ID 1570 | AN ECOSYSTEM SERVICES BASED ENVIRONMENTAL SUSTAINABILITY ASSESSMENT TOOL FOR LAND USE PLANS

Emin Yahya Mentese[1]; Azime Tezer[1]
[1]Istanbul Technical University, Department of Urban and Regional Planning
eminmentese@gmail.com ; tezera@itu.edu.tr

1 INTRODUCTION

The mostly used and agreed sustainability definition is maybe the first one made by United Nations World Conference on Environmental Development (1987) in the Brundtland Report stating that sustainability is a development approach that enables progress today without compromising from the abilities of future generations to develop themselves. There is a consensus that human activities must be sustainable and meanwhile there has to be fixed level of disruption of resources based on human activities that reduces the ability of this capital to sustain for the humanity in the future (Arrow et.al, 1995).

In this aspect, land use planning is one of the most critical tool that shapes our living environment by setting the limits of development and urbanization. Hence planning process itself is an important factor in sustainable development. After a detailed literature review including several researches in the fields of landscape planning, landscape ecology, environmental impact assessment, ecosystem management Leitao and Ahern remark that sustainable land use planning is an inevitable conclusion of the evolution of the planning discipline into the 21st century where new social values such as the key concepts of sustainability (solidarity between present and future generations and the need to balance development with nature) are increasingly being seized upon into planning process and regulations (2002). In addition, there are various scientists claiming that sustainability is one of the integral parts of the landscape planning process (Forman, 1995; Grossman and Bellot, 1999). However it has been observed that planning discipline wasn't rapid enough to fit into the principles of ecology and therefore sustainability must be adopted more efficiently in planning process and administrating lands for which new tools are required (Leitao and Ahern, 2002) since its spatial component is strongly related to inter-dependence of land uses and to spatial processes such as fragmentation (van Lier, 1998).

In order to remove this gap, this study adopts environmental sustainability into urban plans, based on Burkhard's ecosystem service mapping approach (2009) that provides an efficient tool for understanding capacity of land use's ecosystem service provision. However, since Burkhard's approach only deals with the service side of the land use, it does not include the impact side of it and hence does not provide insight on environmental sustainability of land use. As the definition of sustainability suggests, by environmental means, the impact of land use must not exceed environmental limits of the planned area. Therefore, in this study, we made an addition to Burkhard's approach, by putting the impact dimension of land use into our analysis and developed a GIS model that calculates a land use plan's performance based on its ES provision capacity and environmental impact. Here our novel assumption is that a land use plan's environmental sustainability is equal to the difference between ecosystem services provided and environmental impacts caused.

With the development of this GIS tool, it will be available for an urban planner to analyze the sustainability difference between current land use and proposed land use plan and hence it will be available to revise the planning decisions for the good of environmental sustainability.

2 AIM & SCOPE

Basic aim of this study is to remove the gap between land use planning discipline and environmental sustainability phenomenon by developing a tool that helps planners to evaluate their decisions. Therefore, our focus is on the assessment of land use plans instead of the planning process because land use plans are the final output of the process and they are actually a combination of different decisions taken throughout the planning course. Moreover plans provide spatial data and they can be related with similar spatial entities such as land covers. In this regard by benefiting ecosystem services (ES) approach and their mapping techniques in current literature, we developed a standalone GIS tool that lets users evaluate the difference in ES based environmental sustainability level between a proposed land use plan and current land cover. Since our aim is to evaluate the plan's environmental sustainability level, we make the assessment based on regulating ES. Because other ES focus on economic and social benefits provided by ecosystems.

3 METHODOLOGY

In this study we make the assumption that a land use plan's environmental sustainability (EnS) performance is equal to the difference between ES provided and environmental impacts (EI) caused. In order to calculate ES and EI of a land use plan we adopt the methodology provided first by Burkhard et.al. (2009) and then revised by Jacobs et. al. (2014) so called "matrix model". This approach depends on scores for ES provisioning capacity of land covers. These scores are gathered from expert reviews and then enhanced by quantitative data from sources such as actual measurements or simulations where available. In this study we customize this model by using only ES that are directly related with environmental aspects that are known as regulating services in ES literature. On the other hand in scoring process, in order to assess the difference between ES and EI of a land use plan (or a land cover data) we expanded matrix model's scoring scale of "0-5" to "-5 – 5" where negative values correspond to the impacts caused by land use type. In other words we assume that while some of the land cover types (such as forests) increase ES capacity (hence EnS), some of them (such as continuous urban fabric) has negative impact on EnS. For example in a land use plan, while forests provide air quality regulation, industrial land use types (LUTs) not only have zero level ES, but also have negative impact on air quality. Hence, they must be taken into account as sources of EI. In matrix if a value has negative value it is at the impact side of the equation. A fictional sample data is shown in Table 1 where LUT4 has negative impact on ES and EnS as well while LUT1 have positive impact.

	ES^1	ES^2	ES^3	ES^4	ES^5
LUT 1	5	3	-5	-3	2
LUT 2	4	4	-3	-3	3
LUT 3	2	2	-3	-1	2

Table 1: Sample ES scoring table

It must also be noted that although the scores provide insight on the potential on provision and/or impact of LUTs; quantity (area) of the LUTs must also be taken into account because their benefit or impact is directly related with their area. The larger the LUT gets, the larger its service or impact level gets. Therefore, after the scores are assigned, they are multiplied with their areal quantity that provide unified unit for all indicators. But for the ease of mapping and viewing purposes, in calculation areas are converted in "km2" unit.

As a result, this GIS tool calculates EnS level for each land use type by summing ES and EI level it produces based on function below:

$$EnS\ level = LUT\ Score\ x\ LUT\ Area$$

(Formula-1)

3.1 EMBEDDING THE METHODOLOGY INTO SOFTWARE

In order to embed the methodology into software, we preferred to use pre-defined classes for assessment. Since the methodology basically depends on ES and Land Cover relation (as in matrix model), we defined the variables for these two themes beforehand.

Incorporation of land use plans into system is the integral phase of the methodology but it is hard to find a standardized land use planning taxonomy by means of establishing a solid relation with ecosystems. Therefore standardizing these classes is a critical task for increasing the ease of use. Hence we needed to use a common and widely used taxonomy for this study. In this regard, instead of trying to create a new classification, we chose Corine Land Cover dataset since it is one of the most widely acknowledged dataset that can also be used almost in every planning stage as a basemap.

Meanwhile, other important task has been the selection of ES indicators related with environmental sustainability. As defined before, these are basically regulatory services as described in many ES frames, which are composed of environmental benefits provided by ecosystems. For determining the relevant indicators ES indexes of Millennium Ecosystem Assessment (MA) (2005), The Economics of Ecosystem and Biodiversity (TEEB) (2011) and Common International Classification of Ecosystem Services (CICES) (2013) (Table 2) are reviewed. In this study, we preferred CICES categorization since it is the latest version for ES classification and embraces its predecessors.

ES Frame	ES INDICATORS										
MEA	Water purification and waste treatment		Erosion regulation	Water regulation		Air quality regulation	Pollination	Pest regulation	Disease regulation	Soil formation (supporting service)	Climate Regulation
TEEB	Water purification and waste treatment		Erosion prevention	Regulation of water flows	Moderation of extreme events	Air quality regulation	Pollination	Biological control		Maintenance of soil fertility	Climate Regulation
CICES	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows		Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control		Soil formation and composition	Atmospheric composition and climate regulation

Table 2: Ecosystem services categories (derived from The Biodiversity Information System for Europe (BISE) webpage

As a result we pre-defined two themes in the software: Land Cover Classes and Ecosystem Services. When the user uploads the data into system software enables to match uploaded data with predefined classes and reads areal values of the shapefiles to compute EnS scores. The main scoring values (varying between -5 and +5) are also kept in the system and can be updated within a new window including the matrix as described in Table 1.

4 SOFTWARE PROCESS

The software is designed with the aim of reducing software knowledge requirements of a user. Therefore it has a simple and yet comprehensible interface (Figure 1).

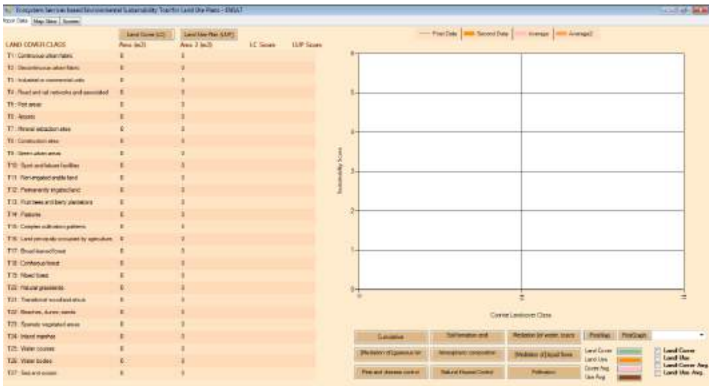

Figure 1 - Main Interface

The left column of the interface includes predefined land cover types gathered from Corine Land Cover (CLC). The right bottom corner includes ES buttons also defined beforehand based on CICES approach. The chart area is used for drawing EnS graphs of input datasets.

“Land cover” and “Land Use Plan” buttons open new dialog windows that let users upload a shapefile format including current land cover data and land use plan. When the land cover and land use plan data is uploaded the first thing system does is to prompt a window to read the land cover/land use classes and areal values (Figure 2).

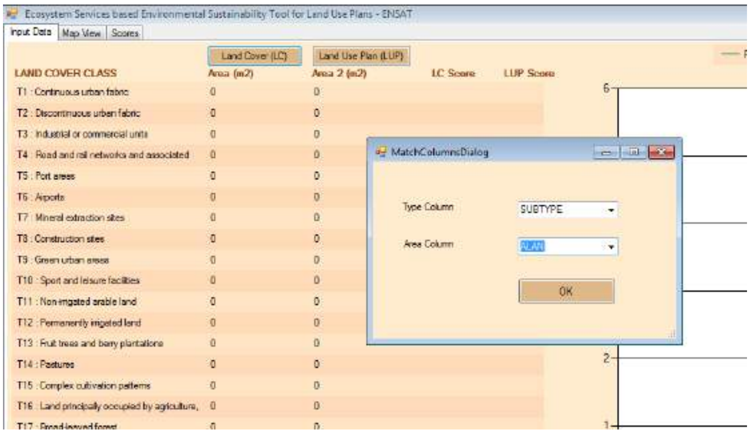

Figure 2: Class Matching Interface-1

But it is highly possible that land cover class names and class names in the uploaded data would not match exactly. So we designed another interface phase (Figure 3) for matching where user can match the classes with the defined ones in the system. For example in Figure 3 there are two incompatible types in uploaded land cover data and by selecting the suitable predefined CLC classes, matching process is completed.

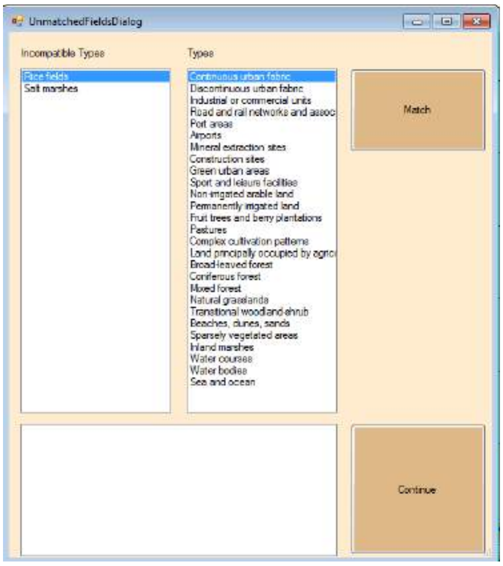

Figure 3: Class Matching Interface-2

After the data is uploaded into system software calculates the EnS scores based on areal values and ES scoring gathered from expert review and/or actual computations/measurements that are kept in “scores tab”. Then system applies “Formula 1” for both datasets and plots their graphic on the system (Figure 4).

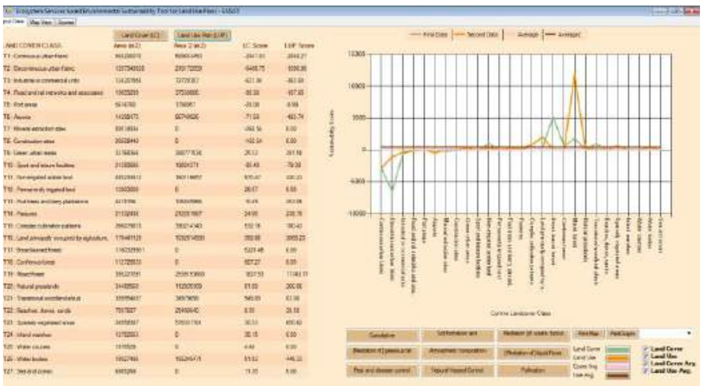

Figure 4: Comparison of Land Cover and Land Use Plan Data

The graphic is plotted as cumulative scores for each land use type which means it is the summation of all ES and EI for each LUT. Nevertheless in cases of special focus or needs, some specific ES can also be looked at. In this case buttons at the right bottom side are used for changing the graphic view for a specific ES title. In this same area of the screen, colours can also be manipulated. In Figure 5 “Natural Hazard Control” ES is looked at. The average values are the arithmetic average of scores for each datasets and they are the main output that enables to understand the change in EnS level.

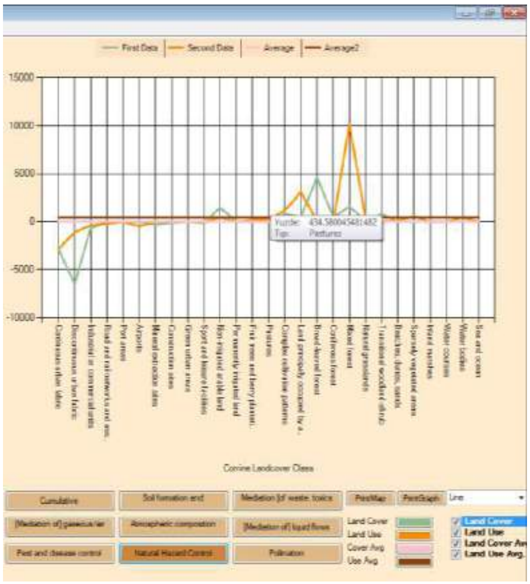

Figure 5: Natural Hazard Control Graphic Plot

In grey taskbar above, “map” tab opens the uploaded shapefiles’ location on Google Maps provided from Google Online Map services (Figure 6). In this panel the map is symbolized between green and red where green corresponds to the scores of the land use types. Green colours correspond to higher scores where reds correspond to lower scores of EnS. There are also tools that helps user to navigate in the map (zoom in, zoom out and pan) and an “info” tool to gather information about the data. The info button reads the dataset’s attribute table and prompts an info screen (Figure 7). The selected polygon is highlighted in light blue. These attributes are implemented via dot spatial framework libraries.

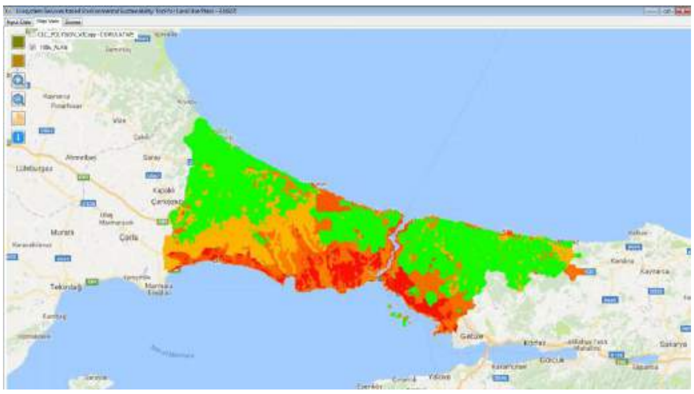

Figure 6: Map View of the Datasets

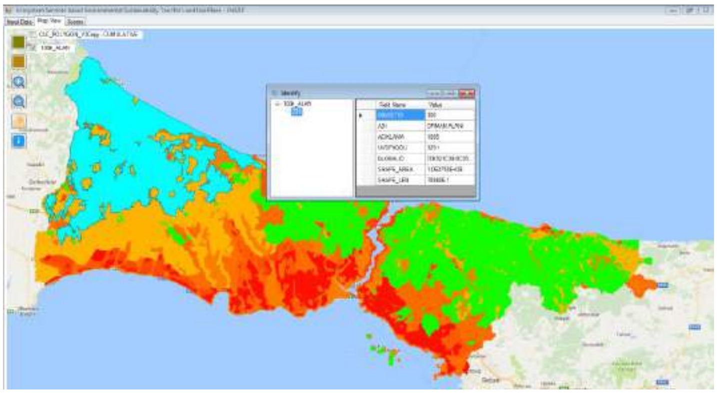

Figure 7: Info Tool in Map View

Next to the map tab there is “scores” tab that opens the tabular matrix where users can manipulate the scoring (acquired from table for their area of planning and generate a unique scoring table for their studies (Figure 8). This table is where ES and EI potential of land covers are scored. These scores are used for EnS calculation in “input data” view. Here the rows are land covers as predefined from CLC and columns are ES that are gathered from CICES frame. The values in the table can be updated by clicking on the scores and hence EnS can be renewed as well. These values are kept in a separate .mdb (Microsoft Database) file and once the table is updated, the .mdb file is updated too.

Ecosystem Services based Environmental Sustainability Tool for Land Use Plans - ENSAT

Input Data | Map View | Scores

Update

ID	ETIKET3	ATMCOMP_CLIMATE_REG	GAS_AIR	LIQ_FLOW	NATURAL_HAZARD	PEST_DISEASE	POLLINATION	SOIL_FORM_COMP	WASTE_TOXIC_(
1	Continuous urban fabric	-5	-5	-5	-5	-5	-5	-5	-5
2	Discontinuous urban fabric	-5	-5	-5	-5	-5	-5	-5	-5
3	Industrial or commercial units	-5	-5	-5	-5	-5	-5	-5	-5
4	Road and rail networks and associated land	-5	-5	-5	-5	-5	-5	-5	-5
5	Port areas	-5	-5	-5	-5	-5	-5	-5	-5
6	Airports	-5	-5	-5	-5	-5	-5	-5	-5
7	Mineral extraction sites	-3	-3	-3	-3	-3	-3	-3	-3
9	Construction sites	-5	-5	-5	-5	-5	-5	-5	-5
10	Green urban areas	1	1	1	0	1	1	0	1
11	Sport and leisure facilities	-4	-4	-4	-4	-4	-4	-4	-4
12	Non-irrigated arable land	1	2	2	3	2	2	2	2
13	Permanently irrigated land	3	2	1	2	2	2	1	2
16	Fruit trees and berry plantations	2	2	2	2	3	5	2	1
18	Pastures	1	1	1	1	2	1	1	1
20	Complex cultivation patterns	1	2	2	3	2	2	2	2
21	Land principally occupied by agriculture, with s...	1	2	2	3	2	2	2	2
23	Broad-leaved forest	5	5	4	4	4	4	5	5

Figure 8: Scoring Matrix

5 CONCLUSIONS

As a result, with the development of this tool, by using GIS capabilities and ES approach, it is easily available to assess a land use plan’s EnS performance compared to its land cover. Hence an urban planner or a decision maker can efficiently understand the level of impact or contribution made by planning process on the planning area by means of environmental aspects. As a part of an ongoing project, there will be updates to this tool to be more inclusive and comprehensive but even in this level, it helps planners to evaluate their planning decisions in the light of regulating ecosystem services and analyse whether these decisions lead to an ecological surplus in the planning area or not. Therefore it serves as an integral system to enhance land use planning decisions that are eventually one of the main pillars of sustainable human development.

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ID 1624 | MEASURING BUILDING DENSITIES (FSI/GSI) FOR THE NETHERLANDS

Arjan Harbers[1]
[1]PBL (Netherlands Environmental Assessment Agency)
arjan.harbers@pbl.nl

1 INTRODUCTION

Densities are a key feature in urban planning and design. Density influences amongst others energy consumption, mobility, livability, food production and economy.

Building densities (that is Floor Space Index (FSI) or Floor Area Ratio(FAR)) relate the gross floor area to the surface of the accompanying base land area. The surface of the base land area can be defined on