m distance from living function areas, 20 areas are within 10m distance, and all areas are within 100m distance from living function areas which justify the 100m threshold which is a kind of maximum distance stewards consider ideal from their home *(Fig.12).*

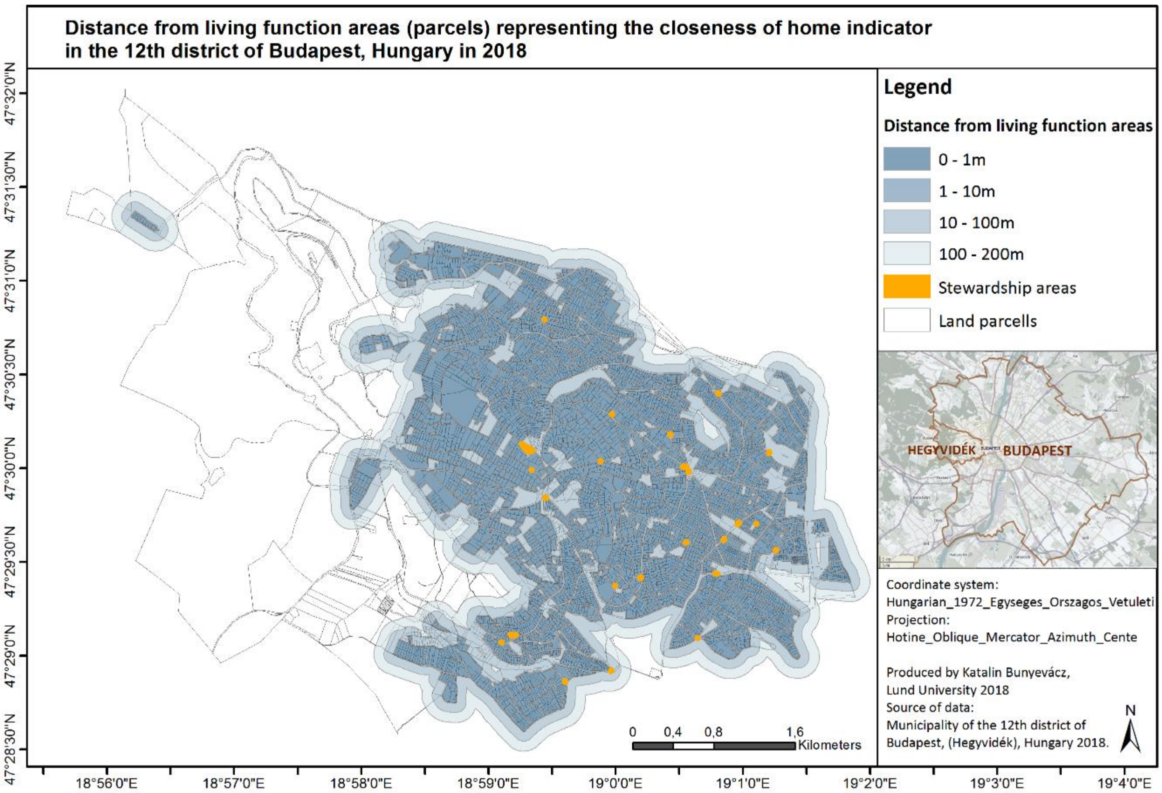


Figure 12. Map of distance from living function areas (parcels) representing the closeness of home indicator and the stewardship areas in the 12th district of Budapest, Hungary in 2018. Data source: Municipality of Hegyvidék.

The map above (*Fig. 12*) can give a rough estimation on which areas have the potential to be included as stewardship areas thanks to their closeness to living function areas. However, the map and the related indicator cannot perfectly represent the closeness to home attribute while, according to the interviews and questionnaire, this is the most important attribute.

The perfect indicator would measure closeness either from the home of the stewards or from the stewardship areas. The second one was experimented in the frame of this project. The map below (*Fig. 13*) shows the areas which are 100 and 200m distance from the existing stewardship areas on the road network. The map was produced by the application of the Service area network analyses tool. Even though the map below could not be included into the multi-criteria analyses, it contributes to reach for the 2nd research objective by generating a new indicator.

In addition, imagining a real life situation, the map can be used to find stewards for specific stewardship areas. By visualizing a buffer zone of the areas, houses/blocks of inhabitants could be identified and those inhabitants invited to be stewards on specific stewardship areas. This way the municipality can initiate targeted campaign when look for stewards. For instance leaflets and posters can be distributed in those houses which are in the buffer of the stewardship area.

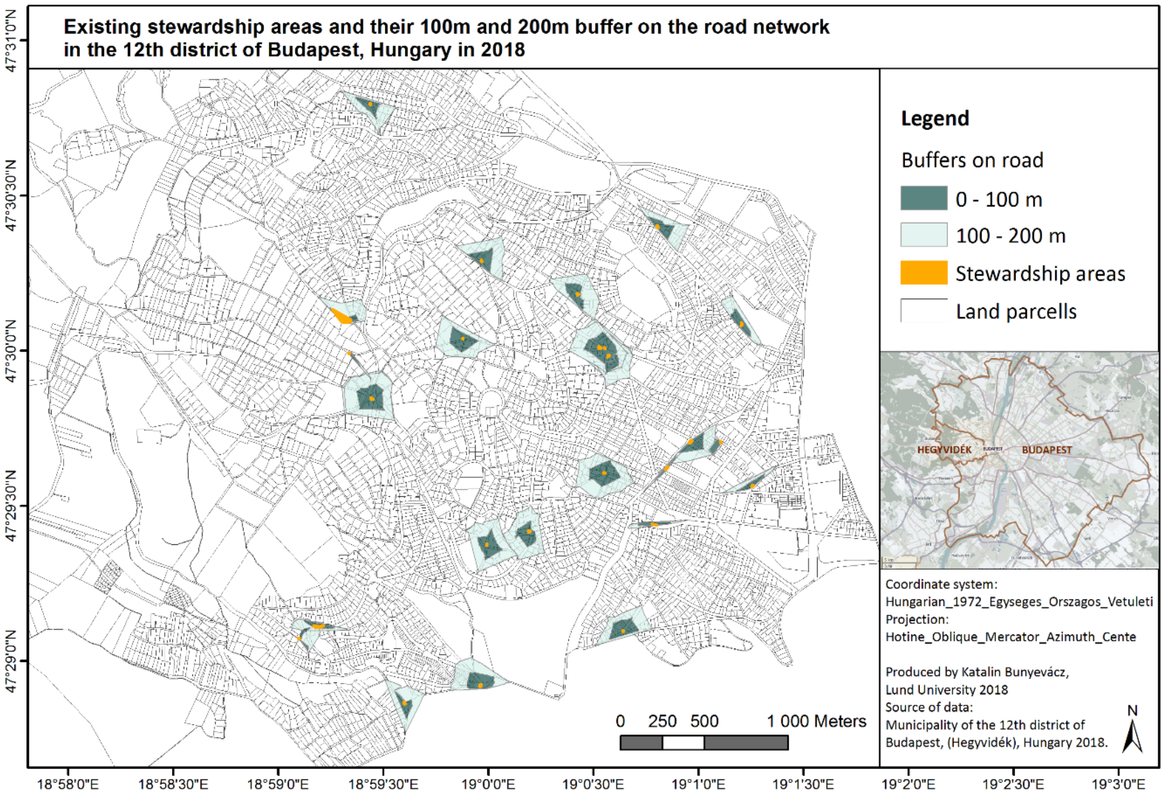


Figure 13. Map of existing stewardship areas and their 100m and 200m buffer on the road network in the 12th district of Budapest, Hungary in 2018. Data source: Municipality of Hegyvidék.

Regarding the **closeness to apartment buildings** indicator *(Fig. 14)*, it was concluded that 2 areas are within 1m distance, 6 areas within 10m, 11 areas within 100m and 13 areas within 200m distance from the intensive living function areas. It can be stated that 42% of the existing stewardship areas are within 100m distance from the intensive living function areas and 50% of the areas are within 200m distance. It justifies the assumption that there is more need for gardening in public places from residents who live in apartment buildings and have no or only common garden. Instead of making any modifications in the thresholds of the indicator, rather the relevance of the indicator itself was justified by the testing. Also, the stewards confirmed it during the interviews.

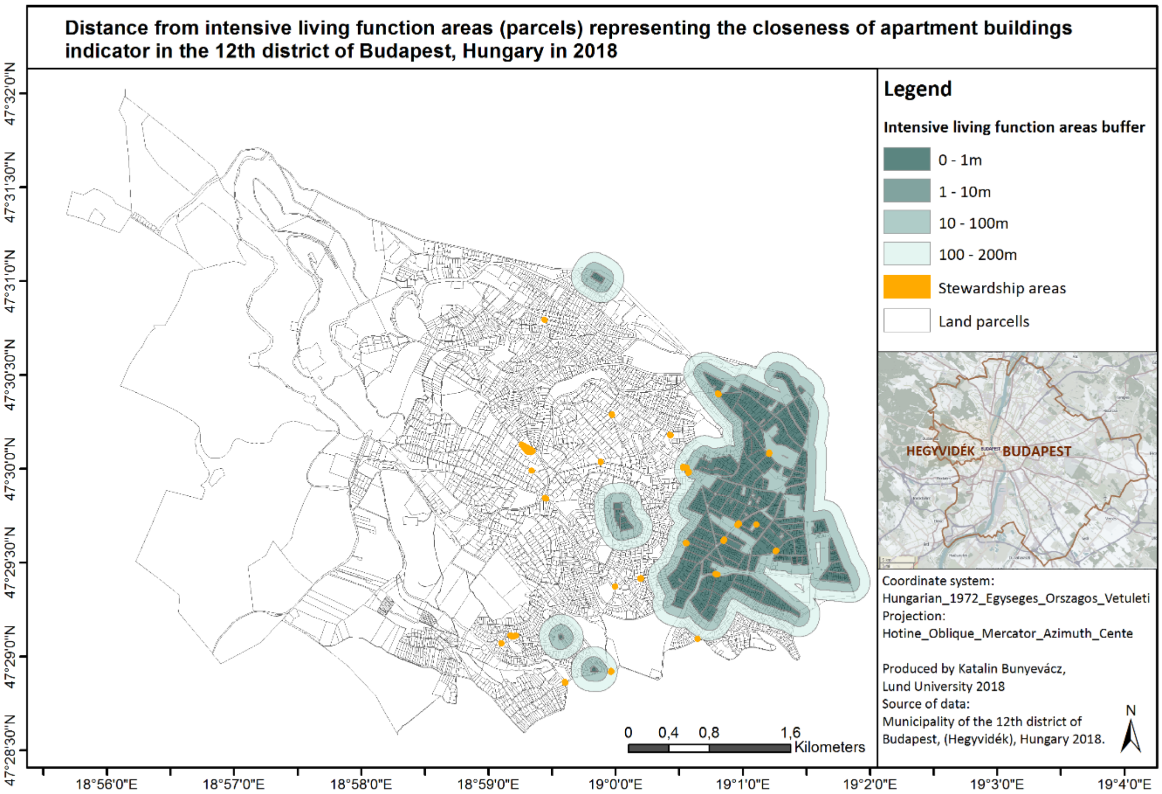
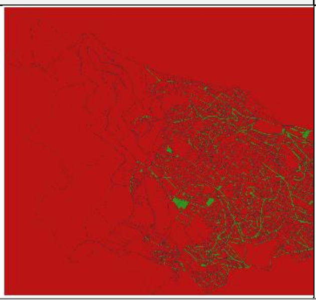
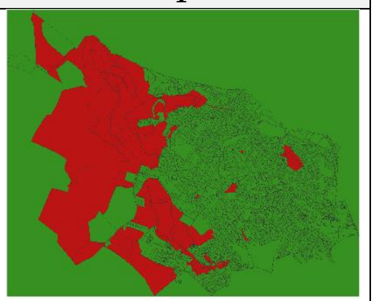


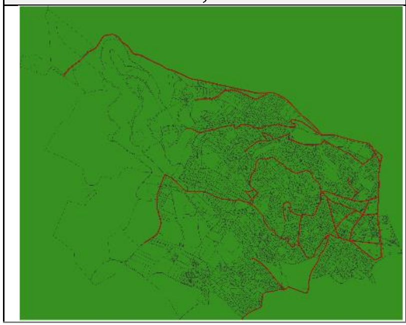
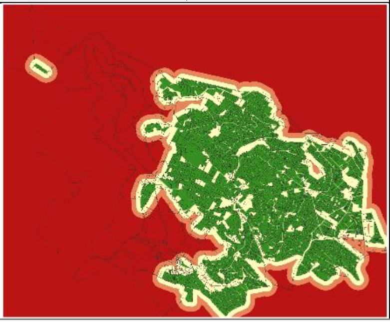
Figure 14. Map of distance from intensive living function areas (parcels) representing the closeness of apartment buildings indicator and the stewardship areas in the 12th district of Budapest, Hungary in 2018. Data source: Municipality of Hegyvidék.

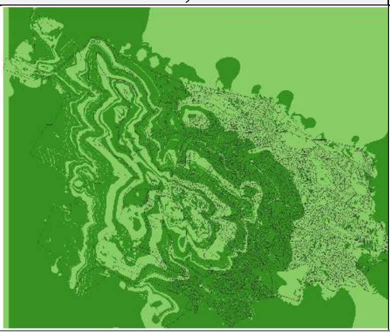
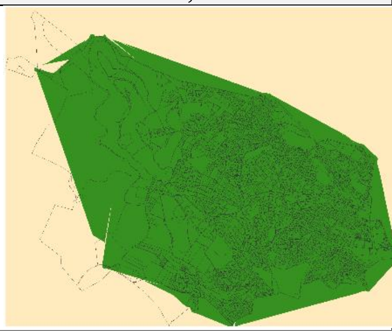
5.4. Multi-criteria analyses

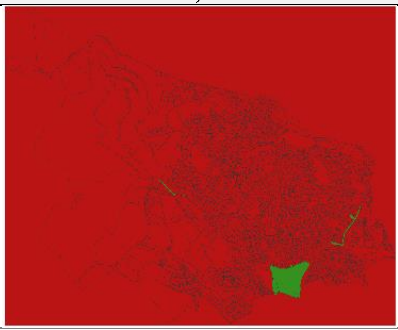
After testing and finalizing the indicators, all produced raster layers with rank values (*Table 6.*) were multiplied by the weight defined in *Table 4* in chapter 4.3 and summarized producing a final map which combine all the indicator weighted values except the *Manageable size* and *Vegetation cover* ones.

Table 7. Indicators, their weight and the raster maps with values from 1 to 5

Indicators	**Ownership**	**No-man lands/green islands**	**Not protected area**
Weight	**1**	**1**	**1**
Raster map Values 1 2 3 4 5			

Safeness, air and noise cleanness	Closeness to home	Closeness to apartment buildings
0,8	0,8	0,4
		

Slope steepness	Water sources available for irrigation	Not to be protected area but close to them
0,2	0,2	0,2
		

Along busy pedestrian area	Sunny
0,2	0,2
	

Discussing the possibility to include further indicators

The next step of the analyses is overlaying the "combined values layer" - prepared by the combination of the layers represents the indicators - on the aerial photo of the district. It was expected that the amount of the areas having high values is limited, as only areas owned by the Municipality and not protected areas can be part of the program which limits the number of the appropriate areas. Thus, this small amount of informal green spaces will be digitalized manually producing a polygon layer which includes the IGS having potential to be included into the program.

At this point two additional indicators planned to be included into the analyses. First, the *Vegetation cover* indicator: an extra field would be added into the attribute table of the prepared potential IGS polygon layer giving class no. 5 to bare soil areas and class no. 1 to the grass areas. The grass and bare soil areas would have been identified manually based on the aerial photo. Following it, this layer would be converted to raster and be reclassified based on the additional field including the ranking values (5 value to bare soil areas and 1 to the grass areas). Unfortunately, after overlaying the ownership-not protected areas combined layer, which narrow down the potential areas, on the aerial photo, it turned out that it is not possible to digitalize the IGSs manually due to the high number of them. These IGSs mean not only the existing stewardship areas but all the green spaces which owned by the Municipality and not protected areas which in Hegyvidék locate basically in every single street.

Thus, the possibility was investigated to identify the IGSs by supervised classification carried out on the aerial photo of the district in Erdas program detecting the grass and bare soil areas. Supervised classification is a technique for analysing remote sensing data by classifying the pixels of an image. In supervised classification, the user select representative samples for each class. Following it, the software groups all pixels into the predefined classes according to their similarity to the sample pixels.

The received raster layer would have been reclassified giving 5 value to areas covered with bare soil and 1 value to the grass areas and 0 to areas occupied by roads, buildings and trees. The idea was to detect the road areas which has a bright, easily detectable colour. The rest of the areas, therefore the non-road areas were assumed to be the green areas along roads. After manually digitalizing the existing stewardship areas, in parallel, checking the type and location of these areas on google street view, it was concluded that it is not possible to detect IGSs by remote sensing technics as these areas could be covered by tree, could be in the shadow of houses, can have a similar colour to the road. Therefore, supervised classification could not give a reliable result, even though the spatial resolution of the aerial photo (0,4 x 0,4m) was high enough for the analyses. Due to the fact that no appropriate method was found for identifying vegetation cover of IGSs, it was decided to move this indicator from the analyses. Even though the indicator is removed from the multi-criteria analyses, it was not removed from the whole methodology. The way of applying this indicator will be discussed in the Discussion chapter's Application of the methodology subchapter.

In parallel, the *Manageable size* indicator would be included into the analyses by applying Calculate Geometry tool on the potential IGS polygon layer and adding a new field into the attribute table with values: 1 to 5 according to the size of the area polygon. The ideal size of an IGS is between 10 m2 to 100m2, thus areas smaller than 10m2 and bigger than 100m2 receive 1 value, areas having size between the interval receive 5 value. Following it, this layer will be converted to raster and reclassified based on the additional field including the ranking values. However, the same problems were raised as at the vegetation cover indicator rooted in the fact that it is not possible to identify IGS by remote sensing tools due to the above discussed reasons. Also, the *Manageable size* indicator is needed to be removed from the multi-criteria analyses but will not be removed from the list of indicators, and the way of applying this indicator will be discussed in the Discussion chapter's Application of the methodology subchapter.

5.5. Summary of the final results

According to the objective of the research the main results of the project is a GIS methodology which based on the identification of important attributes that urban residents and municipalities assign to informal green spaces can be applied for evaluating urban green spaces for inclusion in a Stewardship Program.

The methodology includes a list of attributes, the related indicators which make the attributes measured and the GIS tools and methods applied for the analyses and visualization of the indicators.

5.5.1. Identified attributes suitable to be used in the process of selecting informal green areas to include in a Stewardship Program.

Table 8. Indicators, their importance according to the leaders of the Program and the stewards, and the calculated weight values

ATTRIBUTES identified	**5 STEWARDS'** opinion regarding the importance of attributes in selecting stewardship area	Opinion of the **LEADERS OF THE STEWARDSHIP PROGRAM** regarding the importance of attributes in selecting stewardship area	**WEIGHT** calculated considering the opinion of both, stewards and leaders
Ownership	-	Very important	**1**
No-man lands/green islands	-	Very important	**1**
Not protected area	-	Very important	**1**
Safeness, air and noise pollution	Important	Very important	**0,8**
Original vegetation cover	Slightly important	Important	**0,4**
Manageable size	Important	Important	**0,6**
Closeness to home	Very important	Important	**0,8**
Closeness to apartment buildings	Important	Slightly important	**0,4**
Slope steepness	Slightly important	Slightly important	**0,2**
Water sources available for irrigation	-	Slightly important	**0,2**
Not to be protected area but close to them	-	Slightly important	**0,2**
Along busy pedestrian area	Slightly important	Slightly important	**0,2**
Sunny	Slightly important	Slightly important	**0,2**

5.5.2. Spatial indicators could be used in order to find the identified attributes for selecting informal green areas

Table 9. Attributes for selecting stewardship areas and their indicators

ATTRIBUTEs for selecting stewardship areas	**INDICATORs of the attributes to measure them in GIS**
Not protected area	Green spots being not protected areas.
Ownership	Owned by the municipality or not
Safeness, air and noise pollution	Bus line roads and additional noise polluted roads within 10m distance
No-man lands/green islands	1m and 2m distance from parcell edges
Water sources available for irrigation	Hydrants within 100m distance along road network
Not to be protected area but close to them	Maximum 250m distance from protected areas and having border with protected areas (calculating with 5m distance)
Closeness to home	1m, 10m, 100m, 200m distance from inhabited areas (parcels having living function, not industrial, recreational etc.)
Closeness to apartment buildings	1m, 10m, 100m, 200m distance from intensive living function areas (parcels having living function, not industrial, recreational etc.)
Slope steepness	Slope steepness appropriate for gardening: Plain surface - <5% Slight sloping – 5-12% Moderate sloping – 12-17% Strongly sloping - 17-25 Steep slope – 25 – 45% Very steep slope – 45% <
Original vegetation cover	Percentage of grass cover
Manageable size	The size of the area is not smaller than 10 m2 but not larger than 100m2
Green for advertising	Indicator has not been identified.
Sunny	South and south-west facing slopes
Pedestrian zones - noticable	Pedestrian zones

5.5.3. Outcome of the tested method and applicability of the proposed attributes and indicators

According to *Fig. 15*, the most suitable areas are the dark green ones which are mostly the areas owned by the Municipality and not protected areas. It is recognizable that they are quite narrow areas which locate along roads, however there are also some big, more compact dark green spots over the district having potential to be stewardship area. Beside the quite fragmentally located dark green spots, the east part of the district with its generally light green colour shows an average good potential to include future stewardship areas. It is due to the fact that this is an intensively living function area which means that their apartment houses usually have no gardens. Thus, these residents can have a greater interest in gardening in public areas compared to other parts of the district. Also, the busiest pedestrian areas are located in this part of the district, where new stewardship areas could reach a greater attention.

On the other hand, some quite red lines can be recognized in this part of the district. These represent the busy, noisy bus line roads, which also appear in other parts of the district although not that densely as here. In the middle of the district, where light red colour is typical, some green spots/parcels are high-lighted. These are basically the areas located further from the parcels having households in the Zoning Plan, thus they are likely to be seen as “no man” areas, since neither residents nor the municipality consider themselves being responsible of taking care of them. The less suitable areas are the protected ones which are recognizable on the west side of the map where a compact forestry locate. There are also further protected isolated spots in the district highlighted by red colour.

In chapter 5.3, presenting the testing process of the indicators, it was already highlighted that not all the existing stewardship areas have been selected based on the identified attributes or not all the attributes have been considered at their selection. Still, based on the final combined map, it was concluded that the existing stewardship areas have high scores in average. Thus, in most of the cases the method was able to capture the existing areas which predict that it will be able to be used for identifying also the new ones.

More concretely, 95% of the cumulated pixel area of the existing stewardship areas have scores above the median of the possible scores can an area receive in the analyses. The average pixel value of the existing stewardship areas is 221, while the district level average is 187. The minimum value is 178 at the existing stewardship areas, while the minimum is 118 considering all the pixel areas in the district. In the same time, it can be seen on the diagram below *(Fig. 15.)*, that 60% of the stewardship areas’ scores are around the median value of the district. There are two main reasons behind it, first, there is a stewardship area which has significantly bigger size than the others which influence the numbers. In addition, the Safeness, noise and air pollution indicator having quite high weight negatively influences the stewardship areas’ scores, as most of the areas are unfortunately located next to busy road.

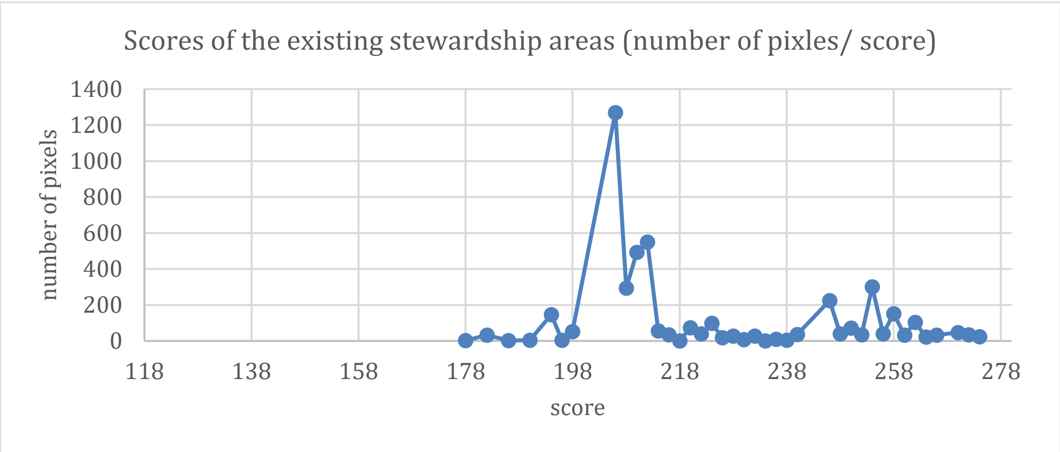


Figure 15. Score of the existing stewardship areas

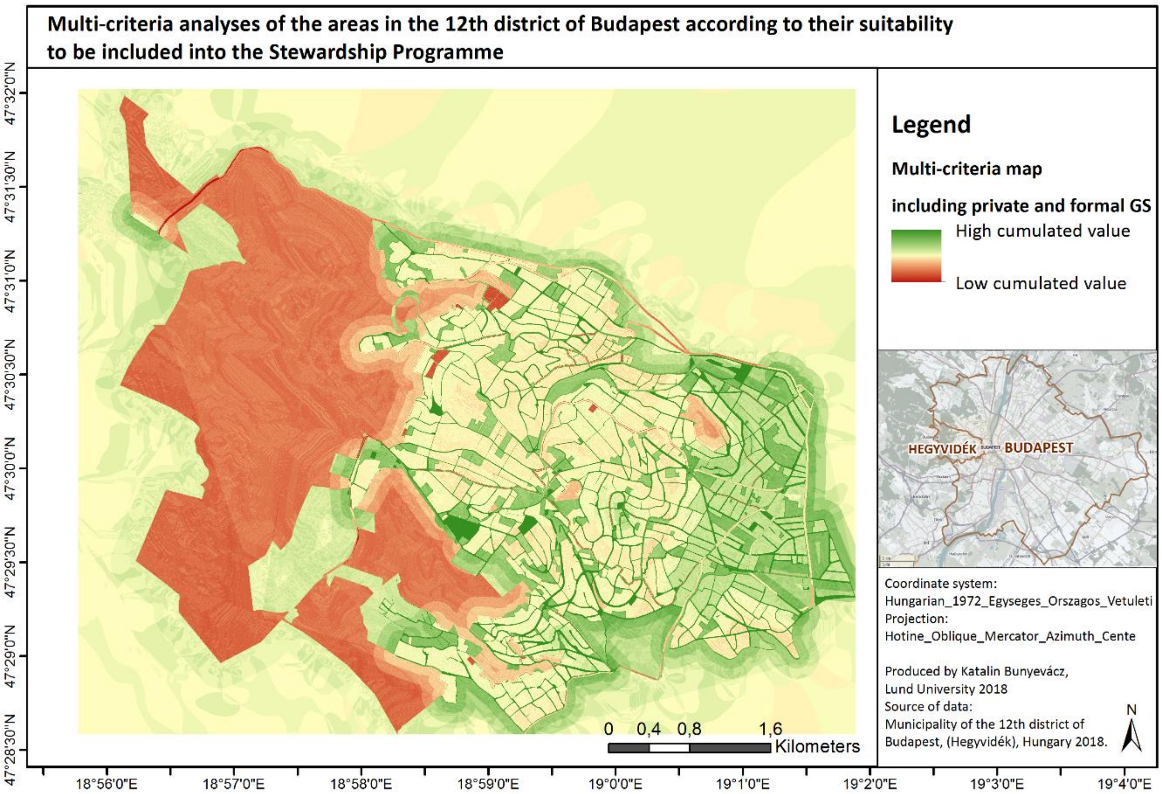


Figure 16. Map of multi-criteria analyses of the areas in the 12th district of Budapest according to their suitability to be included into the Stewardship Programme. Data source: Municipality of Hegyvidék.

As the map above includes the protected areas, the privately-owned areas and the formal green spaces which all cannot be stewardship areas, the public areas owned by the Municipality were extracted from this combined map. This way decision makers applying the map can easier identify areas which have a high potential to be included into a Stewardship program. The public areas were extracted from the raster map by the polygon layer of the Municipality owned areas producing the map below *(Fig.17).* In parallel, also the formal green spaces were extracted which are owned by the Municipality but not being the target of this analyses.

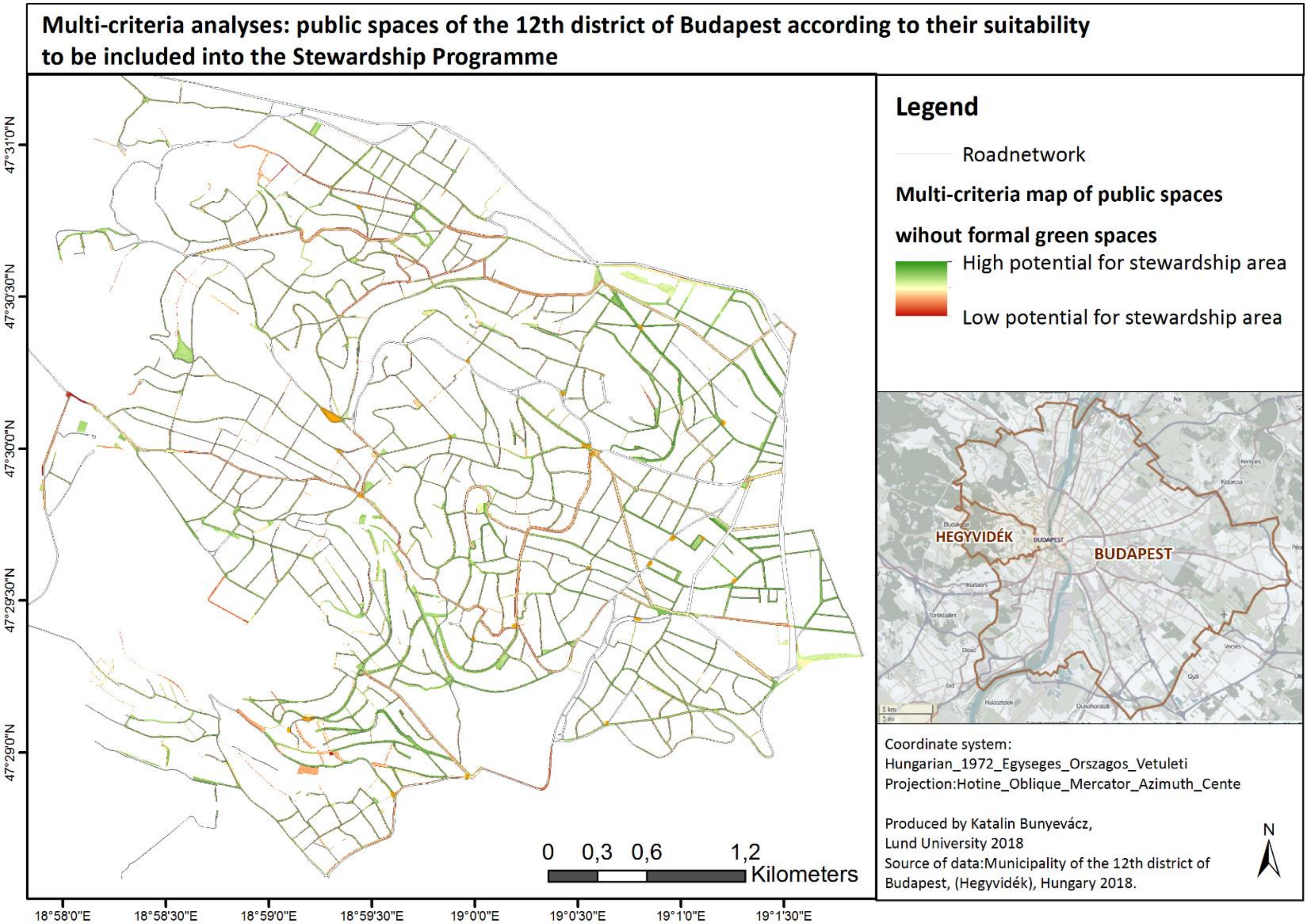


Figure 17. Map of multi-criteria analyses: public spaces of the 12th district of Budapest according to their suitability to be included into the Stewardship Programme. Existing stewardship areas are also presented in orange colour. Data source: Municipality of Hegyvidék

The map above (*Fig.17*) can be applied by Municipality officers, planners or decision makers on the best way if they zoom in to different parts of the map easily identifying new potential stewardship areas. Zooming into the middle north part of the above map the following conclusions can be made about the selected (numbered) areas. Also, the road layer (grey lines) was overlaid on the map cut (*Fig. 18*) in order to exclude the paved road areas focusing on the potential green spaces.

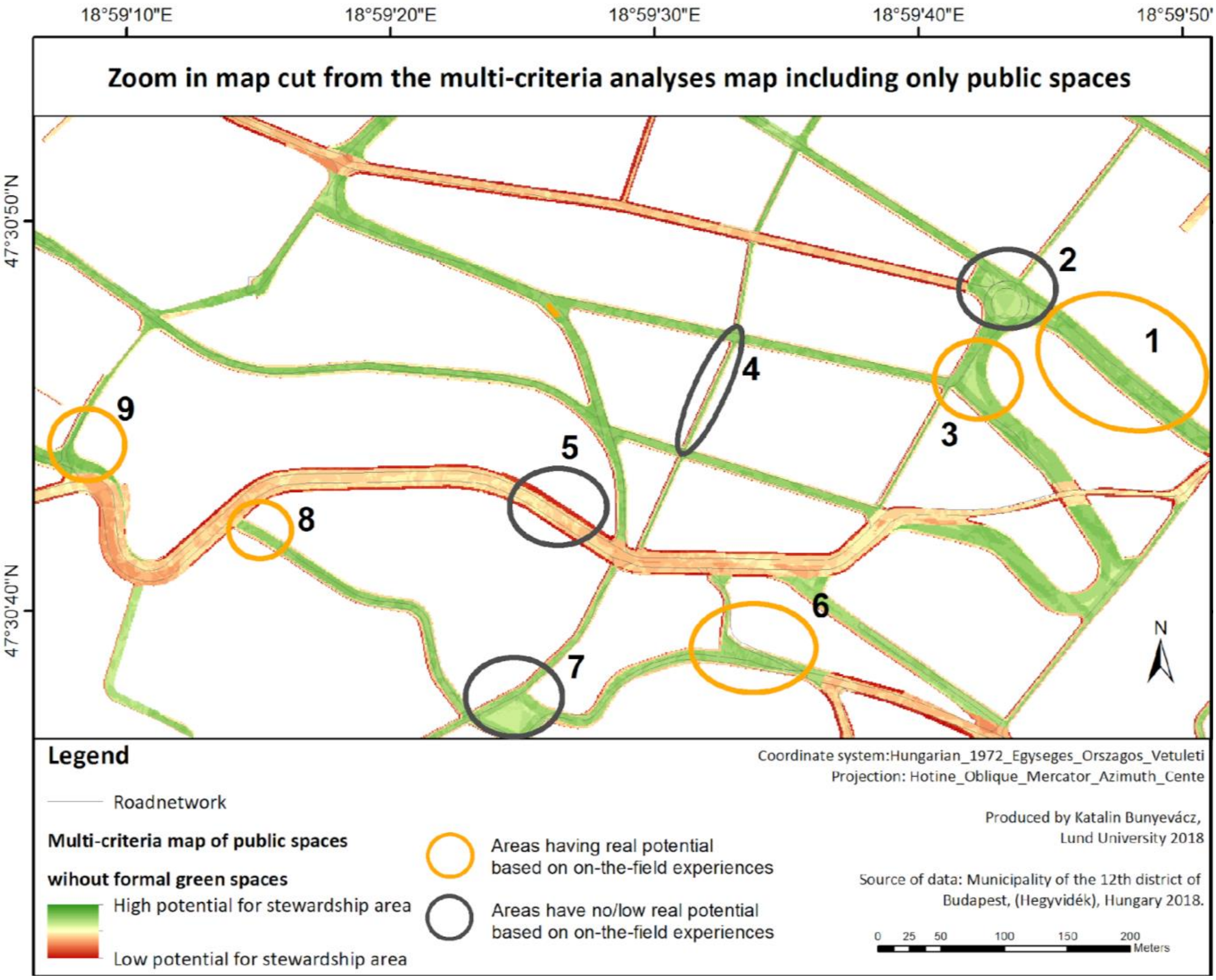


Figure 18. Map of zoom in map cut from the multi-criteria analyses map (Map 16) including only public spaces and overlaying the road network layer (grey lines). Data source: Municipality of Hegyvidék, 2018

1. area: Green spaces are along this road which could be potential stewardship areas.

2. area: It seems that there is a bigger public area with high potential to be stewardship area but this is basically a roundabout. However, on the west north part, there is a small potential area and the roundabout itself also a green space.

3. area: A real potential area locating in the corner of this crossing.

4. area: This is a very narrow stair street having a rather red colour. The green spaces in this street should be taken care compulsorily by the residents as they are right in front of their house.

5. area: This is a typical bus line road where the road occupies the public spaces; there is not much room for creating green spaces. There are mainly parking spaces along the road and a narrow green space which should be taken care by the residents who live there.

6. area: This street junction is indeed a no-man land having high potential to be included into the Program.

7. area: It seems to be also a potential area, though the main part of this area is currently a parking space. Though, there is potential to create green space at some parts of this area as this is also a typical no-man land.

8. area: This area locates at the end of a dead end street where a stairs make connection with the bus line road. Lot of residents pass the stair going to the bus top locating at the end of the stair. There is green space being quite messy which has high potential to be taken care by stewards.

It has to be noted that these conclusions were made partly based on the multi-criteria map, partly based on the local knowledge of the author of the research who lives in this area. Consequently, local knowledge is necessary for the right application of the map. The map can be used as tool for narrow down the number of potential areas and raise attention for the most suitable ones. On the other hand, the map should be investigated jointly by local people or by Municipality staff members having local knowledge before deciding on selecting a stewardship area.

6. Discussion

Discussing the methodology applied, different work stages will be evaluated from different points of view, such as data quality, weaknesses of the results, suggestions for further improvements, adaptability, and comparison to other methods applied.

6.1. Discussing the results of the questionnaires, interviews and the adaptability of the indicators

The interviews and questionnaires had a key role in the identification of the attributes stewards and the leaders of the Stewardship Program assign to informal green spaces when selecting stewardship areas. Regarding the quality of data received, the opinion of both the leaders of the Program and the stewards are reliable, both groups work in the Program in a year experiencing successes and failures. The leaders could be also considered stewards as in many cases they took care of the IGSs instead of stewards.

One could ask why only the stewards and the leaders were asked in the frame of the project. Initially, it was planned to distribute questionnaires in the frame of a festival where the program was promoted but due to the low number of participants in the festival it would not produce representative result. Furthermore, it would have been challenging to ask specific questions from residents who have never worked in the Program. Therefore, it was assumed that residents who are not stewards yet and have no experience of how to be one, cannot give a valuable answer. On the other, new attributes could have been identified this way discovering what prevent or discourages residents from being steward. In future analyses, questionnaires can be conducted also with non-steward residents, although with a different focus: less focusing on the evaluation of the already identified attributes' importance, instead looking for new ones.

It was concluded that there was no contradictory opinion between stewards and leaders regarding the importance of the attributes. Even though it is theoretically possible that an attribute is very important for stewards and slightly important for the leaders, there was no such combination. However, in the case of the *Ownership, No-man lands/green islands and Not protected areas* attributes, the opinion of the stewards were not asked as from their point of view these indicators are basically slightly important or not important at all. In the same time, the importance of these indicators is unquestionable, they are the primary criteria selecting stewardship areas. This is the reason why the stewards were not asked and their opinion were not taken into account in calculating the weights for these indicators.

At most attributes, there was no significant difference between the stewards' opinion. However, in theory, it is possible that contradictory opinions arrive from the stewards about the importance of the attributes.

Unfortunately, answers were received only 5 from 20 stewards, 2 of them were interviewed, additional 3 filled the online questionnaire. Even though, not all the stewards shared their opinion, the conclusions made upon the answers received are considered sufficient for the research. However, further interviews could have been conducted and all stewards could have been reached which would exceed the time frame of this project.

It has to be noted that the questionnaire was not planned to be used for developing the indicators, therefore getting to know for instance that what is the distance which is considered close to home by residents, just get to know how much it is important to have an area locating close to home. Though, it could be a way of extending the research for which there was no room in the current project.

Regarding the adaptability of this part of the method, the list of attributes collected are most probably relevant in all types of cities and districts. Although it is suggested to investigate the weight of these attributes which could differ. Also, the list of attributes should be completed according to the local circumstances.

The **Not protected area** attribute and its indicator is relevant in all types of cities and districts as urban gardening activities is not allowed in protected areas. The **Ownership** attribute and its indicator is also an adaptable one as the main goal of a stewardship program is to find steward for public green spaces for which the Municipality cannot take care.

However, the **No-man lands/green islands** could be considered a more specific attribute, as it is based on a law that says: all residents are responsible for the areas locate right next to their parcel. This law may differ in different cities and countries. Although, the main idea behind this attribute, namely that we are looking for stewards for places which are no-man lands, is relevant in all types of urban environments.

The **Safeness, air and noise pollution** attribute is relevant for all gardening activity. The related indicator, though, can need adaption. Actually, this indicator was formulated specifically for Hegyvidék due to the lack of GIS data about air and noise pollution of the district. If these data are available, more general indicator can be applied which is based on air and noise pollution categories. If noise or air pollution data is not available, but traffic volume of roads data does, it can be also applied for the measurement of these attributes. If none of these data is available, the bus line roads as the generally busy roads can be the base of the calculation which in the case of Hegyvidék gave a nearly full picture about the not safe, from gardening point of view, air and noise polluted areas.

Not to be protected area but close to them attribute and its indicator can be adapted without modification.

Water sources available for irrigation is also an adaptable attribute. However, the related indicator could be different depending on the local availability of water sources and the type of the Program. For instance, in the Program of Hegyvidék, the Municipality took care of the irrigation of the stewardship areas, thus the availability of hydrants was the right indicator. In other Hungarian settlements, though, there are artificial wells on the streets from which water pumping is free. In such settlements, distance from wells could be also an indicator. However, these wells are typical in smaller settlements, not in cities and this GIS method can be applied rather in cities which has a big enough scale to be worth to carry out this GIS analyses.

As another option, the Municipality can decide to not take care of irrigation and operates such a Program in which stewards are the responsible ones. In this case, this indicator could be even moved out from the analyses as it will be replaced by the *closeness to home* one.

Closeness to home, being the most important attribute from the point of view of the stewards, is expected to be relevant in all type of districts and cities. Even though the indicator itself can be adapted, the effect of the indicator in the analysis can be more significant in such cities where different functional areas are located next to each other. For instance, in such cities where industrial or recreational areas are also inserted into living function areas. In these cases, the recreational and industrial area which locate far from the living function areas have lower chance for finding stewards due to the higher distance from the home of potential stewards.

The perfect measurement of this attribute would be to measure closeness either from the home of the stewards or from the stewardship areas. In the first case we would identify the closest areas from the home of steward, in the second case we identify a service area in which residents live close the specific areas. The second one was experimented in the frame of this project in chapter 3.5.2 applying service area network analyses tools for the existing stewardship areas, but the produced map could not be included into the multi-criteria analyses due to its different logic.

Closeness to apartment buildings is also an adaptable attribute with an indicator which assumes a diverse urban structure and building type pattern. However, it is expected that in more dense urban structure, the indicator would show even less than in the case of Hegyvidék. The best alternative would be to measure the attribute by the heights of the buildings based on the assumption that higher buildings in living function areas are apartment buildings. As another solution, the population density of housing blocks data could be applied. Unfortunately, none of these data was available at the Municipality of Hegyvidék to be able to be used in this project.

Discussing this indicator with the leader of the Green Office of the Municipality, it was realized that conducting a more detailed questionnaire with residents is necessary to discover whether the main idea behind the indicator is true: are those residents who live in apartment buildings more willing to garden in public green spaces than those residents who live in houses that have their own gardens

The **Slope steepness** attribute and its related indicator can be meaningful in hilly or mountainous cities or districts. It is also works for the **Sunny** attribute and its indicator which is based on the calculated aspect of the slopes. This indicator could be completed by the heights and closeness of the surrounding buildings applying 3D analyses. Unfortunately, neither the location nor the height of the buildings data were available for this project, but suggested to be used if they are provided.

Furthermore, the Area Solar Radiation ArcGIS tool could have been applied for calculating the sunny indicator. This tool derives incoming solar radiation from a raster surface. It calculates insolation across a landscape based on methods from the hemispherical viewshed algorithm producing an insolation map for the area. The raster map has units of watt hours per square meter (WH/m2) (http://desktop.arcgis.com).

The main idea behind the **Pedestrian zones – noticeable** attribute is to represent places where most people can see a stewardship area. Identifying such places can vary between cities and highly depends on the local circumstance. In the current project, one of the possible solutions specified for Hegyvidék was tested taking into consideration the available data and time. The indicator is based on the assumption that those areas are the noticeable ones which has high pedestrian traffic, thus the pedestrian zones should be identified. There could be different options for identifying the pedestrian zones: in the case of Hegyvidék, they were known from the relevant chapter of the Integrated Development Strategy of Hegyvidék elaborated by transport experts. It can also work, if the surrounding area of the public institutions are selected or zones are framed where many public institutions are located attracting regular pedestrian traffic. As another solution, the exclusively pedestrian streets are selected. However, pedestrian streets are frequently fully paved and if there are any green space, they are usually taken care by the Municipality or other authority. Suggested by the leader of the Green Office, also the road crossing areas having traffic light are places where lot of people look around, thus also these crossing areas can be stewardship areas. Though stewards usually do not like to do gardening such places where lot of people stare at them during their work.

Even though the **original vegetation cover** is considered an important attribute by the leaders of the Program, it was not included into the multi-criteria analyses due to the lack of GIS data about the original vegetation cover of the district. It was investigated to apply remote sensing but these IGSs have too small size to be captured by remote sensing data.

The idea was to detect the road areas which has a bright, easily detectable colour. The rest of the areas, therefore the non-road areas was assumed to be the green areas along roads. After manually digitalizing the existing stewardship areas, in parallel, checking the type and location of these areas on google street view, it was concluded that it is not possible to detect IGSs by remote sensing tools as these areas could be covered by tree, could be in the shadow of houses, can have a similar colour to the road. Therefore, supervised classification could not give a reliable result, even though the spatial resolution of the aerial photo (0,4 x 0,4m) was high enough for the analyses. Due to the fact that no appropriate method was found for identifying vegetation cover of IGSs, it was decided to move this indicator from the analyses.

When a resident selects an area to be included into the program, it is suggested, though, to check on the aerial photo of the district or in google street view the vegetation cover of this area. Alternatively, they need to go to visit the area. Each area newly included into the program should be added to the current database of the stewardship areas. The database table would include a column called original vegetation cover. The original vegetation cover of the area before starting gardening in that field would be uploaded to this column. This way the “free” areas (have not responsible stewards yet) being part of the program can receive values according to their vegetation cover, in order to be able to give priority to those areas which are covered by bare soil (not grass). Therefore, the vegetation cover indicator can be included into a future multi-criteria analyses.

The **Manageable size** attribute is relevant in every type of cities and districts. Due to the lack of data about the informal green spaces in Hegyvidék, the size of them could not be identified. Consequently, this indicator could not be included into the multi-criteria analyses. However, thresholds were set for the indicator based on the knowledge of the leaders and the stewards about the ideal size of these areas.

Even though the **Green for advertising** attribute was removed from the analyses due to the lack of data about the enterprises hosted by the district, it worth discussing here the potential of attracting enterprises to be stewards who are allowed to advertise themselves by the green spots being under their care. Generating appropriate indicator for this attribute will be also the work of the future. In Hegyvidék, at the moment there is no intention from the side of the Municipality to make such agreements with local enterprises as it is not really in line with their philosophy to involve local residents into the maintenance of the green spaces. In their point of view, the Stewardship Program is a voluntary program not a business agreement. However, in other Municipalities this approach can differ.

6.2. Discussing weighting, class thresholds, quality of data and testing of the indicators

Regarding the **weighting of the indicators** which is based on the opinion of the leaders and the stewards, the goal was to make visible distinguish between the indicators even though there is no significant difference between the importance of each indicator and none of them are exclusionary one, except the not protected areas one. This way, the final combined map can show those areas which have higher and lower potential to include stewardship areas.

It was also realized of some indicators that there is no sharp boundaries between **the classes** set by the thresholds. Thus, the application of fuzzy logic was considered which could have been successfully used for the Safeness, air and noise pollution, Slope, Sunny, Close to protected area indicators. On the other hand, there are some indicators whose boundaries are indeed sharp such as the Ownership, No-man lands/green islands, Not-protected areas, Water source available indicators, where fuzzy cannot be used well. Thus, "traditional" classification method was used in the analysis. In addition, even though classification with sharp boundaries cannot represent realistically the analysed phenomenon, people need classification to capture things. To do so, the decision makers of municipalities who will want to understand what the maps show. Clear messages are needed even if it means the loss of some information by the end.

Beside the right identification of the attributes, indicators, weights and classes, the **quality of the GIS data** provided by the Municipality of Hegyvidék, the orthophotos provided by Geodesy Cartography and Remote Sensing (FÖMI) and the public transport lines of Budapest downloaded from the website of the Budapest Transport Centre was key in determining the quality of the outcome of the research. It can be concluded that at some attribute, the available data formulated the indicators themselves. All three sources of data are considered reliable and therefore ensure the good quality of the research's results. It has to be noted here that the adaptability of the whole analyses is highly dependent on the availability of spatial data.

Therefore, it is expected that those cities can apply the method who have GIS system and data available for such analyses. In addition, the method was developed for cities than villages. In villages, due to the small territorial scale of the issue, it is not worth to carrying out this complicated analyses as green spaces can be easier discovered and evaluated by simply visiting them.

As a further point, the **testing of the indicators** should be discussed. Testing was necessary to verify the indicators and check their thresholds in the research. It was a “going to the deep” process discovering place-specific features. At the adaptation of the methodology, it is suggested to go through such testing, as it would be the way of adapting the indicators to the local circumstance or simply check whether they mean the same in that other urban area than in Hegyvidék. Necessarily, a field trip discovering some sample informal green spaces should precede this testing.

In chapter *4.5.1 Indicator testing*, the spatial pattern of the indicators and the reason behind it was closely analysed which anticipated quite well that which indicator will influence significantly and how the final suitability map. In addition, in chapter 4.3. the final map analyses also give a quite close picture in this regard. However, the study can be completed by a leave-one-out sensitivity analyses discovering those indicators which has the highest influence on the result. The concept of the sensitivity analyses is that how the result of the research change if a variable (indicator) is moved out form the multi-criteria analyses.

6.3. Applicability of the indicator maps and the final map

Besides discussing the adaptability and analyses of each indicator, the **applicability of the indicator maps and the final map** resulted from the multi-criteria analyses needed to be explained. The main goal of the final combined map is to show those areas which have high potential and those areas which have low potential to include stewardship areas. The maps – and similar maps in other cities or districts - can be applied according to the following

- If a municipality would like to discover or select stewardship areas, they can check on their multi-criteria map which zones of the district/city have high potential to include suitable stewardship areas and they can focus their research on only those areas.
- If a Municipality already has a working stewardship type of program which need some more visibility to attract more stewards or just raise residents’ attention for the nice work done voluntary by stewards, they can check on the map the pedestrian zones and try to create stewardship areas there.
- It can also occur that a Municipality would like to convince stewards to plant native species in the areas which are close to the protected ones. In this case, the Municipality can also check on the map that which areas of the district is 250m buffer from the protected areas.
- In the most successful community governance programs, the residents choose their own areas. The GIS method developed, can also be used in this case. Firstly, the Municipality can check on the maps whether the area selected by the steward is

protected area and Municipality owned area or not. It is quite important for this to be known at the beginning as only not protected and Municipality owned areas can be stewardship areas. At the areas which compliance with these basic requirements, the Municipality can check the further attributes and inform the steward if, for instance, the area is close to busy, noise and air polluted road.

- Also, the Municipality can suggest to the steward to plant only those species in a particular area that prefer that particular area's slope steepness and sunniness.
- If the area is close protected area, they can suggest the steward to plant native species.
- If an enterprise applies to be steward, the Municipality can offer such place which locates in pedestrian zone, where they would receive more attention advertising better the enterprise.
- The method can be also used for supporting stewards to select area if they have no any good space in mind but would like to join to the Program.

6.4. Comparison of the method applied in the current and previous studies

Comparing the method applied to the ones explained in the studies referenced in the Introduction chapter, it can be concluded that the opinion of the local community provided a strong bases for the research, however more advanced tools applied by other authors - Pietrzyk-Kaszínska et al. 2017, Balram et al., 2005 - are suggested to be used in similar future work. For instance, the online questionnaire could be connected to an interactive map providing geographical context and allow resident to indicate geographical features or a collaborative GIS workshop could be organized. The latter one is recommended especially at launching the program to discover IGSs and local specific attributes.

As another difference compared to the previous studies, authors usually apply 4 – 6 criteria in their analyses, here 11+2 indicator were included into the analyses. The main work of the research was the elaboration of these indicators and less emphasis and less complicated methods were applied in the multi-criteria analyses than in similar studies. The reasons behind it is firstly, that multiply aspects had to be merged taking into consideration both the opinion of the Municipality and the stewards. Secondly, the method applied and developed would like to be a comprehensible one which can be applied in other municipalities and cities initiating Stewardship Programs. The method and the output maps are intended to be understandable by urban planners and decision makers having no or minimal GIS knowledge.

The 13 indicators were developed based on attributes collected from stewards and leader of the Program, thus, the study significantly relies on the information collected from local people by interviews and questionnaire. The previous studies (Pietrzyk-Kaszínska et al. 2017, Rupprecht, C. et al. 2015) dealing with informal green spaces also collected most of the necessary data by qualitative data collection methods. The analyses of these data, though, was carried out only by the application of statistical methods. Following a thorough literature overview, it can be concluded that GIS tools has not been applied so far for the analyses of informal green spaces.

The indicators selected for assessing urban green spaces in the previous studies includes both natural (vegetation cover, quality, soil type) and human ones (accessibility, facilities). In this research, the focus shifted to the human ones like ownership, water source availability, and pedestrian area – noticeability. The analysis basically does not assess the green spots itself but the potential of them to be included into the Program finding stewards who voluntary take care of them. This is a typical difference compared to the studies about urban green spaces.

As a final difference recognized comparing the method to the previous studies: the method of this study is developed to support municipalities in maintaining their informal green spaces. The basis of the evaluation is the potential of green spots whether they are able to be maintained by a resident. In the previous studies, on the other hand, the basis of the evaluation was the value of the green areas without any parameter/criteria which would refer to the maintenance condition of the area. This could be also a conclusion for the formal green spaces analyses to include such parameters/indicators into the analyses which indicate the manageability and maintainability of the areas as the Baycan-Levent at al., 2009 did comparing 24 European cities green spaces.

Regarding the technical GIS part of the research, similar GIS tools and functions (distance analyses, network analyses; raster analyses tools) were applied also in previous urban green space researches such as Raziyeh et al., 2017 and Abebe et al., 2017. In the current research, at most of the indicators, distance analysis tool (buffer) was applied. However, the possibility of applying a network analysis tool was also investigated. Both distance and network analysis tools were applied in the case of the *water sources for irrigation* indicator comparing the results produced by the two tools. It was also tested that the Service area network analyses tool is especially useful for calculating the *Closeness to home* indicator. Although, it can be applied only if the stewardship areas are already known and stewards are looked for in close distance to the areas. It is similarly relevant for the *Closeness to apartment buildings* indicator.

Distance analyses were also applied in the cases of the *No-man lands/green islands* and *Safeness, air and noise cleanness* indicators. Short distances were set as thresholds for these indicators calculated from land parcels and busy roads. Consequently, a network analysis tool would have produced very similar result as a simple distance analysis buffer tool. This was the reason for deciding on a distance analysis tool instead of a network one. Regarding the *Not to be protected area but close to them* indicator, the distance cannot be calculated on road applying network analyses tool as not the road accessibility of the protected areas is the point but the continuity of the vegetation of the protected areas inside the close not protected areas.

Remote sensing data and tools are commonly used in urban green space analyses (Gupta et al., Raziyeh et al., 2017 and Abebe et al., 2017), they were also used and investigated to be used in the current research: Firstly, the applicability of supervised classification for identifying vegetation cover and size of potential stewardship areas were investigated, but they were finally excluded from the analyses as it is not possible to detect such small IGSs by remote sensing technics due to three reasons: these areas could be covered by trees; could be in the shadow of houses; can have a similar colour to roads.

On the other hand, remote sensing data was used for identifying the slope steepness of the district.

In addition, remote sensing could have been used for identifying the height of buildings which information – if it would have been available for the analyses which was not the case - would be included into the analyses of the sunny indicator as beside the orientation of slopes, the height of the nearest buildings determines the sunniness of an area.

7. Conclusions

In the frame of the research a methodology was developed using GIS to identify and categorize informal urban green spaces (IGS) according to their suitability for inclusion in community management services such as the Stewardship Program of Budapest’s 12th district.

Based on the interviews and questionnaires conducted with the leaders of the Stewardship Program and the stewards, 13 IGS attributes were identified.

The most important attribute is the Ownership one as it is primarily those areas owned by the municipality that can be stewardship areas. At the same time, Stewardship areas cannot be protected areas. However, it is suggested they are located close to the protected ones where native species should be planted contributing to local biodiversity. Ideally, they should be close to the homes of the stewards, or at least close to living function areas. Stewardship areas should be no-man lands without responsible persons who take care of them locating further from the privately-owned land parcels. Gardening has to be safe in these areas where air and noise pollution are supposed to be limited. Also, the original vegetation cover and the size of these potential areas have to be appropriate for gardening activity. Moreover, it has to be ensured that water sources are available nearby for irrigation. In addition, the slope steepness and sunniness of these areas are important factors. Finally, it is suggested to create some areas in pedestrian zones where the work of the stewards is more visible, the whole program is more exposed, and green messages are transferable for a wider range of residents.

In order to measure the identified attributes, spatial indicators were established by multi-criteria analyses methods.

The attributes identified and the methods of establishing spatial indicators can be applied in any other districts or cities to select informal green areas which are suitable to take part in a community management services. However, the list of attributes could be completed by further ones suggested to be identified by interviews and/or questionnaires. Also, the related indicators are adaptable, although adjustments and modifications can be necessary according to the local circumstances and the availability of spatial data.

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Talajtan: Filep Gy., Füleky Gy., Stefanovits P.(2010); Mezőgazda Lap és Könyvkiadó Kft, pages 470: https://www.tankonyvtar.hu/hu/tartalom/tamop412A/2010-0019_Kozlekedesi_halozatok/ch03.html

Link to the online questionnaire:
https://docs.google.com/forms/d/e/1FAIpQLScqxZ6vHeRULCRaW5vKiFmi4iB4SbTa4R8BbvaStznf0Sf_wg/viewform?vc=0&c=0&w=1

GIS system of the municipality called Minerva:
http://minerva.bp12ker.hu/minerva/bp12ker/internet.php

9. Annexes

9.1. Interview questions and transcript

The following open-ended questions were asked during the interview with the leaders of the Program:

<u>About the Stewardship Program:</u>

- How does the Stewardship program work?
    - The leaders of the program selected areas and invited residents to take care of them
    - Invitation was done by local newspaper and media, later a board was placed the areas that they are “rented” or stewards invited their neighbour to join the Program
    - Nowadays the stewards has to bring area and a written cooperation agreement is signed by them
- Who is/are responsible for the operation of the program?
    - The Green Office of the Municipality
- What is necessary for a successful operation of the Program?
    - committed residents and human capacity at the Green Office
- What does the Program offer to the stewards, how does the Municipality support their work?
    - The Municipality provides horticultural expertise, plants, flowers and tools for gardening; planting was joint with the residents. Irrigation was taken by the Municipality, it has been changed, and nowadays stewards has to do that.
- How does a resident go about to join to the program?
    - call the Green Office, provide info about the area, agree on a meeting with the Leaders of the Program and sign the agreement

<u>About the Stewardship areas:</u>

- Based on which attributes did you select the stewardship areas? What type of areas are appropriate to be included into the Program?
    - **Safeness**: One of the most important attributes of IGSs is the safeness, which means that doing gardening activity on the area is safe, therefore the IGS is not located next to or surrounded by a busy road. Furthermore, it is accessible without taking a busy road and gardening can be done without stepping to a busy road.
    - **Air and noise pollution:** Gardening is basically a healthy and relaxing activity, if the air is clean enough for physical work and quiet environment is provided. Thus, those IGS are preferred to be include into the Program whose environment has low noise and air pollution typically resulted from high traffic on close roads.

- In Hegyvidék, the busy roads are basically the bus line roads which are, due to their generally high slope steepness, strongly affected by noise and air pollution. Therefore, in Hegyvidék, it is very typical that the surrounding area of bus line roads are polluted while further from them silent, clean, green and sinuous streets go.
- **Water sources available** for irrigation: So far, the municipality took care of the irrigation of the stewardship areas by using the hydrants which are managed by the fire service. Thus, for the Municipality, the closeness of hydrants means an important attribute.
- **Original vegetation cover**: The most appropriate IGSs are the neglected ones, which are aesthetically disturbing. Consequently, the residents living near these areas can be motivated to do something with it. It is better if the selected area is weedy/neglected flower bed instead of covered by grass as, if due to the Program, the grass area turns to a flower bed. If the steward at some point stop taking care of the area, the area will be in even worse condition than before when it was a grass field.
- **Ownership**: Appropriate IGSs should be owned by the municipality of Hegyvidék. However, there are also some stewardship areas which are owned by the Budapest Capital Municipality or has private owner, but the main intention is to find stewards who takes care of public urban green spaces for which the Municipality of Hegyvidék is responsible.
- **Manageable size:** The ideal size of a stewardship area is between 10 m^2 and 100 m^2.
- **Closeness to home:** One of the main attributes, stewards assign to their area, is the closeness to their home.
- **Closeness to apartment buildings**: It is likely that people living in apartment buildings have higher motivation for gardening on public green areas as they have no garden or one not big enough. Therefore, the chance of finding stewards for an area is higher if the area is located near apartment buildings.
- **No-man lands/green islands**: Taking care of green areas in front of private areas are under the responsibility of the owner(s) of the private area determined by law. Thus, these areas should not be included into the program.
- **Green for advertising**: In Hegyvidék, there are some stewards who are not persons but enterprises taking care of an area in front of their shops or office, putting their logo on a table placed on the green spot, which advertises their enterprise by this voluntary work. There is potential for such collaboration between enterprises and the municipality, thus areas which are close to shops or offices can be a high potential for long lasting maintenance by such stewards.
- **Not to be protected area but close to them**: Protected areas cannot be included in the program, however areas located next to or close to such areas can have high potential to be included. In Hegyvidék, the municipality contacted the authority

responsible for the protected areas and, jointly, planted native species on the area close to the protected ones contributing to the maintenance of native species and increasing biodiversity in the district.

  - **Slope steepness** is an important attribute as determines the possibility of gardening.

- Can the list of the stewardship areas be extended? If so, which approach would you use to find these areas?
  - It can be extended, however more capacity is needed from the Green Office to follow the work of the stewards. There is no specific method to find new areas.
- What type of information would you need about potential new stewardship areas not currently available at the Municipality?
  - Most important: ownership, safeness, protected, no man lands
- Do you think that it would be possible/advisable to initiate a Stewardship program using the same approach as here at other districts in Budapest?
  - Yes
- What kinds of districts do you believe would benefit most from a Stewardship program, the typically green- or the inner-city districts?
  - Rather the typically green as 13, 18, 11

<u>About the stewards:</u>

- Are the stewards commonly individuals or groups of people, such as school classes, community of inhabitants or a group of employees at a local enterprise?
  - Rather individuals, but there are also groups and school classes, enterprises.
- Is there a typical group of the society (age, sex, living place) who is especially enthusiastic to be a steward?
  - Not really
- What is the main motivation of the stewards to voluntary work on IGSs?
  - They have no own garden or just common garden, they would like to make an area nice close to their home.
- What would a preferable IGS look like in a typical steward's perspective? Are there any attributes that seem to be particularly important for the stewards?
  - close to home
- What kind of GIS data can be provided by the Municipality for finding the most suitable IGSs?
  - Municipality owned areas vector polygon layer
  - Hydrant vector point layer
  - Protected areas vector polygon layer including
    - National level protection areas shape layer

        - Budapest Capital city level protection areas shape layer
        - Natura 2000 areas shape layer
        - Buffer areas of ecological corridors shape layer
        - Core areas of ecological corridors shape layer
    - Areas having intensive/living function included into the Zoning plan
    - Vector layer of contour lines
    - Road network polyline layer
    - Land registry base map polygon vector layer

9.2. Questionnaire and interview questions

The following questions were asked in the questionnaire and the two interviews with the stewards

Open ended questions:

1. How did you choose your stewardship area?
2. What are the advantages of your stewardship area?
3. What are the disadvantages of your stewardship area?
4. If you do choose stewardship area now, what additional attributes of areas would be important for you? Please list these attributes and indicate the level of importance of them, in your opinion.

	Multiply choice questions	**Possible answers**
5.	How important is safety and cleanness in terms of noise and air pollution, i.e. not located next to a busy and/or bus line road?	1-hardly important, 3-important, 5-very important
6.	How important is the preliminary vegetation cover (tree, shrub, grass, bare soil) of your stewardship area?	1-hardly important, 3-important, 5-very important
7.	How important for you to have your stewardship area the convenient size according to your capacity and need?	1-hardly important, 3-important, 5-very important
8.	What is the convenient size for your area?	smaller than 5 m2 5 - 10 m2 10 - 50 m2 50 - 100 m2 bigger than 100 m2
9.	How important closiness to your home?	1-hardly important, 3-important, 5-very important
10.	Do you live in a block/apartment house without garden or with common garden? If your answer is, no please continue the questionnaire with question 11.	Yes/No
11.	Did it mean a motivation for you to join to the Stewardship Program that you live in a block/apartment house without garden or with common garden?	Yes/No
12.	How important is the degree of slope/steepness for your gardening intentions?	1-hardly important, 3-important, 5-very important

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