

GEOGRAPHIC CITIZEN SCIENCE DESIGN

No one left behind



Edited by **Artemis Skarlatidou** and **Muki Haklay**

UCLPRESS

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Chapter 9

Geographic citizen science in citizen–government communication and collaboration: lessons from the ImproveMyCity application

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Highlights

- The voluntary engagement of citizens in the collection of digital geographic information opens up new forms of interaction between citizens and the government.
- Citizens can become the living sensors of the city by contributing data about georeferenced non-emergency issues, which strengthens the sense of community, increases the responsiveness of local authorities, optimises budget and resource allocation, strengthens trust in government and promotes transparency.
- Creating an interactive space for exchange and communication can help citizens to feel that their voice is being heard by local authorities. Even if the response is not the expected one, momentum is built, promoting and encouraging citizen involvement in voluntary activities.
- Discovering hidden patterns through geographic data aggregation and visualisation, and translating these into knowledgeable insights, is feasible through interactive and customised dashboards such as those supported by the ImproveMyCity application.
- Integrating traditional communication channels in a modern, unified software platform provides local authorities with a more flexible, transparent and efficient system for receiving and managing non-emergency issues.

1. Introduction

Even though local authorities need to listen to and engage with their citizens, few channels exist for meaningful and modern direct communication and collaboration. The application ImproveMyCity (IMC) aims to promote a participatory culture in local communities and to act as an instrument for the concerned citizen whose quality of life can be improved by utilising their smartphone. IMC is an open-source scalable software solution, initially launched in 2012, in the context of the EU's 'People' research programme (FP7). The aim was to enable citizens to report non-emergency local issues, such as potholes, blocked bike lanes, street-light outages, broken sidewalks, discarded trash bins and other deficiencies in their community. The reported issues are automatically routed to the appropriate local authority department which monitors, manages and schedules remedial action. This voluntary engagement of citizens and the collection of digital geographic information data open up new forms of interaction between citizens and their government. The adoption of a non-emergency reporting tool such as IMC allows governments to improve their service delivery and accountability. It also encourages citizens to be more engaged and to play a more explicit role in becoming 'the eyes and ears' of their local authorities.

Citizen–government communication and collaboration tools such as IMC aim to provide cities with the means to advance governance from traditional practices towards modern, analytically driven and decision-making oriented means, under the 'smart everything' paradigm, as stated by [Kominos \(2018\)](#), which converges digital technologies, user engagement and collaboration networks. In the field of citizen participation (GeoParticipation), IMC is considered a local project which uses geospatial tools in order to support citizen participation, and belongs to the fifth wave of changes in the understanding and implementation of public participation where 'the role of citizens has changed from being objects of geographical research to becoming the creators of the agenda and decision-makers within their community' ([Pánek 2016, 304](#)). According to [Haklay's \(2013\)](#) taxonomy (see also [Chapter 1](#) in this book), IMC is a geographic citizen science application which supports geographic data collection and reporting by citizens, and which is based on scientific tools and sensors provided by the most recent mobile devices. It in turn supports various other purposes, including improving local knowledge and promoting advocacy as well as more environmentally friendly and sustainable attitudes to mention just a few. IMC aims to collect geospatial data which are then made available to urban planners, decision makers,

local administrations and communities to support evidence-based decision making. Inviting citizens to collaborate directly with local authorities strengthens the sense of community service, increases the responsiveness of authorities to people's real needs, optimises budget and resource allocation, strengthens trust in government, promotes transparency and allows the future of the city to be planned collectively. Furthermore, by using platforms such as IMC, citizens become aware of the sometimes hidden work and effort of government entities.

Nevertheless, the adoption of an open and transparent geographic citizen science application that allows citizens to report issues and track the actions of local authorities brings some challenges for governments and comes with some political concerns. During personal communication with the authors during the early stages of IMC adoption in 2015, local authority politicians expressed concerns about opening up the process to public scrutiny in case they were not able to satisfy citizen requests. They were worried that their popularity might be reduced and that this could influence election outcomes. This, however, has already been disproved. According to [Buell, Porter and Norton \(2018\)](#), there is significant evidence that citizens' perceptions about their governments and their willingness to engage can be reshaped and enhanced if the government's operational transparency is promoted.

This chapter describes the implementation of the IMC platform in the case of the municipality of Thessaloniki, Greece. The territorial extent of the city and its population growth, combined with continuous funding cuts, led the municipality to turn to more effective solutions to support its operational needs. The goal was to increase the city's efficiency and to achieve better results with fewer resources. Applying modern information and communications technology (ICT) solutions and engaging the citizens in this process led to the adoption of IMC, which has been gradually embedded in the daily operational capacity of the municipality.

2. Prioritising citizen engagement as best practice for local authorities: the case of Thessaloniki

The municipality of Thessaloniki is the second largest in Greece after Athens. According to the 2011 census, it has a permanent population of 325,182 residents. It comprises the central metropolitan area with its historical centre and surrounding areas, as well as districts that extend to the east of the city. Thessaloniki is divided into five local public administration areas. As an organisation, the municipality of Thessaloniki employs

about 2,600 employees and consists of 2 directorates-general, 22 directorates and 8 independent departments as of early 2019.

2.1 Managing non-emergency issues pre IMC

According to [Vasilopoulos \(2017\)](#), prior to the introduction of IMC, the municipality of Thessaloniki relied on traditional administrative practices for reporting non-emergency issues. Citizens could report issues and complaints through the following methods:

- Completing a paper form along with optional relevant evidence such as printed photographs (this method required citizens to visit the municipal premises);
- Telephoning the Call Centre which forwarded the incoming request to the appropriate offices; or
- Completing an online form, which required including personal details with each submission.

These different channels for citizen–government communication were not linked, causing extra delays and difficulties in the overall management. A more detailed description of each method, as explained to the authors by the head of the e-Gov Department for the municipality of Thessaloniki and by the supervisor of the Citizen Transparency and Service Directorate, is provided below.

Paper form

Every incoming document addressed to local authorities in Greece is handled based on specific procedures. In the case of the municipality of Thessaloniki, the steps include: (1) registration of the document and assignment of a reference number; (2) forwarding of the document to the relevant authority involved in the processing and resolution of the request; and (3) information to the appropriate overseeing services or departments and their supervisors, such as the Office of the Deputy Mayor, based on the content of the request. The document is registered in each of the respective directorates, with the Head Officer assigning the issue to the corresponding departments. The head of each department must undertake the necessary actions based on the current availability of resources in terms of personnel, logistics, active subcontracts and materials, and communicate back to the citizen, either orally or in writing, the actions taken. When the issue is resolved, the competent

service closes the request by informing the relevant directorates and the citizen in writing about any outcomes. During the processing of requests, citizens are not aware of their progress unless they manage to locate the department and contact the civil servants managing the task, either orally or in writing.

Call Centre

In Greece, there is no dedicated phone line at a national level for reporting non-emergency issues such as the 311 phone line in the United States that was created by the US Federal Communication Commission in February 1997 with the goal of relieving congestion on the emergency line 911 (Chatfield and Reddick 2017). In Greece, citizens call the relevant local authority offices directly or contact the municipal Call Centre if they are not aware of the appropriate department to contact. The Call Centre forwards the call to the relevant office, where a civil servant records the request and the contact details of the citizen, and the problem is recorded on paper. The report is communicated to the head of the respective department. The process follows the same workflow as with paper-form applications. Again, citizens need to contact the relevant local authority office directly to track the progress of their report.

Online form

An alternative communication channel offered by the municipality is an online web form that allows citizens to submit their issues. Personal details such as identity card number, name, phone, email, home address, problem description and location are compulsory fields. In the online form submission, the data are sent via email to a member of the Call Centre who then forwards it to the relevant department. Depending on the content of the reporting issue, it might also be necessary to print the form and receive an official reference number from the Registrar. Upon submitting the online form, the only feedback to citizens is a confirmation message that the issue has been successfully reported. Citizens are not able to track their issues or be informed about their status unless they contact the responsible local authority office again. Because citizens are not familiar with the municipality's internal structure, identifying the correct office from which to obtain feedback is a cumbersome procedure.

Besides the bureaucracy and the lack of transparency, these approaches have some other significant drawbacks: (1) the requirement of a citizen's physical presence in the municipal premises (for the paper

form); (2) filling in documents and forms which are extremely time-consuming; (3) delays caused by posting the hard copy documents and paper forms to the relevant departments; (4) the lack of feedback to citizens about the progress of their reported issues; (5) the lack of in-house knowledge concerning the amount and type of submitted issues; and (6) the lack of a centralised unified management system, which leads to delays and difficulties in setting up an optimal management strategy for resolving the reported problems. In addition, traditional approaches have a negative impact not only on the processing speed but also in terms of ineffective allocation of human resources, equipment, facilities and budget. This has also affected the overall medium-term operational planning of the municipality. These deficiencies made it obvious that the convergence and the integration of the existing communication channels under a unified platform was a necessity, and the need for a more flexible and efficient system for receiving and managing incoming non-emergency issues, such as IMC, was raised by the mayor and the 2015 City Council of the municipality.

2.2 Managing non-emergency issues post IMC

The municipality of Thessaloniki launched the web-based IMC application in June 2015. In February 2016, the IMC mobile app for Android and iOS was released and offered for free via the Google Play Store and Apple App Store, respectively. The introduction of the IMC app for smartphones was aimed at further promoting citizen involvement in local government, since it was expected that locating and reporting local issues whilst on the move, using a mobile's Global Positioning System (GPS) sensor and camera, would be more efficient for citizens. As of the first quarter of 2019, almost fifty thousand issues had been reported by approximately twelve thousand registered citizens in the municipality. Reporting has steadily increased each year (Table 9.1).

Approximately 63 per cent of the reported issues have been resolved, with their status declared closed, and more than 750,000 notifications have been pushed to citizens and civil servants, significantly advancing interaction between citizens and local government. Based on heat maps and geohash grid maps (see Figure 9.1), the spatial distribution shows that citizens from all neighbourhoods participate, with some areas being more active during specific periods or events. For example, every September, more issues are reported around the location of the Thessaloniki International Fair (TIF) due to more residents visiting the surrounding area.

Table 9.1 Annual number of reports submitted through ImproveMyCity by registered citizens in the municipality of Thessaloniki, Greece

Year	Yearly reported issues	Percentage change	Total number of reported issues
2015 (2nd semester)	1,880	–	1,880
2016	9,743	+418.24 per cent	11,623
2017	14,608	+49.93 per cent	26,231
2018	17,687	+21.08 per cent	43,918
2019 (1st quarter)	5,990	+35.69 per cent	49,908
2019 (end-of-year estimation)	17,970	(estimated until the end of 2019 based on 1st quarter)	67,878

Source: ImproveMyCity analytics reports.

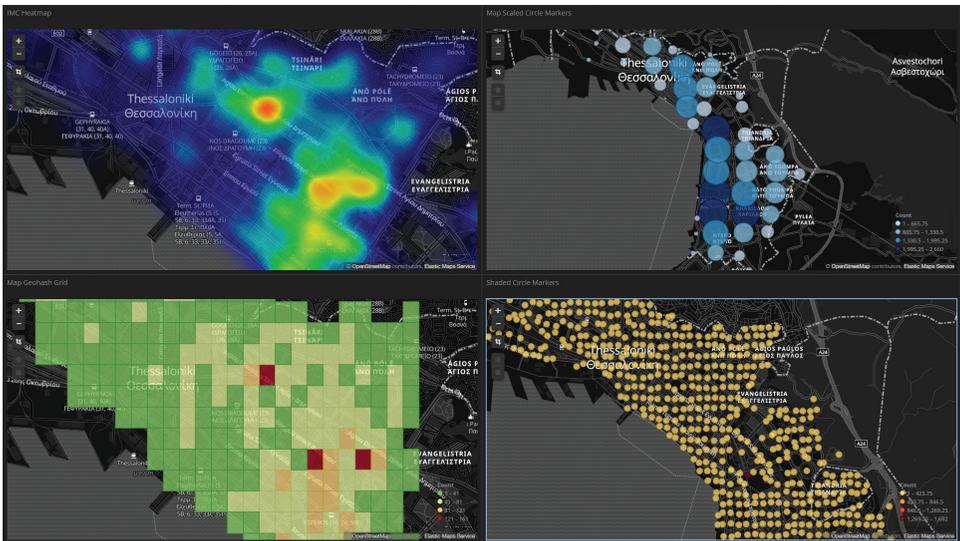


Fig. 9.1 Interactive map-based visualisations from ImproveMyCity (IMC). Clockwise from top left: heat map, scaled circle markers, shaded markers and geohash grid. Exported by authors using the IMC analytics. Basemap © OpenStreetMap contributors. Visualisations created with Kibana from Elasticsearch BV (‘Elastic’).

The majority of registered users submitted up to two issues, but there are some outstanding cases worth mentioning. A single citizen reported 328 issues over a period of three years. There are also user groups and non-governmental organisations that are using common accounts to report problems in a coordinated effort, such as the group ‘Friends of the Historical City Centre’ which had reported 483 issues up to early 2019. Having a number of organised citizen groups using the application for reporting problems is encouraging and denotes strong community-driven user engagement, as broadly supported by research in the context of community informatics. [Gurstein \(2000\)](#), for example, shows how communities harness information and communication technologies to further their social development efforts. Another remarkable outcome is the fact that 93.5 per cent of the citizens whose reports received at least one positive vote by other users of the IMC system have either submitted additional new issues or responded to existing ones with at least one comment (these IMC features are detailed in Section 3). This indicates that interactivity and responsiveness, as suggested by [Phillips and Orsini \(2002\)](#), are critical factors in encouraging and strengthening citizen participation in applications such as IMC.

3. The IMC map-centric application

IMC is a software platform open to any individual or consortia to use and contribute to under the Affero General Public License. It was originally introduced in April 2012 ([Tsampoulatidis et al. 2013](#)) and since then it has had more than twelve thousand downloads. IMC is offered under the freemium business model, meaning that simple and basic services are offered for free but more advanced services and features are offered at a premium. Official support and customised versions were being offered in about 35 municipalities worldwide as of early 2019.

IMC is a modular platform, and its web-based front-end interface (an indicative instance is shown in [Figure 9.2](#)) supports different themes and layout templates so that administrators can customise the interface. Several themes are freely available, including the official one which is based on material design guidelines from [Google \(2019\)](#). There are themes available which are keyboard friendly, use high-contrast colours and are compliant with the WCAG 2.0 level AA accessibility standard ([W3C Web Accessibility Initiative 2019](#)). The front-end interface is map-centric, using either a Google Maps or OpenStreetMap background map. Small cities and rural areas usually prefer Google Maps due to better coverage of

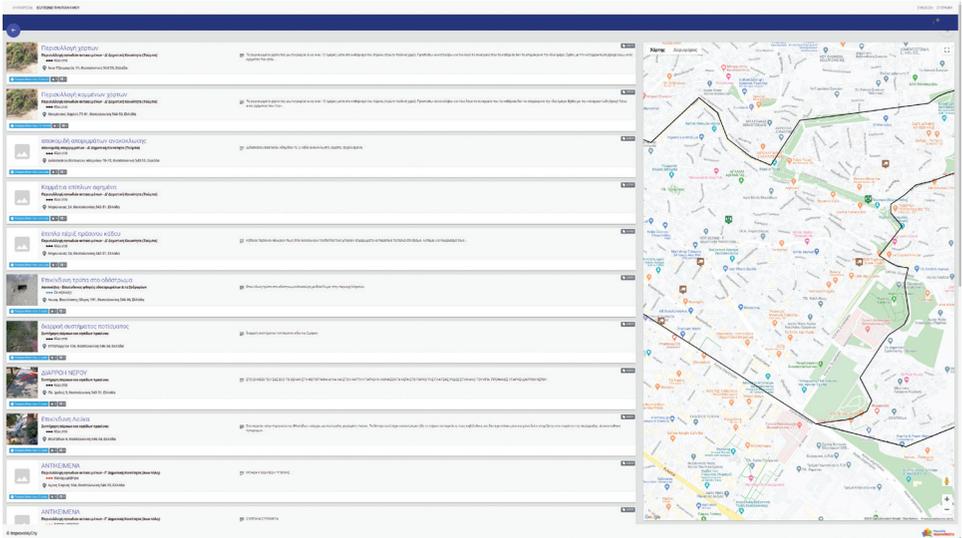


Fig. 9.2 The web-based IMC application front end.
 Source: Powered by improve-my-city.com. Basemap © Google Maps.

road names and numbering. Maps are used to show the location of issues and to allow users to report the precise location of a new issue.

Citizens can use IMC not only to collect data but also to view reported issues on the map, to vote for them to show their support or agreement and to discuss reported issues with other citizens and public administration officials. Discussion is held publicly (under moderation) or privately. This is decided by the administrators during the initial set-up of the platform. Citizens receive notifications automatically on each action concerning their reported issues. In addition to reporting issues, citizens can suggest solutions and ideas for improving their neighbourhood and collect positive votes from other citizens to gain attention and support (Tsampoulatidis et al. 2013).

The organisational structure of each municipality is set a priori in the platform so that the reported issues are automatically routed to the relevant local authority department based on the geographic location of the reported issue and the chosen category. Commonly used categories specified by the administrators are: road maintenance, parks and green spaces, cleaning and recycling, public spaces, buildings and structures, and crime and antisocial behaviour.

IMC is available as an extension package for open-source content management systems such as Joomla! and WordPress and in the cloud as Software-as-a-Service (SaaS), based on a mix of Laravel, Node, React,

Kafka and Elasticsearch technologies. The service model of IMC is based on three main pillars: reporting, administering and analysis.

3.1 Reporting issues

Although anonymous reporting is possible, the overwhelming majority of IMC installations worldwide prefer citizens to be registered because local authorities prefer to interact nominally with their citizens, and obligatory registration eliminates spamming. Reporting is possible through the IMC web-based application and the mobile app. The Android and iOS apps follow the native design interface guidelines and principles as defined by [Google \(2019\)](#) and [Apple \(2019\)](#). Special characteristics for each operating system, such as the ‘Peek Preview’ for the iOS and the floating action button for Android, slightly differentiate the two versions. Login via social network accounts and customised authorisation schemes, such as the Italian Public System for Digital Identity, are both supported. The mobile app allows the uploading of multiple photos directly from the mobile device’s camera and the geolocation is automatically pulled from its GPS sensor. Since the offline-first design approach ([Biørn-Hansen, Majchrzak and Grønli 2018](#)) is followed during the implementation phase, the mobile app can fully operate offline, and it is synchronised with the server automatically when Internet access becomes available.

Push notifications allow local authorities to notify citizens more directly, not only regarding their reports, but also about cultural events, local news and announcements. The first and second screenshots in [Figure 9.3](#) depict the slight interface design differences between iOS (first) and Android (second). The third screenshot shows the clustered markers on the map and the use of custom marker icons which are based on issue categories. The progress and actions towards resolving an issue are displayed as a vertical timeline which is depicted in the fourth screenshot.

Apart from reporting new issues and browsing existing ones or reading notifications, news and announcements, citizens are also able to: (1) edit their own reports if their status is still unmodified; (2) comment publicly or privately; (3) vote positively by giving stars to other issues; (4) filter by area, status, category and ownership; and (5) apply text-based searches.

3.2 Administering issues

Management and routing of incoming issues is performed through the back-end administration interface that serves as an integrated management system and which also includes some basic interactive statistics.

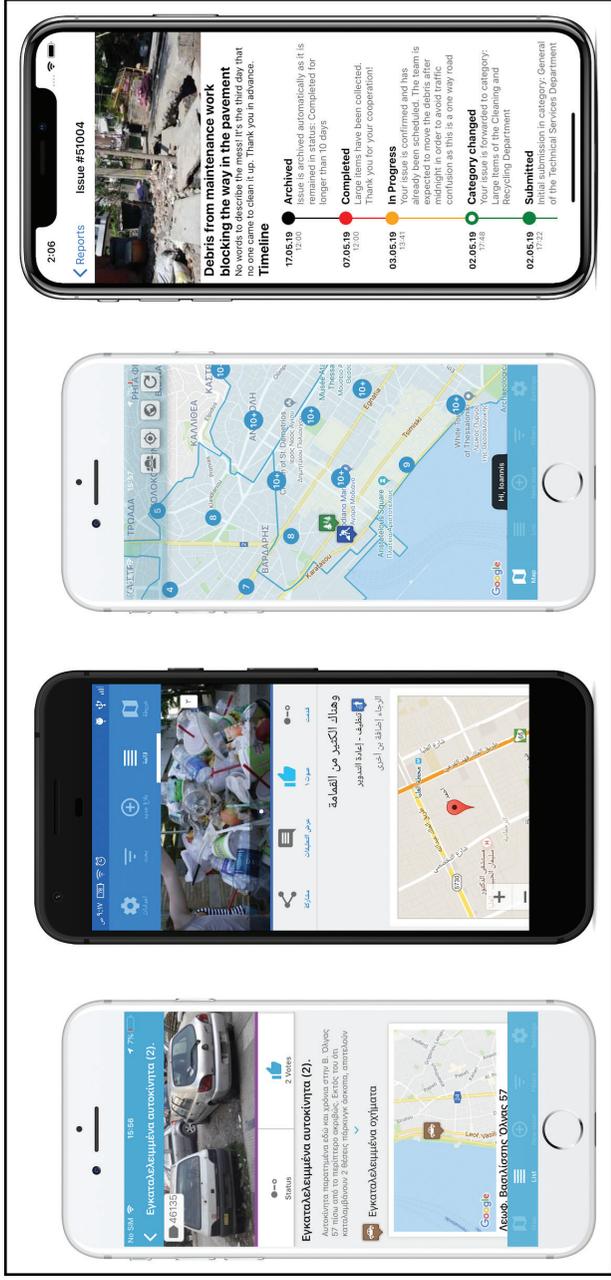


Fig. 9.3 A set of screenshots from the IMC mobile app depicting the differences between iOS and Android. The map, issue details and timeline features are shown as well.

Source: Powered by improve-my-city.com. Basemap © Google Maps.

IMC, unlike other solutions, does not rely only on emails for communication. As Barbeau (2018) justifies, managing the issue life cycle via email is inefficient, since email is not the most suitable medium for tracking individual issues, including information about the assignees and the actions taken, until an issue is resolved. For this reason, each civil servant who belongs to one or more departments has their own credentials to log in to their personal administration user interface (UI). Based on available permissions, the administration UI is dynamically adapted, hiding unnecessary complexity and therefore making the interface more usable for civil servants. Direct communication with citizens is feasible through a rule-based automated notification system which is triggered by certain actions, for example on changing an issue's category or department, or upon updating the status of an issue. Indicative status levels include the following: submitted – acknowledged – in progress – solved – closed – archived. All actions taken on an issue are logged and displayed on a timeline.

The integrated reporting mechanism allows civil servants to check the overall condition of the city by applying composite filters by category, department, area, date range and other criteria. This integrated reporting mechanism can then be used to inform supervisors by sending them automated emails, notifications or, in some cases, a printed paper form. Scheduled to-do reports on a daily, weekly and monthly basis help civil servants assign jobs to their subcontractors more easily. Technically, the back-end provides the Representational State Transfer (REST)-based application programming interface – this is used by the mobile apps, the basic statistics module, the front-end and third-party systems such as e-protocol systems, geographical information systems, maintenance and asset management systems and others.

3.3 Analysis of issues

IMC further supports data analysis through visual analytics which employ map-based visualisations and spatio-temporal filters, graphs, interactive diagrams and tailor-made mechanisms to enable data fusion from public authorities. It also uses external open geospatial data sets in order to provide decision makers with valuable insights and to improve operational activities around the city. Discovering hidden patterns through geographic data aggregation and visualisations and translating these patterns into knowledgeable insights is feasible through the highly interactive and customisable IMC analytics dashboards. These dashboards offer local authorities the necessary tools to identify areas with increased numbers

of reported issues and underperforming departments due to heavy workload or seasonal burden on city infrastructures, and generally facilitates the process of turning simple observations into well-advocated decisions. [Figure 9.4](#) depicts an indicative dashboard from the municipality of Thessaloniki installation.

The target group of the IMC analytics are civil servants, as well as citizens who are interested in detecting patterns about the functioning of their city and wish to investigate additional information further that may help them interpret these discovered impressions. Apart from the IMC-produced data, the analytics dashboard can combine and merge external data sets that are typically generated by governmental departments, either regional or federal, and may be related to: (1) infrastructure such as location of schools, hospitals, parks and public facilities; (2) economic data such as average income per area; (3) health-related data such as satisfaction indicators of health-care services; (4) environmental data such as air and water pollution and electricity consumption; and (5) municipal police-related data such as crime level, traffic and parking spaces, and much more. This type of information can be of great interest, especially when viewed and explored in combination with citizens' submitted issues, and it may be used to reveal insights which would have been otherwise impossible or extremely difficult to observe. For instance, by overlaying geographic information related to the location of schools, hospitals and other critical infrastructures, or by comparing traffic-related information along with a density heat map of submitted reports of the relevant categories, critical decisions such as which issues to resolve first, how to plan city resources for next year or where to invest more for infrastructures can be made with better evidence ([Vasilopoulos 2017](#)). An indicative example of such data fusion is the combination of the location of reported issues concerning illegal parking with that of registered parking spots. This evidence would support the policymakers of the municipality in redefining the ratio between residents' and visitors' parking spots in specific areas of the city.

4. IMC as a geographic citizen science application

In this section, we provide anecdotal evidence from more than six years of use of the IMC application. The emphasis is on the obstacles and side effects of turning citizens into the living sensors of their city and transforming local authorities to be able to accommodate and care for their input smoothly.

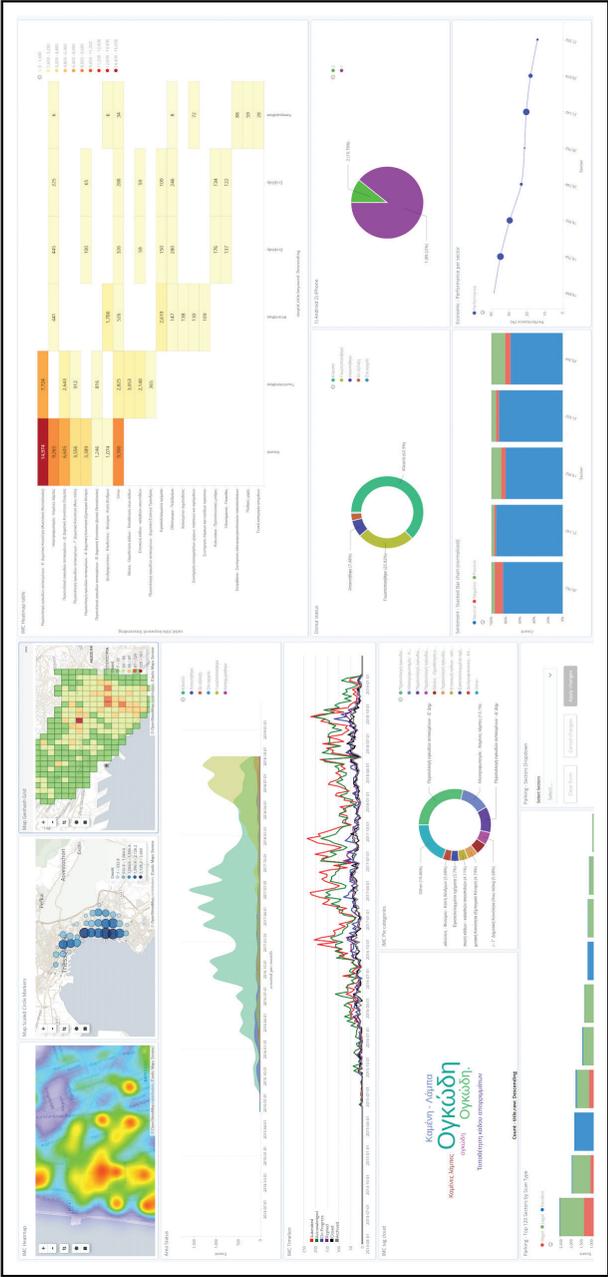


Fig. 9.4 IMC analytics dashboard with an indicative set of various visualisations also combining external data sources which are interactively interconnected. Dashboards can be embedded to existing websites or included in reports. Basemap © OpenStreetMap contributors, Elastic Maps Service.

4.1 A view from the perspective of politicians and civil servants

To overcome preliminary concerns associated with the adoption and utilisation of highly open and transparent geographic citizen science applications such as IMC which are used to report non-emergency issues and eventually incorporate them into existing governmental ecosystems, there is a need to recognise and take a series of actions. First, there is a need for firm political intention and commitment by higher-ranked municipal politicians during the earliest stages of the platform's initiation. Second, key personnel and supervisors need to be well trained on the various aspects of the system and should be able to transfer this knowledge, tailored to the ongoing workflow of each municipal department, to their colleagues. Therefore it is essential to adjust the platform rules and settings to operate consistently with the municipality's ongoing business organisational flow and structural hierarchy in order to make the adaptation of the new technology smoother. Third, civil servants need to appreciate that including the new platform into their day-to-day workflow will benefit them directly, since their work will become more efficient and robust. They also need to recognise that citizens are part of the solution, since they are actually acting as the living sensors of the city.

In order to ensure the long-term successful utilisation of applications such as IMC by local authorities, the following conditions are necessary: (1) the creation of a new centralised administrative structure in the form of an exclusive department which is responsible for the overall unified management and support of the application, (2) the creation and standardisation of relevant procedures and the adoption of an internal accountability process and (3) the continuous support of procedures, rules and structures by supervisors in order to ensure compatibility and integration with existing ICT systems.

4.2 The problem of duplication

One of the challenges in the utilisation of IMC is dealing with multiple reports on the same issue. Not only in the case of Thessaloniki, but also in the majority of IMC installations in Greece and abroad, citizens are reporting the same issue over and over again to put pressure on local authorities and to prioritise their requests. On top of this, multiple reports on the same issue are submitted with minor differences in the way the title and location of the issue are described, and it is not always clear that the same problem has already been reported. To deal with the problem of dupli-

cated reports, during the submission of a new report, users are prompted to fetch from the server all issues in the same category within the last 10 days from a radius of about 20 metres and to return a list of potential problems reported at the same location. The list should contain the title, part of the description and a photo. Greyed-out markers of the suggested issues appear on the input map to denote potentially related reports. The citizen can then follow the link to an existing issue and give a positive vote to show their support instead of reporting the same issue again. It should be kept in mind, though, that acquiring a significant number of votes may take several days or weeks, leading to ineffective and delayed responses from civil servants. As a solution to this problem, [Masdeval and Veloso \(2015\)](#) propose applying a dynamic text analysis on the title and description of the reports in order to help prioritise issues more quickly. A priority level (e.g. normal, urgent) could also be set by citizens during submission and be evaluated by civil servants during the moderation phase.

4.3 Engaging the citizens

Promoting the application via advertising or word of mouth and making citizens aware of its benefits in order to convince them to join the platform is very important. [Skarlatidou et al. \(2019, 2\)](#) highlight that ‘motivating users to remain active, ensuring that users can effectively use the applications, and guaranteeing satisfaction of use, should be central in the design and development’ of citizen science applications. The retention of volunteers who use and contribute to IMC is essential. In the case of the municipality of Thessaloniki, as previously noted, several volunteer groups have created IMC accounts to coordinate their submissions, with a massive positive impact on the way the application is utilised in the long term. Focusing on similar initiatives should therefore be a top priority. In this vain, introducing new features such as push notifications about local events, participatory actions and official announcements alongside a mechanism to invite citizens to act on specific topics (e.g. weekend reporting on accessibility issues on your neighbourhood) can further enhance citizen participation and keep users engaged. Gamification is another technique which is broadly being used for motivating and retaining volunteers. Nevertheless, it should be noted that gamification in the context of IMC was not favoured by local authorities as a potential engagement strategy. It was therefore removed from the provided IMC functionalities.

4.4 Moderation

Although moderation complicates the workflow processes because an extra step is added to the authority's workload, almost all municipalities prefer to enable the moderation mechanism. When a citizen reports an issue, it does not become publicly available until a civil servant validates its content and ensures that the issue complies with the terms of use. As a matter of good practice, the reported issue becomes immediately visible to its owner, who is allowed to make changes (e.g. fix typos or include further information) while the status of the issue remains unchanged.

4.5 UI design recommendations

In this section, we provide a list of design recommendations that have emerged from the feedback we have collected from users of the IMC web-based application and mobile app through Google Analytics and in-app analytics and through user feedback from the open-source community, forums and live chat sessions.

When a new issue is submitted using the mobile IMC app, the initial geolocation is pulled from the device's GPS sensor. Users have the option to make minor adjustments to their location or to set a different location by tapping on the map. A marker is pinned to the new position set by the user, which is reverse geocoded to a readable address. Usability tests demonstrated that this method is not optimal. Due to the small real estate of mobile screens, tapping on the desired location is difficult because the thumb hides the desired area. The suggested method is to put a marker on the centre of the map which remains still, and let users pan the whole map until the static marker is on their preferred geolocation.

User feedback further revealed that IMC mobile app users prefer to submit new issues by following a series of steps rather than by filling in a single form. This way, scrolling is avoided, and form validation becomes more user friendly. Moreover, the problem of having to interact with a map which includes unknown road names is not usually an issue in big cities, but it is still a problem for rural areas. For this reason, the UI design should make it obvious that the address field can be also filled in with free text and not only via the map's reverse geocoding mechanism. Lastly, it is suggested that markers on the map are displayed in clusters based on the zoom level, especially when more than 50 locations are displayed at the same time. Another solution is to paginate the results to display fewer markers on the map.

5. Citizens become partners

Typically, the lack of a unified system for monitoring and managing incoming non-emergency issues prevents the formation of a comprehensive overview of the city because it limits civil servants to monitoring: the volume and type of incoming requests, the average response time, the time needed for an issue to be fully resolved, the geographic distribution of incoming issues and their relationship with other spatial characteristics (e.g. periodic city events), which can be revealed through the use of more sophisticated spatial analysis techniques. To address this, IMC supports the processing of the collected data and corresponding solutions so that civil servants (and citizens) can draw meaningful conclusions and gain a deeper insight into the way non-emergency issues are being managed at city level. This analysis includes the processing of quantitative characteristics of the submitted reports, such as the number of reports on specific geographic areas and the number of votes and comments, in order to reveal information about the intensity and frequency of reported problems. Citizens' subjective attitudes and perceptions can be further analysed using sentiment analysis, which is available as an IMC plug-in, and which can be used to analyse comments and textual descriptions of the reported issues. This in turn can help identify citizens' reactions as positive, negative or neutral.

6. Lessons learned

- Geographic citizen science in the context of non-emergency issues reporting has had a significant impact on the way the city of Thessaloniki is managed in both short-term planning and long-term policymaking.
- Using standards, such as openAPI, geoJSON, WCAG and OAuth, and applying well-accepted design techniques and guidelines such as the 'design for all' approach (O'Ferrall 2019) should be a priority in order to provide a user-friendly interface and seamless integration with third-party systems.
- Ensuring citizens can actually use the application and the retention of volunteers should be central concerns in the design choices and development process of geographic citizen science applications. IMC provides themes that incorporate best practice towards better user

experience such as keyboard-friendly interfaces and offline use of the mobile app.

- IMC relies heavily on principles of openness and transparency, which we found to be fundamental for the smooth operation and adoption for applications of this type. Municipalities which try to limit transparency towards practices they feel comfortable implementing (e.g. by displaying to users only their own submitted issues and not showing issues reported by other citizens) have a negative impact and should be discouraged.
- Less technically able citizens (e.g. older people) and those with disabilities who could potentially face problems using such applications should not be left behind. Besides applying best accessibility practice in the UI, alternative channels of communication such as telephone support must also be available. IMC introduced the ‘Call Centre administrator group’ which allows telephone operators to add issues that are reported by phone directly into the IMC workflow.
- High transparency can also have negative effects. It is essential that personal data are secured and kept confidential and that a series of actions for this is put in place. These actions include the censoring of photos containing sensitive information and the moderation of issues that directly or indirectly refer to physical persons or legal entities.

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