TURAS

TRANSITIONING TOWARDS URBAN RESILIENCE AND SUSTAINABILITY

Deliverable 1.2
Framework for G-ICT infrastructure: integrated database and tools

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1. Introduction

1.1. The scope of the deliverable

Deliverable 1.2) Model of GIS database: Generalised model, demonstrating final version of GIS database and tools providing a framework that could be applied in various contexts and scales, internationally and locally.

Over the course of the project this deliverable evolved to what is now more precisely termed*: Framework for G-ICT infrastructure -- integrated database and tools.*

Deliverable 1.2 is directly related to Task 1.4: *Development and employment of G-ICT tools for specific WP areas*, and Task 1.5 *Training, integration and evaluation - -TURAS City Viewer and tools.*

Task 1.4 Development and employment of G-ICT tools for specific WP areas.
This task involved the development of specific geospatial and information technology (G-ICT) tools for the different WP areas (cities and regions), as well as the utilisation of the tools within the development context.

The scope of this task was to:
- To provide substantive analysis, visualisation and communication tools tailored to each application area, in addition to the general database support with contextual information (TURAS City Viewer / webGIS).
- Integrate the partners' expertise and existing technologies into the tools.
- Work in close collaboration with other project partners especially work package leaders on development of tools and respective applications.

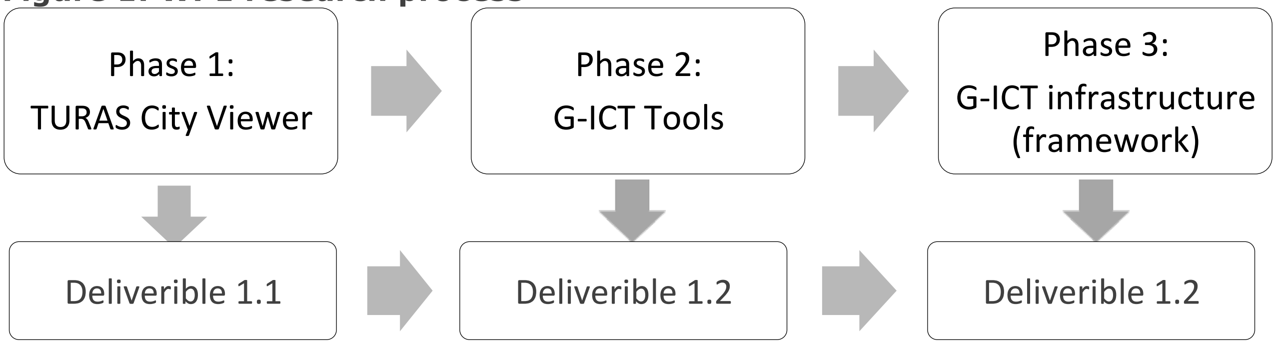
Task 1.5 Training, integration and evaluation- -TURAS City Viewer and tools

The scope of this task was to:
- Provide a training workshop for all project partners on the common support database (webGIS) and tools.
- To assist local authorities in integration of the webGIS framework and tools with their existing ICT and planning infrastructure.
- To evaluate the usefulness of these tools for the local authorities.

1.2. Methodology

The development of the Framework for G-ICT infrastructure -- integrated database and tools -- builds upon Phase 1 of the research project in which the TURAS City Viewer, a contextual webGIS for each of the partner cities was developed (Figure 1). Phase 2: Development of G-ICT tools and Phase 3: Generalised framework completes the research agenda for WP1 of the TURAS project: Geospatial ICT – Support Infrastructure for Urban Resilience.

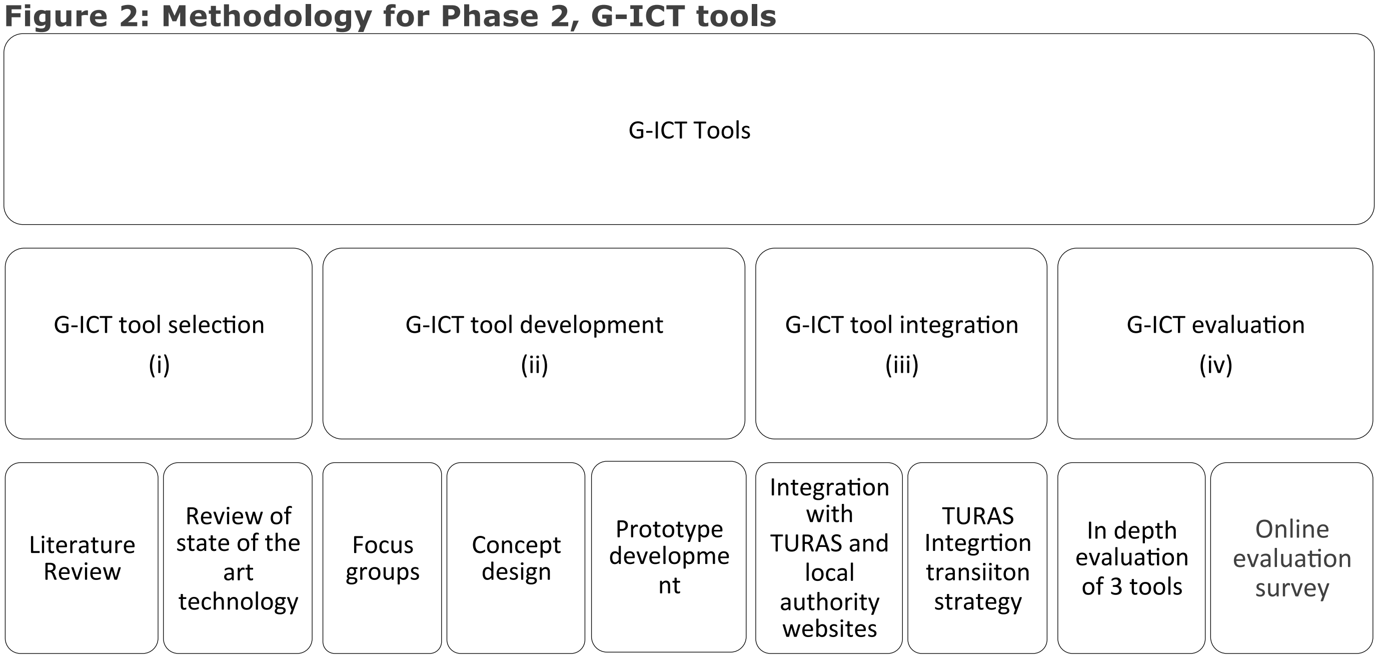
Figure 1: WP1 research process



Phase 2: G-ICT tools and generalised framework

Tool prototyping methodology was used in the development of the G-ICT tools and the Framework for G-ICT infrastructure. This methodology included the selection of tools, tool development, integration and evaluation (Figure 2).

Figure 2: Methodology for Phase 2, G-ICT tools



(i) G-ICT tool selection

- University College Dublin (UCD) was responsible for the co-ordination with other WPs for the initial consideration of tools which were to demonstrate the potential of G-ICT technology to support urban resilience and sustainability.
- A literature review was carried out and a matrix for selecting tools was developed based on resilience issues, resilience principles and planning methods.
- A review of the state of the art G-ICT in urban planning was conducted.
- In collaboration with WP leaders, it was determined what types of G-ICT tools may be appropriate for each of the case study area and relevant urban issues.

- University College Dublin (UCD) worked with each of the WPs to ensure the prototype development and / or integration.
- Total of 8 tools were selected, of which 5 were to be developed by WP1 and 3 to be developed by other WP partners.

Review of the state of the art G-ICT in urban planning

There are various G-ICT technologies – some existing, some emerging -- and many applications for which they are suited and used. To date many of them have been employed for the support of urban planning (Garcia-Doradio et al, 2013), but also many other areas, such as sustainable transport (Bartle et al, 2013) and tourism (Taha, 2012). In addition to traditionally used geographic information systems (GIS) many other G-ICT technologies have been applied across the field of urban planning. They increasingly rely on sophisticated visualisation techniques and new communication channels, such as social media. (Table 1).

Table 1: Examples of G-ICT applications for urban planning

	G-ICT	Planning method(s)	Author	Application	Output
1	Geospatial Video	Visualisation / integration	Mills (2010)	Recording the architectural heritage of New Orleans for the effective integration of heritage conservation into a broad range of resource management and planning activities.	Visual documentation and a spatial archive. Ability to see progress or decline in fine scale.
2	Terrestrial Laser Scanning	Analysis / Visualisation	Sampson et al (2012)	Flood modelling – shows flood wave propagating across an urban domain responds to small scale topographic features, such as street kerbs.	Accurate representation of small scale topographical features in urban areas.
3	3D Modelling	Visualisation / Analyses /Integration	Yuan et al (2014)	Meteorological information and 3D urban morphology data were simplified and integrated to provide the detailed information of the urban permeability distribution for evidence based decision making.	Spatial distribution information, both master and district planning goals for better urban wind environment can be particularly identified and corresponding planning strategies can be established.
4	Serious	Visualisation	Poplin (2012)	Testing the	Simulation of

	Games			movement of a university campus to a new location.	scenarios and the consequences of decisions.
5	Social Media	Communication	Bartle et al (2013)	Use of a geowiki by cyclists to share routes and other cycling information.	Data available on a wide range of scales. Connection with a large audience.
6	Sensor Technology	Analyses / visualisation / integration.	Sempere –Paya and Santonja-Climent (2012)	To evaluate urban waste water networks to prevent critical situations.	Collection of information with sufficient time to deal effectively with critical situations such as flooding or overloading of the waste water system.
7	Virtual Reality Simulation	Visualisation	Watcharasukarn et al (2012)	To measure the long range resilience of urban activity systems to fuel supply decline.	The assessment of the adaptive potential of the respondents.

Rationale for tool selection

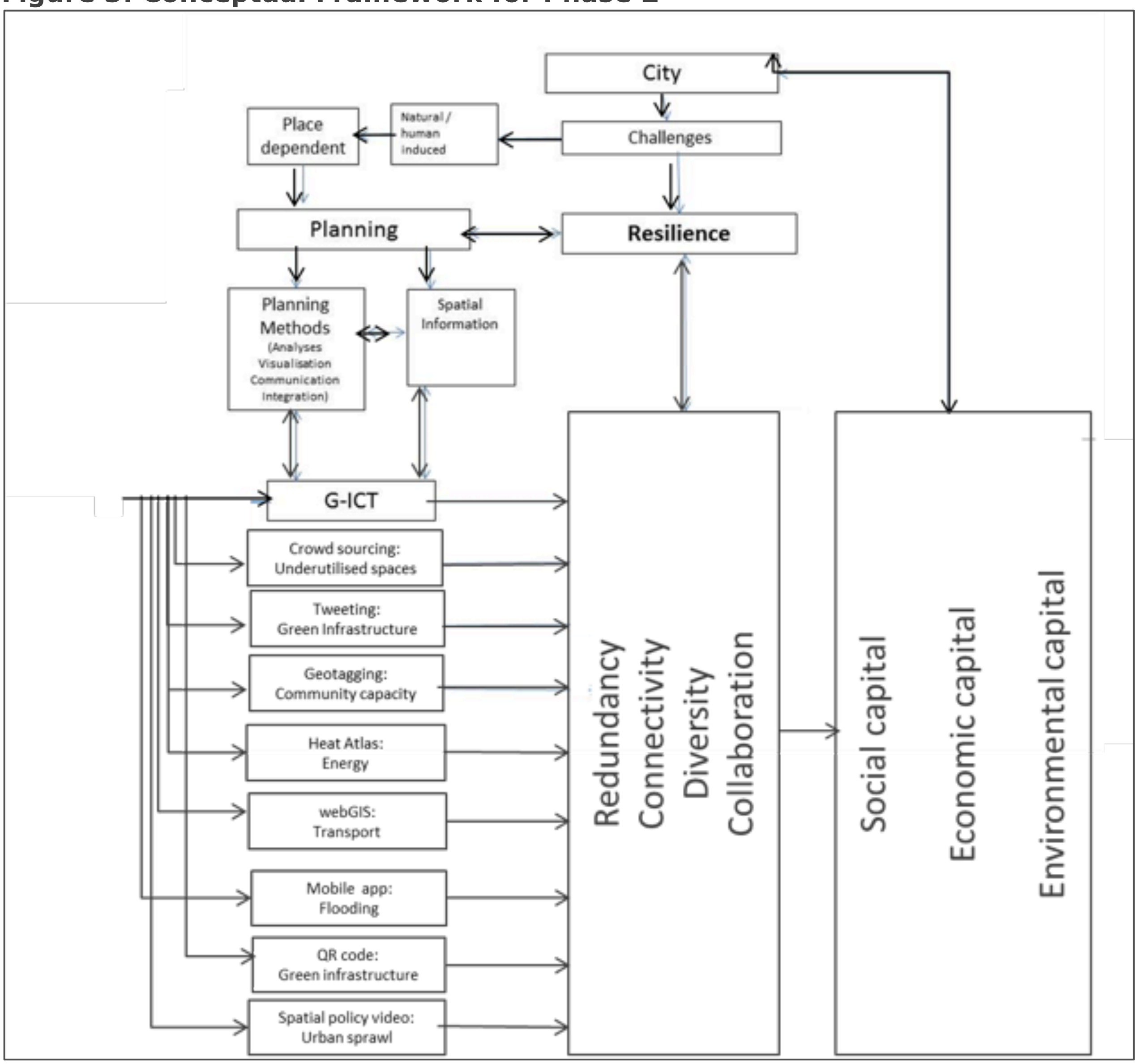
The context of this research is the city which faces increasing environmental, social and economic challenges. These challenges are both natural and human induced and vary across scales. These challenges are place-related and place-dependent; they occur within the streets, neighbourhoods and suburbs of cities and are therefore inherently spatial. Locating, addressing and managing the diverse challenges within the realm of the city requires spatial planning. This places a significant emphasis on approaches, tools and methods which deal with spatial information. Emerging from the fields of information systems and science are Geospatial information and communication technologies (G-ICT) which can incorporate and manipulate this type of data.

As the notion of resilience rapidly gains ground, this research proposes resilience as a way in which to frame the actions addressing the urban challenges and ensuring the transition to a more sustainable future. Resilience is defined as the ability of a city and its enabling environment to maintain, regain and establish functional resources, services and structure on a range of scales in the face of sudden or gradual changes (Wardekker et al, 2010; Ahern, 2011; Longstaff et al, 2010). In order to connect to the process of building urban resilience the most common principles are identified in the relevant multi-disciplinary literature: diversity, redundancy, collaboration and connectivity. These four principles are operationalised in the context of urban issues: underutilised sites, community capacity, green infrastructure, energy, flooding, urban sprawl and transportation.

Connecting these principles to the city requires a definition of city. A comprehensive view of three types of capital -- social, economic and environmental -- as the triple line that underlies the urban context and functioning is used to define cities for the purpose of this research. It is suggested that these capitals allow for identification of areas in which the principles of resilience can be operationalised. That means that in developing these capitals we must ensure that they embed the principles of resilience, i.e., that they are redundant, diverse, collaborative and connected to withstand the current and future challenges.

In order to achieve resilience, it is critical to connect the three types of capitals with the four principles of resilience and to identify opportunities for the application of these principles in cities. Identifying opportunities for redundancy, diversity, collaboration and connectivity of the cities' social, economic and environmental capital requires both the efforts of planners, communities and stakeholders and the appropriate information and tools. The traditional planning methods of analyses, visualisation, communication and integration are fundamental to the process. It is argued that tools that knit these methods together will enhance the effectiveness of identifying opportunities for resilience. Hence the tools to address these challenges and their impacts require the ability to analyse, visualise and communicate spatial information. These ideas and concepts are incorporated into the research framework for Phase 2 (Figure 3).

Figure 3: Conceptual Framework for Phase 2



(ii) G-ICT tool development

- Out of 8 tools, 5 were developed by WP1, and the remaining 3 were developed by the respective WPs and only added to the city-specific pages of the previously developed webGIS City Viewer (Table 2).
- Four of the 5 G-ICT tools in charge of WP1 were developed by a consultant hired based on a tendering process. Future Analytics Consulting (FAC), Dublin was awarded the contract. The fifth tool was developed by Sofproect, contractor under the Sofia municipality.
- FAC and Sofproect were provided with a concept design of the tools which would be required.
- Three tools developed by FAC, Reusing Dublin, Meadows timeline and TwitterGI, were based on more explicit user input:
  - Each of the three stakeholders groups for which the tools were specifically developed took part in a focus group where the information and functionality required for each of the tools were identified.
  - The information and functionality required were then fed into the development process for each of the tools.
- FAC provided initial feedback on what was possible to develop based on budget and technical constraints and undertook the development of the prototype tools in collaboration with UCD and each of the relevant WPs.
- Prototypes of the tools were developed in early 2015 and were then improved with feedback from each of the partners involved.

Table 2: G-ICT tools

City	Topic	Level of development	Tool	Resilience Principle	Planning method
Dublin	Underutilised spaces	Full development	Crowd sourced web mapping	Diversity	Analyses
London	Green Infrastructure	Full development	Twitter and geospatial Analytics	Collaboration	Communication
Nottingham	Community Capital	Full development	Geo timeline	Connectivity	Visualisation
Aalborg	Energy	Development of interface	Heat Atlas	Redundancy	Analyses
Stuttgart	Green Infrastructure	Full development	QR code	Collaboration	Communication
Rotterdam	Flooding	Integrated	Mobile Phone App	Collaboration	Communication
Sofia	Urban Sprawl	Integrated	Zoning policy video	Diversity	Visualisation
Ljubljana	Transportation	Integrated	GIS Portal	Connectivity	Analyses

(iii) Integration

(a) Integration of tools with TURAS website

- The 5 G-ICT tools which were developed by WP1 and the 3 G-ICT tools which were previously developed as part of the different WPs were linked to the TURAS website.
- The integration with the TURAS City Viewer was only in form of links which were to provide a connection and presence within the geographical window.
- FAC had the responsibility for linking these tools to the TURAS site and in doing so created a graphical link or each of the tools.

(b) Integration with local authority websites

- Each of the local authorities have been contacted and asked to link their local TURAS City viewer and the G-ICT developed for their area to their websites.

(c) TURAS integration strategy

- WP1 is currently working with WP7 on incorporating the Framework for G-ICT infrastructure -- integrated database and tools -- into the overall TURAS integrated transition strategy.

(iv) Training and evaluation

(a) Training – TURAS City Viewer

- A training workshop on TURAS City Viewer was conducted with all project partners during the Annual consortium meeting in Rome in November 2013.
- The project partners were instructed on how to use the interactive data retrieval, contribution and visualisation and communications tools. A written manual was also provided and made accessible within the TURAS City Viewer.

(b) Evaluation – TURAS City Viewer

- A user evaluation of Phase 1 of the research (development of TURAS City Viewer) was carried out during the course of the workshop at the Annual consortium meeting in Rome in November 2013.

(c.) Evaluation – G-ICT Tools

- User evaluation of Phase 2 (G-ICT tools) is forthcoming. It will be conducted with all project partners through an online survey.
- Three G-ICT tools will be evaluated as part of WP1 PhD research based on the methodologies for evaluation of information systems. The evaluation will focus on two categories: 1) the quality of the system, and 2) the effects of the system. This evaluation will be undertaken with each of three specific stakeholder groups who provided input into the prototype design. Workshops will be organised with each group to evaluate the pertinent G-ICT applications.

Phase 3: Development of Framework for G-ICT infrastructure -- integrated database and tools

- A literature review was carried out on database integration, integration of tools and applications and the development of interfaces for G-ICT infrastructure.
- Lessons learnt from the experiences of developing both the TURAS City Viewer and the G-ICT tools, as well as integration of those tools with TURAS web site were used as input into conceptualisation of the general framework.

1.3 Partners Involved in D 1.2

University College Dublin is the lead partner for this task. Over the last 18 months they have been working closely with the leaders of other WPs, municipalities, project partners and the technical development team in Future Analytics Consulting (FAC) on the detailed specification, development and implementation of the TURAS prototype G-ICT tools.

2. Content

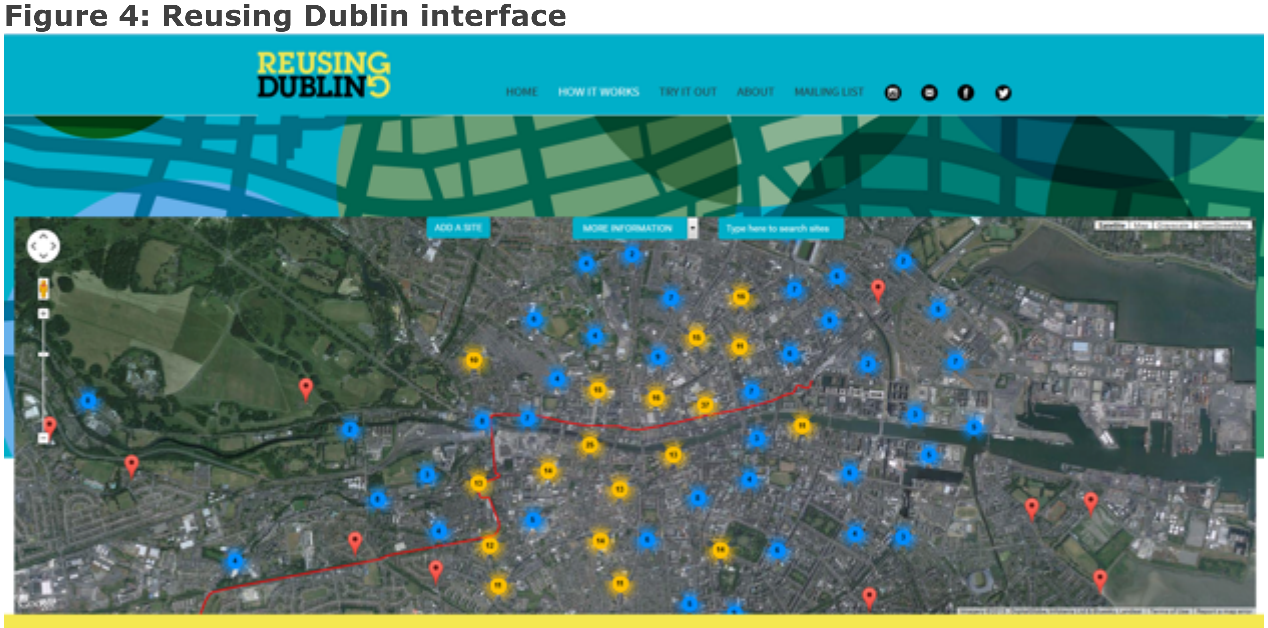
2.1 The G-ICT Tools

In addition to the general webGIS support with contextual information for each of the case study cities and regions (TURAS City Viewer) the WP1 team provided substantive analysis, visualisation and communication tools tailored to each of the project application areas. This resulted in the development of 5 G-ICT tools by WP1 and the linking of 3 G-ICT tools developed by other WP partners into the overall framework for G-ICT infrastructure. The eight G-ICT tools which are incorporated into the framework are outlined below.

2.1.1 Reusing Dublin

Description
Reusing Dublin is a crowd sourced web mapping application for the identification of underutilised sites in Dublin (Figure 4). Reusing Dublin was developed as part of WP3: Urban/Industrial Regeneration, Land Use planning and Creative Design to address the issue of underutilised sites in Dublin and the challenge of mapping them. Reusing Dublin was also developed to gather additional information on underused sites which would aid the planning authority in envisioning the ways to diversify the reuse of these sites, and consequently assisting in developing better economic capital within the city.

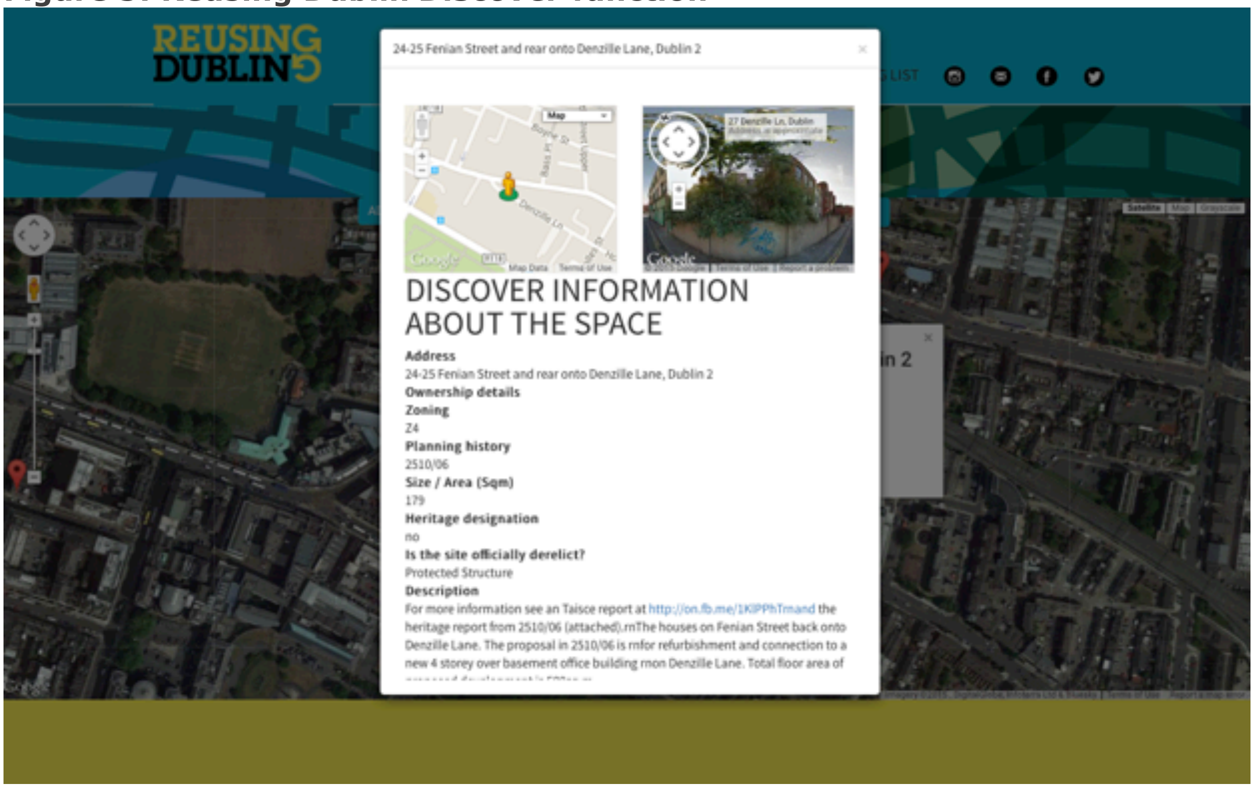
Figure 4: Reusing Dublin interface



Functionality
Reusing Dublin has six main functions: Discover information, Add information, Connect with others, Data layers, Search and Links to social media.

Discover information: By clicking on sites which have already been added to Reusing Dublin a user can discover information about a site (Figure 5). There are 10 different categories of information which can be viewed: address, ownership, zoning, planning history, heritage designation, derelict status, area, suggested uses for the site, why the site has been highlighted and description. The *Discover information* function also has a link to Google maps to show the location of the site and a link to Google Street view as so the user can view the site and the surrounding area.

Figure 5: Reusing Dublin *Discover* function

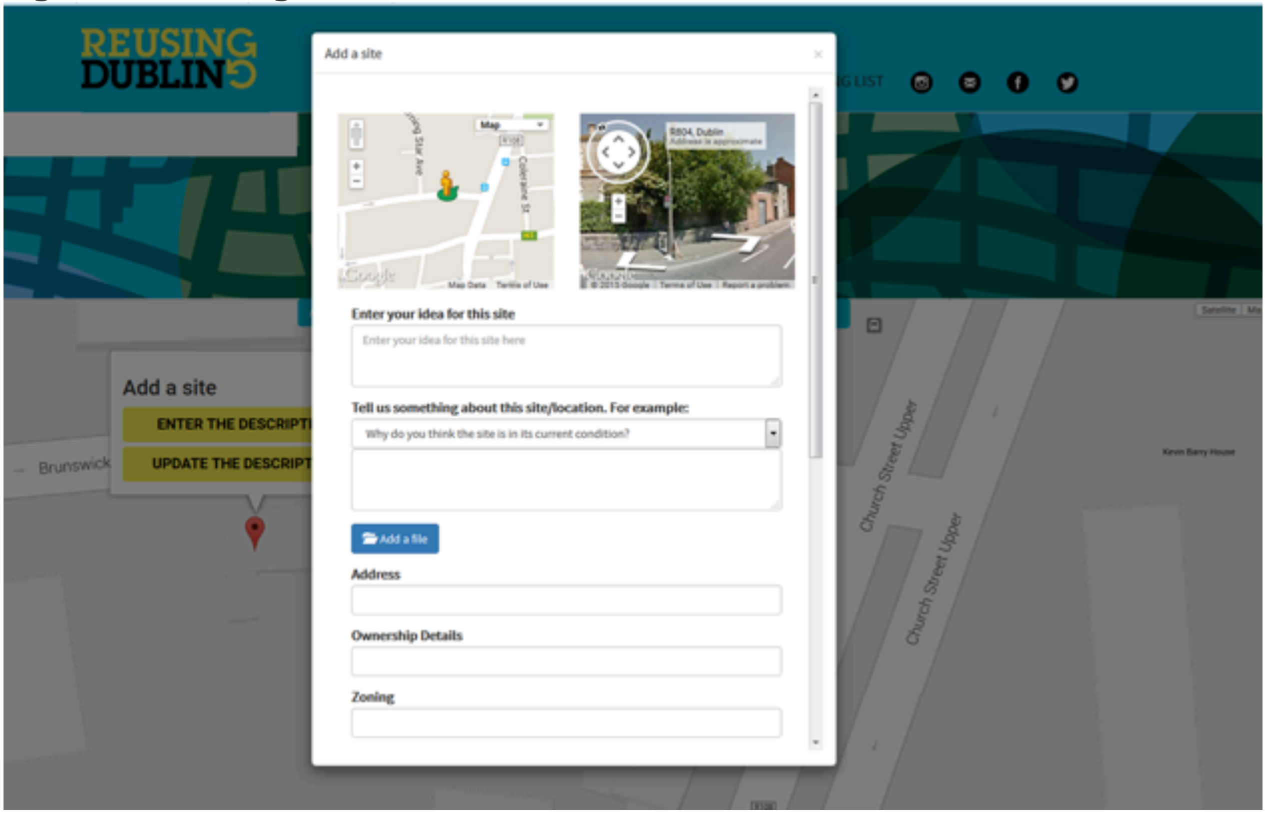


Add information: Reusing Dublin has the functionality to add information (Figure 6). The *Add information* functionality allows any user to add an underutilised site to the web mapping page. There are nine categories of information which the user can input:

1) An idea for the site
2) Any information relevant to the site
3) Address
4) Ownership details
5) Zoning
6) Planning history
7) Size
8) Heritage designation
9) Is the site officially derelict

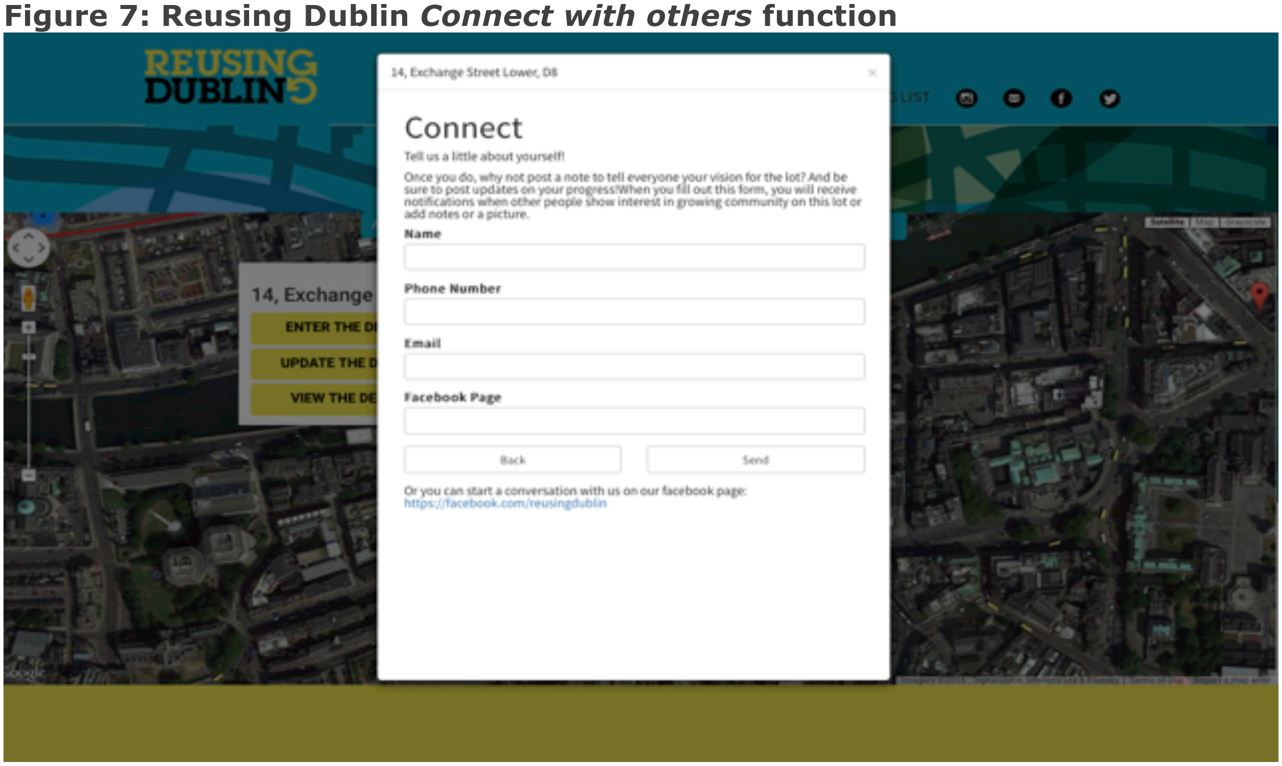
Add a file: The user can add a file to each entry. These files can be text documents, images or videos.

Figure 6: Reusing Dublin *Add information* function



Connect with others: Reusing Dublin also offers the functionality to connect with others about a site (Figure 7). The *Connect* function allows users to leave their details in order to receive notifications when other people show interest in the site. The *Connect with others* function encourages users to engage in conversations about each of the sites.

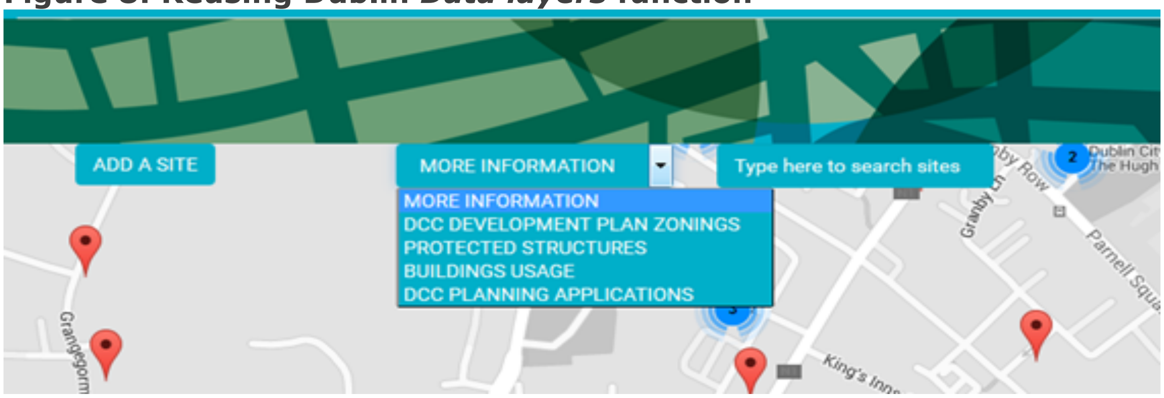
Figure 7: Reusing Dublin *Connect with others* function



Data layers: Reusing Dublin has four different data layers which can be viewed on top of the base map (Figure 8). They are available when the user clicks the "MORE INFORMATION" dropdown bar. The data layers are:

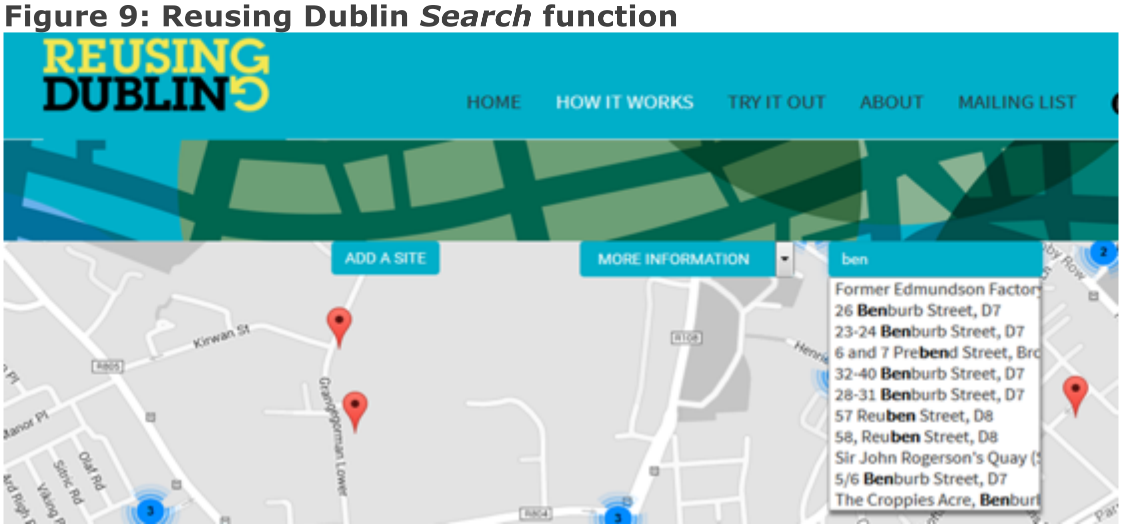
- Dublin City Council development plan zoning
- Protected structures
- Building usage
- Dublin City Council planning applications

Figure 8: Reusing Dublin *Data layers* function



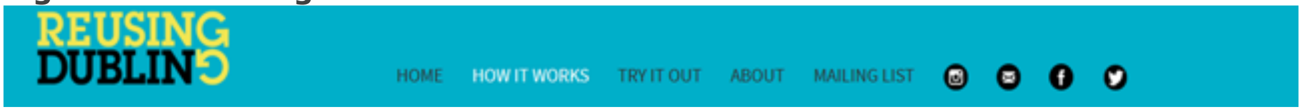
Search: Reusing Dublin has a search functionality which allows users to search the underused spaces which are included in the website (Figure 9). The spaces are searchable by address.

Figure 9: Reusing Dublin *Search* function



Links to social media: Reusing Dublin has links to the Reusing Dublin social media accounts: Facebook [Reusing Dublin Facebook], Twitter [Reusing Dublin Twitter], Instagram [Reusing Dublin Instagram] and the Reusing Dublin email address (Figure 10).

Figure 10: Reusing Dublin *Links to social media* function



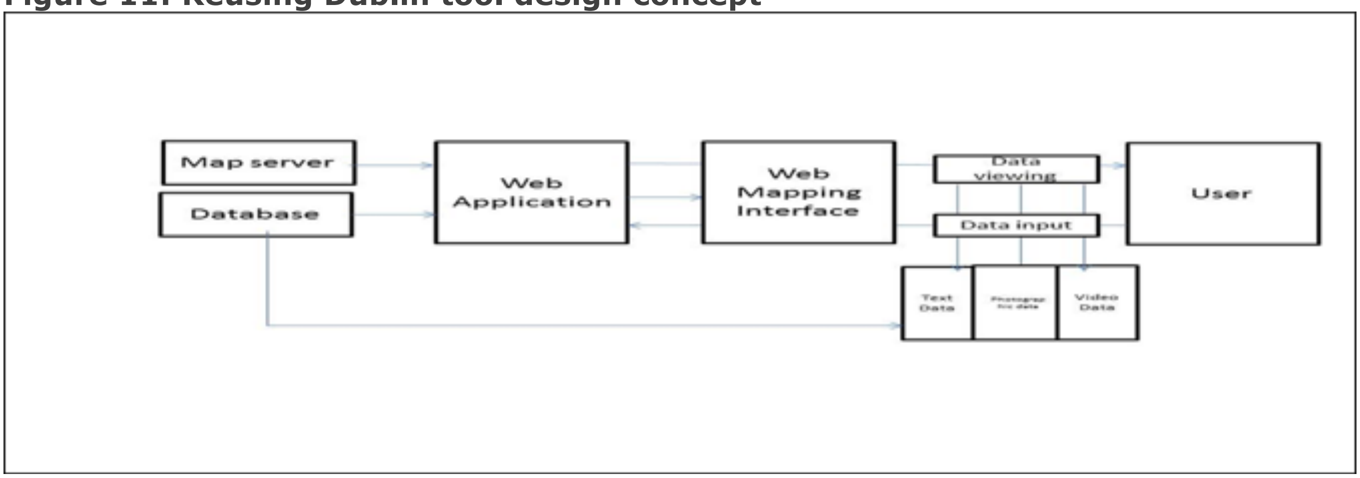
Technical Development

Reusing Dublin was developed by Future Analytics Consulting based on a tool design concept (Figure 11) and using the software outlined below. The tool design concept outlines how the user can both input and view data into the web mapping application through the web map interface. This data is stored using a database and displayed using a map server.

Software

- MySQL - Database management system
- php - Web scripting language, connecting app to database
- HTML - Hypertext markup language, used to develop web pages
- CSS - cascading style sheet, formats design of web pages
- Javascript - web scripting language

Figure 11: Reusing Dublin tool design concept



Links

1. Reusing Dublin

Partners Involved

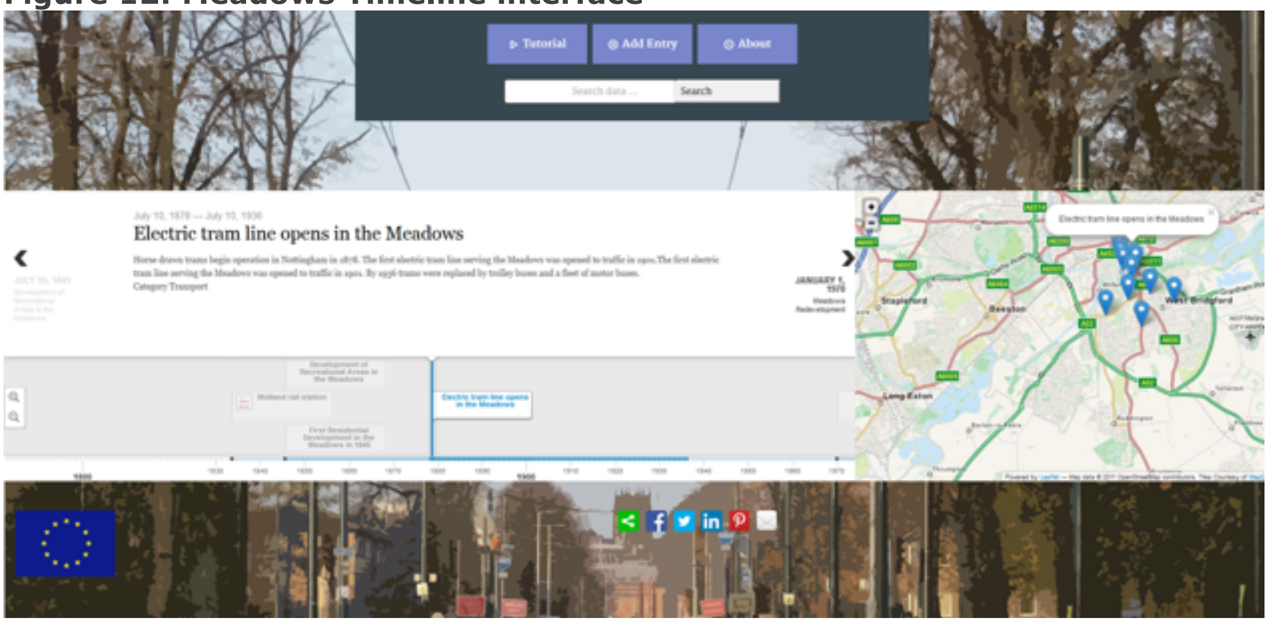
University College Dublin was the lead partner in the development of Reusing Dublin. Reusing Dublin was developed as part of WP3 and all Dublin WP3 partners were involved. Dublin City Council planners and local citizen stakeholders were involved in the development process through a series of focus groups. Future Analytics Consulting undertook the technical development of this tool.

2.1.2 The Meadows Timeline

Description

The Meadows Timeline is a geo-timeline application which links historical events in the community to a community map (Figure 12). The Meadows Timeline was developed as part of WP3: Urban/Industrial Regeneration, Land Use planning and Creative Design to address the issue of community capacity in the Meadows neighbourhood in Nottingham. Connecting to events or knowledge from the past is important to facilitate social learning and problem-solving ability and therefore begin to build community capacity. The aim of building the community capacity is to increase social capital. The ability to visualise information about different geographical areas was essential to the success of identifying both previous and potential opportunities for connectivity within the community.

Figure 12: Meadows Timeline interface

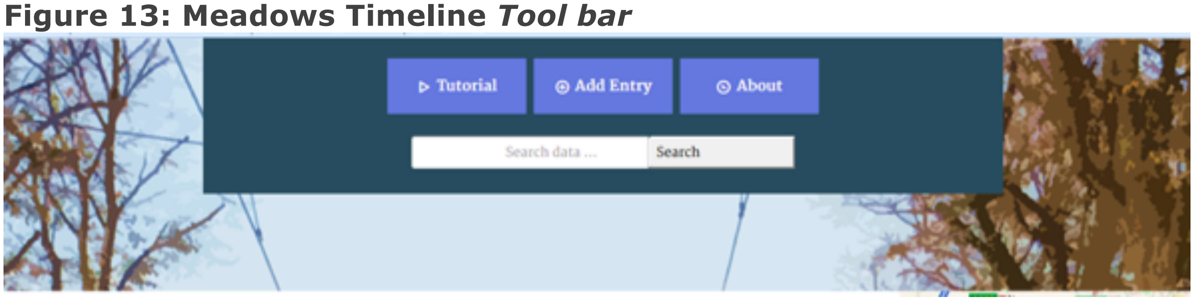


Functionality

The Meadows timeline has five main functions: Tool bar, Tutorial, About, Add entry, Add a file, Search bar, Timeline, and Social media links.

Tool bar: Upon opening the site, the user sees the tool bar with three buttons at the top of the screen: *Tutorial*, *Add Entry* and *About* (Figure 13). The *Tool bar* also has a search function to search entries made on the timeline.

Figure 13: Meadows Timeline *Tool bar*

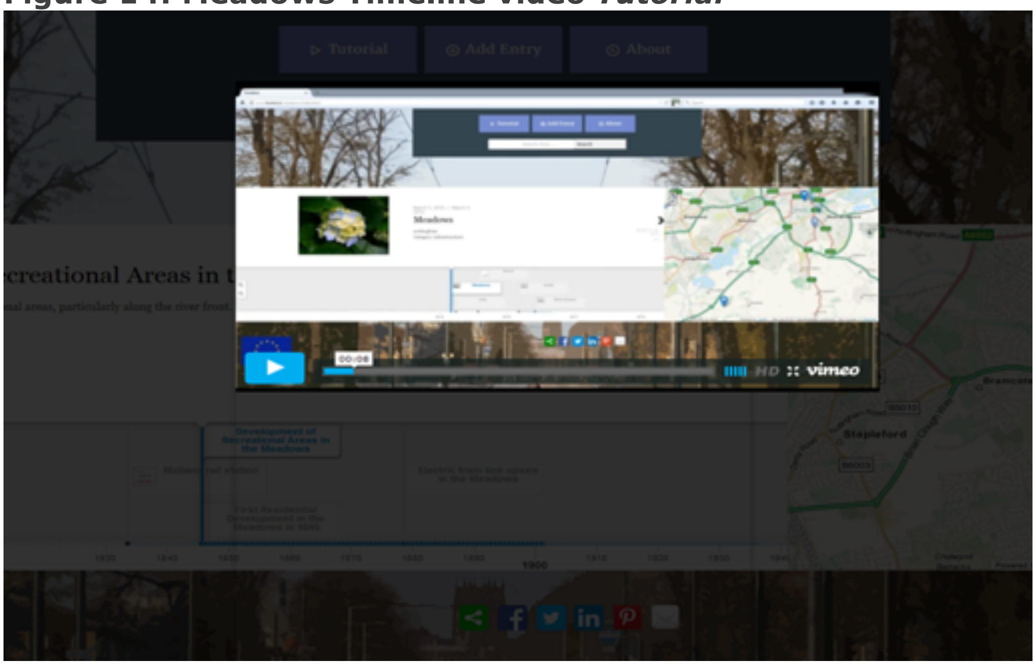


Tutorial: A user can access a brief video tutorial which will show how to use the application by selecting the tutorial option (Figure 14). This function helps those with limited literacy skills access the application.

About: This provides users with information in regards to the application, its purpose, its partnership with TURAS and an invitation to users to add information to the system.

Search bar: A search bar allows a user to search for specific information within the application. If a match is found to the search criteria, the map selects that pointer and the slider will move to the correct location and give the user the information available about the particular site.

Figure 14: Meadows Timeline video *Tutorial*



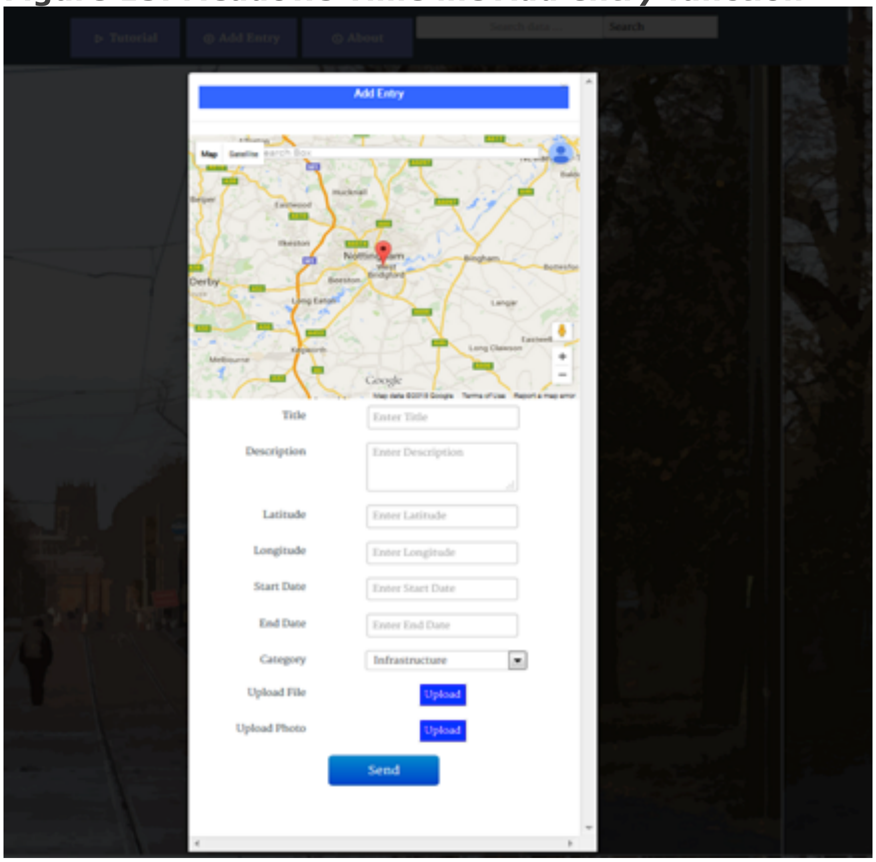
Add Entry: The application allows a user to add an entry to the timeline by clicking the *Add entry* button (Figure 15). The *Add entry* functionality provides the user with a map of the area and allows them to select a location on the map, for which they can make an entry. There are 5 categories of information which the user can input:

- Title
- Description
- Start date
- End date
- Category

Add a file: The user can add a file to each entry. These files can be text documents, images or videos.

Search bar: A search bar is provided to allow users to search for locations in relation to other landmarks in the community. These landmarks have been predefined based on landmarks which were highlighted by the community as being important.

Figure 15: Meadows Timeline *Add entry* function



Timeline: The *timeline* can be scrolled through to access the data points in a chronological order. The timeline is linked to the map. Clicking *"next"* on the *Timeline* brings the user to the next instance and *"back"* brings the user to a previous point (Figure 16). Future projects can also be added to the map as Meadows Timeline stores data up until 2030.

Figure 16: Meadows *Timeline* and map

Social media links: Links to social media are provided at the footer of the page allowing users to share information that has been loaded to the system through sites such as Facebook, Twitter or Linked in.

Figure 17: ***Links to Social media links*** **function**

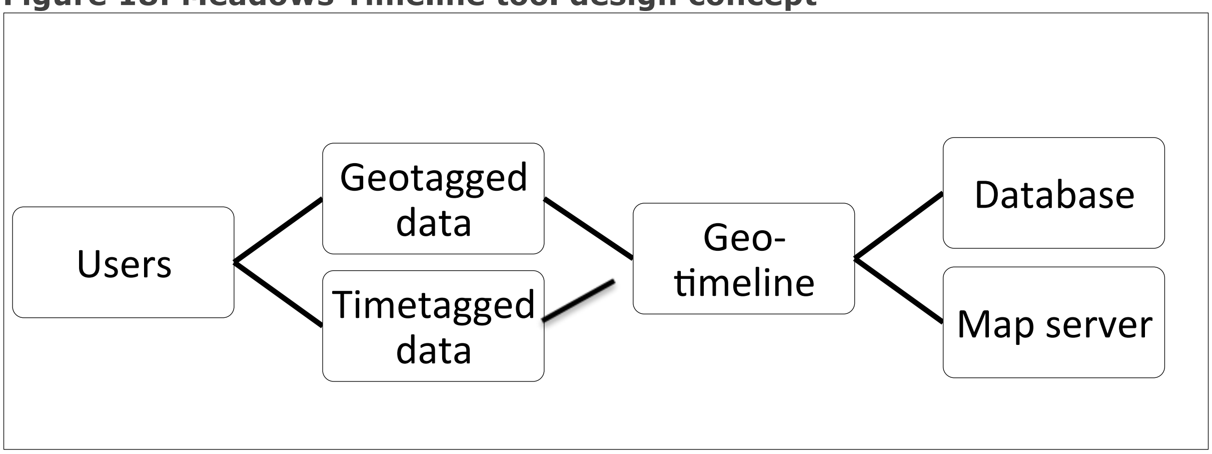
Technical development

The Meadows Timeline was developed by Future Analytics Consulting based on a design illustrated on a schematic diagram in Figure 18. The user can add data which is geotagged and time tagged on the geo-timeline. This is then stored in the related database and displayed through a map server.

Software

- MySQL - Database management system
- php - Web scripting language, connecting app to database
- Javascript - Web scripting language
- HTML - Hypertext markup language, used to develop web pages

Figure 18: Meadows Timeline tool design concept



Links

1. The Meadows Timeline

Partners involved

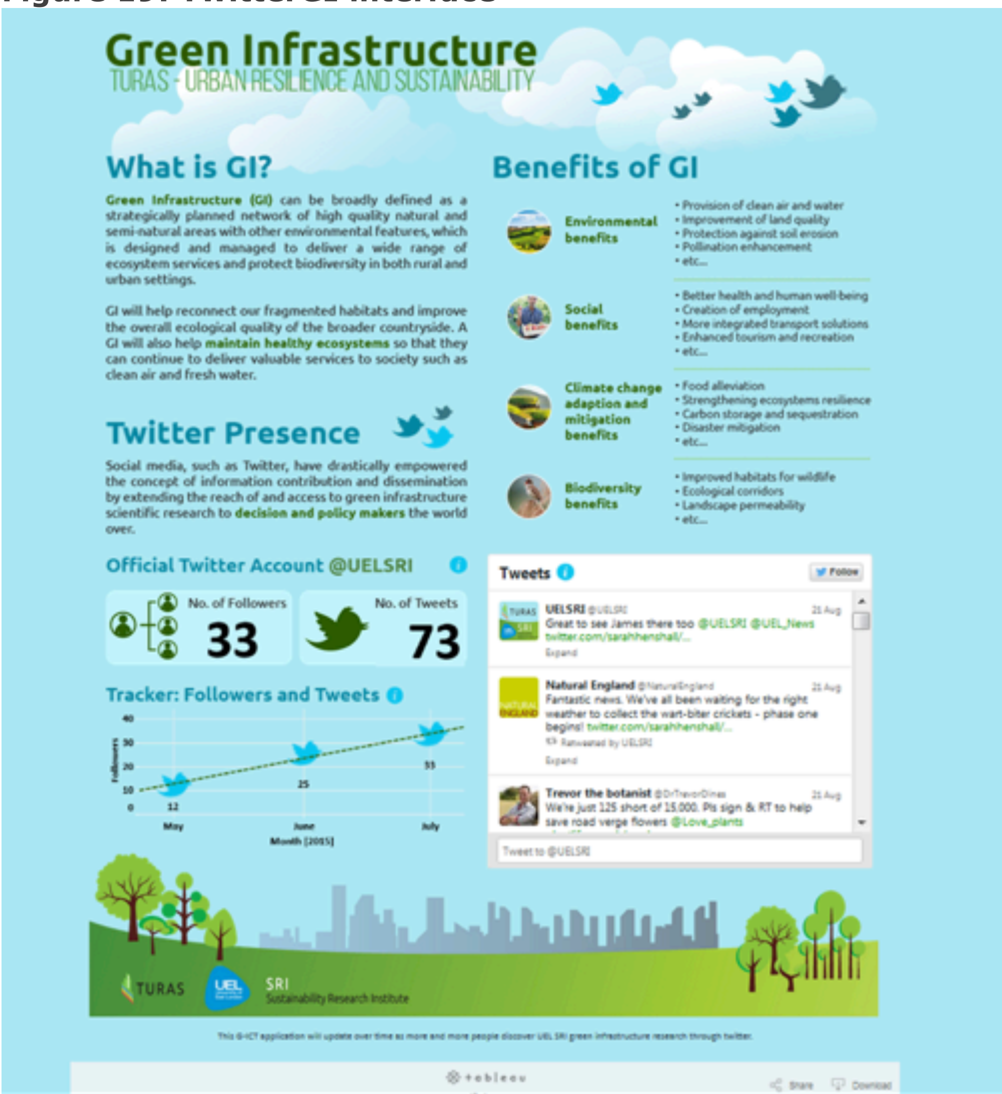
University College Dublin was the lead partner in the development of the Meadows timeline. The timeline was developed as part of WP3 and the main Nottingham WP3 partner, University of Nottingham, was involved in providing feedback and some initial data. Local citizens and stakeholders were involved in the development process through a series of focus groups in the Meadows community. Future Analytics Consulting undertook the technical development of this tool.

2.1.3 TwitterGI

Description

TwitterGI is a Twitter dashboard which shows graphically the information behind the distribution of tweets about green infrastructure (Figure 19). TwitterGI was developed as part of WP2: Greening Public and Private Green Infrastructure to address the issue of collaboration on green infrastructure. The aim of TwitterGI is to increase the dissemination of green infrastructure research to a range of local and national stakeholders. In doing so, the tool makes policy makers more aware of green infrastructure and climate change policies. At the same time the application provides access to scientific data about green infrastructure and climate change in the London area in an attempt to increase its environmental capital.

Figure 19: TwitterGI interface



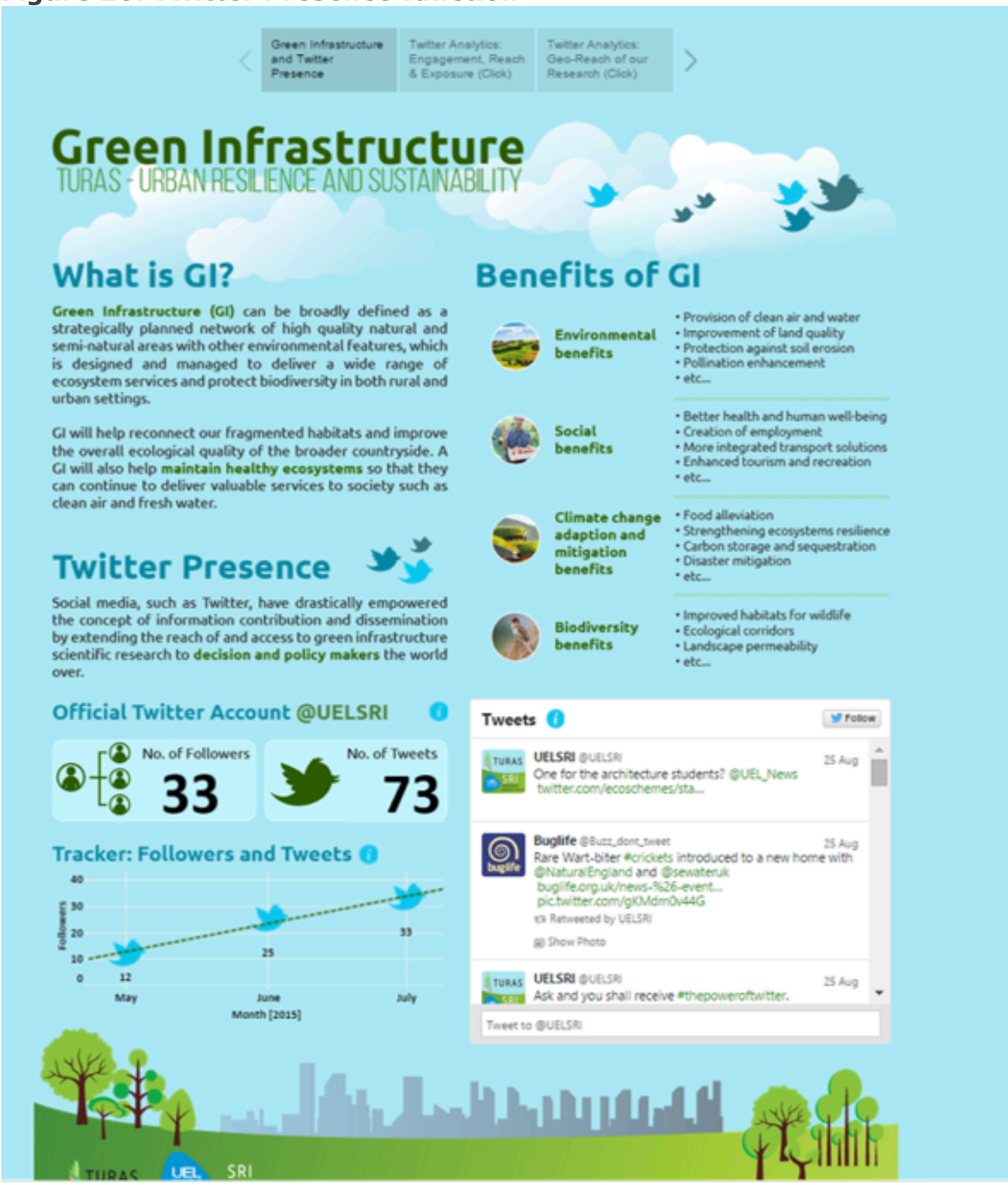
Functionality

TwitterGI has three main functions: Twitter presence, Twitter analytics engagement, Hashtag tweets, Most retweeted, Followers, Reach and exposure and Twitter geographic reach.

Twitter presence: This tracks the Twitter through the Twitter API account (Figure 20). The *Twitter presence* page shows the number of followers and tracks the followers through a simple diagram. This reflects the presence of the account on

Twitter. The Twitter presence page also provides a live link to all Twitter activity from the Twitter account.

Figure 20: *Twitter Presence* function



Twitter analytics engagement: The *Twitter analytics engagement* page gives an overview of the engagement with the Twitter account (Figure 21). It provides information on the Twitter handle, the followers and tweets as well and who is engaging with the account.

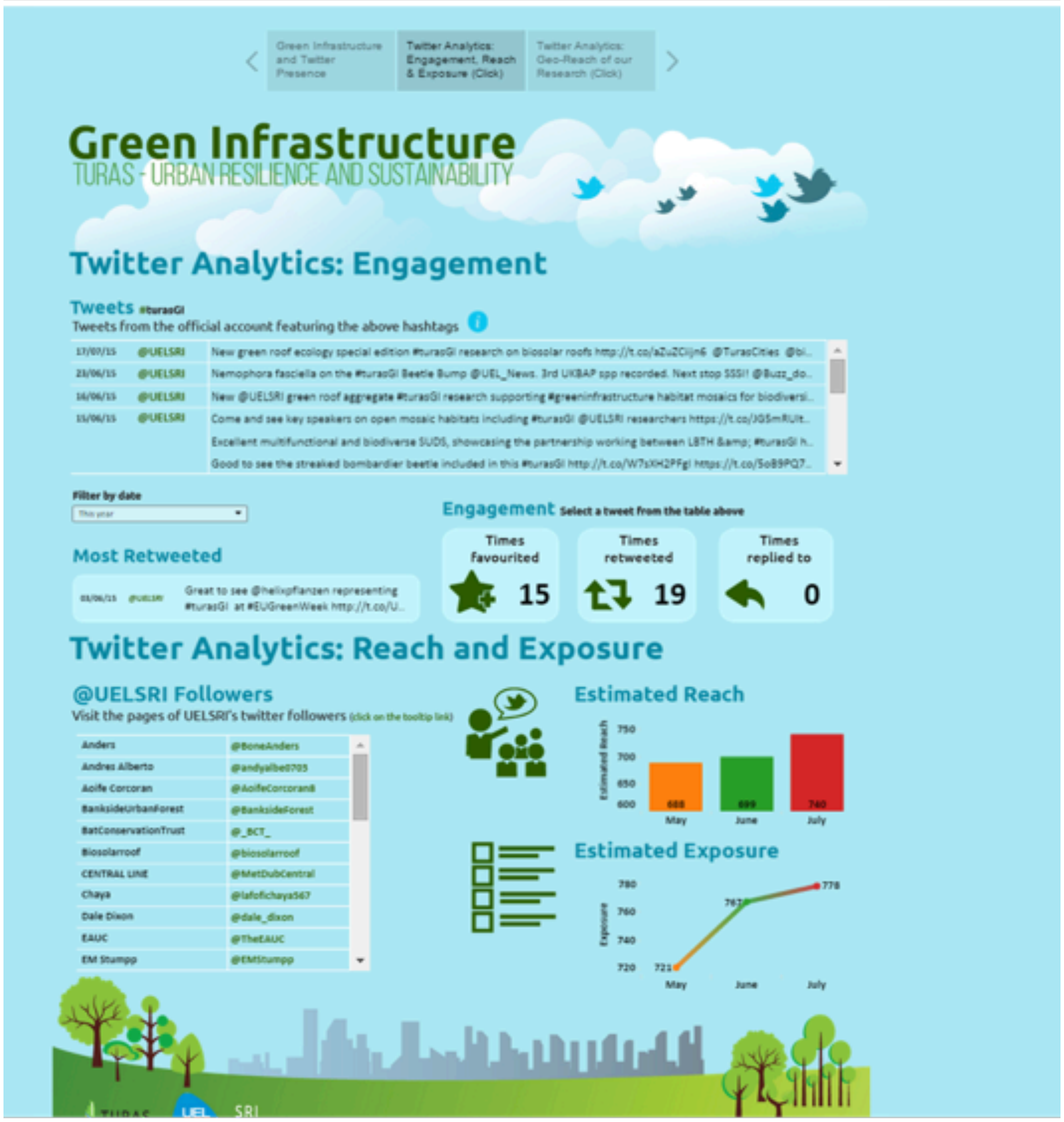
Hashtag tweets: The user can see all tweets which have used the assigned TURAS hashtag #turasGI. This allows the user to see who is posting about the research.

Most retweeted: The page also shows the most retweeted tweet attributed to the account. This allows the user to see where the interests of the majority of the followers lie.

Followers: The Twitter analytics engagement page also shows the Twitter account followers. Allowing the user to see who they are engaging with.

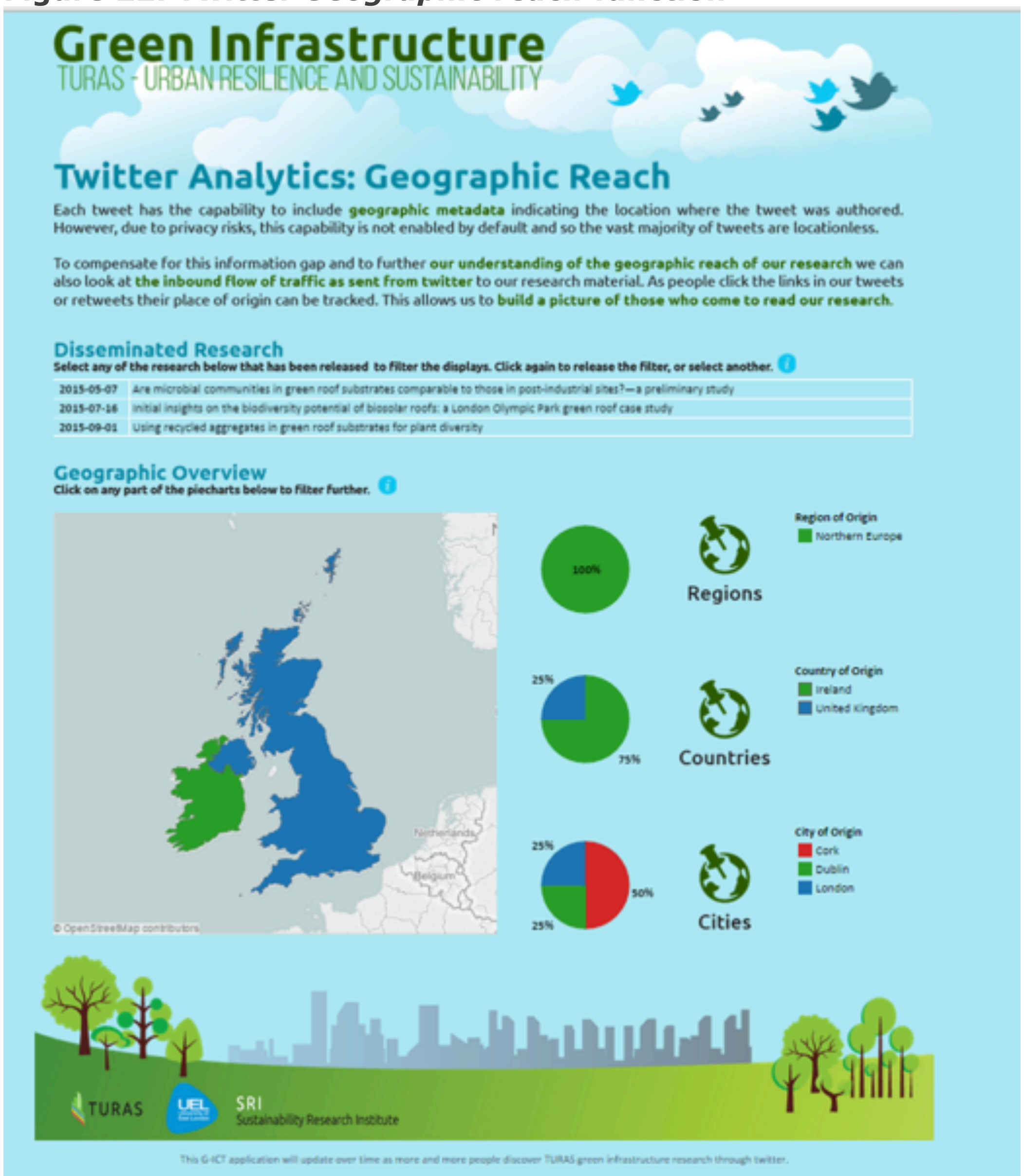
Reach and exposure: The page shows the estimated reach of the tweets and the estimated exposure. The reach shows the total number of estimated unique Twitter users that tweets about the search term were delivered to. Exposure is the total number of times tweets about the search term were delivered to Twitter streams, or the number of overall potential impressions generated.

Figure 21: *Twitter analytics engagement* function



Geographic reach: This page shows the geographical reach of the data (Figure 22). It shows the locations of the Twitter followers who have engaged with the account. The data can be visualised by region, country or by city.

Figure 22: Twitter *Geographic reach* function



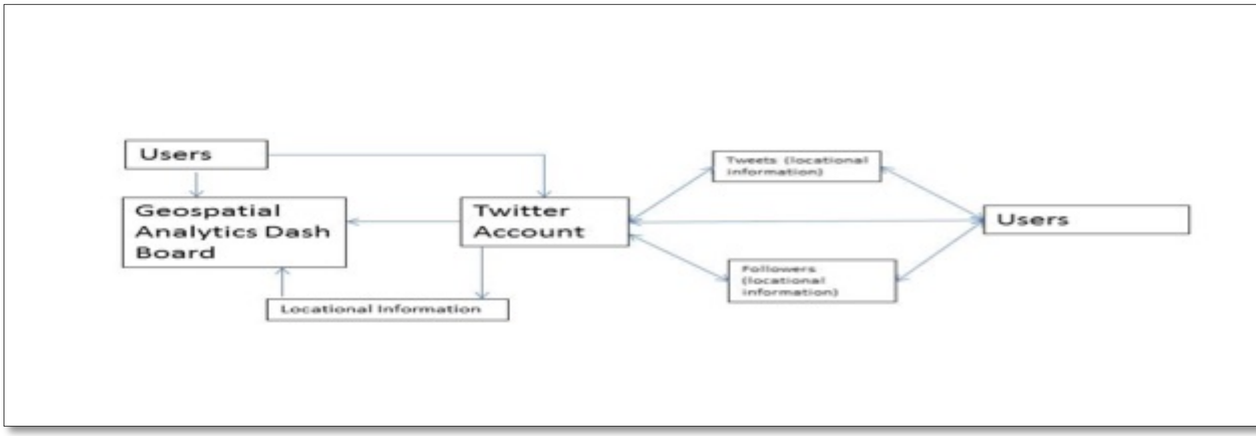
Technical development

The application was developed by Future Analytics Consulting based on the concept tool design (Figure 23). The information attributed by the users is collected through the host Twitter account and displayed on the geospatial analytics dashboard. The application is developed with the software outlined below:

Software

- RStudio - Tool used to query Twitter API
- R - Programming language used for statistics and data analytics
- Tableau - Design for infographics
- HTML - Hypertext markup language, used to develop web pages
- Javascript - Web scripting language

Figure 23: TwitterGI tool design concept



Links

1. TwitterGI

Partners involved

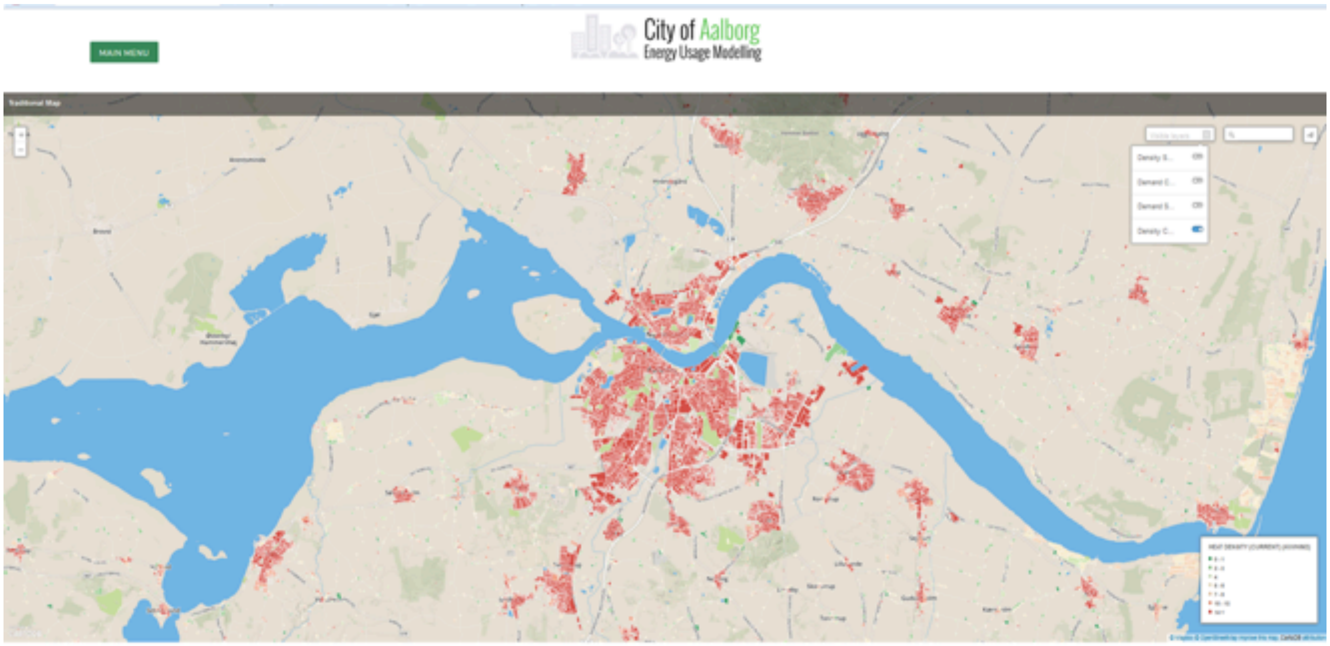
University College Dublin was the lead partner in the development of the TwitterGI tool. TwitterGI was developed as part of WP2 Greening Public and Private Green Infrastructure with the main partner, University of East London in the process which involved a series of focus groups with researchers and academics in the university. Future Analytics Consulting undertook the technical development of this tool.

2.1.4 Aalborg Heat Atlas

Description

The Aalborg Heat Atlas is a web-based GIS viewer that was developed as part of the TURAS project to map the distribution of energy consumption across the Aalborg built up area (Figure 24). The Aalborg Heat Atlas was developed as part of WP4 - Climate Change Resilient City Planning and Climate-Neutral Infrastructure to address the issue of energy usage and potential savings in Aalborg. The Aalborg Heat Atlas aims to support a better understanding of energy demand and energy savings within the city for future sustainability planning. The goal of this project is to develop methods to improve on heat consumption and ultimately to convert to a 100% renewable energy system. The objective is to reduce the heat demands in buildings by as much as 50% and improve the economic and environmental capital of the city.

Figure 24: Aalborg Heat Atlas interface



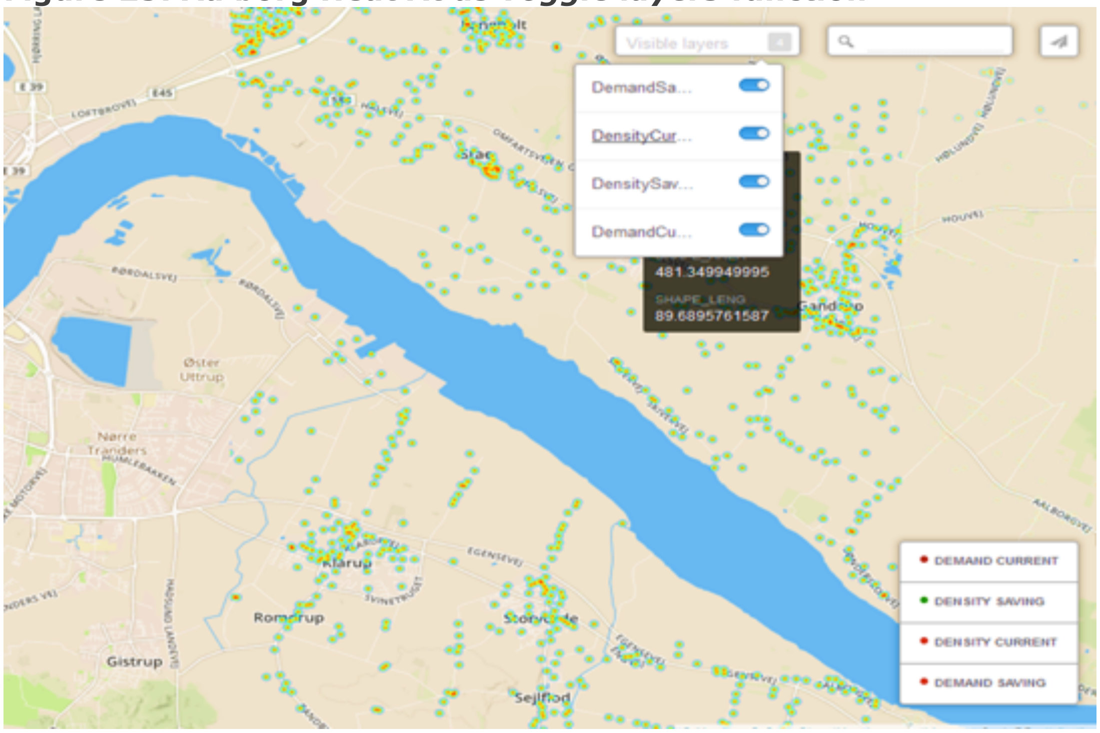
Functionality
The Aalborg Heat Atlas has six main functions; main menu, toggle layers, zoom, measurements, about and social media.

Main Menu: The main menu button allows the user to select the format of the map between the standard application with the coloured zones denoting energy usage and a heat mapping application.

Toggle Layers: Users can toggle on/off layers from the panel of 'visible layers' (Figure 25). These layers relate to:

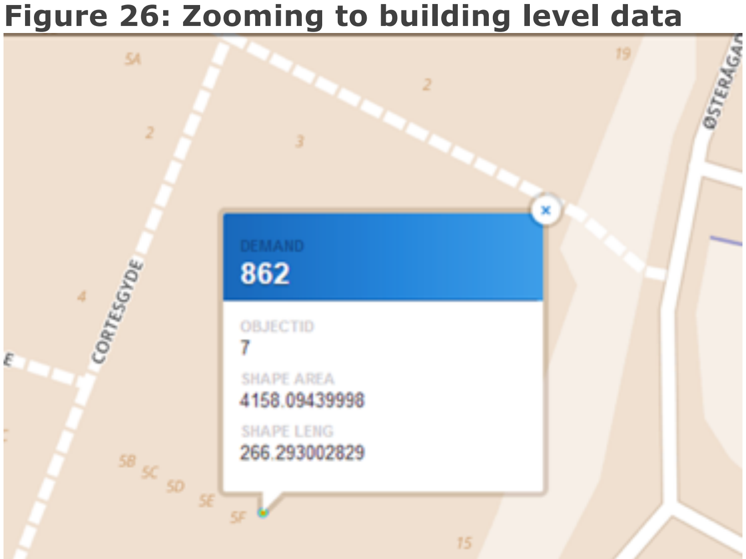
- *HEAT DENSITY (CURRENT) (KWH/M2): Current data on energy consumption for each building in Aalborg. Actual consumption data is divided by footprint of the building to establish heat density metric.*
- *HEAT DENSITY (SAVING) (KWH/M2): Simulated scenario for reduction in energy consumption for each building based on the HEAT DENSITY (CURRENT). Actual consumption data is divided by footprint of the building to establish heat density metric.*
- *CURRENT DEMAND (MWH/YEAR): Actual current MWh consumption of energy by buildings in Aalborg.*
- *DEMAND SAVING (MWH/YEAR): Simulated reduced scenario for MWh consumption of energy by buildings in Aalborg.*

Figure 25: Aalborg Heat Atlas *Toggle layers* function



Zoom: Users can zoom in and out on base map from city level down to building level to better interrogate data (Figure 26).

Figure 26: Zooming to building level data



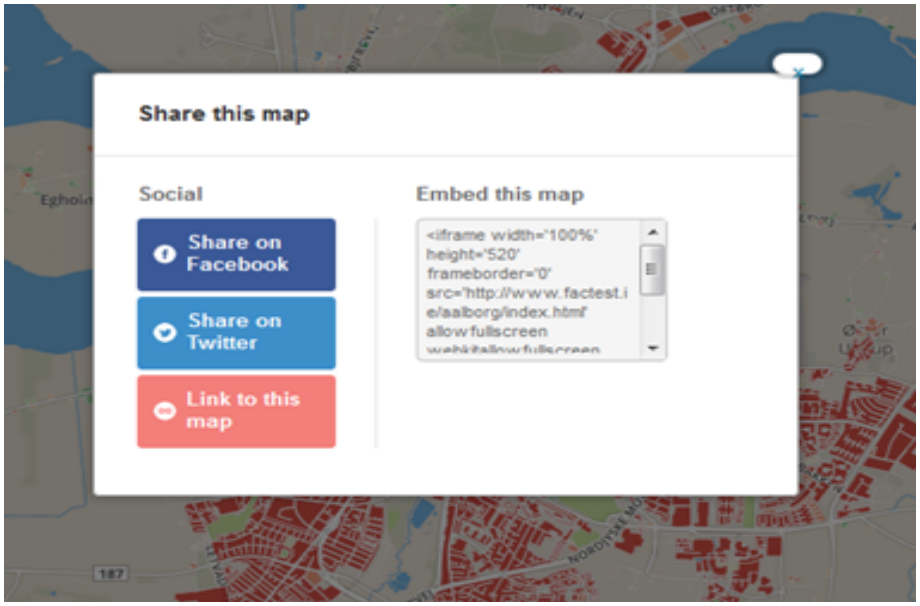
Measurements: Users can see precise measurements for specific parcels by hovering over or clicking on each parcel (Figure 27).

Figure27: Aalborg Heat Atlas *Measurements* function

About: There is also an “about” section which provides information about the application.

Social Media: There is the function to share the map on Facebook and Twitter or provide a link to the map in an email (Figure 28). The link also provides users with a script to embed the map in their site or application.

Figure 28: Aalborg Heat Atlas *Social Media* function



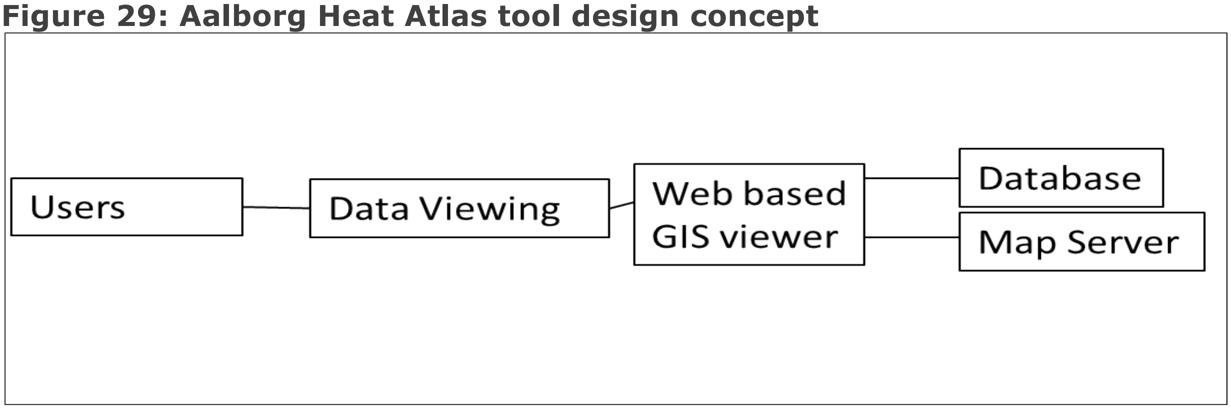
Technical development

The application was developed by Future Analytics Consulting based on a tool design concept (Figure 29). The users have the ability to view the data on web based GIS viewer. The data is stored in an associated database and published using a map server.The application is developed on the following software:

Software

- PostgreSQL - Database management system
- PostGIS - Support functionalty for PostgreSQL
- CartoDB (Cloud SaaS) - Cloud service for designing 3D spatial data
- HTML - Hypertext markup language, used to develop web pages
- Javascript - Web scripting language.

Figure 29: Aalborg Heat Atlas tool design concept



Links

1. [Aalborg Heat Atlas]

Partners involved

The Aalborg Heat Atlas was developed as part of WP4 Climate change Resilient City Planning and Climate-Neutral Infrastructure. The main partner involved in gathering and analyses of the data was the University of Aalborg. University College Dublin was responsible for the conceptual design of the Aalborg Heat Atlas interface. Future

Analytics Consulting undertook the technical development of the interface for this tool.

2.1.5 "Das Grüne Zimmer" QR code

Description

Das Grüne Zimmer QR code is a QR code which provides information and spatial data about the Green Living Room project in Ludwigsburg in the Stuttgart region of Germany (Figure 30). Das Grüne Zimmer QR code is developed as part of WP2 Greening Public and Private Green Infrastructure to address the issue of green infrastructure in Stuttgart. The QR code allows any visitor to the Green Living Room with a mobile phone to access any available information about the Green Living Room. The code is expected to enable the engagement with the general public on the issue of green infrastructure with a view of improving environmental capital in the city.

Figure 30: Das Grüne Zimmer" QR code interface

Functionality

"Das Grüne Zimmer" QR code has 7 primary functions: Mobile first responsive website, Introduction, Video, Data, 3D model, information and contact.

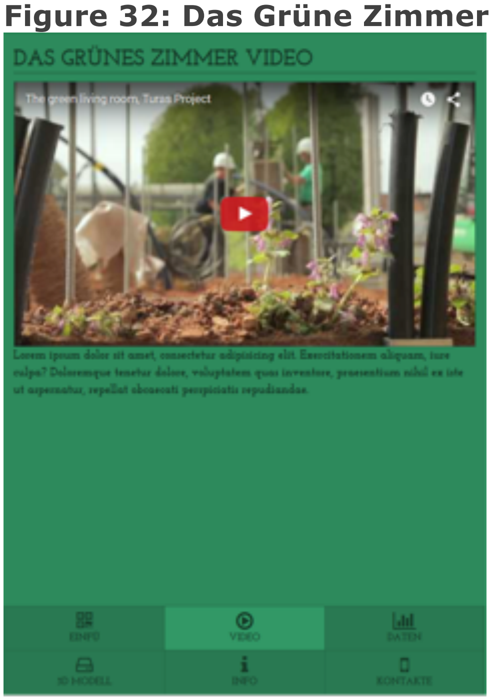
Mobile first responsive website: "Das Grüne Zimmer" QR code links to a mobile first responsive website which allows the website to be adaptable to multiple screen layouts. It is from here the other functions are available.

Introduction: users are presented with contextual information related to the project and a range of images of the Green Living Room (Figure 31).

Figure 31: Das Grüne Zimmer *Introduction* function

Video: The *Video* function links to Das Grüne Zimmer promotional video which was completed to demonstrate the Green Living Room project in action. The video allows the user to visualise the Das Grüne Zimmer (Figure 32).

Figure 32: Das Grüne Zimmer *Video* function

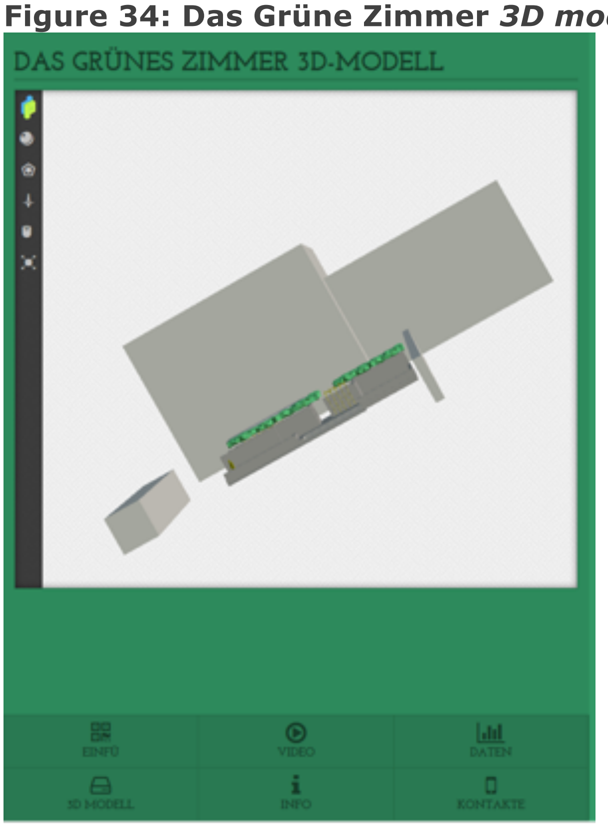


Data: Heatmap data measurements of the surfaces of the Green Living Room and the surroundings, showing the change in heat levels around the Green Living Room from blue in the morning to red in the afternoon and back to green / blue in the night (Figure 33).

Figure 33: Das Grüne Zimmer *Data* function

3D Model: Users can view the 3D model of the Green Living Room, and also pan and navigate through the 3D environment (Figure 34).

Figure 34: Das Grüne Zimmer *3D model* function



Information: This function provides online links to dissemination materials and to relevant information about green infrastructure which has been provided by project partner (Figure 35).

Figure 35: Das Grüne Zimmer *Information* function

Contact: This gives the relevant information about project partners such as contact email address and websites (Figure 36).

Figure 36: Gas Grüne Zimmer *Contact* function

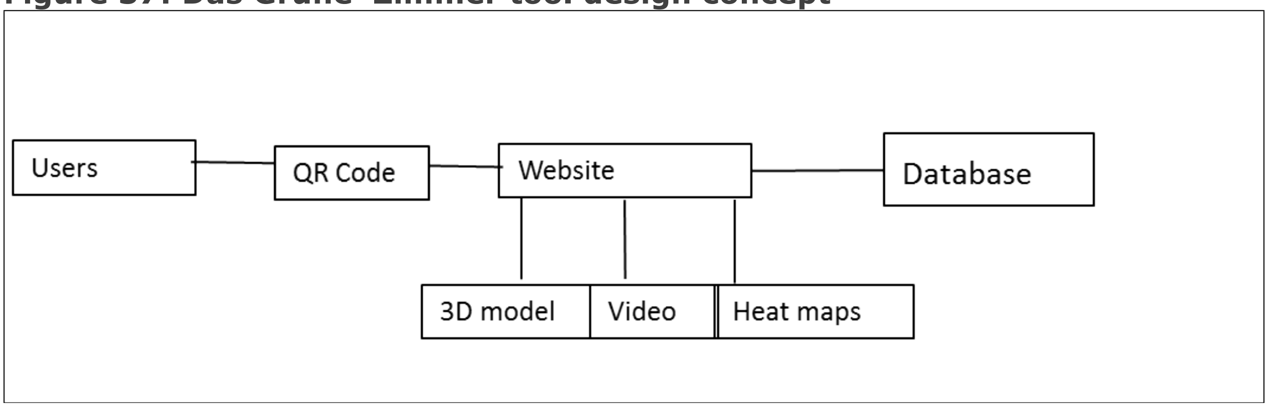
Technical development

The application is developed by Future Analytics Consulting based on a tool design concept (Figure 37). The user scans the QR code which redirects them to the website where the information such as heat maps, 3D model and video are displayed. The QR Code was developed using the following software:

Software

- CSS, cascading style sheet, formats design of web pages
- HTML, Hypertext markup language, used to develop web pages
- Javascript, web scripting language
- Cinema4D: 4D software
- AJAX: A group of interrelated Web development techniques used on the client-side to create asynchronous Web applications.
- 3D viewer: WebGL-based system
- QR Code download: https://play.google.com/store/apps/details?id=la.droid.qr.priva&hl=en

Figure 37: Das Grüne Zimmer tool design concept



Links

1. **Das Grune Zimmer**

Partners involved

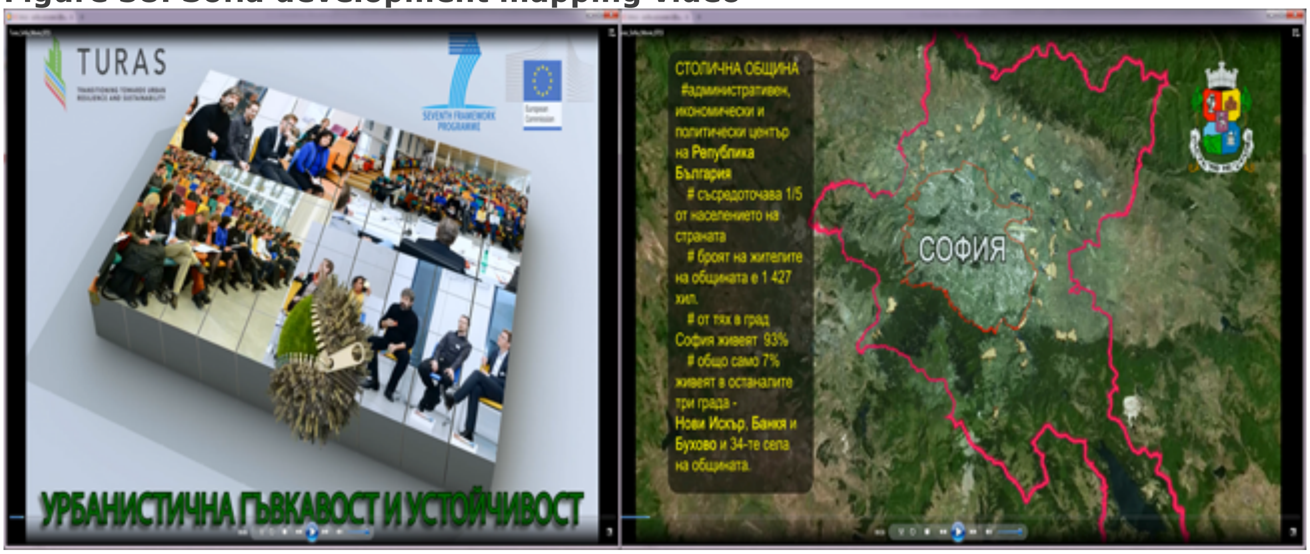
University College Dublin was the lead partner in the development of the Das Grüne Zimmer" QR Code. Das Grüne Zimmer" QR Code was developed as part of WP2 Greening Public and Private Green Infrastructure. There were three main local German partners involved in developing the concept idea for the QR Code, including Helix Pflanzen, Region Stuttgart and the University of Stuttgart. Future Analytics Consulting undertook the technical development of this tool.

2.1.6 Sofia development mapping video

Description

The Sofia development mapping video focuses on the integration, communication and visualisation of a spatial plan for Sofia (Figure 38). The Sofia development mapping video was developed as part of WP5 – Limiting Urban Sprawl in order to address the issue of urban sprawl and the development of measures and policies that will contribute to the sustainability and resilience of urban areas under constantly changing urban conditions. The video aims to provide a visual resource for the local community to promote TURAS and to better understand the policies for suburban development and control of growth of Sofia Municipality. The goal is to increase engagement and collaboration with local stakeholders and in doing so improve the city’s social and environmental capital.

Figure 38: Sofia development mapping video



Functionality

The video has one main function: visualisation.

Visualisation: The main functionality is the visualisation of suburban development policy in a comprehensible manner.

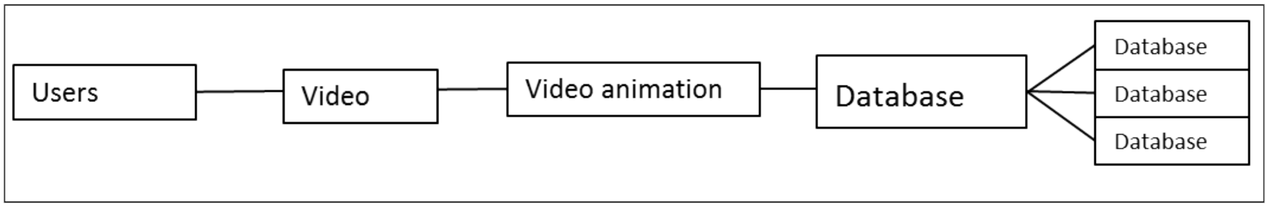
Technical development

The application was developed by the Sofproect team based on a tool design concept (Figure 39). Three databases containing information on planning in Sofia feed into one database for the video display. The video was developed using the following software:

Software

- Access software: Database
- Arc Map: GIS software
- JASHAKA software: Video animation software, open source program for video composing, animation and special effects
- Autocad: Computer-aided drafting software program

Figure 39: Sofia development mapping video tool design concept



Links

1. **Sofia development mapping video**

Partners involved
University College Dublin was the lead partner in the development of Sofia's policy visualisation video. Sofia Municipality team and the Sofproect team developed the video with the assistance of WP5 partners University of Varna.

2.1.7 Rotterdam City Delta application

Description
The Rotterdam City Delta app is a way to explore the city while discovering the measures Rotterdam takes to protect itself against the ever present water: sea, river, rain and ground water (Figure 40). The application is part of WP4 Climate change Resilient City Planning and Climate-Neutral Infrastructure which addresses the challenge of flooding in Rotterdam. The Rotterdam City Delta app allows the user to discover the broad network of innovative solutions such as multifunctional dykes, water plazas and the Maeslant Barrier. The users can learn about the actions Rotterdam as a delta city takes to protect itself against flooding in a time where new challenges present themselves as a result of climate change. Smart spatial design and multifunctional solutions contribute to a more attractive and economically strong city and therefore increase its economical capital.

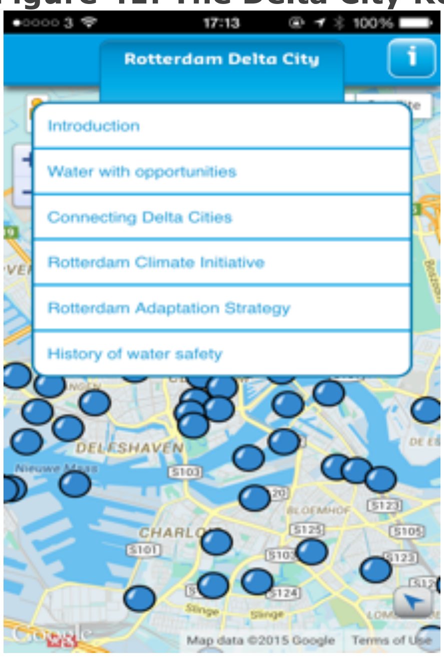
Figure 40: Rotterdam City Delta App interface

Functionality
Rotterdam City Delta app has 3 main functions: Main menu, Map and Information icon.

Main menu: The main menu provides an introduction to Rotterdam, the effects of climate change and the Rotterdam Climate Proof programme (Figure 41). There are 6 main sections to the *Main menu*:

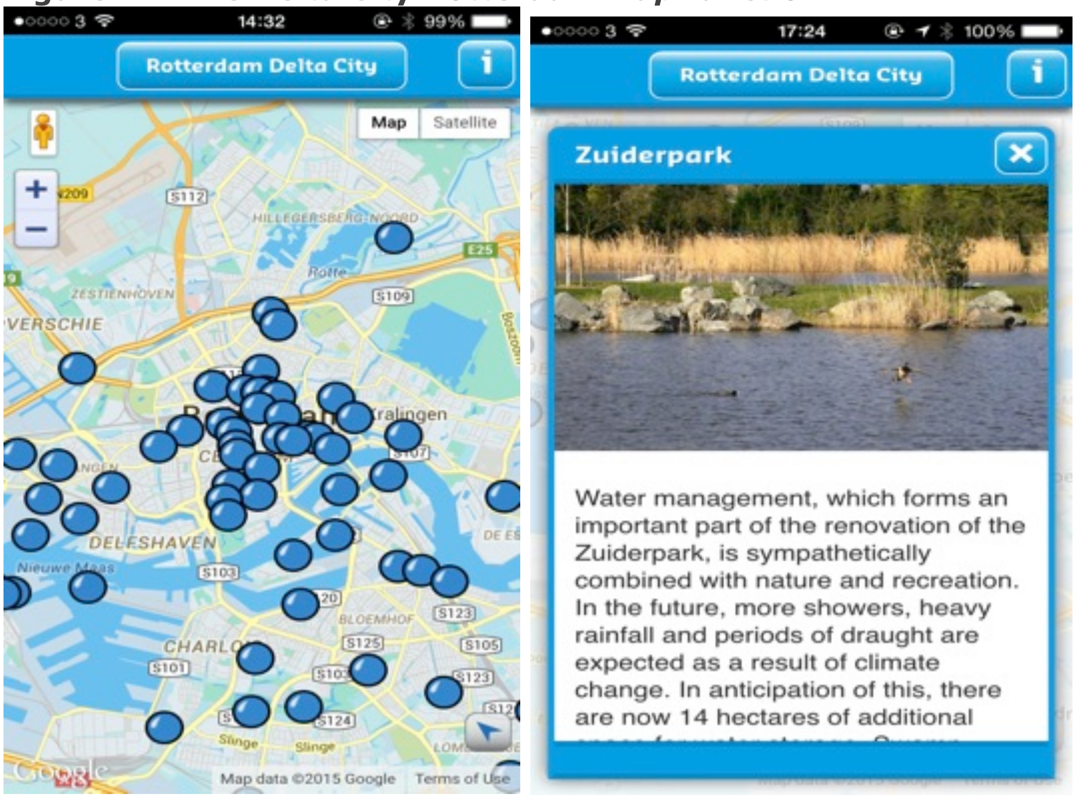
- Introduction
- Water with opportunities,
- Connecting delta cities,
- Rotterdam Climate Initiative
- Rotterdam adaptation strategy
- History of water safety

Figure 41: The Delta City Rotterdam app *Main menu* function



Map: The map shows the measures Rotterdam takes to protect itself against water: sea, river, rain and ground water (Figure 42). Unique hotspots allow the user to discover the broad network of innovative solutions such as multifunctional dykes, water plazas and the Maeslant Barrier. It allows the user to navigate their way across the port city of Rotterdam.

Figure 42: The Delta City Rotterdam *Map* function



Information icon: Provides information about the application's publication, design and development team and sources of information and images used in the application (Figure 43).

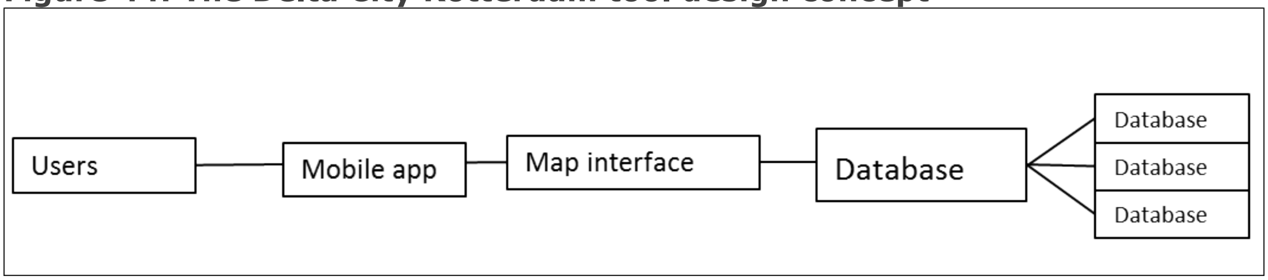
Figure 43: The Delta City Rotterdam *Information icon* function

Technical development

The application is developed by RNW Concept design with Tremani based on a tool design concept (Figure 44). Databases feed into the main database for the app. Data are displayed using a map interface. The user can access the map through a mobile phone app. The app was developed using the following software:

- iOS - Operating system for Apple devices. 12.8MB iOS
- Android - Operating system for Android devices. 7.8MB Android.

Figure 44: The Delta City Rotterdam tool design concept



Links

1. Delta City Application

Partners involved

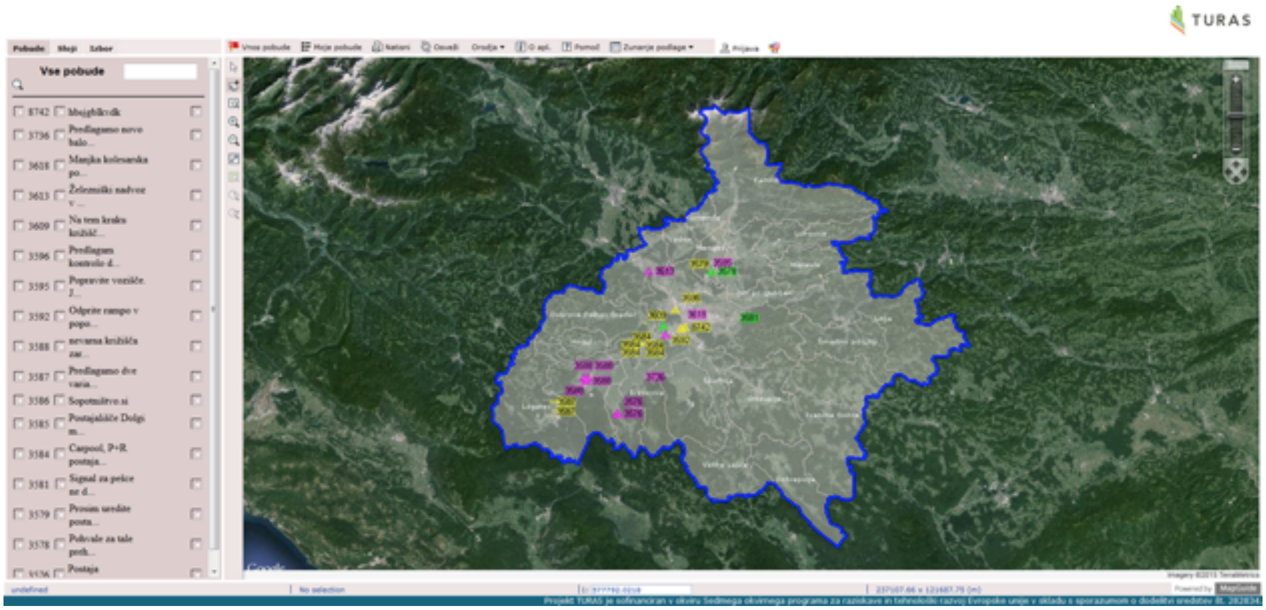
The Rotterdam City Delta app was developed by the City of Rotterdam. The application is part of WP4 Climate change Resilient City Planning and Climate-Neutral Infrastructure. WP4 lead partner VU University Amsterdam and University College Dublin assisted in the associating the application to the TURAS project. Future Analytics Consulting were responsible for the technical linking of the application with the TURAS website.

2.2.8 Ljubljana Urban Region Public Participation (LUR PP) webGIS

Description

The LUR PP webGIS is a GIS platform with a user webGIS interface to enable e-participation and to encourage the public to be active in improving public transport and traffic infrastructure for more sustainable mobility (Figure 45). The LUR PP webGIS is developed as part of WP4 - Climate change Resilient City Planning and Climate-Neutral Infrastructure and aims to address transport planning in Ljubljana. The objective is to enhance public participation in the public transport planning process with the goal of increasing environmental capital.

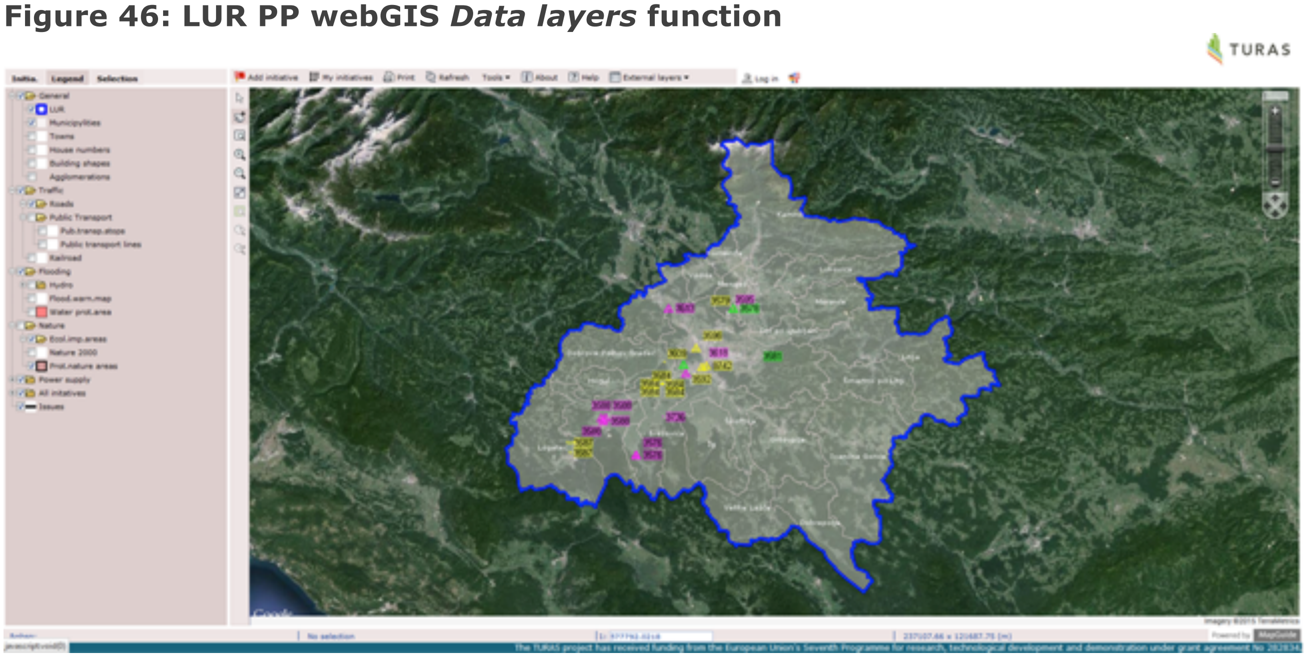
Figure 45: LUR PP webGIS interface



Functionality
The application has 8 here main functions: Data layers, Add initiative, My initiatives, External layers, Help, Tools, Refresh, and Print.

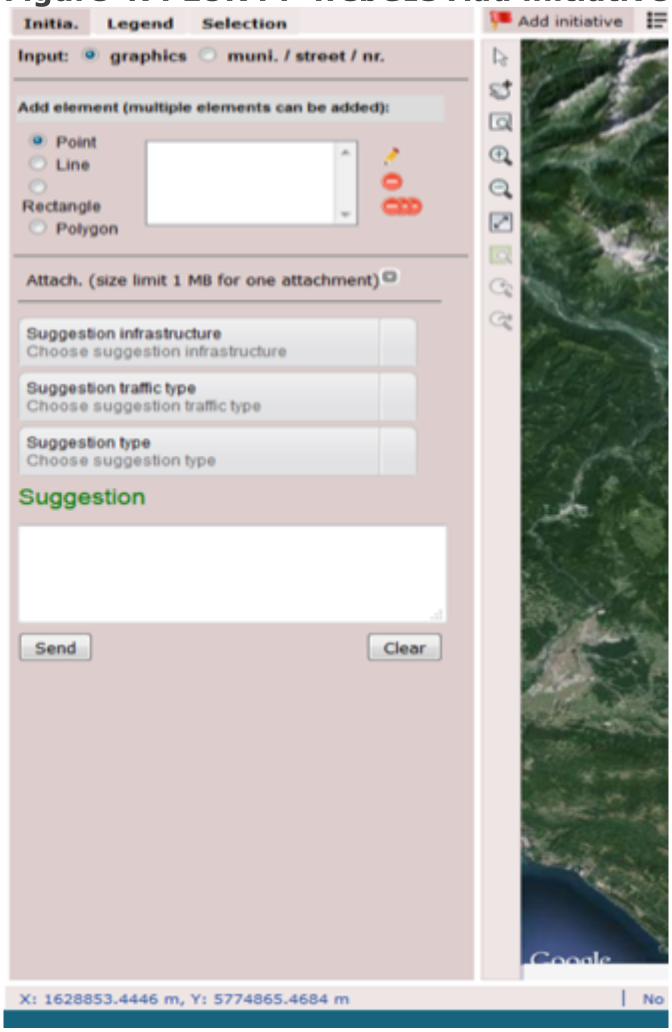
Data layers: The application has a number of data layers relating to transport, flooding and nature. The user can toggle the layers on and off and overlay different layers (Figure 46).

Figure 46: LUR PP webGIS *Data layers* function



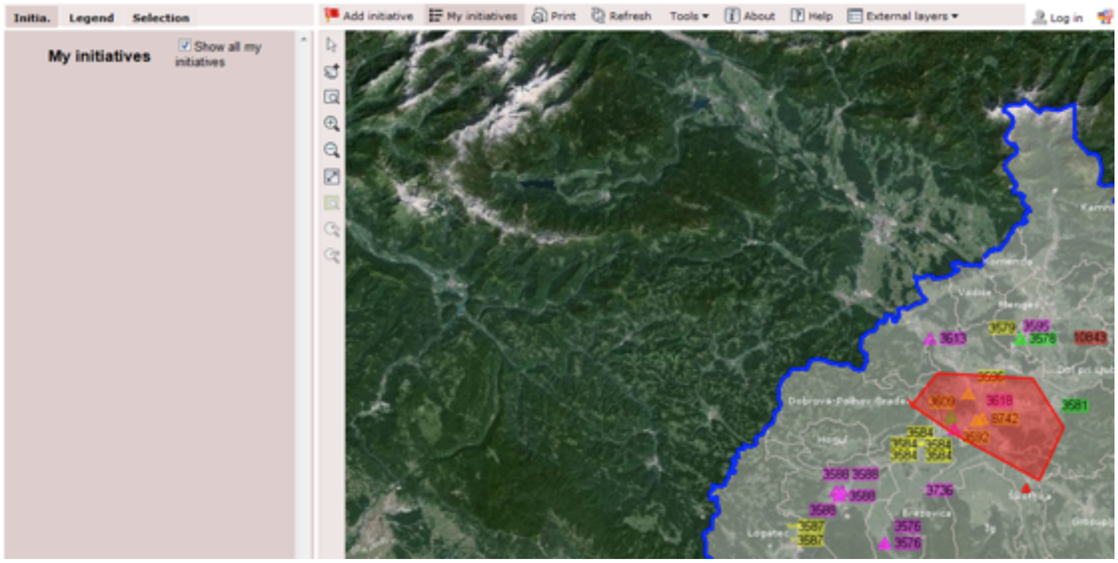
Add initiative: LUR PP webGIS *Add initiative* function allows the users to ask questions, comment, suggest or respond to relevant themes such as transportation and flooding for different areas (Figure 47). The users can locate the area they want to discuss by drawing a polygon or placing a point or line on the webGIS interface.

Figure 47: LUR PP webGIS *Add initiative* function



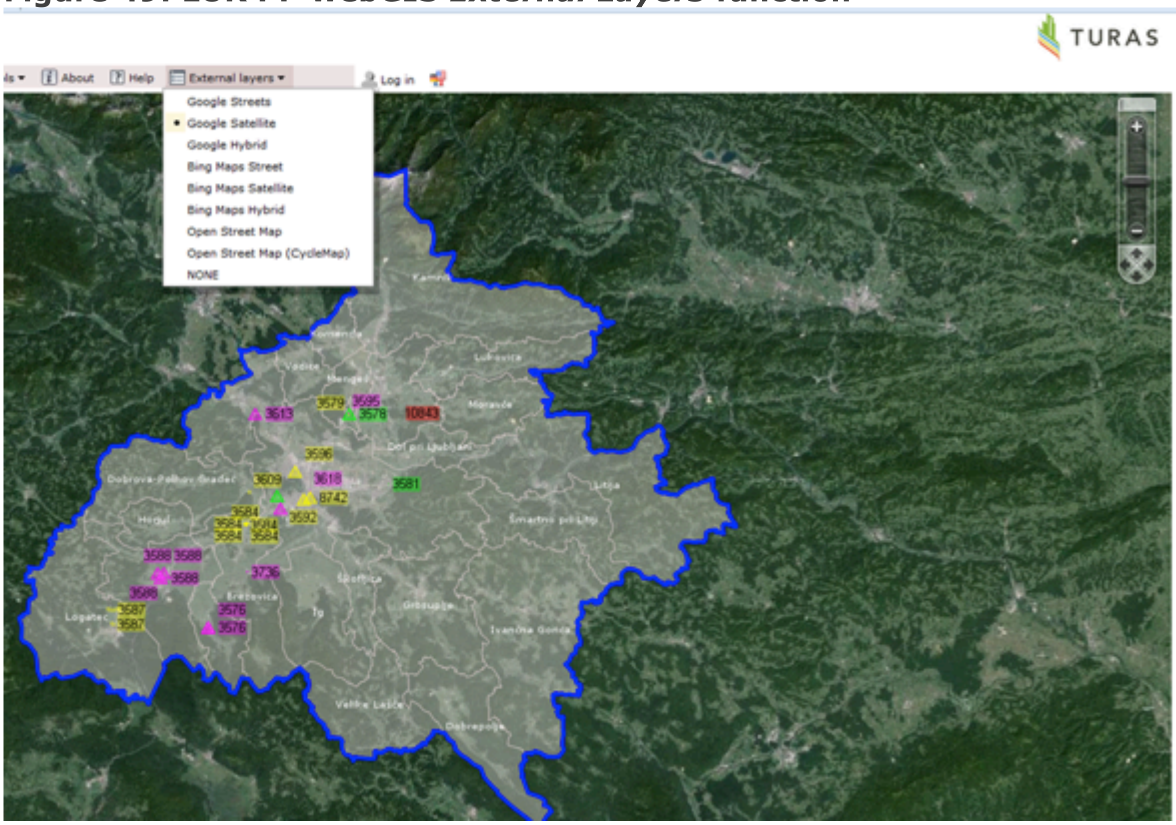
My initiatives: When the user adds initiatives to the map the "*my initiatives*" function allows the user to view all previous initiatives added (Figure 48). This allows the user to keep track of their interactions with the webGIS on the different issues.

Figure 48: LUR PP webGIS *My initiatives* function



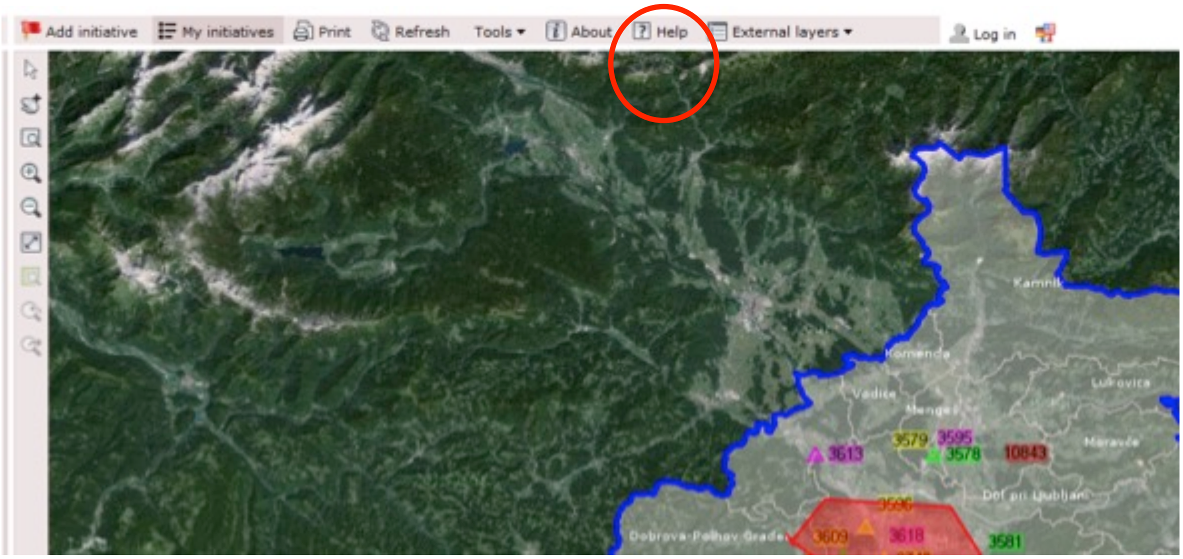
External Layers: This function provides the user with a list of external map layers they can use as the base map such as; Google Streets, Google Satellite, Google Hybrid, Bing Streets, Bing Satellite, Bing Hybrid and OpenStreetMap and OpenStreetMap Cycle Map.

Figure 49: LUR PP webGIS *External Layers* function



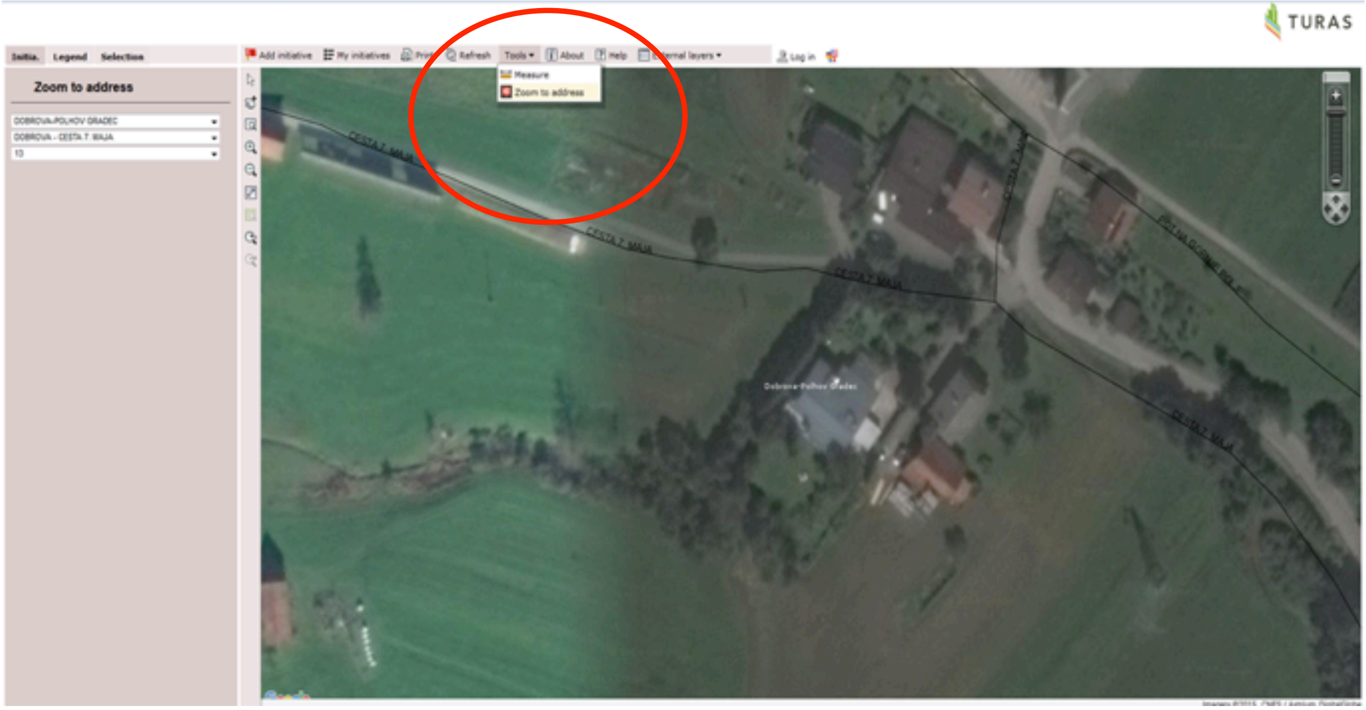
Help: The help function provides a link to an external help page that the user can access (Figure 50).

Figure 50: LUP PP *Help* function



Tools: The tools function provides links to two tools; the "*measurement tool*" and the "Zoom to address tool". The "*measurement tool*" allows the user to measure distances on the map and the "*zoom to address tool*" allows the user to select an address on the map based on municipality, street and house number.

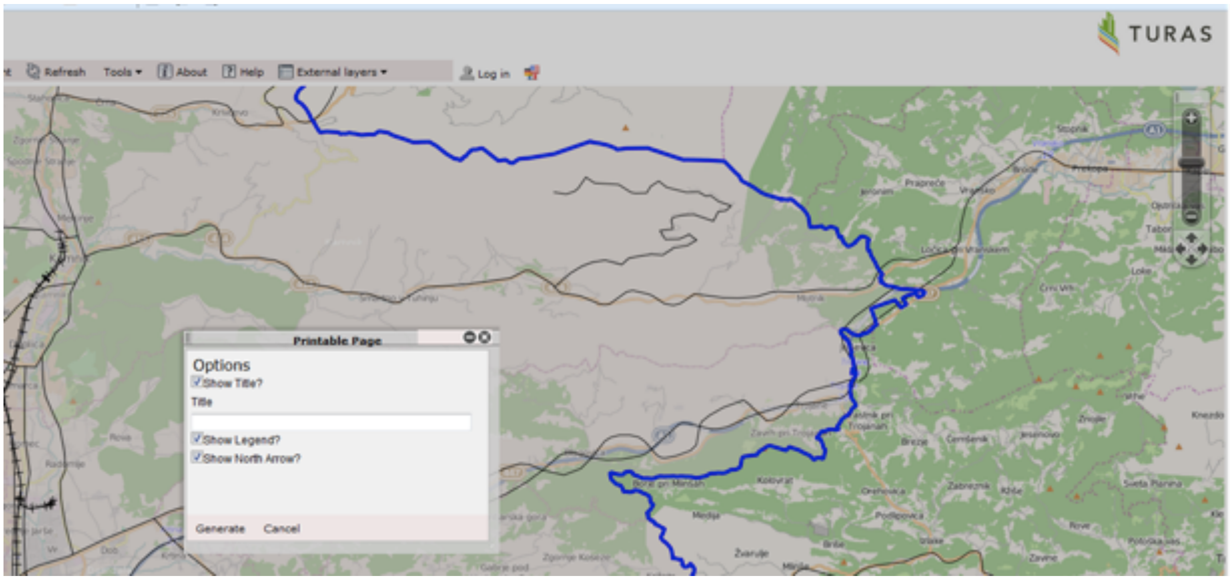
Figure 51: LUP PP webGIS *Tools* function



Refresh: This function allows the user to refresh the screen.

Print: The print function allows the user to print the webGIS as a map (Figure 52). It offers the functionality of being able to print with or without map elements such as the north arrow, legend and the title.

Figure 52: LUR PP webGIS *Print* function

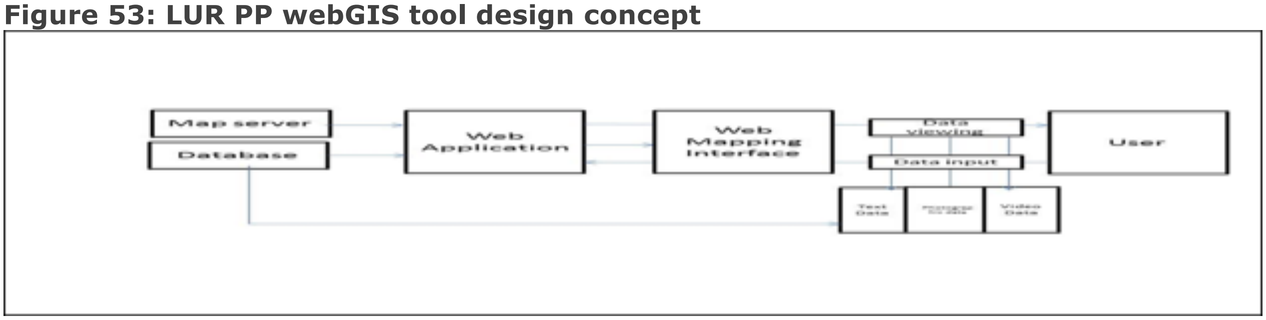


Technical development
The application was developed by Regionalna razvojna agencija (RRA) LUR the Regional Development Agency of the Ljubljana Urban Region based on a schematic design presented in Figure 53. The LUR PP webGIS was developed using the following software:

Software

- Access software: Database
- Arc Map: GIS software
- HTML - Hypertext markup language, used to develop web pages
- CSS - cascading style sheet, formats design of web pages
- Javascript - web scripting language

Figure 53: LUR PP webGIS tool design concept



Links

1. **LUR PP webGIS**

Partners involved

RRA LUR the Regional Development Agency of the Ljubljana Urban Region was responsible for the development and maintenance of the LUR PP webGIS. Future Analytics Consulting were responsible for the technical integration of the webGIS with the TURAS website. University College Dublin oversaw the integration of the LUR PP webGIS with the TURAS website.

2.3 Framework for G-ICT infrastructure -- integrated database and tools

2.3.1 Literature review

This literature review explores three disciplinary areas deemed relevant for the development of the framework for G-ICT infrastructure: databases and database integration, integration of tools and functionalities and interfaces for integrated ICT frameworks. The main concepts and recent research in three disciplinary areas are introduced below.

2.3.1.1 Databases and database integration

There has been an explosion of data and available urban datasets in recent years. This has partially been due to advances in ICT and related technologies, whereby data for cities can be collected through a variety of different means ranging from satellites to ICT devices and sensors (Togawa et al, 2015). The unprecedented proliferation of data has posed significant challenges in managing, processing and interpreting of this data (Ma et al, 2015). One of the challenges will be to manage this data consistently where different data types can be integrated, accessed and used for city-wide decision and policy making.

The most basic requirement for managing this type of data will be the use of a database. A database is a collection of data, typically describing the activities of one or more related organizations (Ramakrishnan et al, 2000). A large proportion of data is stored and managed in databases, and indeed database management systems (DBMSs) have been the technology of choice for data and information storage and retrieval. DBMS are widely used commercially and are classified according to the type of data model employed: hierarchical, network, relational and object orientated (Anumba, 1996). DBMS have many advantages such as the ease of access, reduced application development time, data integrity and security (Ramakrishnan et al, 2000). One of the main benefits of using a DBMS is the ability of the DBMS to manage complex data (Polese et al, 2000).

Much of the data in relation to cities has a locational or spatial element. This type of data requires the use of a geodatabase or spatial database. A geodatabase or spatial database is designed to store, query, and manipulate geographic information and spatial data (Stamolous, 2015). A geo-database system extends a traditional business database system by incorporating spatial data types in its data model and query language. Furthermore, it supports spatial data types in its implementation, including spatial indexing (Breuning and Zlatanova, 2011: Güting, 1994). In geodatabases, data may be modelled in tables (relational database approach) or as objects (object-relational or object-oriented database approach) as parts of a geo-data model (Breuning and Zlatanova, 2011). Geo-DBMSs now make it possible to manage large spatial data sets in data bases that can be accessed by multiple users at the same time (Arens, 2005). Geo-database management systems were originally developed in response to new requirements for geo-database applications. Developments began in the 1980's with geo-databases designed on an object oriented basis and today can deal with 3D and 4D geometric data types supporting temporal changes in 3D geo-objects (Breuning and Zlatanova, 2011).

National and regional initiatives which manage spatial data commonly use Spatial

Data Infrastructures (SDIs). SDIs are being developed all over the world to facilitate the use of spatial data in different sectors of society (Vandenbrocke et al, 2013), on all different levels from local to state/provincial, national, and international regional levels, to a global level (Nedovic-Budic et al, 2004). Benefits of developing SDIs include improved access to data, reduced duplication of effort in collecting and maintaining data, better availability of data, and interoperability between datasets (Strain et al, 2006). SDI's are now into their third generation, a generation based on a synergy between SDI and Volunteered Geographic Information (VGI) (Budhathoki, et al, 2008). SDI's have infiltrated many of the disciplines and communities of practice which have a role to play in the urban environment such as land use planning (Vandenbroucke et al, 2013) and built heritage (McKeague et al, 2012). Urban environments are now in benefiting from what Masser (2010) discusses as the economic, social and environmental benefits of SDI including promoting sustainable development and better natural resource management and monitoring. To facilitate access and exchange of environmental spatial data across the European Union (EU), the European Community (EC) has established the INSPIRE directive. The Directive came into force in 2007 and is centered on data, applications and network services, but not on integrated tools. It is also more supportive of regional spatial data and initiatives and less suitable for urban projects.

The glut of data in various forms and in huge quantities that we have experienced over the last few years calls for a new generation of database systems incorporating new, more effective and efficient solutions and techniques to fully take advantage, for solving real problems, of the availability and richness of vast data resources (Kacprzyk et al, 2015). Some of this new generation of database systems is outlined below.

Database integration

There are different approaches for database integration. For the purposes of this research four main approaches for were examined: data warehousing, cloud computing, federated databases and MySQL /PstgresSQL.

(i) Data warehousing

A data warehouse is a repository which contains all data relevant to the management of an organization and from which the information and knowledge needed to effectively manage the organization can be extracted (March and Hevner, 2007). Data warehousing environments (DWEs) have emerged as a core component for the decision-making process, providing high quality informational data. Through the ETL (extract, transform, load) process, DWEs consolidate large amounts of data of interest from heterogeneous and distributed data sources into a specialized database, the data warehouse (DW) (Teixeira et al, 2015). The general approach of the data-warehouse solution is to design and schedule extraction, transfer, and load (ETL) procedures to periodically transfer data from the daily operational database to the research database (Jeu-Yu et al, 2013).

There are, however, potential problems with data warehousing. Often operational systems are not designed to be integrated and data extracts must be performed manually or on a schedule determined by the operational systems. Furthermore, acquired data from external sources is rarely in a form conducive to integration (March and Hevner, 2007). What further complicates the issue of data warehousing is that time sensitive applications may not work in the data warehousing model due to the nature of some of the applications requiring real time updates. Conventional DWs store only conventional data, such as data of numeric, alphanumeric, and date types. As a result, conventional DWEs only support the ETL process and the on-line analytical processing (OLAP) based on conventional data. Conventional data types have a total order relation, and therefore can be sorted and searched using ordinary relational operators (i.e. <,≤,>,≥). However, decision-making users cannot use the conventional DWEs to issue OLAP queries over complex multimedia data, such as images. This is related to the fact that, differently from conventional data, complex data do not have a total order relation, and therefore cannot be sorted and searched using ordinary relational operators (Teixeira et al, 2015).

(ii) Cloud computing

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell and Grance, 2011). Private cloud, community cloud, public cloud, and hybrid cloud are the four major patterns of cloud deployment (Chou, 2015).

A cloud environment can achieve the advantages of storage scalability, universal access, document format consistency, and easier collaboration (Jeu - Yu et al, 2013). The cloud offers the user or organization the benefit of being able to outsource the database management, thus reducing the cost and responsibility of running one’s own (Ylber Januzaj et al, 2015). Another one of the main advantages of state of the art supportive technologies such as cloud computing is that they can be used with little or even no modifications to support the creation of Policy Making 2.0 applications and tools (Koussouris et al, 2015).

Cloud computing is beneficial to the development of applications and tools mainly due to the types of integration cloud computing can offer. There are four types of integration that can be provided by cloud service providers (Li et al, 2013). Two of which are of interest: User interface integration and Data integration. UI integration provides a united portal to all enterprise applications or information, which enables users to share and collaborate inside and outside of enterprise boundaries. Data integration is the first step to conduct application integration and operates on an enterprise database and the level of data source by transferring data from one source to another.

Cloud computing can provide an elegant solution to data storage, but with considerations for cost, data security and data ownership (Ylber Januzaj et al, 2015). Cloud computing is also highly dependent on internet speed; keeping up to date with the latest internet technologies offers a solution to this challenge (Ylber Januzaj et al, 2015).

(iii) Data federation

A federated database is one which allows for the integrating of heterogeneous databases via a global schema. The federated database provides a unified database interface for global applications (Butenuth et al, 2007). A federated database delivers a unified, consistent, and transparent view of all the integrated data

(Hohenstein, 1997).

The federated architecture is well suited for migrating a set of autonomous and standalone database systems (DBSs) (i.e., DBSs that are not sharing data) to a system that allows partial and controlled sharing of data without affecting existing applications (and hence preserving significant investment in existing application software Larson and Shieth 1990). The implementation does not disrupt the current application and the fact that each database that is in the federation remains completely self-contained means there is no need to change the structure or replace the system that is already in place (Butenuth et al, 2007). Some of the other advantages of data federation are: quicker development time; real time data access; only requested data returned; and reduced data storage and data transfer (Hohenstein, 1997).

Despite the substantial advantages, the federated approach comes with its own drawbacks such as: query performance is not as good as in a data warehouse; if data is archived off source, data is no longer available in federation tool; still queries against original data sources; and only contains as much data as source system contains (Jajodia and Wijesekera, 2001).

Federated approaches to data integration have been used in recent projects by adapting the emerging technologies, such as peer to peer networks, cloud technologies and PaaS/SaaS. The Earth System Grid Federation (ESGF) project’s architecture employs a system of geographically distributed peer nodes, which are independently administered yet united by the adoption of common federation protocols and application programming interfaces (Cinquini et al, 2014). The nodes in the ESGF are all part of a federation; each peer node can be controlled by a web application and continually exchange information. This ESGF project uses a dashboard to collect, store and manage information regarding the federation. It is composed of three parts: the information provider, the dashboard catalogue and the user interface.

(iv) MySQL and PostgreSQL

MySQL and PostgreSQL are open-source relational database management systems, which allow users to create and manage their databases through queries. Both systems use the Structured Query Language for extracting database information. MySQL was originally developed to handle large databases much faster than existing solutions (Giacomo, 2005). PostgreSQL is not as fast, but is known to be a more database system with many more features (Giacomo, 2005).

The advantages of approaches such as MySQL and PostgreSQL are that they are open source and therefore not as costly as other options. Other advantages to these systems is that they runs on all major operating systems, including Linux, UNIX (AIX, BSD, HP-UX, SGI IRIX, Mac OS X, Solaris, Tru64), and Windows (PostgreSQL, 2015). One of the advantages of MySQL is its speed and reliability which have made it a popular alternative to proprietary database systems. MySQL is also easy to install and maintain (Giacomo, 2005). One of the benefits of using PostgresSQL is that it is highly customizable and runs stored procedures in more than a dozen programming languages (PostgreSQL, 2015).

Integration of ICT tools and functionalities

Information and communication technologies (ICT) have been identified as a promising enabler for the modelling complex processes, collaboration among various stakeholders and thus simplifying the decision making process even under the most complicated and demanding conditions (Koussouris et al, 2015). It is these capabilities that put ICT at the forefront of resilience planning.

Emerging information and communication technology (ICT) and big data techniques are expected to effectively support smart city management (Togawa et al, 2015). Various network-connected information devices that can observe and accumulate various kinds of data on cities and regions are already in wide use (Togawa et al, 2015). They have the ability to analyse, visualise and communicate data but also gather user generated content and harvest the collective knowledge of citizens (Koussouris et al, 2015). Nevertheless, even though a large number of ICT initiatives exist it will be their integration and combined effect which will achieve the greatest results.

Platforms and ecosystems

Togawa et al (2015) highlight that there is still a gap in combining top down (data and functions) and bottom up (data and functions) in management systems based on ICT and big data to support urban and regional matters. This has begun to be addressed by the use of software platforms and ecosystems. The theory of software platforms and ecosystems posits that software development today is increasingly based on pre-existing ‘platforms’ consisting of ‘building blocks’ offering basic functionality, which are used for developing ‘modules’ that provide additional features fulfilling specialized needs of specific user groups (Gawer, 2010 and Tiwana et al., 2010).

The platforms are defined as an extensible codebase of a software system providing core functionality, shared by numerous modules interoperating with it and the interfaces through which it can be operated and used (Ferro et al, 2013). The module is defined as the *add on* software subsystem that connects to the platform in order to add functionality to it. The ecosystem is defined as the collection of the platform and the modules that have been developed around the platform (Ferro et al, 2013).

There are examples of these platforms such as the PADGETS project described by Ferro et al (2013) as a centralized cross-platform approach to social media exploitation by government agencies in their public policy making processes. Togawa et al (2015) discuss the development of the community system network in Shinchi, Fukushima. The community network system was a platform designed to provide a bidirectional information network infrastructure through an interface between smart meters and tablet terminals installed in facilities, residences and structures. The network linked regional and city data with the aim to integrate community and citizens.

Highly important to the functioning of these platforms and ecosystems are the user interfaces (stable specifications and design rules that describe how the platform and moduеles interact and exchange information) and the architecture (the blueprints that describe how the ecosystem is partitioned onto a relatively stable platform). It is necessary that the platforms come with user friendly interfaces. Intuitive interfaces based on device technologies that are commonly used by different stakeholder groups, e.g., smart phone interfaces that seem familiar to them, should be developed as main user interfaces for these platforms (Koussouris et al, 2015; Togawa et al (2015). Koussouris et al (2015) also highlights the importance of developing different interfaces for different stakeholder groups. Different people understand and process information in different ways based on the context of their operation and their role in the policy making chain (e.g., policy makers, modellers, practitioners and citizens). It is therefore important to offer different user interfaces where each one is best able to facilitate the intended audience and usage needs. Dashboards are a type of interface which works well with platforms and platform ecosystems. Quality dashboards provide information on standardized performance metrics at a unit or organizational level to leaders, to assist with operational decision making (Dowding, 2015).

2.3.2 Proposed Framework

Based on the experience from working with all 8 G-ICT tools as part of Phase 2 and the knowledge gained from undertaking the literature review on integration of databases, tools and functionalities, the Resilience Dashboard framework for G-ICT infrastructure -- integrated database and tools has been developed. The Resilience Dashboard is conceptualised as a loosely integrated computing ecosystem (platform) which incorporates various functional modules and tools and draws on a variety of data sources, including the user generated content and sensors. The main purpose of the dashboard is to provide information support for the needed strategic planning and management processes; ultimately, it should enable the transitioning towards urban sustainability and resilience. The framework is general and conceptual in nature, with technical detailing and prototyping left for future development.

2.3.3 Resilience Dashboard

The Resilience Dashboard Platform is an innovative cloud application for urban resilience planning. It offers different tools and functionalities for the integrated and efficient management of urban resilience challenges. The Resilience Dashboard Platform is a modular system offered as a service in which several software modules collaborate with the system (Figure 54). The modules work in a bilateral way providing data to the system but also using the information from the main system and other modules. This information is gathered through four main data sources; API's, user generated content, network services and embedded devices. The Resilience Dashboard Platform and modules are presented to the user through a dashboard interface which can be user specific depending on the modules selected. The Resilience Dashboard is delivered to the end user through three main delivery channels: pc, tablet and smart phone (to facilitate mobile access to the dashboard).

The Resilience Dashboard is underlined by a set of standards and protocols and technical principles. The Resilience Dashboard adheres to all national and international standards and protocols in relation to the specific Resilience Dashboard elements. One of the main standards the Resilience Dashboard adheres to is the ISO/IEC JTC 1/SC 38 - Cloud Computing and Distributed Platforms standard. This standard outlines six ISO standards on cloud computing, related to data management, cloud computing interfaces, Open Virtualization Format, architecture, vocabulary and web services management. The Resilience Dashboard also adheres to standards relating to the sharing of data and in particular spatial data. These are outlined as part of national spatial data infrastructures (NSDIs); the INSPIRE Directive outlines standards for the sharing of European environmental data. Adhering to these standards increases the interoperability of the data.

The Resilience Dashboard is also be based on technical principles such as:

Open Standards- preference is made towards open technologies that are freely (publicly) available, rather than the exclusive proprietary products of a particular company or organisation. This reduces costs; simplifies integration; increases flexibility; and provides broad public benefits.

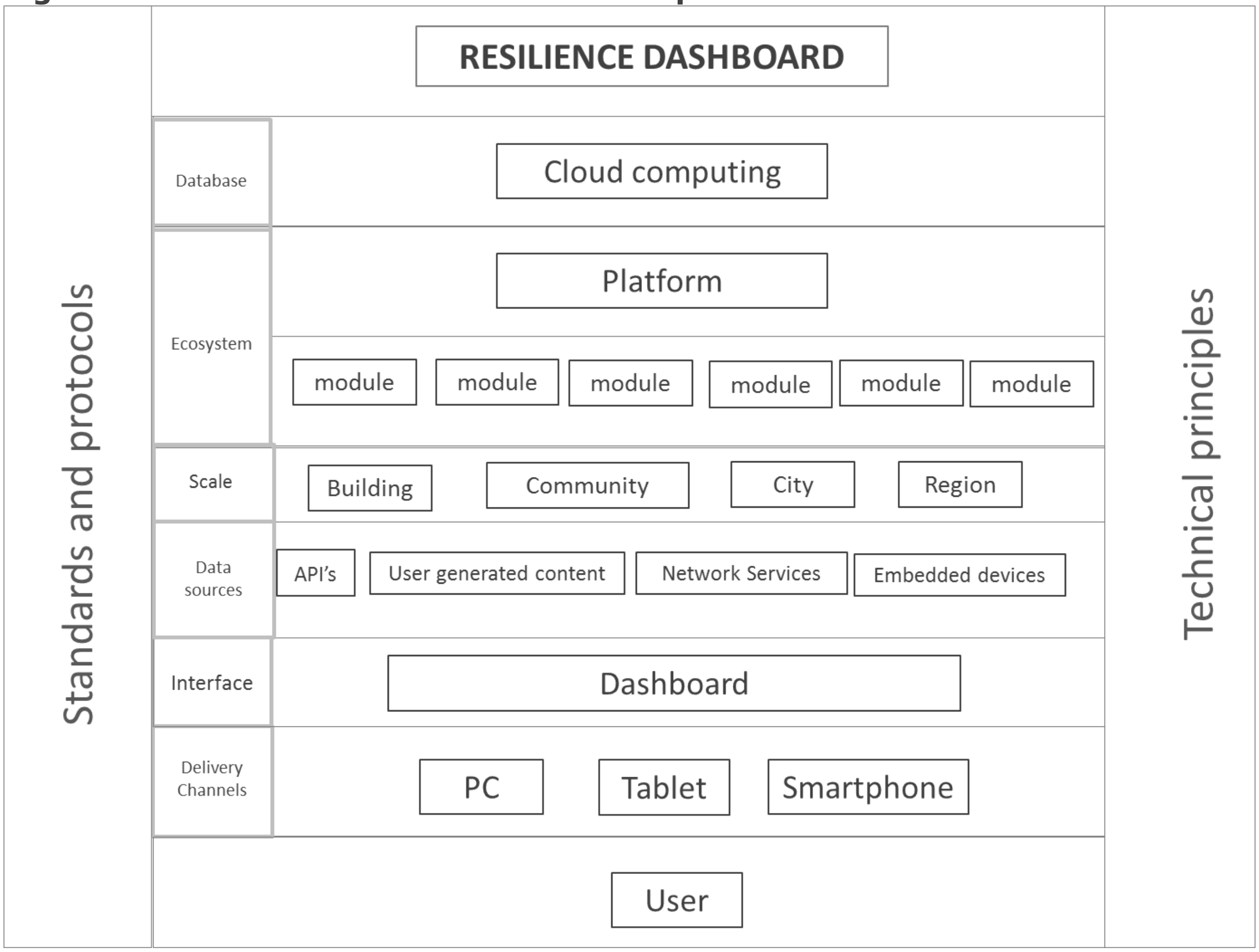
Security – the Resilience Dashboard aims to provide environment in which the data, platform and modules have appropriate protection from unauthorized access or interference, and from accidental or malicious destruction. Providing an environment that fosters good practice to maintain confidentiality, integrity and availability will be key to the Resilience Dashboard.

Reliability – the Resilience Dashboard works on the principle of reliability whereby it aims to be stable and operational on all networks to all users 24/7.

Flexibility – the Resilience Dashboard provides a platform which allows the user to use the tools and functionalities appropriate to their task and at the places and times that they need them. The Resilience Dashboard is an adaptable platform which can incorporate the ongoing changes in ICT and G-ICT.

Usability- the Resilience Dashboard is based on the principle of usability. The platform should be easily understood, used and attractive to all user groups. It is about ensuring the platform is engaging and easy-to-use, has logical consistency, and maximises efficient working by minimising task time.

Figure 54: Resilience Dashboard -- conceptual model



Resilience Dashboard elements
The Resilience Dashboard is made up of the following elements:

Cloud database
The Resilience Dashboard operates on an online Cloud Platform for the user to manage all datasets. It offers a hybrid database design that supports both in memory and on disk storage with public and private cloud databases. These databases are hosted on the Cloud and a backup made on the server of the hosting organisation.

The Resilience Dashboard platform (RDP*)***
The RDP is the central module that communicates to all other modules, manages access to data, monitors the performance of the included functionalities and tools and unifies the GUI elements of the included functionalities and tools.

Resilience Dashboard interface
A geospatial dashboard is recommended as an interface for the core platform and for the integrated modules - functionalities and tools. The Resilience Dashboard is a user friendly interface where all data, information, tools and functionalities will be available from one visual display (Figure 55). The Resilience Dashboard is able to summarize and integrate key performance information across an organization into a visual display as a way of informing operational decision making on different scales.

The Resilience Dashboard provides a virtual web-based and mobile place, the e-collaboration platform, where data and information can be gathered, shared and contextualised to provide up-to-date situation awareness.

Login: The Resilience Dashboard has a user login. This allows the user preferences to be saved.

Menu: The Resilience Dashboard has a menu on the left hand side of the screen. This provides the user to the range of functionalities, tools and data the dashboard can offer.

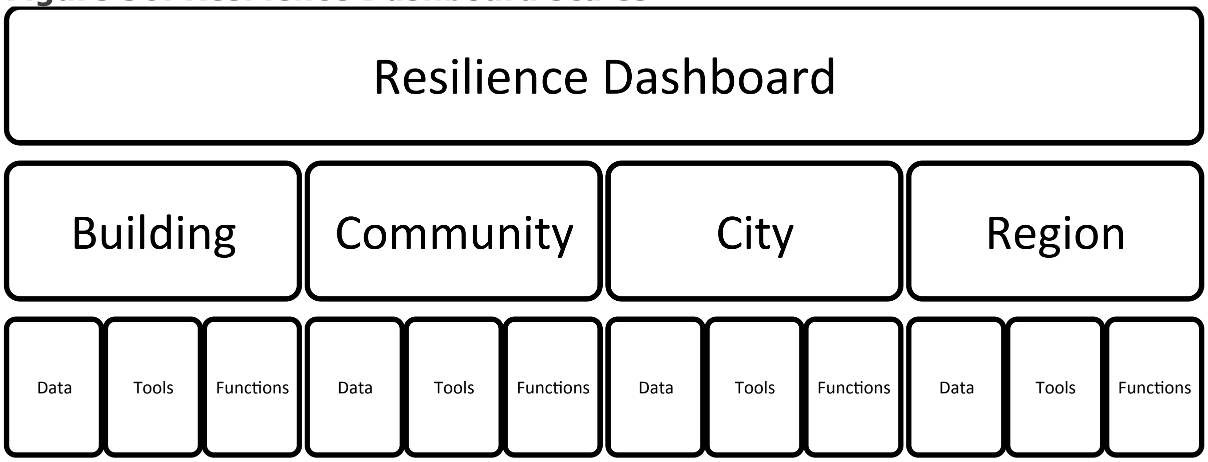
Figure 55: Resilience Dashboard interface

2.3.3.1 Modules –tools and functionalities

(i) Scales

One of the main features of the dashboard is the ability to store, visualise, analyse and communicate data at different scales. The Resilience Dashboard has 4 different scales: Building, Community, City and Region. Each scale has scale specific tools, functions and data relevant to that scale (Figure 56). Data acquired through various sources are classified and stored at appropriate (single or multiple) scales.

Figure 56: Resilience Dashboard scales



The users are able to select the appropriate scale which they are interested in and for which relevant data, tools and functionalities are accessible. Each scale opens on a separate page (Figure 57). The user is able to toggle between scales.

Figure 57: Resilience Dashboard at building scale

(ii) Data

The Resilience Dashboard works on a mix of "organisational" and "user generated data". It is suggested these two data sources can greatly complement each other.

Organisational data consists of traditional spatial and non-spatial data which are commonly used for planning and decision making for buildings, communities, cities and regions. Institutional data are supplied from traditional data sources such as local authorities or official census agencies, with specific source depending on the data type and scale. The data can be derived from some of the “modules” which draw data from other sources with an internal procedures similar to ‘data-mining’. The Resilience Dashboard can also access data from the National Spatial Data infrastructures (NDSI), especially for data on a regional scale.

User generated data comes in the form of data from crowd sourcing or social media feeds. This user generated content provides information on ground conditions e.g. flooding, traffic congestion or the status of a specific building or property. This type of data provides a live view of what is happening at the specific scale and in the specified area.

Data menu tab: The data is available from the main menu. It allows the user access to all data as well as the associated functions.

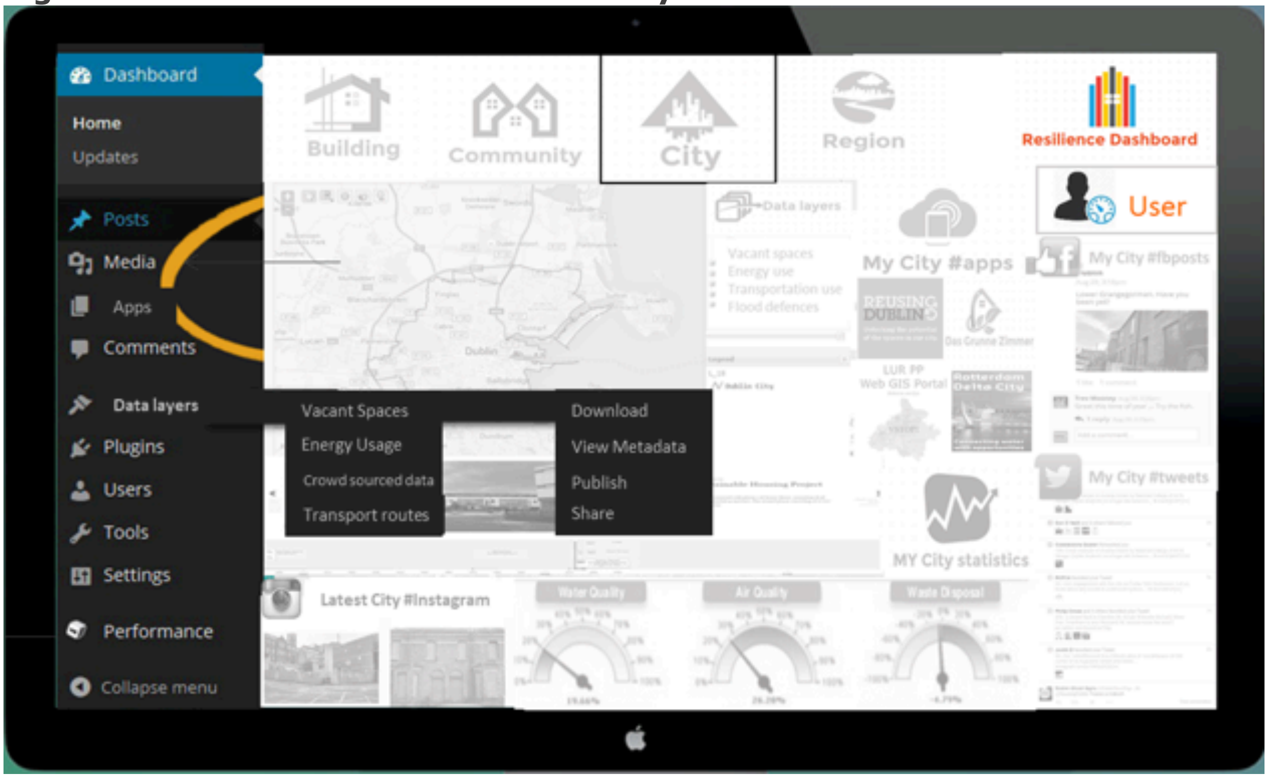
Data layers: The Resilience Dashboard has a range of different data layers available to view as part of the webGIS. The layers are available by theme (Figure 58). These data layers can be manipulated online or downloaded.

Publish as open data: The data that is collected through the Resilience Dashboard are published as open datasets and accessible for download under the “data layers” tab.

View Metadata: The user has the facility to view the associated metadata for each of the available data layers. This provides the user with the appropriate information for the reuse and integration of the data.

Share: The user can also share the data. This tab provides the users with a link to the data which they can share with others.

Figure 58: Resilience dashboard data layers



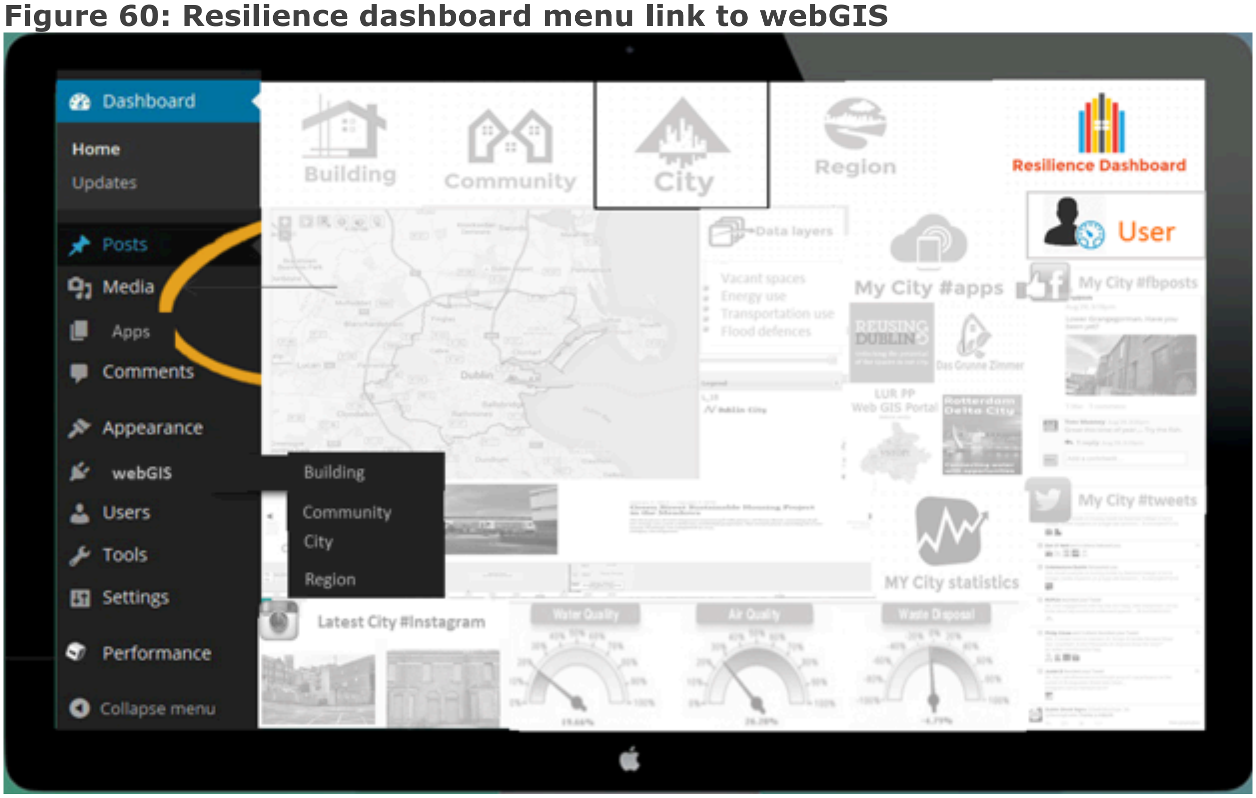
(iii) WebGIS

Central to the Resilience Dashboard is the webGIS where it is possible to visualise the spatial data (Figure 59). The webGIS displays data at different scales based on the user's selection. The user is able to overlay different spatial data layers from different sources and different time points. The user is able to visualise and analyse quickly and easily activity, trends and events at each of the scales.

WebGIS menu tab: The user is also able to switch between webGIS scales from the webGIS menu tab on the left hand side of the dashboard (Figure 60). This allows the user to change the scale of the webGIS on the main page without changing the other applications.

Figure 59: Resilience Dashboard webGIS

Figure 60: Resilience dashboard menu link to webGIS



(iv) WebGIS modules: Geo-timeline and Heat Atlas

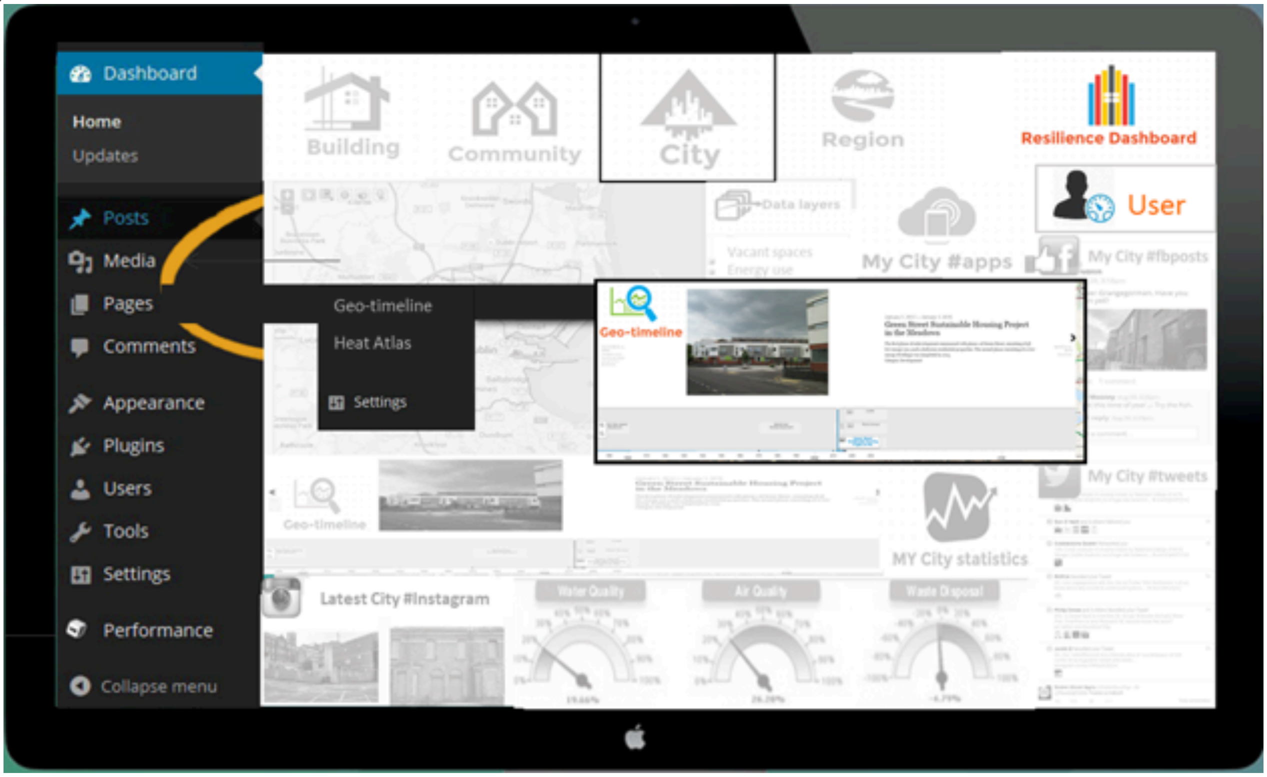
The webGIS has modules which are linked directly to it such as the Geo-timeline and the Heat Atlas (Figure 61). The data from these modules is available on the webGIS as data layers as well as the standalone applications.

Geo-timeline: The Geo-timeline is one of the modules which is linked to the Resilience Dashboard platform. The Geo-timeline is linked to the webGIS map on the main page but is also available as a separate entity under "Pages" from the main menu.

Heat Atlas: The heat Atlas is another one of the modules which is linked to the Resilience Dashboard platform. The Heat Altas is linked to the webGIS map on the main page but will also be available as a separate entity under "Pages" from the main menu (Figure 62).

Figure 61: Geo-timeline and Heat Atlas data layers on webGIS

Figure 62: Geo-timeline and Heat Atlas



(v) Social Media feeds

One of the main ways for the Resilience Dashboard to gather "user generated" content is through the use of social media feeds. The Resilience Dashboard has three main feeds (Figure 63):

Twitter feed: Tweets with the relevant building, community, city and region hashtags.

Facebook Feed: Facebook posts with the relevant building, community, city and region hashtags.

Instagram Feed: Instagram pictures with the relevant building, community, city and region hashtags.

Each of the three social media feeds are available on the main dashboard page.

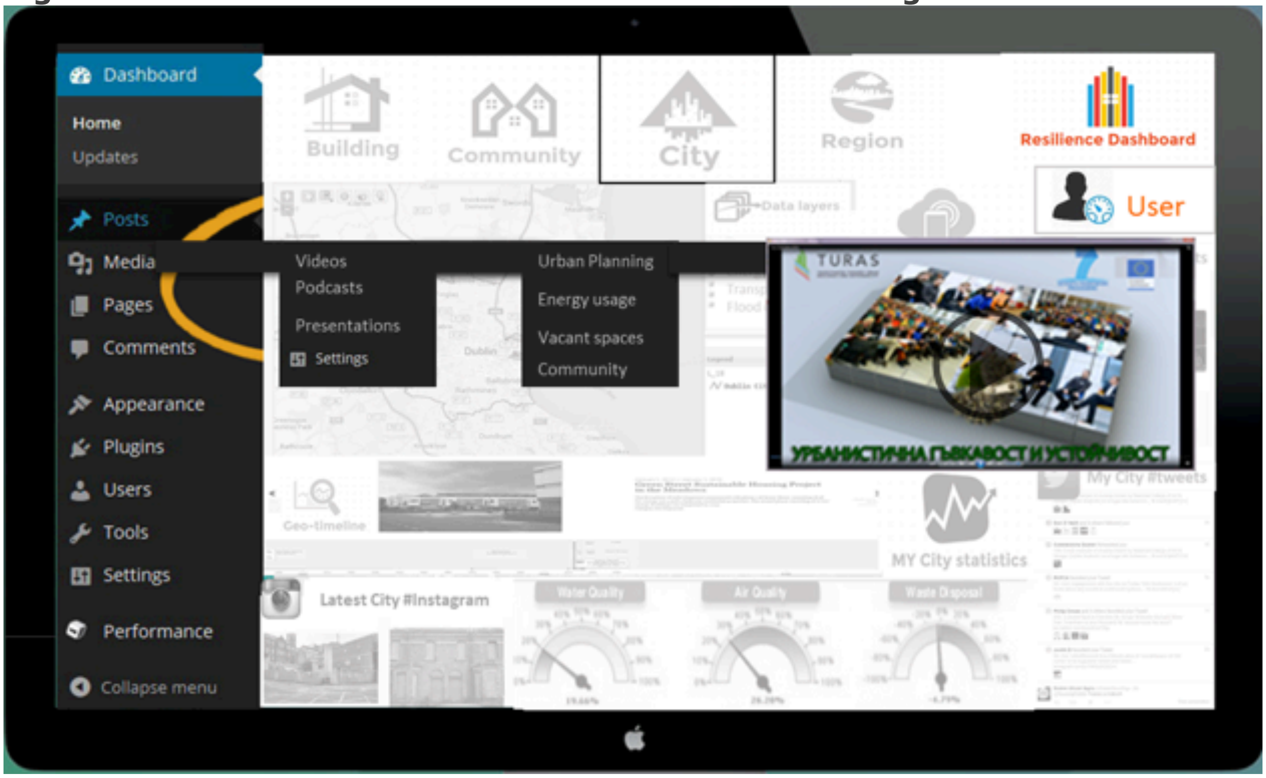
Figure 63: Resilience Dashboard social media feeds

(vi) Multimedia links and storage

The Resilience Dashboard also has multimedia links and the ability to store multimedia files (Figure 64).

Multimedia menu tab: The user can access multimedia files such as videos, podcasts and presentations through the multimedia menu tab. Each of the multimedia files is available on the different themes. These are usable on a mobile device so the user has constant access. The user is also able to upload their own personal multimedia files when logged in under their user name.

Figure 64: Resilience Dashboard media links and storage

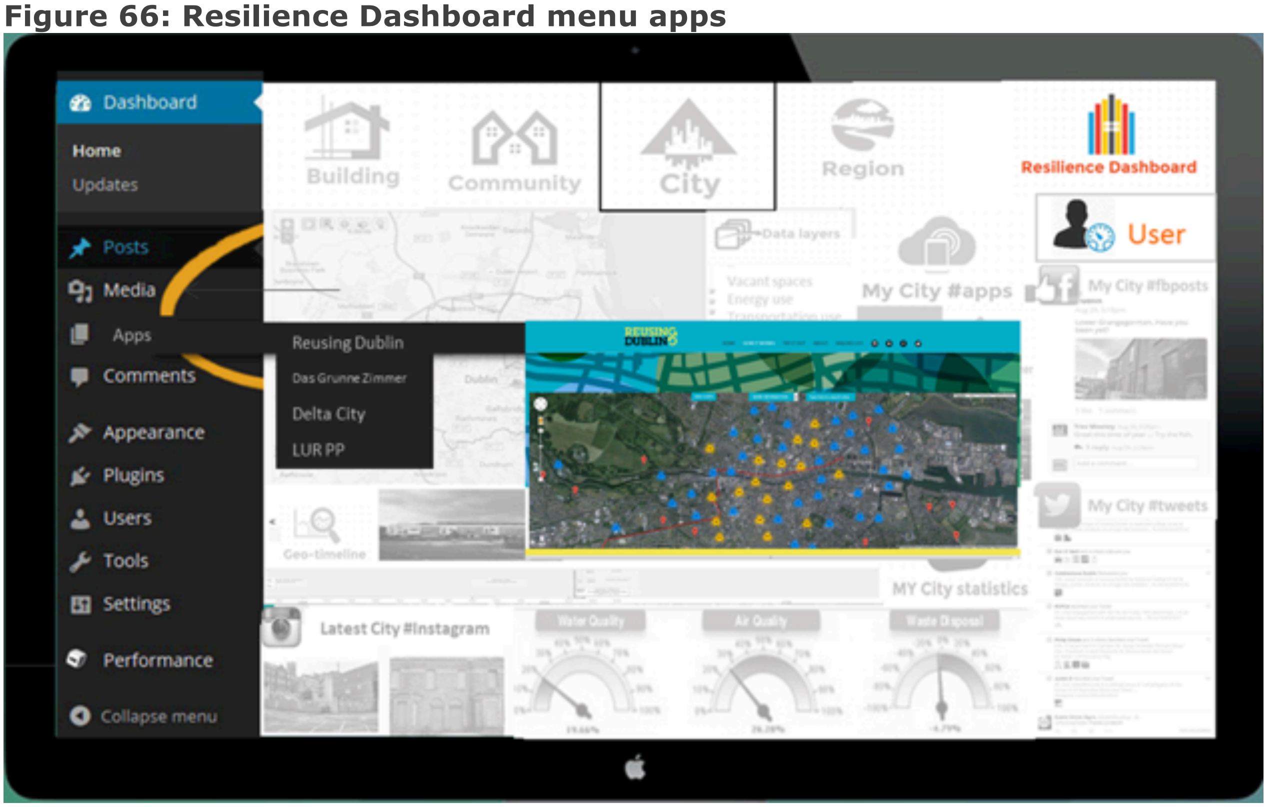


(vii) Resilience Dashboard apps

The Resilience Dashboard also links to a range of different mobile phone applications which are being used for the different scales: building, community, city or region (Figure 65). The users is able to select the applications which they would like visible on the main page of the Resilience Dashboard and also through the pages tab on the main menu (Figure 66).

Figure 65: Resilience Dashboard apps

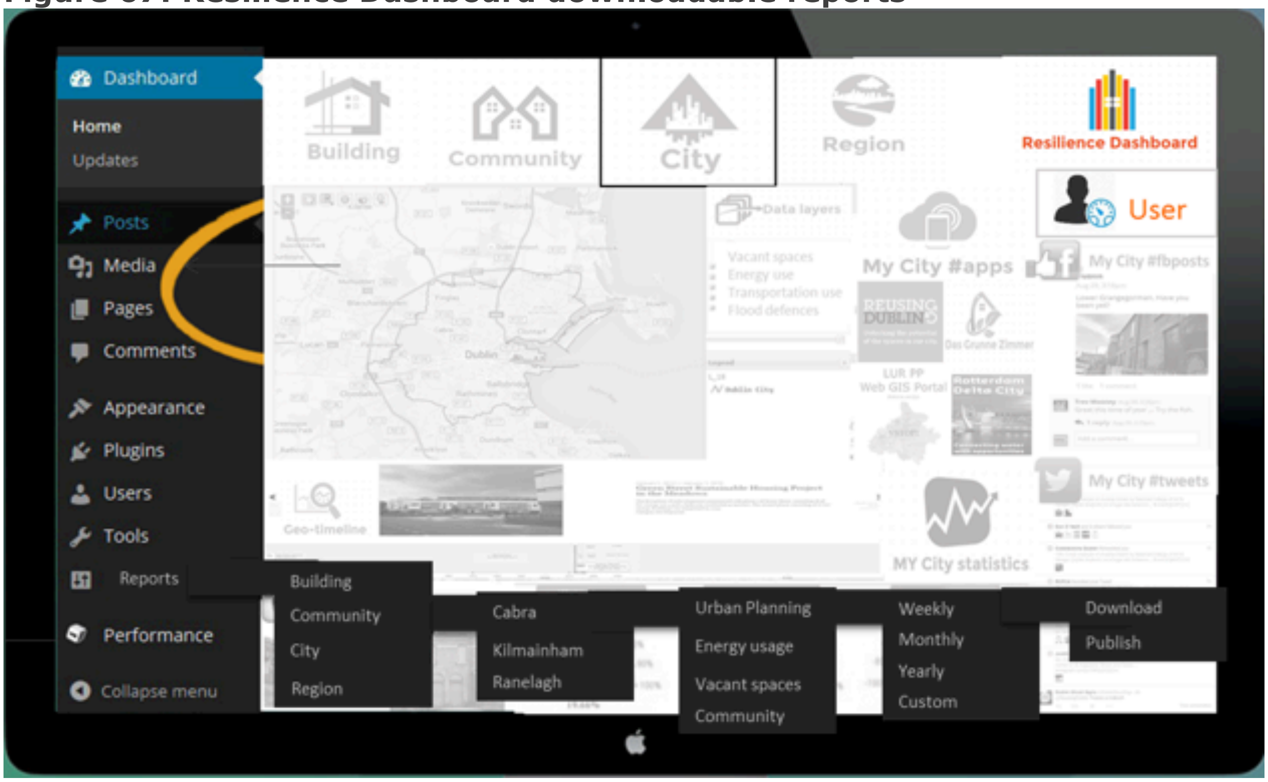
Figure 66: Resilience Dashboard menu apps



(viii) Downloadable reports

Downloadable reports are available from the Resilience Dashboard. The reports are generated based on the data collected and stored on the Resilience Dashboard. The user is able to download or publish a report at each of the four scales (Figure 67). The user can generate a report on any data theme for which data is available. The report can be generated for different time frames from the most recent week or month to a yearly or customized time frame report.

Figure 67: Resilience Dashboard downloadable reports



(ix) Sensors

The Resilience Dashboard also draws data from a number of sensors. The sensors gather data on all four scales: building, community, city and region and the type of sensor differs depending on the scale. The user is able to view the sensor data from the sensor tab on the main menu (Figure 68). Sensors are important data streams for the dashboard as they provide real time information on what is happening at each of the scales and also alerts the user to any events which are significantly above or below the threshold value.

Figure 68: Resilience Dashboard sensors

(x) Resilience indicators

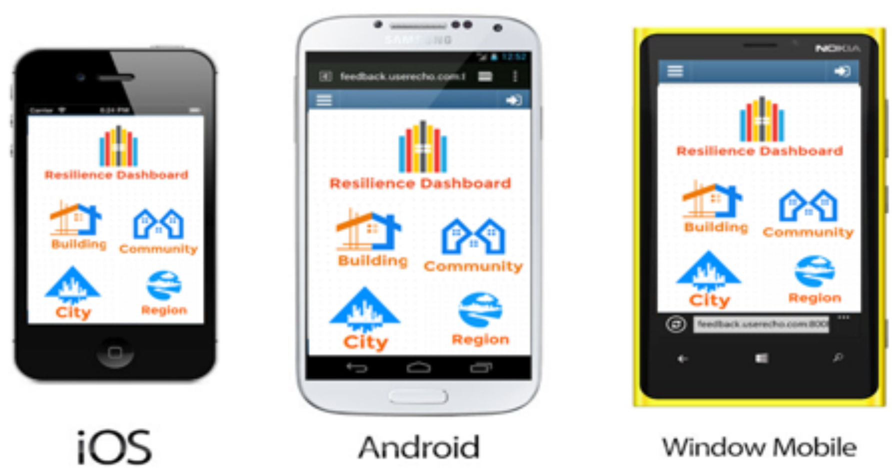
The Resilience Dashboard also has a number of "resilience indicators" which measure the progress towards resilience of the building, community, city or region (Figure 69). These resilience indicators depend on the scale and are based on different themes e.g. the resilience indicators for a building would consist of energy usage, water consumption and percentage of green infrastructure. The resilience indicators are displayed on the main page of the Resilience Dashboard.

Figure 69: Resilience Dashboard – resilience indicators

2.3.3.2 Resilience dashboard mobile phone application

The Resilience Dashboard is both desktop and mobile compatible. The Resilience Dashboard is a mobile phone application which can be downloaded in Android, iOS and Windows Mobile (Figure 63). This allows for on the go access to the dashboard for all users.

Figure 70: Resilience dashboard mobile phone application



2.4 Implementation context

In order for a framework for G-ICT infrastructure -- integrated database and tools such as the Resilience Dashboard to work, an enabling environment is required. This environment would be one where the culture embraces ICT tools and applications, the citizens are actively engaged as active data contributors and users and where the generated data is open for everyone to use

ICT does not operate in vacuum and, as any other technology advancement, is a result of wider developments, namely: scientific, innovation, social-economic, cultural and institutional (Schlichterand and Danylchenko, 2014). This is true for the Resilience Dashboard. For the Resilience Dashboard to be effective it needs to be embedded in a culture which not only embraces ICT tools and applications but a culture which is willing to engage with these tools to co-manage the city and address its resilience issues. As Cegarra-Navarro et al (2014) state that without the support provided by a positive attitude towards technologies, platforms that create knowledge such as the Resilience Dashboard will not succeed. The enabling culture not only applies to citizens but to politicians and decision-makers as well. There needs to be political will to exploit the power of ICT tools and a willingness to provide the necessary monetary support as well as strategies for the inclusion of such tools in organisations (Koussouris et al, 2015). Public bodies should consider organising specialist teams of policy experts, researchers and developers in order to ensure the successful impact of such technologies.

As well as monetary support there needs to be long term political commitment to these types of initiatives. Ben Letaifa (2015) discusses how leaders are focusing on how state-of-the-art technology that can transform local public services but there is no clear public authority who coordinates or sponsors the process. This creates grey zones regarding who has the political legitimacy and the financial capacity to steer such technologies. Clarity on who finances and legitimises G-ICT developments such as the Resilience Dashboard will need to be formalised through legislative and programmatic initiatives and structures at all levels, including an international scale. The EU has begun to legislate for the sharing of environmental spatial data between public bodies through the INSPIRE Directive. However, INSPIRE is limited to data and network services, while integrated systems such as the Resilience Dashboard, which incorporates diverse data types, tools and functions, require frameworks which reflects this complexity.

This positive attitude towards ICT such as the Resilience Dashboard depends on the successful engagement of citizens and stakeholders both as data producers and data users. Citizen engagement refers to the ways in which citizens participate in the life of a community in order to improve conditions for others or to help shape the community's future (Cegarra-Navarroa et al, 2014). The hosting organisation of the Resilience Dashboard will need to invite people to engage as Koussouris et al (2015) state: the sole offering of technologies falls short if it is not accompanied by substantial targeted efforts to both attract and sustain end users. Cegarra-Navarroa et al (2014) highlight how many initiatives facilitated by ICT have been characterised by low levels of citizen engagement. Most of real-world applications of urban computing involve people, and therefore require a comprehensive understanding of different groups and participation styles (Salim and Haque, 2015). The engagement of citizens enables a two-way communication between citizens and decision makers, potentially resulting in profound changes to existing city management processes (Salim and Haque, 2015).

In addition to an enabling culture and successful engagement the Resilience Dashboard should operate in an open environment where it is clear and transparent who the data generators are and who the data users are. This open and transparent environment should be based on but also foster a level of trust. This openness is embedded in a central element of the Resilience Dashboard which is its database. All different types of data are required to drive the platform and the associated modules. The Resilience Dashboard needs to be focused around the use of open data. Open data is data which is freely accessible to anyone and can be viewed online and downloaded in a variety of formats. The Resilience Dashboard should act as an open data portal and provide a way for third-party software applications to easily access and use the data. This allows for further analysis of the data, the development of better data driven apps, all of which have the ability to feed back into the Resilience Dashboard and allow for data driven decisions. There is a need now for open data and open access data streams.

Designing and steering a common G-ICT framework for urban resilience requires strong political leadership, resources and a culture where there is full understanding of the community (residents, businesses, organizations) of the requirements to inspire the vision and address the local challenges.

3. Conclusions

This report gives a detailed account of Phase 2 and Phase 3 of the WP1 research and results in the completion of Deliverable 1.2 of the TURAS project. This completes the research phase of WP1 with both deliverables now complete. WP1 will continue to work in conjunction with WP7 on the integration of the outcomes of the WP1 research into the Integrated Strategy (IS).

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