The role of PPGIS in the creation of a vibrant cycling community in Rotterdam, the Netherlands

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Introduction

This paper discusses the application of GIS in public participation (PPGIS) to contribute to the optimization of the bicycle network in Rotterdam, the Netherlands. The aim of improving the bicycle network is to increase the number of rides which leads to less Co2 emissions, less noise, more efficient use of the outdoor space and a healthier population (Nijland and Van Wee, 2006).

Rotterdam has approximately 600 kilometers of cycle paths. On working days 160.000 citizens travel by bicycle. Another 160.000 Rotterdammers never cycle. Of the four major cities in the Netherlands, citizens of Rotterdammers are the least likely to cycle. The municipality of Rotterdam set the target of increasing the number of bicycle rides by 10% in 2018 (Gemeente Rotterdam, 2016).

To enhance the involvement of citizens and to gain insight into the shortcomings of the bicycle infrastructure, facilities and impediments, a public participation platform (PPGIS) is requisite.

Tulloch (2008) defines Public Participation GIS as the field within geographic information science that focuses on ways the public uses various forms of geospatial technologies to participate in public processes, such as mapping and decision making. Brown and Kyttä (2014) add characteristics such as a focus on urban areas in developed countries, data collection through individuals and the ownership of data held by the PPGIS sponsor.

The first two chapters of this paper describe technological events and social, political and environmental aspects offering leads to develop a PPGIS. The next section discusses the advantages and disadvantages of PPGIS comparing to traditional forms of participation. Chapter four carries on briefly through the development process of a PPGIS for a cyclists community. Subsequently, the roles and organisational aspects of a PPGIS community are exemplified. Finally, a set of criteria is presented by means of which a PPGIS can be assessed for performance.

Technological developments

The digitisation of communication using smartphones at the beginning of 2000 has had a vast impact on people's behaviour, knowledge gathering, knowledge sharing and the decision-making processes. New technologies and applications simplify the communication process and to make decisions. Distance, time or the size of a community are no longer an obstacle to working together.

The launch of operating systems such as MacOS and Windows have enabled software companies to develop applications with a graphical interface. The transition from text to mouse and touch controlled software has dramatically increased the number of users because they do not have to learn instructions by heart. Complementary, more attractive and better-designed hardware (Norman, D.A., 2014), for example, the iPad and the Nest thermostat, improves the user experience and usability of products and services. The events above incite organisations to develop applications and games such as Second Life, Twitter, Facebook, WhatsApp or Minecraft with a high level of interaction and collaboration.

A common denominator in this type of applications is the interaction between users, the user as a content producer and a certain extent of entertainment. When a virtual or physical location is assigned to an event insight are gained into what people think about a particular topic or what the topic is being discussed (trending topic). With the availability of 4G and WiFi hotspots, users can share their ideas and respond to other people's initiatives at any time and any location. People are enticed to share information about road interruptions (Waze) or speed controls (Flitsmeister) but also to improving one's own (geographic) data by automatically forwarding user data to the back-end systems (Tom Tom).

In addition to the existing broadband connection and mobile networks, individuals now also have access to innovative hardware. It is not only available for sale and affordable but also comes in a common-or-garden package such as the Arduino sensor kits. Drones to monitor and record their surroundings on video, sharing sensor data containing the air quality in a neighbourhood are just one click away on Amazon. The creation and use of small, manageable sensors that can be connected to the internet or publish data through a mobile app are within everyone's reach (Seeed Studio, 2018).

Despite the fact that Google and Tesla are still experimenting with self-driving cars, it is already clear that these autonomous vehicles need very detailed maps to make their way through traffic. Perhaps even more interesting is the development in which a car owner becomes a moving data collector by all the sensors and cameras on board. This data can, in turn, be used to analyse and share the traffic situation in real time, but also to collect data together with other motorists and cyclists that can substantiate infrastructural decisions. Data is then not only converted into 2D but also into 3D or 4D information. In the case of 4D, the dimension of time is also made clear.

From a software point of view, there are also exciting developments. Augmented reality brings information about the user's environment within reach. Applications such as Urban Sketcher (Allen, 2011) show that stakeholders can participate in the development of urban areas through augmented reality. Developers and designers are coerced to create user-facing applications. Otherwise, people will not even consider using their solutions. Agile methodologies for software development stimulates developers, designers and end users to consider and develop usable and user-friendly solutions.

Application Programming Interfaces allow online environments to exchange information with each other via open standards such as XML or JSON and offer the possibility to access the collected data as open data to the outside world. More and more information is made available as open data to users who enrich their data and applications with it. OpenStreetMap or the postcode map of the Netherlands are examples of geographically open data.

The developments outlined above can be divided into two forms of participation. In the first form, the participant consciously participates. He shares information and participates in discussions or (online) activities. In the second form, a person does permit for example to share his location or to monitor his internet behaviour but is not aware that this information is used to inform other users or to analyse behaviour. In this way, organisations such as Google and Tom Tom use the speed of locomotion to show other travellers where traffic jams occur and where it can continue. The enormous amount of data that is recorded through apps, websites and sensors lend itself to data analysis and prediction of behaviour.

Social, political and environmental aspects

If the design is a social process in which not only the original designer but also the end user plays an import part, the construction of a PPGIS can also be identified as a social process in which the public contributes to combine hardware, software and geographic data to optimise the bicycle infrastructure of a city. PPGIS assists in the decision-making process. According to Frieling (1997) 'Citizens have to retake their political responsibility to liberate themselves from the ongoing bureaucratisation and jurisdiction of society'. In complex infrastructure projects or more specific in the constitution of a bicycle network a wide diversity of political interests arise. Depending on the maturity and willingness of local politicians and policymakers a distinct level of public participation can be chosen.

To determine which approach best fits in with the decision-making processes of potential travellers in order to achieve an optimal network the ladder of citizen participation (Weideman and Femers, 1993) has been taken as a fundamental principle.

Stage	**Examples of the approach to optimise a bicycle infrastructure,**
Public participation in the final decision	Amalgamation of an online environment and local meetings assemble cyclists, policymakers, mobility experts, road authorities and urban designers, using cyclists' data in a PPGIS to make fact-based decisions.
Public participation in assessing risks and recommending solutions	PPGIS surveys pot-holes and air quality details through a mobile app. Participants suggest improvements.
Public participation in defining interests, actors, and determining agenda	Participants use a PPGIS to map points of interest and priorities regarding the bicycle infrastructure.
Public right to object	Cyclists use a PPGIS to file a complaint with the road maintenance authority about future road adjustments.
Inform the public	The municipality of Rotterdam sends out an e-mail newsletter to inform stakeholder about roadworks.
Public right to know	The municipality of Rotterdam publishes the current bicycle network, facilities, shortcomings and future improvements on a website.

Table 1: Framework for public participation: 'The Ladder of Citizen Participation' (Weideman and Femers, 1993) applied to the theme of public transport network optimisation.

In the case of the construction of a PPGIS and the development process that leads to correct operating procedures, several social trends have an impact.

First of all, an increasing number of individuals lost their trust in governments, big enterprises and media (2017 Edelman Trust Barometer, 2017). Citizens are disillusioned with the democratic process because the outcome of referenda is ignored. Still, excessive salaries are paid to bankers, and social media companies resell private data to third parties. Organisations deploying PPGIS have a real challenge to gain the trust of potential participants. Next, to the level of trust between participants and organisations, trust between participants is also an important a point of particular interest. Naming and shaming on social media and online vandalism dissuade individuals to participate in online initiatives. People are afraid to be no longer in charge of the conversation or their contribution. Simultaneously, peer pressure forces people to participate in online events or using mobile applications such as WhatsApp or Instagram to prevent to become an outsider.

Privacy is another interesting social phenomenon in online behaviour. In one way people do not want to share their private data and personal details with organisations or strangers in an online community. At the same time, at the back of their mind, humans understand that telecom providers and banks know everything about a person's behaviour. If the compensation of an organisation, in money, time or information is alluring, a person throws his principles overboard and shares even the most intimate data and opinions.

From a positive perspective, some social innovations are observed. First, people are getting used to participate in events and build trust through crowdsourcing and crowdfunding. Second, globalisation and the fact that an increasing amount of people work from home, coffee bars or flexible workplaces stimulates online collaboration. It teaches people to work together in an online environment using applications like Skype or Google Hangouts. It is a useful leg up to online participation. Finally, people are getting more

mature. Information that was not available is now just one click away. Online participation using GIS offers individuals to bring forward their ideas and share their opinion.

Traffic is the most significant cause of air pollution in Rotterdam. The burning of fossil fuels releases pollutants and gases. The municipality of Rotterdam started several initiatives to reduce air pollution such as the establishment of an environmental zone and cycling stimulation programs. PPGIS has the potential not only to optimise the visual infrastructure but also to improve the living conditions by mapping the black spots.

Traditional versus online public participation

Comparing offline vis-à-vis online public participation also reveals the advantages and disadvantages of PPGIS. Traditional dedication to geographic information requires less background knowledge and computer skills than PPGIS. Senior or less computer savvy citizens can also use a legible paper map and some markers. When using PPGIS, the primary focus will be on the map and interactive elements. A traditional participation process will divide the attention among maps, photo's, sound, video, materials and scale models. It is still more comfortable for a group of participants to discuss a topic around a table containing the above elements comparing looking at a computer screen that can only be operated by one person at a time. However, collaboration using online chat, whiteboards and maps or a multi-user, digital table-top for managing a GIS (Anslow, Campos and Jorge, 2017) facilitates the participation processes as well.

If public participation becomes co-creation process, participants also need the hardware and software to contribute. Traditionally every person can collect information and examples to put forward.

The bicycle infrastructure in Rotterdam area affects a large group of citizens. A PPGIS is ideal for defining and analysing the preferences and wishes for the geographical distribution of the network for such a large group of people. Offline forms of public participation do not offer a solution for processing large numbers of inputs and are more suitable for small focus groups.

Developing a PPGIS

Although off the shelf PPGIS such as Maptionnaire are available and contain many functionalities, the intended participation platform requires specific features. After establishing a vision, setting goals, priorities and planning, it is essential to involve users of the PPGIS in the development process. User involvement to define customer journeys includes the user requirements based on personas.

Participants will be recruited from existing communities such as the 'Fietsersbond' and 'Fietsfan010'. Early involvement of cyclists will encourage them to also participate in the PPGIS community. A community manager will deduce personas from the pool of participants.

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Together with system requirements, established from the perspective of policymakers, user stories are formulated and translated into tasks. Diverging interests of policymakers and citizens have to harmonised before applications will be developed. Sanoff (1989) admonishes to form a coalition with all stakeholders to reduce tensions through interaction and collaboration, set priorities and impact, and take the plunge about conflicting issues. A successful collaboration requires the same level of knowledge and definitions.

During the development of the tasks, users, designers and developers sit next to each other to continually tune the required functionality. Deliverables will be tested in the field to evaluate the proper operation. Technical shortcomings, performance issues or inadequacy of the user interface will be reported and solved during an iteration process. When a deliverable has been approved documentation and training material for the benefit of participants will be drawn up. Before launching the PPGIS application means of communication will be prepared to inform journalists, citizens, officials, policymakers and remaining stakeholders.

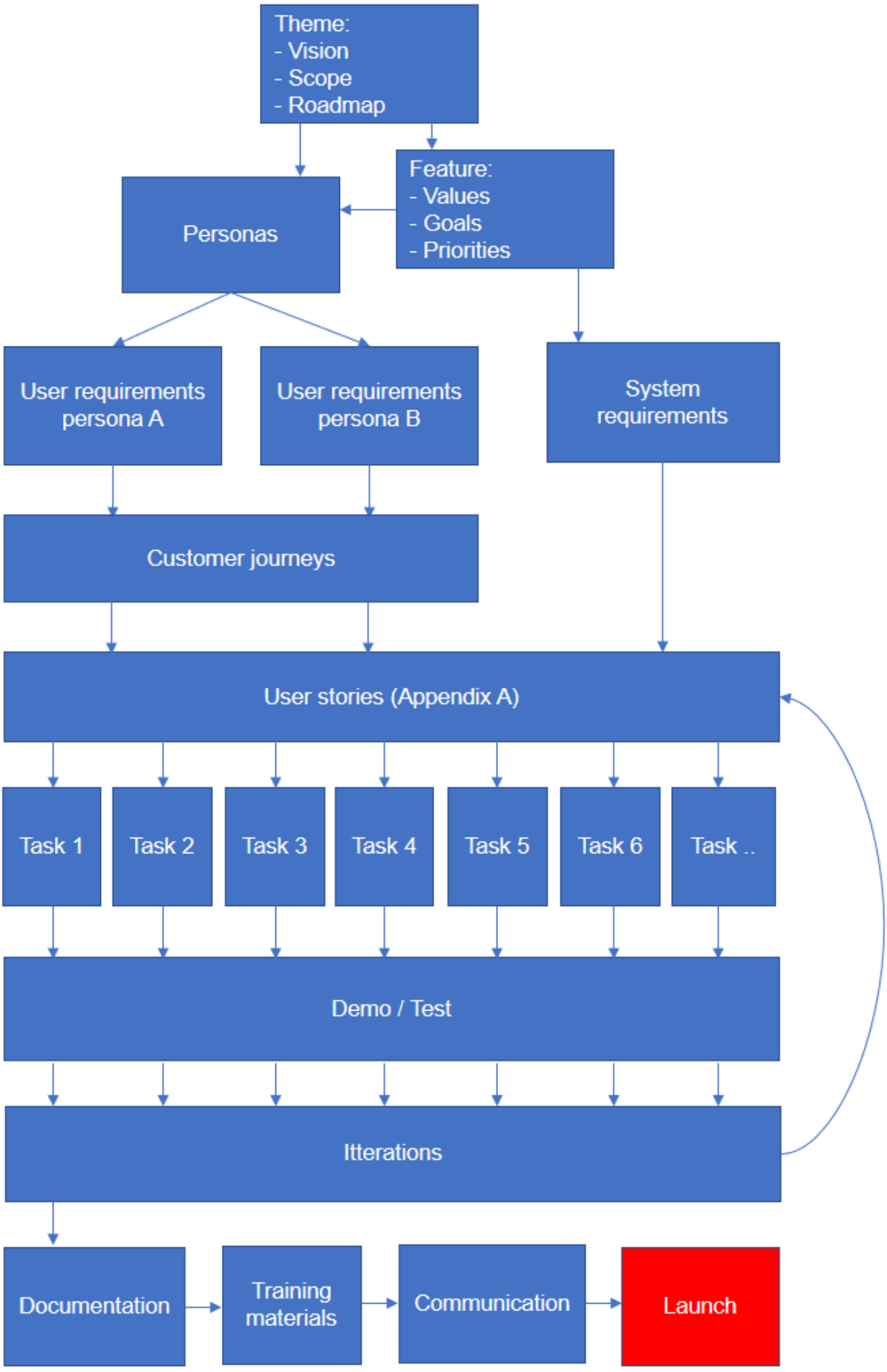

Figure 1: Development process PPGIS

Implementation and management of the PPGIS community

Before launching a PPGIS community, a professional organisation must be set up. Within the community different roles can be distinguished:

Position	Tasks and responsibilities
Community manager	The central point of contact. Manages relationships with all stakeholders and coordinates activities of community professionals. Draws up a development and maintenance plan, set priorities and control the budget. Organize online and offline community events and workshops.
Moderator / content manager	Monitors usage of the PPGIS community and communication with and between participants. Publishes enticing content.
Developer / support engineer	Maintains the PPGIS community, responsible for hosting and development of new applications and optimises functions. Supports community members answering technical questions.
Advocate	Strong communicator, 'selling' the PPGIS community persuading people to join and participate actively. Present the community at networking events.
Data analyst	Analyses the cycling behaviour based on GPS data and discovers hotspots of shortcomings.
Participants	Citizens are having an interest in an attractive and optimum operating bicycle infrastructure. Nielsen (2006) states that in communities 90% of the users only consume the information, 9% contribute occasionally, and only 1% is continuously active in contributing information. Although each participant submitting a point of improvement yields profit, a minimum number of 300 participants, social demographic and geographical dispersed among Rotterdam, must be realistic, given the 160.000 cyclists (Gemeente Rotterdam, 2016).

Table 2: Roles, tasks and responsibilities in a bicycle PPGIS community

Volunteers or paid professionals can fill the above roles. Depending on the availability of people, budget and business case, a choice must be made.

By approaching bicycle communities such as the Fietsersbond, Fietsfan010 and Swapfiets already hundreds of potential participants can be recruited. After the launch of the bicycle PPGIS, it is paramount that participants can quickly enter, share and examine collected findings. A poll or voting system should be installed to support the democratic process. Even more critical to motivating participants is the succession of entered shortcomings and suggestions to improve the bicycle infrastructure and to influence the decision-making process. The commitment of the road administrator and the municipality is a condition for following up the improvements that have been made. This process should be in place before the community starts.

Components of the success of PPGIS

The development and nurturing of a PPGIS take much effort. To measure the performance of the bicycle PPGIS a mix of the information systems success model established by Delone and Mclean (2003) and the usefulness, performance and effectiveness of support instruments (Pelzer, P. et al.), 2014), (Pelzer, P., 2017) have been framed. The following indicators enable a community manager to assess his PPGIS.

Performance indicator	Exemplification
Social learning	The extent to which participants start to know how cycling infrastructure, route and behaviour influence their experience and comfort. Gaining knowledge about air pollution on specific routes.
Effectiveness	The extent to with participants are able to use the PPGIS and succeed in their tasks.
Added value	Applications and advantages towards traditional forms of participation (offline): automatic capturing of participants' positions, analysis of large volumes of data, connecting and sharing sensors data (air pollution, noise)
Usefulness	Citizens get to know their environment and city better. Cyclists get in contact with fellow bikers and learn to collaborate and reach consensus on social issues.
Communicative value	Are policy makers capable of conveying their plans, interests and motivations to cyclists?
Data (quality)	Are base maps and additional layers containing routes, points of interests, infrastructural elements and environmental complete, valid, unique, accurate and consistent? To what extent is the collected data interoperable with external systems?
Information quality	Management reports: relevance, understandability, timeliness and completeness
Service quality	Response times of community support staff, quality of the feedback, empathy and accuracy.
Flexible	To what extent can the PPGIS be adapted during use in response to user wishes or changes in the environment.
Level of interaction	The extent to which the PPGIS facilitates user inquiries and suggestions. The level of interaction between participants.
Level of detail	Map scale, map details, background information about infrastructural adjustments.
Reliability	How reliably do participants rate the information in the PPGIS? Which instruments are offered to test the reliability? How does the PPGIS guarantee a participants' privacy? How is the security of the personal data adjusted?
Transparency	To which extent is it clear to participants how decisions are made, analysis are utilized, and adjustments in the PPGIS are made.
Utility	Does the PPGIS do precisely what it has to do?
Technical performance	Response times, uptime of servers and technical functioning of applications and web services.
System use	The extent to which participants actively use the PPGIS (frequency, nature and purpose of use)
Net benefits	The extent to which the PPGIS contributes to the quality of life of participants (air quality, accessibility and citizens satisfaction), improved decision-making process, cost reductions through more efficient infrastructure maintenance and fewer cycling accidents.

Table 3: PPGIS assessment criteria

Conclusion

A more complex world requires better insight into citizens behaviour and their needs. Citizens are becoming increasingly empowered, and they wish to consult with policymakers and experts to form the city. GIS and the underlying map layers make it easier for participants and professionals to work together and develop a common language. Representativeness of the group of participants is an essential point of attention. People from all walks of life must participate in the PPGIS cycling community to prevent specific population groups or cultures from giving too much control to the community and the underlying outcomes. Alternatively, to prevent socially vulnerable people from being excluded. Defining and applying personas then helps to check whether all target groups are well represented.

Collaboration is not only useful in a PPGIS cycling community but also in the development of the PPGIS ecosystem itself. Public participation in the creation of a PPGIS motivates people to participate in the community and prevents usability flaws.

To keep a community vibrant, clear rules must be agreed in advance and commitment is expected in the form of active participation. Also, proper instruction in how the community, PPGIS and devices work is required. Moderation and support of the community are necessary to manage and motivate participants. The way in which privacy and personal data is secured is crucial to ensure the trust of the participants.

PPGIS plays a central role in providing access to functions that facilitate the decision-making process: collecting data, sharing data, scenario planning, analysis and interpretation of data, visualising and presenting data and assessing data.

This paper defined a broad set of indicators by which the performance of a PPGIS can be tested. Monitoring the indicators and adjusting the course of the community if necessary, contributes to the success of the PPGIS.

Developing and managing a successful PPGIS for optimising a bicycle network arises many challenges. Not only should budget and resources be available to develop a PPGIS, but also to adopt the proposed modifications to the bicycle infrastructure. From a social point of view, it is paramount that participants are rewarded through gaining acknowledgement for their effort. Citizens will only remain involved if the ideas that have been introduced are really being put into practice. Fortunately, mobile technology has changed the roles of citizens from obeying subjects into assertive participants. It is up to policymakers and local government to offer the right instruments to start a dialogue and transform citizens demand into pragmatic solutions that make life more pleasant.

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Appendix A – User stories

a. I like to install a PPGIS app on my Android Phone or iPhone.
b. I want to use the same PPGIS functions in a web browser.
c. I want to manage my personal data.
d. I like to use the PPGIS while I am cycling.
e. I like to save my routes and share them anonymously in the PPGIS.
f. I want to monitor my trip and get real-time information about:
- Directions in the text (spoken) and on a map
- Weather conditions (precipitation, wind direction and temperature)
- Diversions, disruptions and accidents
- Road conditions (potholes, pools)
- Bicycle facilities (sheds, bicycle mechanics, public transport transfers)
- Outdoor air conditions (PM 10, PM 2.5, CO, NO), noise pollution

g. I want to report diversions, disruptions, accidents, potholes, pools, broken traffic lights, bicycle queues and dangerous situations through easy to use buttons on the screen linked to the X and Y coordinates even when I wear gloves or if it rains.
h. I want to request for a specific bicycle facility (shed, cycling path, traffic light) through easy to use buttons on the screen.
i. I want to add additional photos and comments to the entered defects at a later moment.
j. I want to vote on ideas that have been put forward.
k. I like to have the opportunity to give feedback on the PPGIS app or website.
l. We (community staff) want to employ an unalterable and pre-defined set of symbols and classifications to make participants familiar with the GIS vocabulary and prevent the proliferation of data.
m. We like to monitor user statistics (downloads and usage app, usage website).
n. We want to get an overview of the entered shortcomings and comments in a table and on a map after selecting a date or a period.
o. We want to analyse hot spots of defects on the map
p. We want to visualise traffic intensity
q. We like to host a whiteboard and stream webcasts to discuss with participants and stakeholders usage and desired improvements of the bicycle infrastructure, co-browse the map and share photos online.
r. We like to share online courses to train participants.
s. We want import the data from the PPGIS into other Geographic Information Systems.
t. We like to register inquiries and feedback from participants.