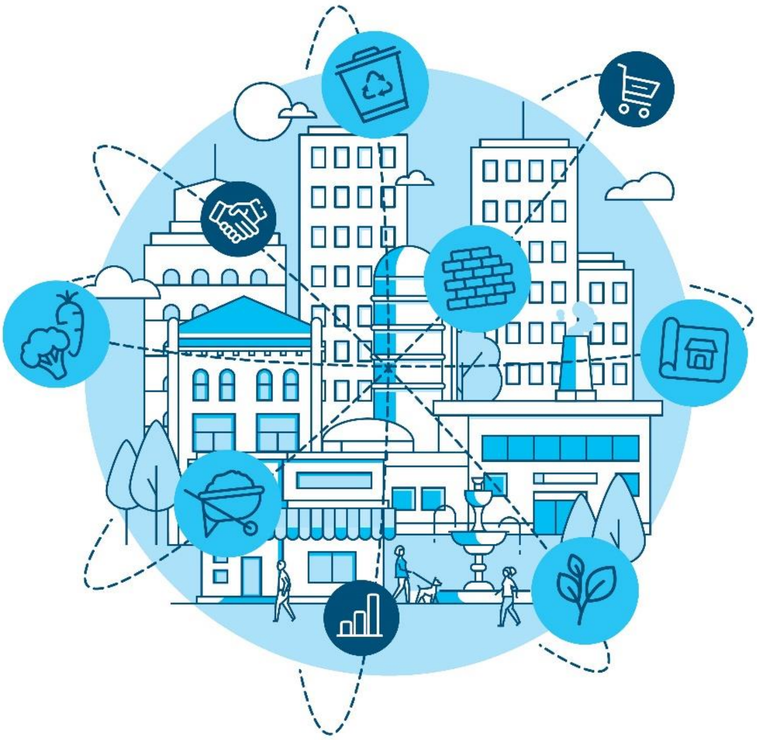
Report on the Wellbeing monitoring tool development & City simulation platform

IDENER



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Abstract	This report details how IDENER has developed the Well-being monitoring tool & City simulation platform
Keywords	Well-being, IT software tool, City platform, Seville
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Contents

1. Executive Summary

The Wellbeing monitoring tool has been developed using web frameworks based on Python such as Flask and Django. Those frameworks will be supported by specific modules and tools developed in Python for data analysis, machine learning and geographical information systems. Those tools include basic libraries for numerical tools and visualization such as Numpy and Matplotlib and more specific libraries for data analysis and ML such as Scipy, Scikit-Learn, Keras, Pytorch and advanced visualization such as Bokeh. The initial deployment of the tool will be done using either Virtual Machines (e.g., with VirtualBox) or Docker containers.

Scrum methodology has been strictly followed for the development and the tasks and subtasks necessary for developing each feature, and sections of the Graphical User Interface has been clearly defined, including expected results and goals. The philosophy behind the development has been to approach each feature individually, then create the first version of one of the web apps for citizens and managers and then, deploy them in a virtual machine.

Thanks to this approach for the development, all the members involved in the development of the CityLoops platform have been able to contribute directly to the programming activities. Those more experienced in mathematical modelling, scientific programming and data analysis easily learned a web framework such as Django and those experience in other web frameworks and/or Python would quickly acquire the knowledge for developing the CityLoops platform in Django. In addition, other partners developing software tools for the CityLoops project have already used Django and provided support and tools which can be adapted to the needs of the CityLoops platform in Seville.

2. Introduction

Machine learning and Data-Driven Applications have been gaining popularity in recent years. However, the final deployment requires a combination of different mathematical, programming and web development skills (or creation of graphical applications using frameworks such as Qt5 or GTK+).

Django is a very popular framework for web development with a very smooth learning curve, allowing the full development of web applications from initial concepts to final user products very quickly taking into consideration the most important aspects of security. These advantages overcome some limitations of other frameworks such as verbosity and complexity or steeper learning curves. Besides those limitations related to the development of the software platform, the use of Django as a framework also helps to improve the performance of the applications developed with other popular web frameworks. Dynamic applications did not always perform well, and complex single-page applications may have a significant lag, making them inconvenient to use due to their size.

Even if Django is an easy-to-learn framework for web development, it has been used in developing professional sites and platforms such as Instagram, Spotify, YouTube, BitBucket, DropBox, The Washington Post, Mozilla, Pinterest and even websites of NASA or National Geographic. The other additional advantage consists in using a single web framework other Python module without using communication protocols or separated containers with the back-end operations.

For the back-end part of the application, the data analysis and machine learning have also been powered by Python libraries. Communication between data sources has also been managed with Python when needed.

The initial developments have been provided to the managers for testing in containers or virtual machines to facilitate direct deployment in any computer. Virtual Machines allow preparing a complete operating system with the pre-installed CityLoops platform in a single file which can be directly executed by the user using Virtual Box, KVM, VMware or Hyper-V. Similarly, Docker containers allow running virtual servers to deploy web applications very quickly, even not booting an OS with the main advantage of allowing continuous integration. However, if an application is designed to run in a Docker container on Windows, then it cannot run on Linux or vice versa.

A GitHub repository has been created with a clean Django project to serve as a template to implement the initial features of the CityLoops platform. Once the main functionalities and widgets have been developed and tested, they have been all integrated on a single common application panel (e.g., like a dashboard), and interactions between them have been implemented and tested. This corresponds to Stage 1 of the development. Stage 2 has been the full development of one of the CityLoops platforms (i.e., Wellbeing monitoring tool) without taking into consideration aesthetics or final product aspects, only a basic front-end and main functionality. Stage 3 has been reproducing this development in all the remaining applications, obtaining an initial version fully functional of all the CityLoops applications. Finally, Stage 4, will consist of adding the aesthetics and improving UX and GUI, together with the deployment of citizens' web pages for visualization and services.

Now that the technologies for development have been presented. Let us briefly discuss the main goals and functionalities of each platform.

The CityLoops platform for Seville´s wellbeing (WB) monitoring has two main goals: the determination of the current wellbeing both in the city and in the different districts; and the evaluation of the impact of the demonstration actions from CityLoops on the wellbeing. The software tool for managers will combine data regarding economic, social, demographic, environmental and waste with circular indicators. This way, the tool will determine a new composite indicator that determines the relationship between wellbeing and the demonstration actions, focused on circularity. Managers will have access to a simulation framework that quantifies the influences of such circular demonstration actions from CityLoops on well-being. The software tool for citizens will provide data about the new composite indicators (well-being-circularity), demonstration actions, and impact estimations on the city´s well-being.

CONTEXT

The city of Seville, located in the south of Spain, has 700,000 inhabitants and a surface area of 140.42 km2. It is the most populated city in Andalusia, the fourth in Spain. Municipal solid waste management is one of the main concerns of the city management and a critical area of its circular economy approach.

The demonstration actions of the CityLoops project represent another step towards advancing Seville's path towards a more circular city, which is aligned with the declaration that the city itself led in 2017, together with more than 200 municipalities in Spain the which underlines the importance of Local Governments to put into practice the commitment, the need to implement the Circular Economy.

Seville's declaration for the Circular Economy is also aligned with its City Model of the Seville 2030 Strategic Plan.

On the other hand, the city of Seville understands its commitment to the 2030 Agenda for sustainable development of the United Nations and assumes it as the standard of its strategic and sectoral planning. Likewise, the Seville 2030 Strategic Plan is aligned with the Sustainable Development Goals (SDG).

Other local and sectoral initiatives and plans converge in the Seville 2030 Strategic Plan, such as the Local Waste Management Program, currently the draft, which will incorporate, if the results are satisfactory, the actions piloted within the framework of the project CityLoops.

The OW flow optimisation tool is expected to contribute to the following outcomes:

- Advance in the fulfilment of the European, national, and regional objectives, in selective collection, recycling and not disposal in a landfill, marked by Directive 851/2018 and 850/2018.

- Strengthen the education, awareness and knowledge of citizens and other socio-economic agents related to the bases of the circular economy concerning the improvement of biowaste management.
- Increase the amount of material that can be recovered/recycled / recovery, and therefore, reduce the amount of material that is deposited in landfills.

IDENER has developed the IT software tool in collaboration with Seville´s cluster. Seville's cluster of partners for the CityLoops project includes the Municipality of Seville, LIPASAM (Municipal Solid Waste Management company), EMASESA (Municipal Wastewater Treatment Management company) and IDENER (Private Research company). Together these partners are committed to the CityLoops' approach to close the loops of waste material in the city, promoting a circular economy approach to the city's development.

3. Definition of functionalities

3.1 Functionalities of WB platform for citizens

- Forms for query: The citizen will provide data about its location. The WB CityLoops platform for citizens will show the wellbeing indicators, circular indicators and composite indicators per district and city.
- Dropdown list: The citizen could select a district. The WB CityLoops platform for citizens will show the demonstration actions deployed and the estimated impact on the indicators.
- Map showing: A widget with a map (using OpenStreet Maps) will be presented to the citizens showing the city's current status regarding the indicators.
- Dashboard showing the current data on indicators: The dashboard will show the data on each indicator measurement.
- Control panel: A set of buttons will be included in the application to clean the forms, do the query, and export information. Logos of the involved partners (Emasesa, Lipasam, Municipality of Sevilla, CityLoops project) will be included providing additional information.

3.2 Functionalities of WB platform for managers.

- District representation of Seville Data: The city of Seville will be divided into a discrete representation of districts and overlapped over a real map of the city, including public infrastructures related to wellbeing.
- Data request of each district: Each district will be represented by different social and economic aspects, public infrastructure, and the potential demonstration actions from the CityLoops project.
- Evolution of the well-being indicators: Data about the evolution of the well-being indicators will be represented in a time-lapse, showing in the last frame the estimation in the next years according to the data provided by the manager through the platform.
- Evolution of the circular indicators: Data about the evolution of the circular indicators will be represented in a time-lapse showing in the last frame the estimation in the next years according to the data provided by the manager through the platform.
- Estimation of the well-being CityLoops indicators: Using the data provided by the managers, and the results from the analysis through the ML methods, the platform will present the indicators values.

4. Stakeholders' identification. Public and private.

The platform for each use case within Seville will have two versions, one for managers and authorities and another for citizens.

The idea is that the platform version for citizens has only visualization capabilities and widgets using data provided by managers or results from the corresponding CityLoops platform for partners.

Therefore, the applications for managers will consist, at least, in a data collection tool where managers will provide the data to power up the data-driven applications or the visualization widgets in the platforms for citizens. Additionally, the platforms for managers may have additional capabilities for decision support. The applications for citizens show interactive visualizations of the data provided by managers and will use the available widgets to get information about specific questions regarding CDW.

5. Functional Requirements.

This section lists specific functions and object-oriented designs linked to functionalities of the CityLoops platform.

- ORM/SQL database management (included already using Django)
- Machine Learning functionalities: regression, clustering.
- GIS / OpenStreetMap data management.
- Web Apps, Widgets and data visualization.
- Data collection and data analysis.
- PostgreSQL 12.6
- Django 3.2
- OSGeo4W
- Leaflet
- Gdal: (required modules installation: wheel; pipwin; numpy; pandas; shapely; gdal; fiona; pyproj; six; rtree; geopandas)

6. Design Requirements

6.1. List of Components of WebApp for Well-being tool (WB)

Table 1 – Web Form for Query and Data Collection

WB_APP001	**Web Form for Query and Data Collection**
Platform version	Basic User or Citizen
Description	This component of the Cityloops platform for WB is a web form where the citizen or basic user will introduce the parameters of a query to consult wellbeing indicators, circular indicators and composite indicators per district and city. Some fields of these data include postal code, district, street name, etc. Once all the fields of the form are completed, and the button “Show” is pressed, two actions occur. Database of WB generation by districts is updated, and the query is sent to the back-end function, which will provide as answer the wellbeing indicators, circular indicators and composite indicators according to the location of the user”
Input Data and Widgets	Text Edit (Postal Code), Comboboxes (District), Push Button (Search, create the query)
Output / Results	The database of WB by the district will be updated (all the queries will be incorporated in a dedicated database). Once the button is clicked, the wellbeing indicators, circular indicators and composite indicators will be highlighted on a map.

Table 2 – Web Form for Query

WB_APP002	**Web Form for Query**
Platform version	Basic User or Citizen
Description	This component of the CityLoops platform for WB is a web form where the citizen or basic user will introduce the parameters of a query to see the CityLoops´ demonstration actions deployed and the estimated impact on the indicators. The user will select a district among those in which CityLoops´ demonstration actions are implemented. Once the district is selected, and the button “Show” is pressed, two actions occur. Database of WB generation is updated, and the query is sent to the back-end function, which will provide as answer the location, status, and description of “CityLoops´ demonstration actions”
Input Data and Widgets	Comboboxes (District), Push Button (Show, create the query)
Output / Results	The database of WB by the district will be updated (all the queries will be incorporated in a dedicated database). Once the button is clicked, the “CityLoops´ demonstration actions” will be highlighted on a map and the information on status and impact on indicators

Table 3 – OpenStreet Map showing districts highlighted and CityLoops´ demonstration actions.

WB _APP003	**OpenStreet Map showing districts highlighted and CityLoops´ demonstration actions**
Platform version	Basic User or Citizen / Manager or Admin
Description	Widget imported from OpenStreetMaps showing a map of Seville City, including some additional layers, such as polygons representing the districts of Seville in terms of administrative divisions and waste generation. Locations of CityLoops´ demonstration actions will be marked in the initial map. Once the query is done and the result of checking the demonstration action is obtained, the related information will be highlighted in the map as well as the district.
Input Data and Widgets	Map imported from OpenStreetMap library. Additional layers added, including district representation, indicators, and demonstration actions
Output / Results	Points and polygons highlighted on the map.

Table 4 – OpenStreet Map showing districts highlighted and & indicators.

WB_APP004	**OpenStreet Map showing districts highlighted and & indicators**
Platform version	Basic User or Citizen / Manager or Admin
Description	Widget imported from OpenStreetMaps showing a map of Seville City, including some additional layers, such as polygons representing the districts of Seville in terms of administrative divisions and waste generation. Indicators will be marked in the initial map. Once the query is done and the result of checking the selected district is obtained, the indicators will be highlighted in the map as well as the district.
Input Data and Widgets	Map imported from OpenStreetMap library. Additional layers added, including district representation, indicators and demonstration actions
Output / Results	Points and polygons highlighted on the map.

Table 5 – Visualisation of demonstration actions Status

WB_APP005	**Visualisation of demonstration actions Status**
Platform version	Basic User or Citizen / Manager or Admin
Description	This part of the platform for WB will present the status and the expected evolution of the demonstration action and indicators. Once the district is selected in the menu, the corresponding demonstration action will be highlighted in the map of WB_APP002 / WB_APP003 and the status of the action and the related indicators will be presented in the panel
Input Data and Widgets	ComboBox containing the list of actions and indicators to select. Panel with several plots showing the status of the actions and the projection based on past data
Output / Results	Bar Plots with the evolution of the actions and line plots with the projected evolution.

Table 6 – Updating data of the demonstration actions and indicators.

WB_APP006	**Updating data of the demonstration actions and indicators**
Platform version	Manager or Admin
Description	The responsible for the management of this app will collect the information about the status of the indicators measures and will update the corresponding XLSX or CSV file, which will be loaded into the platform. The information about the status of the demonstration actions will be part of the inputs for the decision-making process when recommending a new action to be deployed.
Input Data and Widgets	The input of this data may be done in two possible ways: 1) a table widget within the WB platform or by an external CSV file which will be loaded into the WB platform.
Output / Results	Once the data is loaded (or updated) into the system, the visualisation panel WB_APP5 of the demonstration actions will be refreshed, showing the updated data and a corrected projection.

Table 7 – Manually loading data of WB generation by the district.

WB_APP007	**Manually loading data of WB generation by district**
Platform version	Manager or Admin
Description	CityLoops Platform for WB will collect the data (stored in Municipality of Sevilla or Lipasam servers) from the users. This data will include the district name, indicators measure of WB and circularity. However, it may be necessary to complete this data with additional data introduced manually (or corrected).
Input Data and Widgets	Loading CSV or XLSX file or modifying the data directly in the WB platform (this must be decided)
Output / Results	Updated data about WB generated in each district of Seville city.

6.2. List of Components of WebApp for the City Simulation platform

Table 8 – Description of the Homepage of the CityLoops Platform

GCP_APP001	**Description of the Homepage of the CityLoops Platform**
Platform version	Basic User or Citizen
Description	When the citizens access the home page (or index page) of the CityLoops platform for Seville City, they will find a right or left panel where the logos of the organisations involved (Municipality of Sevilla, Lipasam, Emasesa) and the logo of the project CityLoops, will be presented. When those logos are clicked, the user will be redirected to the corresponding sites. The homepage should include a short description of the project and the Platform for Seville. The centre of the webpage will present three elements (GPC_APP002, GCP_APP003, GCP_APP004) At the bottom of the page, it could be included a statement and a link to Idener (as creators of the platform)
Input Data and Widgets	None
Output / Results	Redirect the visitor to the corresponding

Table 9 – Logo/Button and Visualisation of Info from CDW WebApp

GCP_APP002	**Logo/Button and Visualisation of Info from CDW WebApp**
Platform version	Basic User or Citizen
Description	A button/logo will be presented together with a selected visualisation from the CDW tool. This could be the map presenting the “clean points” and the status of those clean points. This visualisation is not interactive, and it has the objective of presenting the most significant result which can be found in the specific CDW WebApp.
Input Data and Widgets	None
Output / Results	Redirect the visitor to the corresponding

Table 10 – Logo/Button and Visualisation of Info from OW WebApp

GCP_APP003	**Logo/Button and Visualisation of Info from OW WebApp**
Platform version	Basic User or Citizen
Description	A button/logo will be presented together with a selected visualisation from the OW tool. This could be the map presenting the OW specific routes in a map and the tons of OW collected. This visualisation is not interactive, and it has the objective of presenting the most significant result which can be found in the specific OW WebApp.
Input Data and Widgets	None
Output / Results	Redirect the visitor to the corresponding

Table 11 – Logo/Button and Visualisation of Info from Wellbeing WebApp

GCP_APP004	**Logo/Button and Visualisation of Info from Wellbeing WebApp**
Platform version	Basic User or Citizen
Description	A button/logo will be presented together with a selected visualisation from the Wellbeing tool. This could be a figure with the values of some indicators (to be decided together with Seville partners) This visualisation is not interactive, and it has the objective of presenting the most significant result, which can be found in the specific Wellbeing WebApp.
Input Data and Widgets	None
Output / Results	Redirect the visitor to the corresponding

7. Wellbeing Module development

This Section details all the necessary data transformations that have been carried out for the calculation of wellbeing. Additionally, a module has been prepared where different Machine Learning-based models have been trained to predict wellbeing. For this purpose, data from the different districts of the city of Seville from 2015 to 2018 was used. This data is composed of different columns, and these columns can belong to three groups:

- Social columns: The columns grouped under this category represent a factor related to the sociological situation of the inhabitants residing in a given district. Some columns can affect positively (e.g., neighbourhood associations) or negatively (e.g., number of detainees) to the Wellbeing calculation.
- Environmental columns: These columns represent different environment-related variables in the district. As in the previous case, some columns will increase the value of wellbeing, and others will decrease it.
- Economic columns: Columns related to the economy in a specific sector or district within the city. Following the same methodology as the previous ones, some economic columns can positively (e.g., activity percentage) or negatively (e.g., increase in unemployment compared to previous years) affect the Wellbeing calculation.

The rest of this section is organised as follows: (1) details the steps that comprise the data; (2) presents the calculation of wellbeing value; (3) proposes a Machine-Learning method to predict the wellbeing; and (4) concludes this research work with future research directions.

7.1. Data preparation

This subsection details all the steps that have been carried out to manipulate the data to solve null values, detect possible outliers, and treat columns that negatively affect wellbeing. These steps are presented below:

1. Import CSV. This dataset is of Spanish origin, so special characters have to be read using *'latin1'* as encoding. This dataset contains 44 rows by 84 columns. Some of these columns (*"distrito", "superficie m2", "YEAR", "Distrito_id")* will not be useful for the calculation of wellbeing, and others will be divided into social, environmental, and economical. A visualisation of the original dataset is shown in the following image.

distritos	superficie m2	poblacion_ini	densidad_ini	poblacion_fin	densidad_fin	Hombres 0-4	Hombres 5-9	Hombres 10-14	Hombres 15-19	...	Licencias de nuevas_viviendas	superficie_nueva
CASCO ANTIGUO	4.225862	59277	14027.197290	59081	13980.816220	1,279	1,334	1,213	1,068	...	0	
MACARENA	3.172994	75427	23771.554560	74980	23630.678150	1,609	1,789	1,511	1,521	...	6	
NERVION	3.202262	51118	15963.091090	51117	15962.778810	1,139	1,232	1,276	1,172	...	64	
CERRO-AMATE	7.390000	89045	12049.391070	88626	11992.692830	2,214	2,727	2,126	2,016	...	140	
SUR	7.560000	72128	9540.740741	71630	9474.867725	1,691	2,099	1,971	1,992	...	4	

Figure 1. Original dataset.

2. Create a list for each category of columns (social, environmental, economic). Social columns are 53; environmental is 16, and economics are 11. There is a total of 80 useful columns to Wellbeing calculation. Remember that initially there were 84 columns minus 4 columns that are not useful to the wellbeing calculation (*"distrito", "superficie m2", "YEAR", "Distrito_id")*.
3. Remove characters from excel (e.g., ",") and replaced columns that contain "-" by NaNs for further treatment.
4. Change the column type of object columns that are numeric to numeric columns.

```
distritos                                      object
superficie m2                                 float64
poblacion_ini                                   int64
densidad_ini                                  float64
poblacion_fin                                   int64
                                                 ...
Paro anual medio                              float64
Activos (miles de personas)                   float64
Tasa de actividad (%)                         float64
Precio medio de vivienda de 2ª Mano □ /m2      object
Precio medio de alquiler □ /m2                 object
Length: 84, dtype: object
```

```
distritos                                      object
superficie m2                                 float64
poblacion_ini                                   int64
densidad_ini                                  float64
poblacion_fin                                   int64
                                                 ...
Paro anual medio                              float64
Activos (miles de personas)                   float64
Tasa de actividad (%)                         float64
Precio medio de vivienda de 2ª Mano □ /m2     float64
Precio medio de alquiler □ /m2                float64
```

Figure 2. Type of columns

5. Count the total number of Not a Number (NaNs) for each column. 4 columns contain NaNs that have to be fixed.

```
materia organica nº Contenedores              22
Precio medio de alquiler □ /m2                11
Renta neta media por hogar                    11
Precio medio de vivienda de 2ª Mano □ /m2     11
densidad_ini                                   0
                                              ..
distrito_id                                    0
Zonas verdes y de recreo m2                    0
YEAR                                           0
aceite nº Contenedores                         0
distritos                                      0
```

Figure 3. NaNs per column before data treatment.

6. The NaNs treatment is different for each column, as they represent different properties for each district.

- *"Materia organica nº Contenedores":* rows that contain NaNs represent areas where there are no containers. Therefore, the NaN values will be shifted by a value of 0.

	distritos	YEAR	materia organica nº Contenedores
0	CASCO ANTIGUO	2015	NaN
1	MACARENA	2015	NaN
2	NERVION	2015	NaN
3	CERRO-AMATE	2015	NaN
4	SUR	2015	NaN
5	TRIANA	2015	NaN
6	MACARENA-NORTE	2015	NaN
7	SAN PABLO-SANTA JUSTA	2015	NaN
8	ESTE	2015	NaN
9	BELLAVISTA-LA PALMERA	2015	NaN
10	LOS REMEDIOS	2015	NaN
11	CASCO ANTIGUO	2016	NaN
12	MACARENA	2016	NaN
13	NERVION	2016	NaN
14	CERRO-AMATE	2016	NaN
15	SUR	2016	NaN
16	TRIANA	2016	NaN
17	MACARENA-NORTE	2016	NaN
18	SAN PABLO-SANTA JUSTA	2016	NaN
19	ESTE	2016	NaN
20	BELLAVISTA-LA PALMERA	2016	NaN
21	LOS REMEDIOS	2016	NaN
22	CASCO ANTIGUO	2017	27.0
23	MACARENA	2017	10.0
24	NERVION	2017	17.0
25	CERRO-AMATE	2017	6.0

	distritos	YEAR	materia organica nº Contenedores
0	CASCO ANTIGUO	2015	0.0
1	MACARENA	2015	0.0
2	NERVION	2015	0.0
3	CERRO-AMATE	2015	0.0
4	SUR	2015	0.0
5	TRIANA	2015	0.0
6	MACARENA-NORTE	2015	0.0
7	SAN PABLO-SANTA JUSTA	2015	0.0
8	ESTE	2015	0.0
9	BELLAVISTA-LA PALMERA	2015	0.0
10	LOS REMEDIOS	2015	0.0
11	CASCO ANTIGUO	2016	0.0
12	MACARENA	2016	0.0
13	NERVION	2016	0.0
14	CERRO-AMATE	2016	0.0
15	SUR	2016	0.0
16	TRIANA	2016	0.0
17	MACARENA-NORTE	2016	0.0
18	SAN PABLO-SANTA JUSTA	2016	0.0
19	ESTE	2016	0.0
20	BELLAVISTA-LA PALMERA	2016	0.0
21	LOS REMEDIOS	2016	0.0
22	CASCO ANTIGUO	2017	27.0
23	MACARENA	2017	10.0
24	NERVION	2017	17.0
25	CERRO-AMATE	2017	6.0

Figure 4. NaNs treatment for "Materia organica nº Contenedores".

- *"Precio medio de alquiler € /m2":* rows that contain NaNs are only in the 2015 year, so in these rows, the value from 2016 has been copied. An example for one specific area is presented as follows:

	distritos	Precio medio de alquiler □ /m2	YEAR
43	LOS REMEDIOS	8.913367	2018
32	LOS REMEDIOS	8.786283	2017
21	LOS REMEDIOS	8.174483	2016
10	LOS REMEDIOS	NaN	2015

	distritos	Precio medio de alquiler □ /m2	YEAR
43	LOS REMEDIOS	8.913367	2018
32	LOS REMEDIOS	8.786283	2017
21	LOS REMEDIOS	8.174483	2016
10	LOS REMEDIOS	8.174483	2015

Figure 5. NaNs treatment for "Precio medio de alquiler € /m2".

- *“Renta neta media por hogar”:* rows that contain NaNs are only in the 2018 year, so in these rows, the value from the previous year (2017) has been copied. An example for one specific area is showed in Figure 6.

	distritos	Renta neta media por hogar	YEAR
43	LOS REMEDIOS	NaN	2018
32	LOS REMEDIOS	44587.0	2017
21	LOS REMEDIOS	43406.0	2016
10	LOS REMEDIOS	42623.0	2015

	distritos	Renta neta media por hogar	YEAR
43	LOS REMEDIOS	44587.0	2018
32	LOS REMEDIOS	44587.0	2017
21	LOS REMEDIOS	43406.0	2016
10	LOS REMEDIOS	42623.0	2015

Figure 6. NaNs treatment for “Renta neta media por hogar”.

- *“Precio medio de vivienda de 2ª Mano € /m2”:* rows that contain NaNs are only in the 2015 year, so in these rows, the value from 2016 has been copied. An example for one specific area is presented in Figure 7.

	distritos	Precio medio de vivienda de 2ª Mano □ /m2	YEAR
43	LOS REMEDIOS	2357.834233	2018
32	LOS REMEDIOS	2251.451092	2017
21	LOS REMEDIOS	2150.427008	2016
10	LOS REMEDIOS	NaN	2015

	distritos	Precio medio de vivienda de 2ª Mano □ /m2	YEAR
43	LOS REMEDIOS	2357.834233	2018
32	LOS REMEDIOS	2251.451092	2017
21	LOS REMEDIOS	2150.427008	2016
10	LOS REMEDIOS	2150.427008	2015

Figure 7. NaNs treatment for “Precio medio de vivienda de 2ª Mano € /m2”:”.

7. Check that all NaNs have been fixed (Figure 8). The number of total NaNs per column is presented in the following illustration. It has been checked that there is no NaNs in any column.

```
Precio medio de alquiler □ /m2    0
Mujeres 20-24                     0
Hombres 80-84                     0
Hombres '85-90                    0
Hombres 90 y más años             0
                                 ..
YEAR                              0
aceite nº Contenedores            0
envases nº Contenedores           0
restos nº Contenedores            0
distritos                         0
Length: 84, dtype: int64
```

Figure 8. Total number of NaNs per column (after NaNs treatment).

8. As mentioned above, some columns could have a negative impact on well-being. Therefore, it is necessary to make some transformation of these columns in order to represent useful information for the final calculation of wellbeing. These columns are as follows:
   - “*Contenedores organicos*”. This column represents the total number of organic bins in a district. If 0, this value does not directly subtract from wellbeing but does not add to it either.
   - “*Paro anual medio*”. This column counts the average annual unemployment in a certain district. Therefore, it will be positive for well-being if unemployment is decreasing from the minimum value since 2015. In case of unemployment increases, wellbeing will have to decrease. Sign criteria (whether a column is positive or negative) have not yet been taken into account; these steps are only intended to show how the increase has been calculated. The next images reveal

the change of this column from absolute value to the difference of unemployment with respect to the minimum value from 2015. In the case of positive value, it will represent that (Figure 9).

	distritos	YEAR	Paro anual medio
42	BELLAVISTA-LA PALMERA	2018	70326.33333
31	BELLAVISTA-LA PALMERA	2017	74924.08333
20	BELLAVISTA-LA PALMERA	2016	81297.41667
9	BELLAVISTA-LA PALMERA	2015	85065.25000

	distritos	YEAR	Paro anual medio
42	BELLAVISTA-LA PALMERA	2018	0.00000
31	BELLAVISTA-LA PALMERA	2017	4597.75000
20	BELLAVISTA-LA PALMERA	2016	10971.08334
9	BELLAVISTA-LA PALMERA	2015	14738.91667

Figure 9. "Paro anual medio" column after treatment.

- "*Precio medio de vivienda de 2ª Mano € /m2*". This column shows the average purchase price of a second-hand house per square metre in a given district. Therefore, it will be positive for wellbeing if the average cost decreases from the minimum value since 2015. In case the average purchase price is increasing, welfare should decrease. The following pictures reveal the change of this column from the absolute value to the difference of unemployment from the minimum value since 2015 (Figure 10).

	distritos	YEAR	Precio medio de vivienda de 2ª Mano □ /m2
42	BELLAVISTA-LA PALMERA	2018	1653.405500
31	BELLAVISTA-LA PALMERA	2017	1673.773017
20	BELLAVISTA-LA PALMERA	2016	1753.715625
9	BELLAVISTA-LA PALMERA	2015	1753.715625

	distritos	YEAR	Precio medio de vivienda de 2ª Mano □ /m2
42	BELLAVISTA-LA PALMERA	2018	0.000000
31	BELLAVISTA-LA PALMERA	2017	20.367517
20	BELLAVISTA-LA PALMERA	2016	100.310125
9	BELLAVISTA-LA PALMERA	2015	100.310125

Figure 10. "Precio medio de vivienda" column before/after treatment.

- "*Precio medio de alquiler € /m2*". This column represents the average rent price of a house per m2. The same criterion has been followed in the previous point, taking the minimum value since 2015 and calculating the difference concerning that year (Figure 11).

	distritos	YEAR	Precio medio de alquiler □ /m2
42	BELLAVISTA-LA PALMERA	2018	8.144808
31	BELLAVISTA-LA PALMERA	2017	7.625883
20	BELLAVISTA-LA PALMERA	2016	7.220200
9	BELLAVISTA-LA PALMERA	2015	7.220200

	distritos	YEAR	Precio medio de alquiler □ /m2
42	BELLAVISTA-LA PALMERA	2018	0.924608
31	BELLAVISTA-LA PALMERA	2017	0.405683
20	BELLAVISTA-LA PALMERA	2016	0.000000
9	BELLAVISTA-LA PALMERA	2015	0.000000

Figure 11. "Precio medio de alquiler □ /m2*" column before/after treatment.*

9. Once all the columns have been treated, the next step is to normalise the data between 0 and 1 so that all columns move in the same numerical ranges. This is done because there are columns that go from 0 to 10 and others from 0 to 10.000 and having columns with different numerical ranges can make the calculation of wellbeing more affected by the different numerical ranges. Only the columns that will be used for wellbeing calculation were normalised. The method to normalise the data is MinMax normalisation:

    1. $$x_{norm} = \frac{x - \min(x)}{\max(x) - \min(x)} \quad (1)$$

    The next images reveal the dataset before and after the normalisation process.

	poblacion_ini	densidad_ini	poblacion_fin	densidad_fin	Hombres 0-4	Hombres 5-9	Hombres 10-14	Hombres 15-19	Hombres 20-24	Hombres 25-29	...	Licencias de nuevas_viviendas	superficie_nu
43	25447	1765.92644	25533	1771.894518	627	659	696	630	638	610	...	68	
38	48412	5161.19403	47929	5109.701493	831	1013	1092	1071	1003	1163	...	139	
33	58693	13889.00063	58378	13814.459630	1123	1282	1303	1161	1138	1406	...	388	
35	51450	16066.76780	51595	16112.048300	1151	1213	1310	1244	1203	1229	...	280	
36	88643	11994.99323	89433	12101.894450	2065	2404	2673	2115	2345	2889	...	19	

Figure 12. Dataset before normalisation.

	poblacion_ini	densidad_ini	poblacion_fin	densidad_fin	Hombres 0-4	Hombres 5-9	Hombres 10-14	Hombres 15-19	Hombres 20-24	Hombres 25-29	...	Licencias de nuevas_viviendas	superficie_nue
0	0.004436	0.001115	0.004505	0.001145	0.010282	0.004779	0.034291	0.010094	0.010021	0.003361	...	0.139918	
1	0.292211	0.155234	0.283969	0.153669	0.101475	0.134926	0.156627	0.153696	0.162422	0.235714	...	0.286008	
2	0.421042	0.551409	0.414355	0.551440	0.232007	0.233824	0.221810	0.183002	0.218789	0.337815	...	0.798354	
3	0.330280	0.650262	0.329715	0.656430	0.244524	0.208456	0.223973	0.210029	0.245929	0.263445	...	0.576132	
4	0.796346	0.465435	0.801869	0.473183	0.653107	0.646324	0.645042	0.493650	0.722756	0.960924	...	0.039095	

Figure 13. Dataset after normalisation.

10. As mentioned above, some columns (*'Precio medio de alquiler (€ /m2)', 'Precio medio de vivienda de 2º Mano (€ /m2)', 'Paro anual medio', 'Nº de Detenidos'*) negatively affect the calculation of wellbeing, so these columns should have a range between -1 and 0. Therefore, these columns have been multiplied by -1 to obtain this range.

7.2. Wellbeing calculation

This section presents how the well-being value is calculated based on coefficients. This will be done in four steps:

- The first step consists of giving a coefficient to each column category (social, environmental, economic). The sum of this weight should be 1; therefore, a higher weight will represent that wellbeing is favoured by that group of columns. For example, a coefficient of 0.5 for social, 0.2 for environmental, and 0.3 for economic means that the columns within the social category have a greater impact than the economic and environmental categories. The following formula will give the weight of each column.

$$coeff_{social} + coeff_{\mathrm{environmental}} + coeff_{economics} = 1 \qquad (2)$$

- Once this value has been defined, the next step is to give a weight to each column within the category. This weight will be given in a range from 0 to 10, whereby 0 means that it contributes nothing to wellbeing and 10 means that it contributes as much as possible to wellbeing within the weight of this category.

$$\sum_{i=1}^{N^{\underline{o}}\ of\ columns} coeff_{col_i} = 1 \qquad (3)$$

$$coeff_{soc\_col_i} = \frac{weight_{col_{social_i}}}{(Nº\ of\ social\ cols)} * coeff_{social} \quad (4)$$

$$coeff_{env\_col_i} = \frac{weight_{col_{env_i}}}{(Nº\ of\ \text{environmental}\ cols)} * coeff_{\text{environmental}} \quad (5)$$

$$coeff_{ecs\_col_i} = \frac{weight_{col_{economics_i}}}{(Nº\ of\ economics\ cols)} * coeff_{economics} \quad (6)$$

Where, $coeff_{soc\_col_i}$, $coeff_{env\_col_i}$, $coeff_{ecs\_col_i}$ are the coefficients that represent the importance of each column in well-being. $weight_{col_{social_i}}$, $weight_{col_{env_i}}$, $weight_{col_{economics_i}}$ are the weights defined by a user/researcher set to each column, ranging from 0 to 10, given the importance of each column based on scientific knowledge. $coeff_{social}$, $coeff_{\text{environmental}}$, $coeff_{economics}$ are another coefficient previously set by the user/researcher that represents the importance that each category affect to wellbeing. In case it is desired that all three categories affect the same, it is only necessary to enter the same value in all three categories.

- Once the coefficients representing the weight of each wellbeing column are obtained, the next step consists of multiplying this coefficient by the corresponding column. The value of this column has been previously normalised between 0 and 1 for columns that have a positive effect and between 0 and -1 for columns that have a negative impact. The following images show the dataset before/after this stage.

poblacion_ini	densidad_ini	poblacion_fin	densidad_fin	Hombres 0-4	Hombres 5-9	Hombres 10-14	Hombres 15-19	Hombres 20-24	Hombres 25-29	...	Mujeres TOTAL	Nucleo familiar con 0 Hijos	Nucleo familiar con 1 Hijos
0.004436	0.001115	0.004505	0.001145	0.010282	0.004779	0.034291	0.010094	0.010021	0.003361	...	0.003502	0.002271	0.000158
0.292211	0.155234	0.283969	0.153669	0.101475	0.134926	0.156627	0.153696	0.162422	0.235714	...	0.314498	0.499148	0.215064
0.421042	0.551409	0.414355	0.551440	0.232007	0.233824	0.221810	0.183002	0.218789	0.337815	...	0.430835	0.810733	0.264803
0.330280	0.650262	0.329715	0.656430	0.244524	0.208456	0.223973	0.210029	0.245929	0.263445	...	0.353773	0.483135	0.217117
0.796346	0.465435	0.801869	0.473183	0.653107	0.646324	0.645042	0.493650	0.722756	0.960924	...	0.810984	1.000000	0.712301

poblacion_ini	densidad_ini	poblacion_fin	densidad_fin	Hombres 0-4	Hombres 5-9	Hombres 10-14	Hombres 15-19	Hombres 20-24	Hombres 25-29	...	Mujeres TOTAL	Nucleo familiar con 0 Hijos	Nucleo familiar con 1 Hijos
0.000028	0.000035	0.000170	0.000072	0.000194	0.000030	0.000216	0.000063	0.000252	0.000021	...	0.000044	0.000043	0.000002
0.001838	0.004882	0.010716	0.009665	0.001915	0.000849	0.000985	0.000967	0.004086	0.001482	...	0.003956	0.009418	0.002705
0.002648	0.017340	0.015636	0.034682	0.004377	0.001471	0.001395	0.001151	0.005504	0.002125	...	0.005419	0.015297	0.003331
0.002077	0.020449	0.012442	0.041285	0.004614	0.001311	0.001409	0.001321	0.006187	0.001657	...	0.004450	0.009116	0.002731
0.005008	0.014636	0.030259	0.029760	0.012323	0.004065	0.004057	0.003105	0.018183	0.006044	...	0.010201	0.018868	0.008960

Figure 14. Dataset before/after of coefficient stage.

- Therefore, the wellbeing will be calculated as the sum of all columns that have been previously multiplied by the coefficient. An example of wellbeing with a random coefficient from 2015 to 2018 is presented in Figure 15.

	distritos	YEAR	Wellbeing
9	BELLAVISTA-LA PALMERA	2015	3.247853
5	TRIANA	2015	2.421800
4	SUR	2015	2.374561
3	CERRO-AMATE	2015	2.345181
7	SAN PABLO-SANTA JUSTA	2015	2.331161
2	NERVION	2015	2.327797
6	MACARENA-NORTE	2015	2.143142
8	ESTE	2015	1.947953
10	LOS REMEDIOS	2015	1.884126
1	MACARENA	2015	1.566865
0	CASCO ANTIGUO	2015	1.211274

distritos	YEAR	Wellbeing
CERRO-AMATE	2016	2.418423
SAN PABLO-SANTA JUSTA	2016	2.258636
TRIANA	2016	2.103519
ESTE	2016	1.971437
LOS REMEDIOS	2016	1.953766
CASCO ANTIGUO	2016	1.844854
SUR	2016	1.652235
BELLAVISTA-LA PALMERA	2016	1.635680
NERVION	2016	1.367414
MACARENA-NORTE	2016	1.358915
MACARENA	2016	0.961728

distritos	YEAR	Wellbeing
NERVION	2017	2.432851
MACARENA-NORTE	2017	2.108742
SAN PABLO-SANTA JUSTA	2017	2.047648
CASCO ANTIGUO	2017	1.972651
BELLAVISTA-LA PALMERA	2017	1.907864
CERRO-AMATE	2017	1.868422
SUR	2017	1.779018
ESTE	2017	1.685382
MACARENA	2017	1.491164
TRIANA	2017	1.456162
LOS REMEDIOS	2017	1.196412

distritos	YEAR	Wellbeing
SAN PABLO-SANTA JUSTA	2018	1.986750
NERVION	2018	1.983555
TRIANA	2018	1.870476
MACARENA-NORTE	2018	1.792111
MACARENA	2018	1.777882
CERRO-AMATE	2018	1.777646
LOS REMEDIOS	2018	1.559152
BELLAVISTA-LA PALMERA	2018	1.411626
ESTE	2018	1.341311
CASCO ANTIGUO	2018	1.297203
SUR	2018	1.174056

Figure 15. Well-being examples from 2015 to 2018.

7.3. Well-being prediction

Once well-being has been calculated, it is possible to train some prediction models to predict if some variable changes and to analyse whether this change has been beneficial or negative for wellbeing. For this purpose, different approaches are proposed, ranging from statistical models to advanced models based on deep learning. Since the dataset is quite small (only 44 rows), it is possible that advanced techniques based on supervised learning may not work very well, since it is a fact that the accuracy of these models increases as the number of data increases. However, these approaches will be implemented to have a comparative approach to justify this assumption.

The first approach involves basic regression techniques, from which training data a model is fitted to learn from that data. For this purpose, the data have been divided randomly into two sets following a proportion of 80/20:

- Train set: Dataset used to fit the models.
- Test set: Dataset used to evaluate the model using data that the model has never seen.

In more complex approaches (Deep Learning approaches), an additional data division is required (validation set). The training set is the sample of data used to train the deep neural network. In contrast, the validation set is the sample of data used to provide an unbiased evaluation of a model trained on the training dataset while tuning model hyperparameters. The test set is the sample of data used to provide an unbiased evaluation of a final model fit on the training dataset. The ratios of the division in the neural network-based approaches have been 90/10/10, for train/validation/testing.

Three different prediction models have been implemented:

- Multivariate linear regression. Linear regression is a type of parametric regression model that makes a prediction by taking the weighted mean of the input characteristics of an observation or data point and adding a constant called the bias term. This model will be trained with the objective of minimising a cost function to accurate wellbeing predictions.

- Support Vector Regression (SVR). SVR is a modification of the Support Vector Machine (SVM) to regression problems. It is used to enhance its generation capability by reducing the empirical risk and confidence intervals. SVM constructs a hyperplane or set of hyperplanes in a high dimensional space, which can be used for classification or regression problems. The original data could be not linearly separable in a finite state, so, for this reason, the original finite-dimensional space is mapped into a much higher-dimensional space, presumably allowing an easier separation in that space. The kernel function is the key feature of SVM, which maps data into higher dimensional space. These functions can be a different type (e.g., linear, non-linear, polynomial, radial basis function (RBF) and sigmoid).

Support Vector Machine can also be used as a regression method, maintaining all the main features that characterise the algorithm. SVR uses the same principles as the SVM for classification, with only a few minor differences.

- Artificial Neural Network (ANN): They are inspired by the neuron operation, where a group of neurons are interconnected to form a neural network. Mathematically, they can learn any mapping functions and have been proven to be a universal approximation algorithm. ANNs are also very tolerant of noisy and incomplete datasets. The core of the ANN's structure is the neurons that are grouped into layers. A multilayer perceptron network (MPL) is an ANN with multiples layers. Every connection has a weight attached which may have either a positive or negative value associated with it. The neurons sum all the signals it receives, which each signal being multiplied by its associated weights on the connection. The output of the sum is then passed through an activation function that usually is non-linear to give the final output of the neuron. It is called an activation function because it governs the threshold witch the neuron is activated and the strength of the output signal.

  Input data is passed in the forward direction through the network to generate an output value. Each hidden layer accepts the input data, process it according to the activation function and passes the results to the next layer; this procedure is called Forward-Propagation.

  Once the output value is generated, this value is compared to the expected output, and the error between both values is calculated. The error is then propagated back through the network, one layer at a time, and the weights are updated according to the amount that they contribute to the error. The process is called the Back-Propagation algorithm. This algorithm minimises the loss function by adjusting the network's weights and biases. The parameters of the networks are updated using different optimisers algorithms. The most common optimiser in the last years is Adam (Adaptative Moment Estimation).

The results of the first two models are below. The results of the third model have been presented in a separate table and are not directly comparable with these first two approaches, as they have a different data split in train/validation/testing (Figure 16). These models have been trained using as inputs the columns that have been used for the calculation of wellbeing, but always considering that a set of test data is left to evaluate the results.

Model	MAPE Train (%)	MAE Train	MBPE Train (%)	MBE Train	MAPE Test (%)	MAE Test	MBPE Test (%)	MBE Test
LinearRegression	0.0000	0.0000	-0.0000	-0.0000	0.1405	0.0023	-0.1368	-0.0022
SVR_linear	10.6058	0.1724	-3.8829	-0.0144	6.4526	0.1074	-2.3556	-0.0245
SVR_poly	4.2695	0.0741	0.9673	0.0291	6.0277	0.1094	3.2409	0.0707
SVR_rbf	4.3831	0.0759	-0.6770	0.0038	5.4466	0.0903	-1.2487	-0.0143
SVR_sigmoid	11.1393	0.2082	-0.9580	0.0327	3.9269	0.0692	-1.4476	-0.0151

Figure 16. Results of the Linear regression and SVR prediction models.

Regarding the results of the models based on neural networks, 48 pieces of training have been carried out with different hyperparameter settings (different number of layers, different number of neurons, learning rate, etc.). The training process consists of learning the best values of the weights and biases in the training set so that the structure is able to correlate its output value with respect to the input values. The difference between a Deep-Learning approach and a traditional one is the handling of the generalisation error. This error is defined as the error when new input sequences are introduced into the trained model. Typically, the usual approach is to estimate the generalisation error by the metric error in the validation set that is independent of the training set.

The criterion taken as a training stop condition is known as early stopping and helps us to prevent overfitting on training data. Every time an epoch is performed, the error in the validation set is calculated. If this error does not decrease with increasing training number, the training is terminated. Once a complete training has been completed, a new one is started with a different hyperparameter configuration. The following table reveals the results of the best model for each hyperparameter configuration (Figure 17).

MAE_test	MAPE_test (%)	MBE_test	MBPE_test (%)	MAE_val	MAPE_val (%)	MBE_val	MBPE_val (%)	MAE_train	MAPE_train (%)	MBE_train	MBPE_train (%)
0.0123	0.6717	-0.0076	-0.3876	0.0105	0.7656	-0.0093	-0.6960	0.0143	0.7701	0.0047	0.1525
0.0115	0.6823	0.0064	0.4248	0.0138	0.8467	-0.0039	-0.2966	0.0114	0.6175	0.0101	0.5377
0.0119	0.6956	0.0063	0.4101	0.0149	0.9031	-0.0036	-0.2711	0.0164	0.8586	0.0144	0.7331
0.0120	0.7167	0.0120	0.7167	0.0070	0.4395	0.0018	0.0352	0.0171	0.9063	0.0168	0.8833
0.0126	0.7173	0.0112	0.6444	0.0075	0.4808	0.0001	-0.0556	0.0148	0.7688	0.0135	0.6745
0.0135	0.7410	0.0042	0.2683	0.0131	0.8357	-0.0045	-0.3528	0.0139	0.7360	0.0094	0.4332
0.0142	0.8132	0.0003	0.0296	0.0185	1.1879	-0.0049	-0.4336	0.0201	1.1271	-0.0010	-0.1814
0.0161	0.8989	0.0095	0.5641	0.0171	1.0536	-0.0027	-0.2471	0.0189	0.9874	0.0155	0.7455
0.0150	0.9089	0.0053	0.4289	0.0059	0.3490	0.0027	0.2135	0.0157	0.9477	0.0092	0.5998
0.0191	1.0519	0.0078	0.4605	0.0140	0.8743	0.0003	-0.1443	0.0213	1.1418	0.0184	0.9321
0.0194	1.0946	0.0095	0.5131	0.0133	0.8317	-0.0001	-0.0988	0.0178	0.9665	0.0164	0.8697
0.0206	1.1463	0.0078	0.4524	0.0144	0.9240	0.0010	-0.0732	0.0210	1.1067	0.0172	0.8421
0.0209	1.1627	0.0018	0.1590	0.0196	1.2504	-0.0067	-0.5313	0.0159	0.8746	0.0110	0.5635
0.0221	1.2302	0.0180	1.0193	0.0177	1.1090	0.0022	0.0025	0.0230	1.2054	0.0208	1.0397
0.0217	1.2314	0.0172	1.0021	0.0140	0.8283	0.0059	0.2326	0.0278	1.4764	0.0265	1.3937
0.0245	1.3583	0.0182	1.0425	0.0125	0.7795	0.0018	-0.0209	0.0278	1.5343	0.0252	1.3585

Figure 17. Results of ANN to predict wellbeing.

At the light of the different errors, it can be seen that the model that works best with the given data is the linear regression model. This may be due to different factors. Firstly, the wellbeing has been calculated by doing a linear combination of the columns of the dataset, so models that learn non-linear relationships from the data (e.g., ANN, SVR) are very complex approaches to a simpler problem. On the other hand, these models learn better as the number of data increases, and for this problem, the amount of data given is very limited.

8. City simulation platform development

The city simulation platform has been developed by creating an HTML template in which all the interface elements have been included, including header, links to each of the applications and the logos of the companies involved in the development of the application.

In addition, a CSS file has been created to style the elements of the HTML template.

9. User Workflow

9.1. Citizen platform

On the WB main page, the user will see a form including a list of the city districts and a text box where they will introduce their zip code. Two buttons are located below the form: the left one submits the form (“Get Well-Being indicators”), and the right one resets all the form fields (Figure 18).

At the right of the form, a map will be shown with all the districts of the city highlighted with a different colour for each one of them.

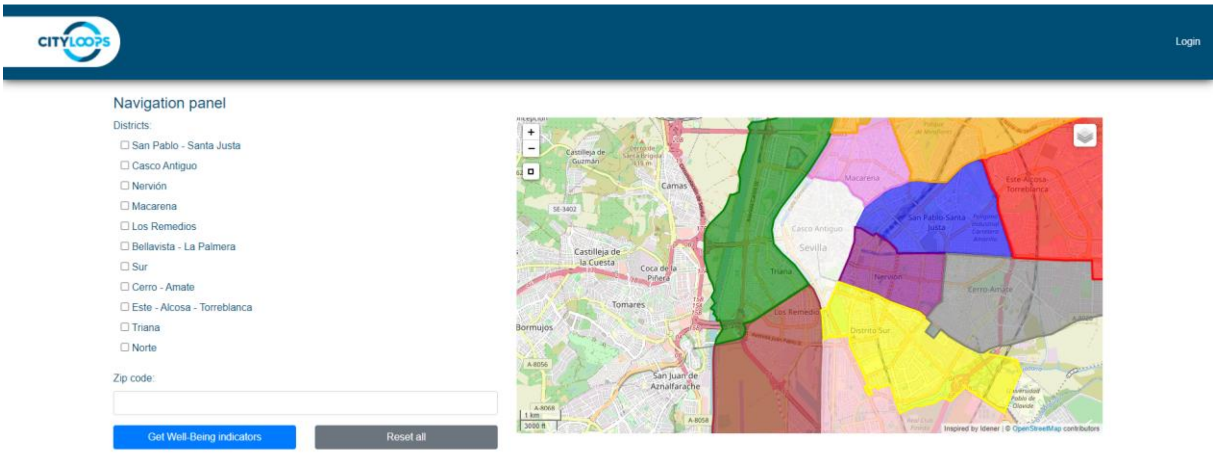


Figure 18. WB platform main page.

When the user clicks on the submit button, the application will show the results in a column that will appear between the original form and the map (Figure 19). The column will contain a collapsible with each district that the user selected in the form. Inside each section, the user can see the Wellbeing score for that district and its social, economic, and environmental indicators.

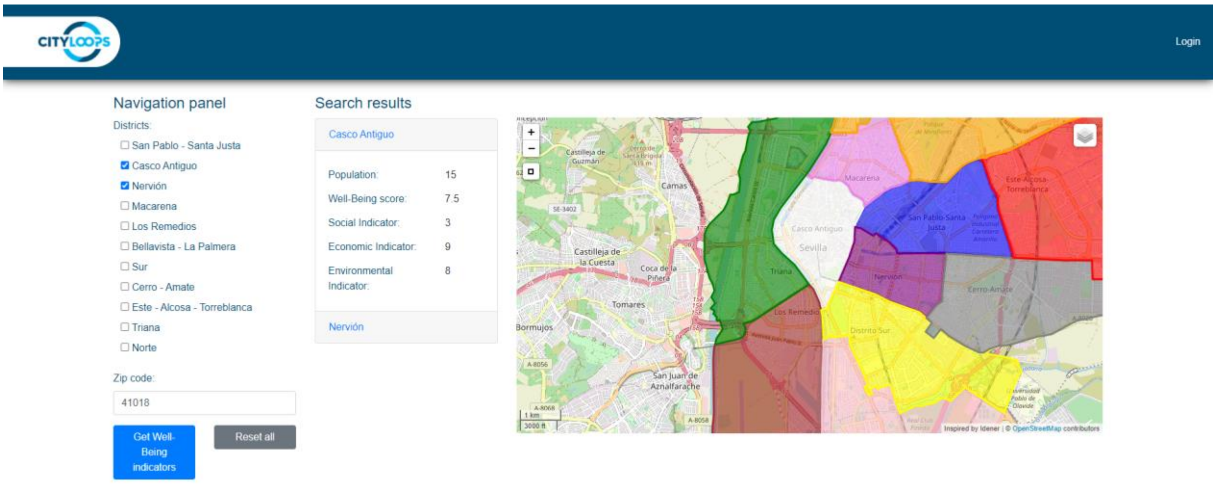


Figure 19. WB platform main page showing the results.

9.2. Manager platform

The manager platform has several pages to perform actions related to the management of the application and its resources.

To access the manager platform, the user must click the “Login” link at the top right corner of the page. This will lead them to the login page, in which they can enter their username and password to access the manager platform (Figure 20).

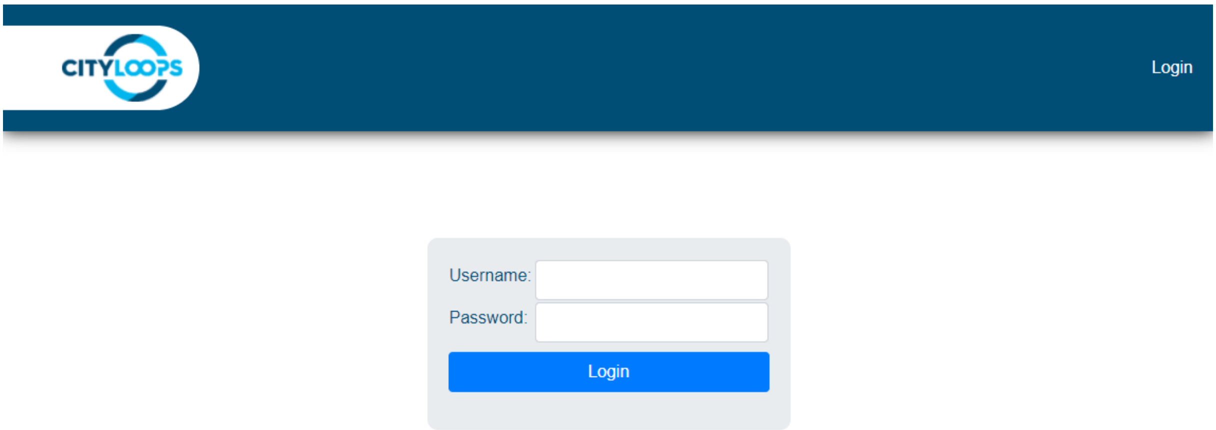


Figure 20. Login screen.

After logging in, the application lets the user access the pages to perform the Well-Being analysis and change the dataset used in the said analysis (Figure 21).

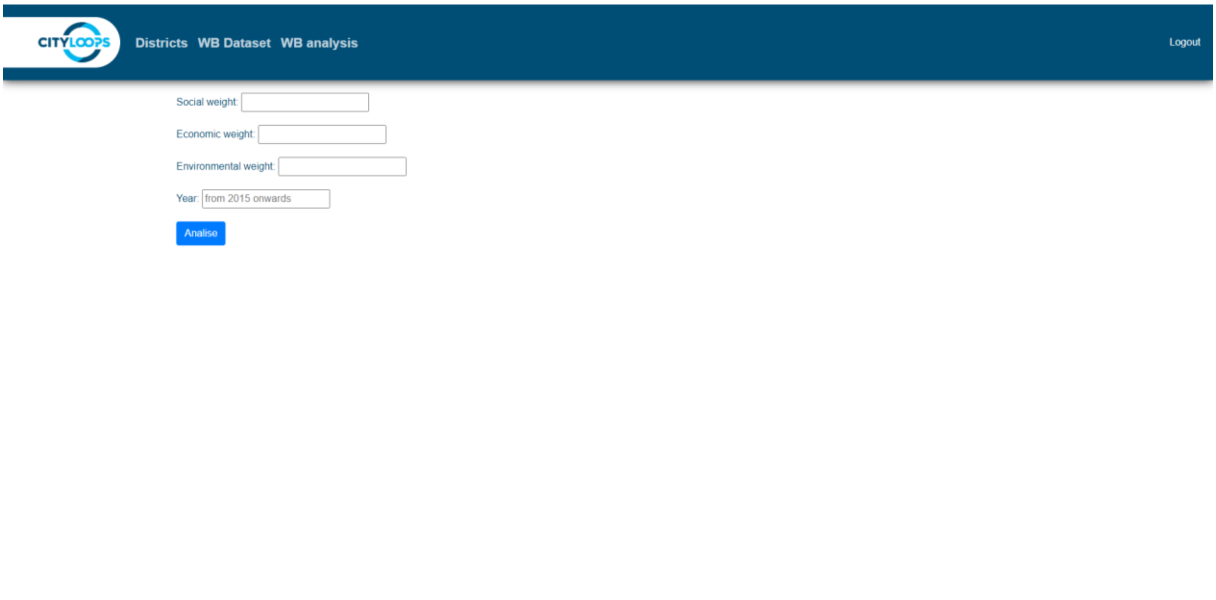
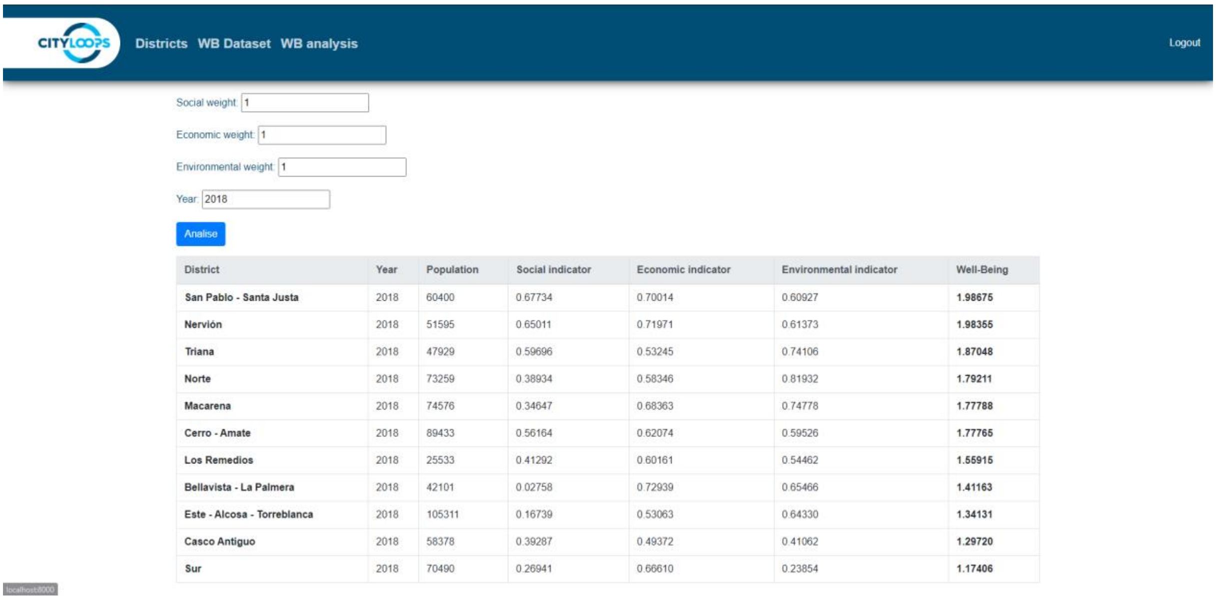


Figure 21. WB analysis.

When the user presses “Analyse”, the app shows the results (Figure 22).



District	Year	Population	Social indicator	Economic indicator	Environmental indicator	Well-Being
San Pablo - Santa Justa	2018	60400	0.67734	0.70014	0.60927	1.98675
Nervión	2018	51595	0.65011	0.71971	0.61373	1.98355
Triana	2018	47929	0.59696	0.53245	0.74106	1.87048
Norte	2018	73259	0.38934	0.58346	0.81932	1.79211
Macarena	2018	74576	0.34647	0.68363	0.74778	1.77788
Cerro - Amate	2018	89433	0.56164	0.62074	0.59526	1.77765
Los Remedios	2018	25533	0.41292	0.60161	0.54462	1.55915
Bellavista - La Palmera	2018	42101	0.02758	0.72939	0.65466	1.41163
Este - Alcosa - Torreblanca	2018	105311	0.16739	0.53063	0.64330	1.34131
Casco Antiguo	2018	58378	0.39287	0.49372	0.41062	1.29720
Sur	2018	70490	0.26941	0.66610	0.23854	1.17406

Figure 22. WB analysis result.

The manager can also change the dataset file used in the application, apart from the weights of every parameter in the dataset.

9.3. City simulation platform

When the user enters the platform, they will see two sections below the page header. The first section presents three buttons (Figure 23). Each button takes the user to one of the application platforms (Construction and Demolition Waste, Organic Waste and Wellbeing).

Below the first section, there is another with the logos of the organisations involved in the application development. When the user clicks each logo, it will take them to the organisation web page.

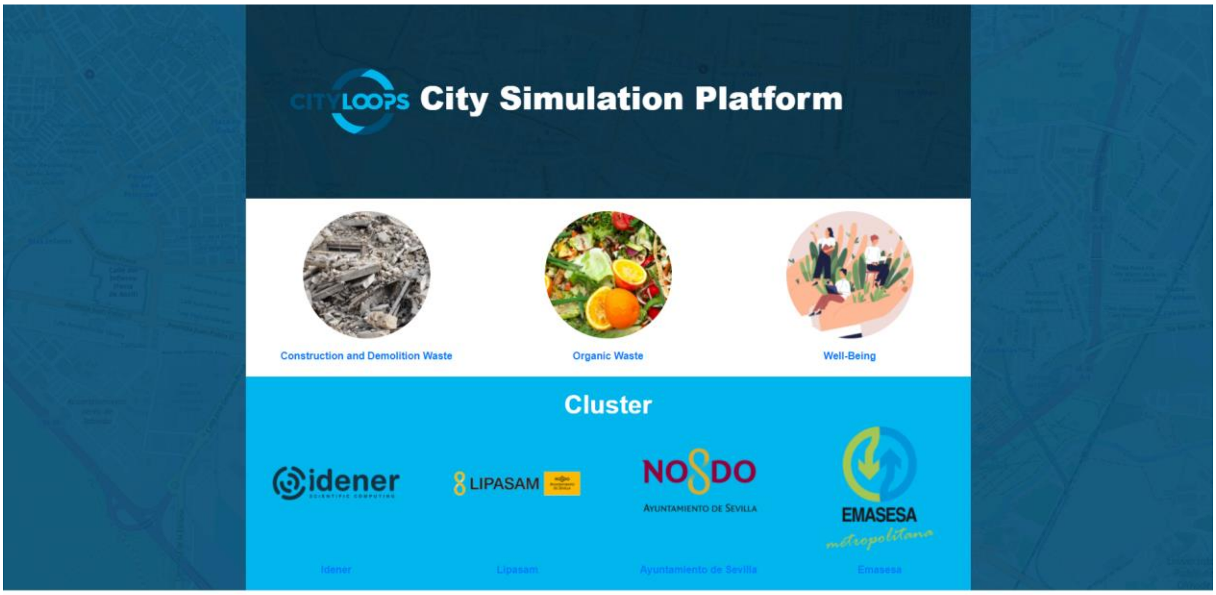


Figure 23 City Simulation Platform

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