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Master Thesis: New Media and Digital Culture

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# The Influence of Digital Twins on Policymaking and Urban Planning

## A Case Study on Tygron Geodesign Platform


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**Abstract**

Digital tools such as simulation software and digital twins are increasingly incorporated in the urban planning and policy making processes. The multitude of advantages of the implementation of these data-driven tools, however, is not problematized enough. In this thesis, I studied a digital twin used day to day within Dutch municipalities and provinces, developed by Tygron. In my research, I analysed how different user group engage with the software and how different levels of users' data expertise influence what the tool communicates to the users. Subsequently, I defined what consequences, challenges and advantages, the software has on the broader social practice. In my research, I approached the tool from a critical data studies perspective and investigated it structurally as a data assemblage. I studied how the concept of mediatization unfolds in Tygron's digital twin and what implication it has on the way the software represents the reality. Through applying the walkthrough as well as conducting a number of expert interviews I analysed the software's interface and the experience of the users. In my research, I defined different user layers engaging with the software. Each of them has different objectives for using the tool and approaches the software with various levels of technical expertise. My research showed that the goal of the users as well as their data literacy influences the way the various groups perceive the results produced by the software.



***Keywords:*** digital twin, simulation software, urban planning, policymaking, data assemblage, mediatization

# Table of Contents

# 1. Introduction

Recent research in the field of urban planning shows that currently close to 55% of the world's population is living in urban areas. This number is only expected to grow resulting in anadditional 10% by the year 2050 (Strange 2018, 15). The management as well as sustainable and efficient planning of urban areas is therefore, in the light of such rapid global urbanization, one of the most important challenges of the twenty-first century.

Even though 440 of the world's 600 most economically significant cities are in the developing nations (Strange 2018, 14), the challenge of sustainable management of urban areas is also a priority on the agenda of developed countries. An example of such a country can be the Netherlands where since June 2014, the government has been working on a revised Environmental and Planning Act which would improve regulations for spatial plans. The Dutch regulations for planning of living areas consists currently from hundreds of laws regarding water management, environment, monuments protections, nature, noise, buildings and infrastructure. With the passing on the new Environmental and Planning Act, the Dutch government is hoping to simplify the rules and to make them clearer so that they work in favour of innovation and development as opposed to them being an obstacle. The new act should allow for the social goals to be reached quicker and more effectively as the simplified regulations would support the process (Ministerie van Infrastructuur en Milieu, 2016). In the Environmental and Planning Act, of great importance is also the role of the citizens in urban planning. The act stands strongly for making collaborative planning with the participation of the citizens more customary. It also strives to connect the citizens with the governmental organizations and make the dialogue between them more fruitful (VNG, n.d.).

The coming into force of the new Planning Act demands a reorganization of work processes within the municipalities. To aid these processes and to make urban planning faster and more efficient, new digital tools are incorporated into the work of policymakers. In the era of data driven governance, tools which are able to generate insights from data are growing in importance. Among these, so-called digital twins are becoming more popular. A digital twin is a digital representation of a physical object in the world, for example the environment of the cities. It is more than a three-dimensional map of the city as it can represent the dynamic interaction of traffic flow, weather conditions, CO2 emissions and other pollutionary issues. It also affords a layered view taking streets, water supply and sewage system, electricity grid etc. into consideration. It simulates the behaviour of its real equivalent and offers an interface that

can be used for monitoring the past and present state of the object as well as make predictions about the future (Kaur et al. 2020, 4).

The technological innovations in the field of urban planning bring many opportunities but also pose numerous challenges. Because of the approaching implementation of the new Environmental and Planning Act, digital tools which allow for verifying if building plans comply with an abundance of spatial regulations in a reduced amount of time are increasingly interesting to urban planners and are often integrated in the work processes of the municipalities. Even though such tools are recurrently used for real world urban initiatives the advantages that they bring to public management and the implications that they have on the societies are not problematized enough. In order to be able to responsibly and ethically incorporate such software however, it is crucial to critically investigate how these tools work, how and by who they are designed, how they are marketed, what data do they operate on, how do they translate data into visually convincing spatial representation and furthermore, to study what possible implications can such tools have on the social practice when used by different user groups which vary in the levels of data expertise.

For that reason, in my research I investigate software developed by a Dutch software company Tygron, where I am currently employed. The company's product, the Tygron Geodesign Platform, is a digital twin which, based on the input data, visualises a chosen area as a 3D model. The platform operates per default on open data; however, the users can make the project more complex by uploading their own data relevant to the project that they are working on and an issue they want to model. The platform makes use of various calculating models and machine learning in order to simulate and visualize different urban scenarios and aid decision making for urban dilemmas. On a technical level, the Tygron software is based on a game engine and because of that, it carries a number of affordances. The software has a number of fixed mechanisms which adapt to every project created in the Platform. Because it is based on a gaming engine, the software generates a detailed environment where shadows of objects, times of the day and the laws of physics are applied to any case created by the user. These properties make Tygron a flexible tool which can be used to model any area of the world. Furthermore, the game mode engine enables the deployment of the software in a multi stakeholder mode which allows different users to join the session. The software is often used

in the interactive mode as a serious game which engages multiple stakeholders in a discussion about urban issues.

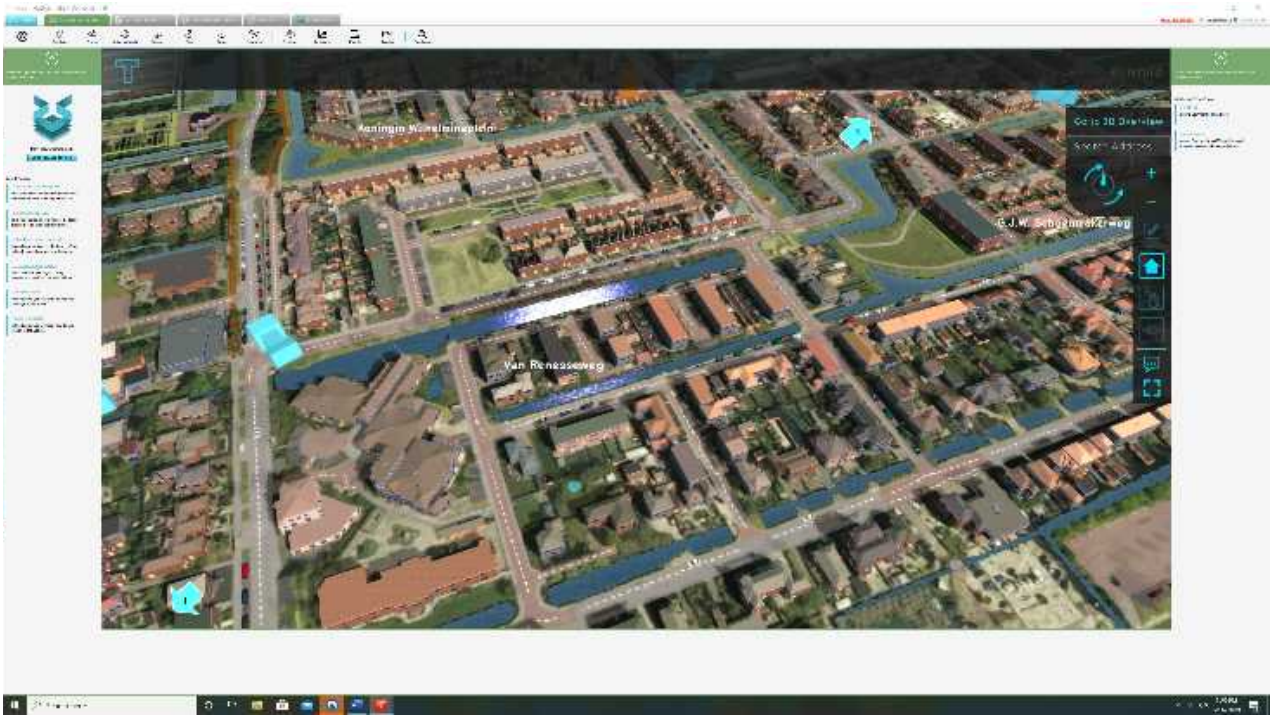

*Figure 1 The interface of the Tygron Geodesign Platform*

In my research, I study the tool as a data assemblage (Kitchin 2014,6) and I structurally look at how different user layers engage with the Tygron software, as well as what the tool communicates to users with various levels of expertise and data literacy. Furthermore, I investigate what consequences (challenges and advantages) simulation software has on the broader social practice: the public management and urban planning. I situate my work within critical data studies (Iliadis & Russo 2016, 2) as well as the concept of mediatization (Hjarvard, 2007, 3). My research connects to the discourses on smart cities and public management; however, the focus of my inquiry lays on the datafication of urban planning.

In order to investigate the object of my research thoroughly I combine a number of methods. I approach the tool as a data assemblage (Kitchin 2014,6) which enables me to structurally study the different building blocks of the software as well as the user groups which engage with the tool. In the first part of my analysis, through applying the walkthrough (Light, Burgess and Duguay 2018) method, I analyse the interface and the affordances of the software. I combine it with an adapted model of Fairclough's critical discourse analysis (2013) through which I investigate the way the tool is marketed, distributed. In the second part of my analysis, I discuss how the tool is received among the users who work within the urban planning and public management domain. In order to research the users' experiences of working with the

tool I conduct a number of semi-structured expert interviews with users who rely on the tool in their daily work. Moreover, I identify the consequences that the implementation of digital twins in urban planning might have on the broader social practice.

## 2. Theoretical Framework. The mediatization and datafication of urban planning

It is widely recognised by scholars that information and communications technology will play an increasingly important role in the future management of the cities (Storper 2014, 2). Data and data-driven decision making becomes ever more important for public management. Numerous aspects and layers of the city are datafied and therefore the city itself becomes a giant data producing organism. As Storper claims, the cities of today have a digital skin which consists of the "widespread implantation of sensors into urban and household environments, together with ubiquitous mobile broadband communication technologies that can transmit both deliberate communications and automated user data" (2014, 2). The sensors which are embedded in the digital skin of the city collect day by day enormous quantities of information. The so called big data are generated not only by the sensors and smart devices connected within the Internet of Things system but they are also everything that the citizens generate while browsing the web or being active on social media. As mentioned by Storper, "big data" are becoming a more prominent source of insights into the city for the management governance and the experience of urban life (2014,3). Because the many promising opportunities that big data offers the incorporation of big data analytics is increasingly present in the practice of urban management, planning and policymaking.

The shift to data-driven governance is almost always accompanied by the incorporation of algorithms in the public management. As the society becomes more digitized, the use of algorithms in governmental processes becomes more frequent. As a result, more and more important decisions about real world issues and people are made by the algorithm. (Janssen and Kuk 2016, 371). They are used to automate certain decision making processes as they hope that they can make decisions in a more efficient and neutral way.

The incorporation of tools and algorithms that are hoped to aid and automate parts of the decision making processes and urban planning nevertheless carries numerous challenges for the public management. A number of these critique points has been addressed by the emerging field of critical data studies. They are often technologically complex tools which lack transparency in how the calculations are done and what data has been used for them. They

carry a persuasive objectivity that together with the intrinsic trust in the tool commonly results in lack of the reflection upon the produced results. When investigating the Tygron Platform and analysing the different user layers of the tool, their varying level of data literacy and the role of data in different context of use, I address the issues already recognized by the critical data studies approach, as well as discuss challenges which are not yet sufficiently considered by the field. In my research, I argue that the lack of the critical approach to data-driven tools is reinforced by the lack of competency within governmental organizations under which I understand the lack of sufficiently developed data management department, scarce access to employees with expertise in data as well as the limited access to training in the tools. Furthermore, I argue, drawing from, Kitchin that data-driven tools can reinforce technocratic governance. He claims that all of the aspects of the city can be reduced to data and therefore can be measured, monitored and treated as purely technical problems which can be addressed through technical solutions (Kitchin 2014, 9). According to Janssen and Kuk, such form of governance assumes that complex societal problems can be reduced to well defined and structured units which are independent from political and social context and can be treated independently from such socio-political realities (2016, 371). Contrary to that belief, Janssen and Kuk argue that algorithms are not “standalone black boxes'‘. They are a product made by humans and human intentions, biases, limitations and assumptions are embedded in their technical inner workings (2016, 374). Therefore, algorithms and the decisions made by them are both affected by the quality of data that is fed to the algorithm as well as they are influenced by the political and social context and the human bias within which they were created. Such algorithms are implemented in various systems and tools developed to aid public management. One of such tools is the software application Tygron which I analyse in this paper.

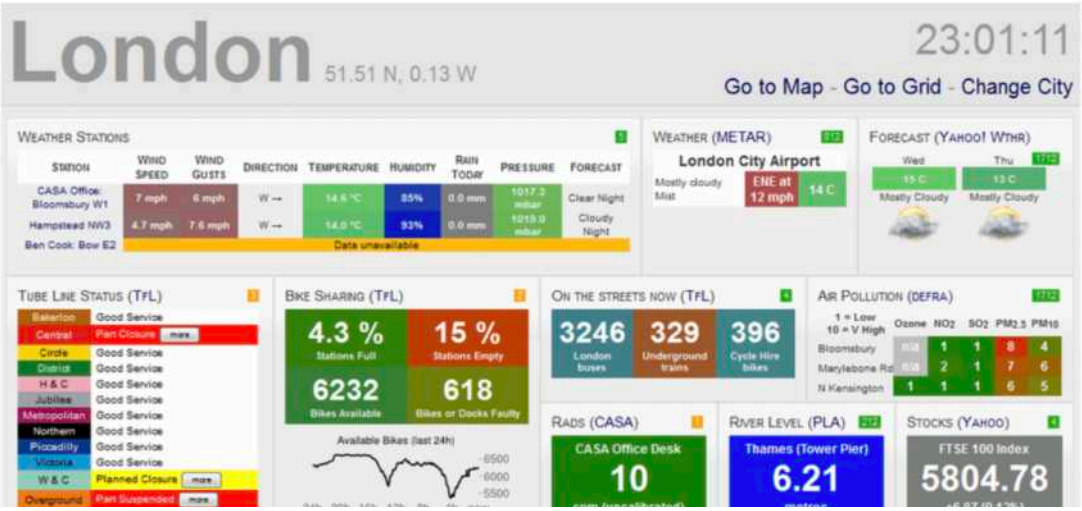

*Figure 2 The London City Dashboard (Source: http://citydashboard.org/london/)*


*Figure 3 The Dublin Dashboard (Source: https://www.dublindashboard.ie/pages/index)*

Another data-driven practice of increasing use in urban management is the development and implementation of a city dashboard. Such dashboards have already been put to use in, among others, cities such as London, Boston, Sydney and Dublin (fig. 1,2). Based on open and real time data of different sources, they visualize different aspects of the city which allows the government and the citizens to gain insights into different aspects of the city in a quick and readable way. The dashboard initiatives are however criticized as the ones that hold a realist epistemology. According to Kitchin at al., they are appealing to city managers because they reduce the complicated system of a city which is grounded in the historical, political, economic and social context to neatly structured information. The visualized information contained by the dashboard appears to be the truth about the reality. Such information is often seen as neutral, objective and easily manageable and comparable and the public managers fail to reflect upon the inherent politics of the dashboards as well as the technical and methodological issues that are related to it (Kitchin et al. 2015, 24).

The limited critical reflection upon the data-driven technical innovations, their increasingly frequent incorporation in the public management as well as the possible risks that they carry led me to approaching my research into the Tygron's digital twin from a critical data studies perspective. Data are the units that capture our reality. Datafication, the ability to render into data many aspects of the world that have never been quantified before (Cukier & Mayer-Schoenberger 2013, 29) allows for every aspect of our life to be translated into neatly structured, organized and manageable units that can be processed and analysed. Data can

therefore be a vehicle to storytelling; they conceptualize our world in a certain way. Data are generated within and tied to specific histories, ideologies and philosophies which are often not acknowledged in the processing and analysing data. As Iliadis and Russo argue, data are therefore not only "about" one thing (2016, 2). Depending on how the data has been processed and selected, they can strive to be a representation of the world or try to reconceptualize it and manipulate it through concealing the underlying context in which they have been generated.

The notion of datafication can be discussed in the context of a high modernist ideology which stands for the standardization of weights and measures where complex and local social practices are turned into a standardized grid which allows to centrally record, monitor and measure these practices (Scott 1988, 2). In his seminal critique of top-down governance, James Scott notes that highly modernist governments firmly believed that scientific and technical progress can help control and improve societies (Scott 1998,4). In such conditions, the cities as well as their citizens are treated as measurable and standardized units therefore the questions asked about the systematized environments have definitive and quantitative answers (Scott 1998, 342). The way societies and cities are registered by the state in this modernist understanding is however very limited as it implies that the world can be reduced into neatly manageable units. This is also the case with translating reality into data in the process of datafication. The actual territory and its social relations is much more complex and in the process of translating the world into a systematic and organized grid, an underlying context is lost. Therefore, data represent a highly reductionist view where the social, cultural, economic and political aspects of societies are not taken into consideration. As a consequence, simulation software which operates on data in order to present the users with results, produces knowledge which conceals the complex net of factors that influence the data and only represents the distilled, systematized parts of reality which can easily be quantified. Tools which produce a misrepresentative image of reality, similarly to the already discussed data dashboards, can therefore result in reductionist governance which fails to recognize all of the vital irregularities which are invisible to the simulation software, but which are inseparable from a living, complex organism of a city. Governance which fails to recognize the factors which do not fit in within the standardised grid, is in the long run not sustainable as it is not prepared for unplanned improvisation. Following the thought of Scott, "the more schematic, thin, and simplified the formal order, the less resilient and more vulnerable it is to disturbances outside its narrow parameters" (1998, 351).

Data and the way they conceptualize the world is especially interesting to the field of media studies because it can be related to the concept of mediatization. Mediatization denotes the processes through which core elements of a cultural or social activity (e.g. politics, religion, language) assume media form" (Hjarvard, 2007, 3). In addition, mediatization can in its essence be compared to the concept of datafication which has even been recognized by the scholars to be the 4th, most recent after digitization wave of mediatization (Couldry & Hepp 2016, 34). In the process, every bit of life, even complex issues such as urban planning are turned into quantitative data that can be collected, processed and analysed and, subsequently read and visualized through a shared digital infrastructure. Among others, in dashboards, data visualizations, apps or through simulation software and digital twins. Through tools such as the Tygron software, we can use the data to create a digital representation of urban areas, manipulate them, experiment with them, reconstruct them to suit our needs; both for the purpose of serving good and bringing improvement to the liveability of the cities as well as for supporting our biases and ideologies.

In digital twins, data is mediatized into a representation that is visually persuasive and can be perceived as the truthful representation of the area. In my analysis I argue however that these tools are powerful and technologically complex mediums which need to be analysed as such.In my research, I argue that the Tygron Platform is a *data assemblage* understood after the writings of Kitchin as "technological, political, social and economic apparatuses and elements that constitute and frame the generation, circulation and deployment of data" (Iliadis & Russo 2016, 3). I claim that the tool consists of technological layers such as the data layer, the game engine and the calculation models as well as the user layers. I argue that mediatization is taking place on four different user levels of the tool, namely:

- the **developers** who translate whole landscapes into the medium,
- the **advisors and domain experts** who insert the data which determine interactions of the various elements of different elements,
- the **policymakers** who use the software in order to improve their decision making processes and test various urban scenarios,
- the **citizens** to whom the data layer is concealed, only see the visualization and simulation prepared by the experts.

On all of these layers, data is handled in a different context and for a different purpose. The various users have different expertise and data literacy which in turn results in various understanding of data and interpretation of results delivered by the tool.

## 3. Method. Inquiring into data assemblages and its uses

In order to thoroughly investigate the object of my study, I combine a number of techniques. I inquire the different layers of Tygron's data assemblage (Kitchin 2014, 6). Here, I identify and describe 3 different user layers which engage with the tool: the developers, the experts and the citizens. I analyse the interface and features of the software by conducting a walkthrough (Light, Burgess and Duguay 2018) as well as, on the hand of a critical discourse analysis (Fairclough 2013), discuss the discourse surrounding the tool and the implications it has on the social practice.

The critical discourse analysis that I use for the purpose of this research is based on an adapted tripartite model proposed by Fairclough (2013). This model allows me to systematically investigate the technical inner workings of the tool, the tool's production and reception, as well as to discuss the consequences that the tool has on the broader social practice. It allows me to define, per user layer of the assemblage, which affordances of the software are made available to the different user groups, to what extent can the users access the data used for the simulation as well as what level of expertise is needed to engage with the tool on different levels. By analysing the experience of the users, I describe which modes of deployment are the most frequently used per group and further, what challenges and advantages do they carry.

Firstly, applying the walkthrough method of Light, Burgess and Duguay (2018), I analyse the object of my research. The method deploys a walkthrough technique to systematically step through different stages of a user flow of the software. By engaging with the interface of the tool, I examine the technological mechanisms of the software to investigate how it guides users and shapes their experiences (Light et al. 2018, 3). Approaching the tool in such a way allows me to describe the key features of the software, its affordances and the three modes of deployment embedded in the software. I discuss which data sources are used by the tool for basic calculations and to what extent are the users able to customize their project by importing their own data and applying custom made calculation models. In my research I perform the walkthrough based on several tutorials that are embedded in the Tygron software

and which are made available to the users as learning materials. The documentation of the walkthrough can be found in the Appendix of this paper.

In the second part of the discourse analysis, I analyse the distribution and the experience of the users with the platform. The walkthrough method will provide me with a corpus of data for my analysis. In addition, combined with the ethnographic research conducted while being employed at the company, it will allow me to analyse the intended and marketed purpose of the tool as well as identify its implied ideal users and uses (Light et al. 2018, 1).

Working as an intern at Tygron allows me to gain insights into how the tool is used and what the experiences of the users are who rely on the Platform in their daily work. In order to investigate how the software is perceived by the users and to verify or falsify the results of my empirical studies, I conduct a number of expert interviews with the company's clients who have worked on projects in which Tygron software was deployed. The interviews allowed me to characterize the three different user layers of the data assemblage as well as to identify the challenges and advantages of the deployment of the tool for urban planning and policymaking. The interviewees are employees of municipalities and water authorities as well as experts in using Tygron for interactive simulation sessions within municipalities. The questions should retrieve additional information about the objectives of the clients towards working with a digital twin as well as gaining insights on the way they perceive and understand the data visualized by the tool in its different modes of deployment. The full list of interview questions is attached in the Appendix of this paper.

The semi-structured with open questions give the interviewees more freedom to elaborate on their thoughts and experiences (Adams 2015, 494). The organic structure of the interview provided me with rich spontaneous and instinctive insights on the experience of the interviewed users. They also allowed to make the tacit knowledge and the inherent practices connected to developing and using Tygron explicit. The semi-structured interview method proves to be especially appropriate as the interviewees are experts in the field of policymaking and urban planning. Because of their considerable experience, the interviewees were able to elaborate on interesting leads within the more conversational setting of a semi-structured interview (Adams 2015, 494). It provided me with a broader range of material. Because of the fact that the interviewees work at various governmental and non-governmental organizations, a possible limitation is the reluctance of the interviewee to comment on the work processes which involve the work manner of their colleagues. The individual interviews however,

allowed the clients to share their experiences anonymously which provided me with more detailed insights on the users' initial reactions to the software.

Despite the advantages of semi-structured interviews, this method has also proved to have many limitations. The contacting of potential interviewees and scheduling the interviews has consumed a considerable amount of time. This method relies heavily on the co-operation from the interviewees side and awaiting responses from clients proved to be a long and uncertain process. Even with the help in contacting the clients received from Tygron, the process of contacting and interviewing the users exceeded the time that I initially assumed would be needed. This, in result, has delayed my research considerably. Another limitation in organizing the interviewees was the outbreak of the COVID-9 virus, due to which all contact with the interviewees was restricted to online forms of communication. It is also important to mention that all interviews, with one exception, were conducted in English. In one case, I have decided to conduct it in Dutch as it gave my interviewee a bigger fluency and freedom in his answers. It is important to note however, that since my proficiency in Dutch is limited the quality of the asked questions might have been impaired.

The questions for the interviewees are organized in three groups. The first one consists of general questions about the reception of the software, its advantages and its affordances. The second group concerns data culture of the institutions that employ the interviewees. The last, third group consists of questions regarding the evoking of civic participation with the help of the software. Depending on the interviewees and their affiliation with different institutions, I chose to ask those questions which were the most applicable to my interlocutor's work and experience. Based on the answers given by the interviewees I have documented the conversation by writing notes which summarize the contents of the interview. The notes to all of the interviews can be found in the Appendix of this paper.

In the last, third part of the critical discourse analysis, I discuss the consequences that using the tool can have on broader social practice. In my analysis I claim that depending on the mode of the deployment and the level of data expertise of the user, the tool communicates policy in different ways and therefore can influence the policymaking in different ways. Basing my arguments on both theoretical research as well as insights provided by the experts interviewed during my time of employment at Tygron, I will present the limitations that different user groups have while working with the tool. I explain how these limitations influence the degree of critical engagement with the tool and suggest how the degree of critical

reflection towards the incorporation of data visualisation tools, or the lack of such, can influence how the users perceive the results communicated by the software.

## 4.1 Analysis of the software's interface and affordances

The Tygron Geodesign Platform is a digital twin of a city which based on input data, simulates various urban scenarios. The software can be used for visualizing and tackling pressing urban planning issues such as housing, quality of life, climate adaptation and the energy transition. The actions taken by the user in the software are visualised in a 3D environment of the interface which represents the 3D model of the world. The software allows the user to view the current situation based on the most recent open data as well as to plan and test future scenarios and the various proposed plans drawn onto the project area. The Platform is on a technical level based on a gaming engine and because of that it not only has extensive visualization properties but also operates with a number of set principals embedded in the software which constitute the 3D environment of the simulation. Certain laws of physics such as the gravity, water flow, times of the day as well as shadows corresponding to the position of the sun simulated in the software are fixed and apply to any project created in Platform. The software therefore makes a foundation for importing relevant to the plans, maps and data that will make the calculations possible. Because of that, Tygron is a flexible tool which can be applied to any area of the world and therefore is of value to urban planners across the globe.

The tool is advertised as a digital twin that helps to make faster and more thoroughly informed decisions and therefore, its main application is contributing to solving the world's biggest urban challenges. The Platform is mainly promoted as a tool that can be helpful to the work processes of governments, urban designers, planners and engineers. It promises to translate data into valuable to the users insights and therefore bring improvement to the current work manner of the organizations. It is also emphasized that the users have the access to a strong technical support department where they can exchange tips about the software and seek technical advice. [1]

[1] Based on the promotional materials on Tygron's homepage. https://www.tygron.com/en/

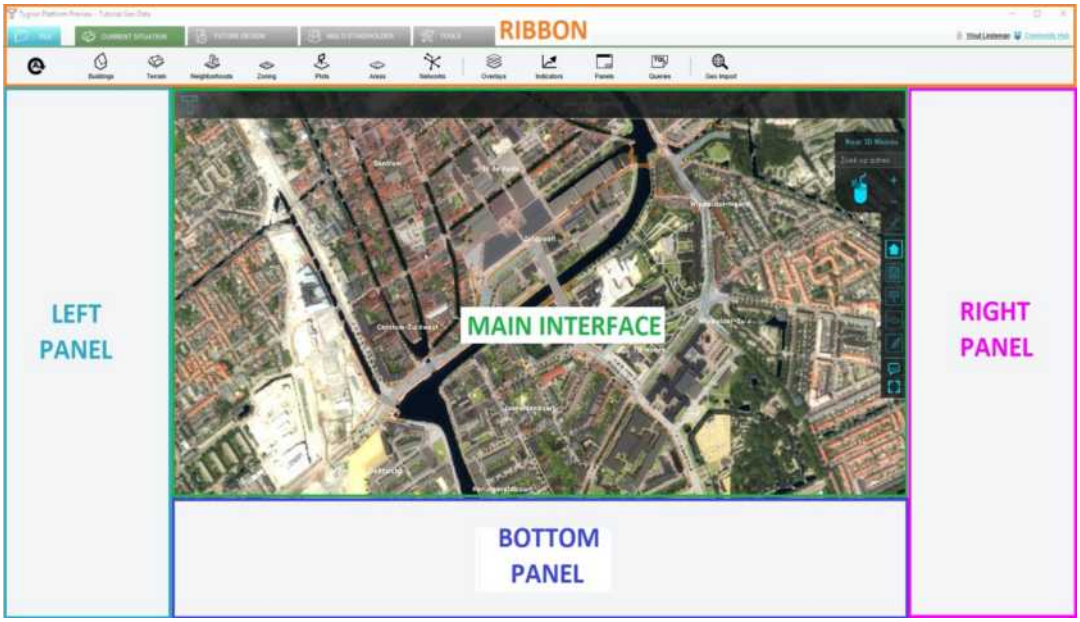


*Figure 4 The structure of the interface (Source: Tygron Wiki page)*

The access to the Platform is cloud based as all calculations are performed by a high-performance GPU supercomputer located in the company's office. The supercomputer, contrary to regular computers, performs the calculations using the GPU (graphical processing unit) instead of the CPU (central processing unit) allows for nearly instant calculations and visualizations; therefore, the users can see the result of their decisions and actions taken in the software immediately. The high speed of the calculations unique to the super computers makes it possible to test multiple scenarios in a row without a prolonged waiting time, therefore the tool can be used for leading discussions about urban plans which are visualized on the spot. The service offered by Tygron is cloud-based which means that the company gives the users access to the application on demand through the internet. Because the calculations are performed remotely by Tygron's supercomputer, the only hardware requirements that are posed on the users are the ones related to the possibility to visualize the 3D world on the users' devices, the requirements are not related to the calculation capacity of users' hardware.


*Figure 5 Loading screen of a project in the Tygron Platform showing how the open data is imported into the project from various sources*

In order to create the 3D model world, the Platform uses geo, vector and raster data. Per default it uses open data sets to perform the calculations. Moreover, Tygron supports the import of users' custom data hosted in ArcGIS, a platform which allows for managing, organizing, analysing and sharing spatial data which is maintained by the Environmental Systems Research Institute (Esri). This as a result adds another, more commercialized and externally maintained data source to the Tygron data assemblage. Among the open data loaded into the project by the software is the data on terrain elevation, water, infrastructure, constructions, street objects and ownership plots. Because the data belongs to and is managed by external parties, the simulation conducted by the software and the visualized information is dependent on the quality, completeness and recency of the data. Apart from the open data sources, the user is given the freedom to enrich the project by uploading their own data sets. The software also supports the import of Building Information Models (BIM) which correspond visually with their real-life equivalents. This contributes to a higher degree of realism of the visualized project area. The data uploaded by Tygron is encrypted and it is the user who has the exclusive access to it. The users create and edit the projects within their own,

password-protected domain to which the company does not have the access. The access to the projects and the data used in them can only be granted to Tygron by the users themselves.

The different data that the Platform generates the 3D world upon is visualized to the users in the form of an overlay. The overlays are maps projected onto the project area which visualize the data loaded into the project. The information from a data set is therefore translated into a visualization which is easily readable by the user while the data set is concealed from sight. The data stating different aspects of the area is split into multiple layers which can be drawn onto the map according to the user's needs. The overlays visualize various elements of the area such as the heat, traffic, noise, flooding, liveability and property. The different data layers available can be applied or concealed by the user according to his needs, intentions and the specific project. It is therefore important to note that the expert user who is conscious of how the tool works is in charge of which information is made visible on the map and therefore has control over what the visualization communicates.

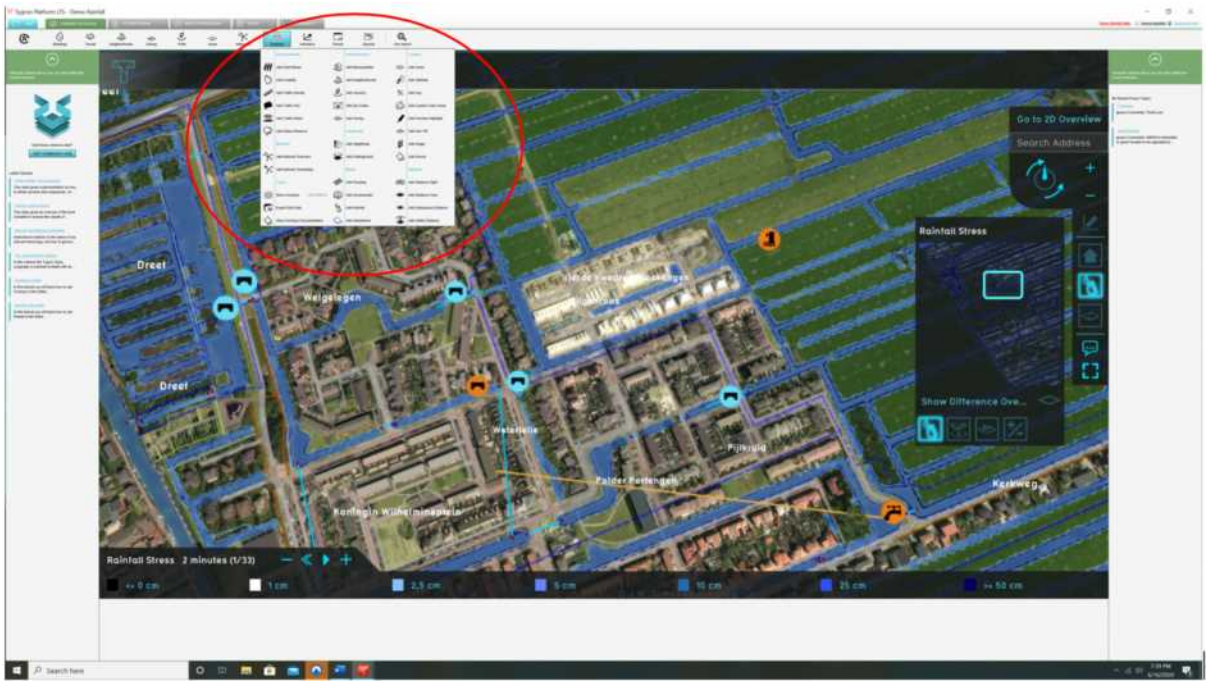


*Figure 6 The overlays menu*

The simulation seen by the users in the visualizations is a result of a calculation performed on the input data with the help of the calculation model. The calculation performed according to the model provides the users with feedback on their actions which is communicated in the form of, among others, indicators, overlays and attributes. The models built into the software are the ones relating to traffic noise, $NO_2$ emissions caused by the traffic,

liveability, heat stress as well as models related to water such as the flooding, groundwater and rainfall mode. The models created by Tygron are per default in line with the Dutch governmental standards. The software does however support custom models created by the user which suit the standards or the project of the user's organization. Such models can be created by the user in an Excel file. The template for custom calculation models as well as various tutorials and webinars on the topic of user made calculation models are made available to the users on the company's Wiki page.

### 4.1.1 Modes of deployment of the Tygron Geodesign Platform

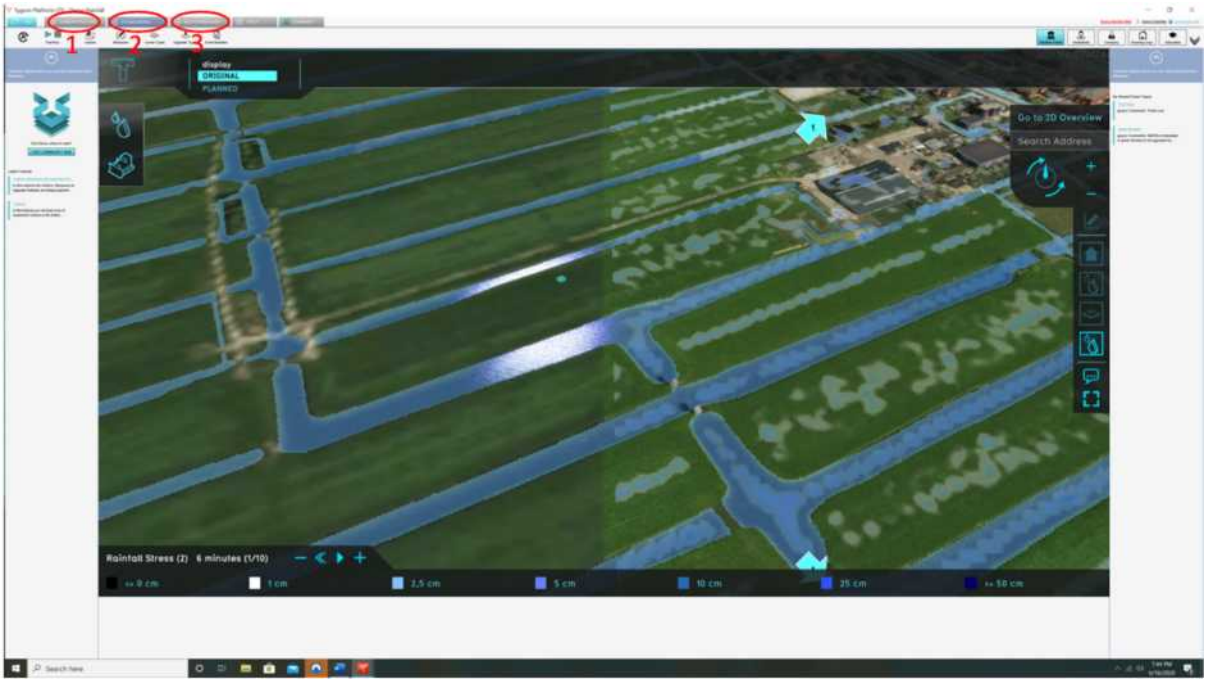


*Figure 7 The Interface of the Tygron Platform showing different modes. 1: Current Situation, 2: Future Design, 3: Multi Stakeholder*

The software can be used in three different modes. The first one, the *current situation*, allows the users to view the state of the project area in real-time. Making use of the various modules and overlays, the user is able to read information about the area from different maps which are drawn onto the neighbourhood. The data values are indicated by different colours which are defined by a legend located at the bottom part of the interface. The *current situation* mode is the state in which the user prepares and refines the area plan which will be the starting point to running the simulation of a future scenario. The data sets which are the foundation of the calculations performed by the software are only visible to the users if they decide to upload

their custom data sets in the project creation phase. Once the simulation has started, the data is converted to easily readable visual representation. The calculation models which are the backbone of the Platform are at this point completely concealed. The user is provided exclusively with visual representation of the data which does not inform him about the formula which was followed to perform the calculation.

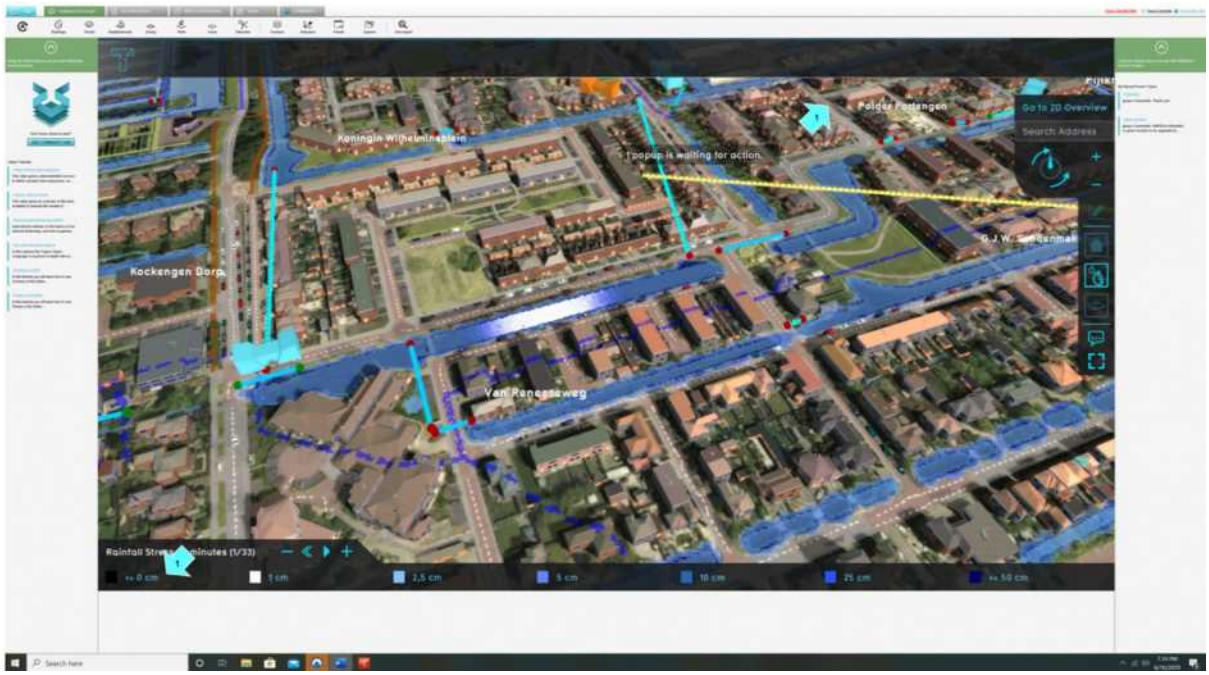


*Figure 8 Current situation mode. The applied rainfall overlay and the colour legend with the water level mark*

The second mode of deployment is the *future scenario* mode. In this mode, the user can make alterations to the base, current situation scenario and subsequently test them by running a simulation. Every action taken will have a consequence on the other aspects of the modelled area since every element of the word exists in relation to the other elements of the ecosystem. By testing a scenario, the user can clearly see how the proposed solution will influence the other aspects of the neighbourhood (see Appendix 2, the walkthrough). Based on the previous project of the user, the Platforms also provides an estimation of the costs of the taken actions which gives the user an indication of the impact that the solution will have on the stakeholder's budget. This however, can differ per project and modelled location and therefore needs to be

verified and corrected if needed in order to provide the user with a useful and correct prediction.

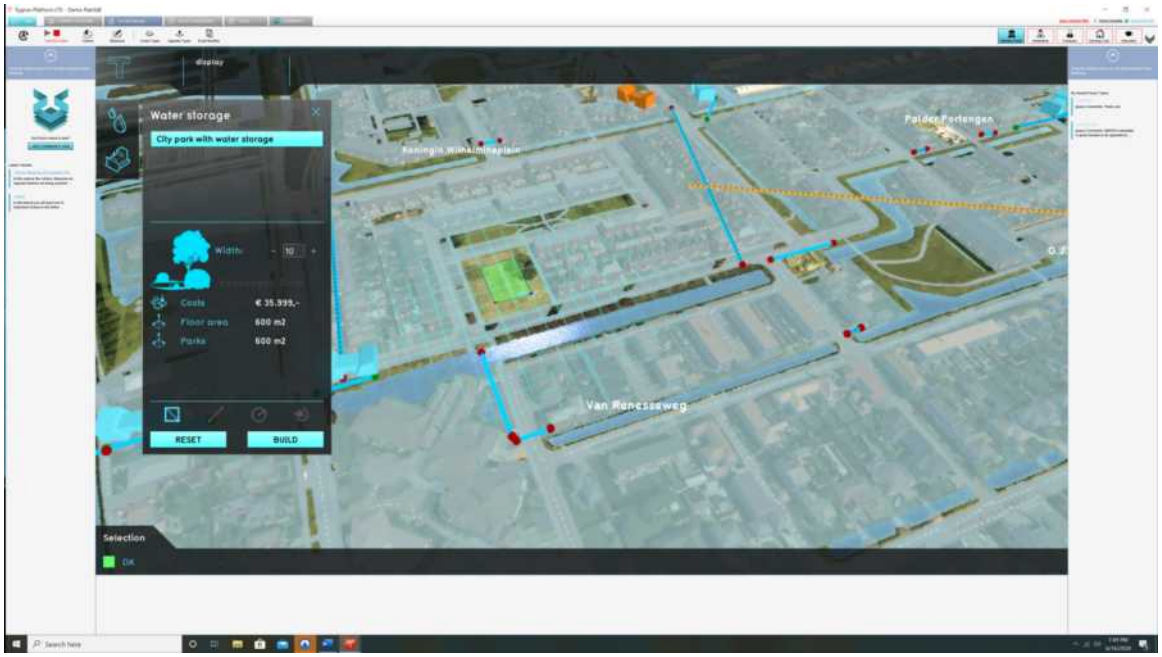


*Figure 9 Accepted building plan indicated in in green*

As I argue in the further chapters of this paper, because of its visualization and simulation properties, the software is well suited for facilitating communication. The changes made to the modelled areas and the consequences of these changes are visualised by the software very realistically and they are easily readable. Since the calculations are performed almost immediately, the discussion about changes to urban areas is not delayed by the need to draw new maps manually and that in turn accelerates the decision making process. The software is not only suitable for discussions within the governmental institutions, but it can also aid the communication between the government and the citizens. The proposed changes to the neighbourhood can be visualized right in front of the eyes of the citizens helping them to imagine how the discussed solutions would directly impact their living environment. Because of the complexity of the tool however, there is a risk that such a tool could be used to present a manipulated image that acts in favour of the governmental initiative. When presented with the visualization produced by the software, the citizens do not have the access to the technical foundations of the tool which influence the way the visualization looks like. They are not aware what data has been involved or excluded while performing the calculations, they do not have the knowledge on the construction of the calculation models according to which the data has been processed within the software. They only have the access to the visual layer prepared for them by the experts and public managers who are in charge of

the technical backbone of the software. By concealing the inner workings of the software, the tool gains a persuasive objectivity which can influence the way citizens think about the proposed urban solutions.

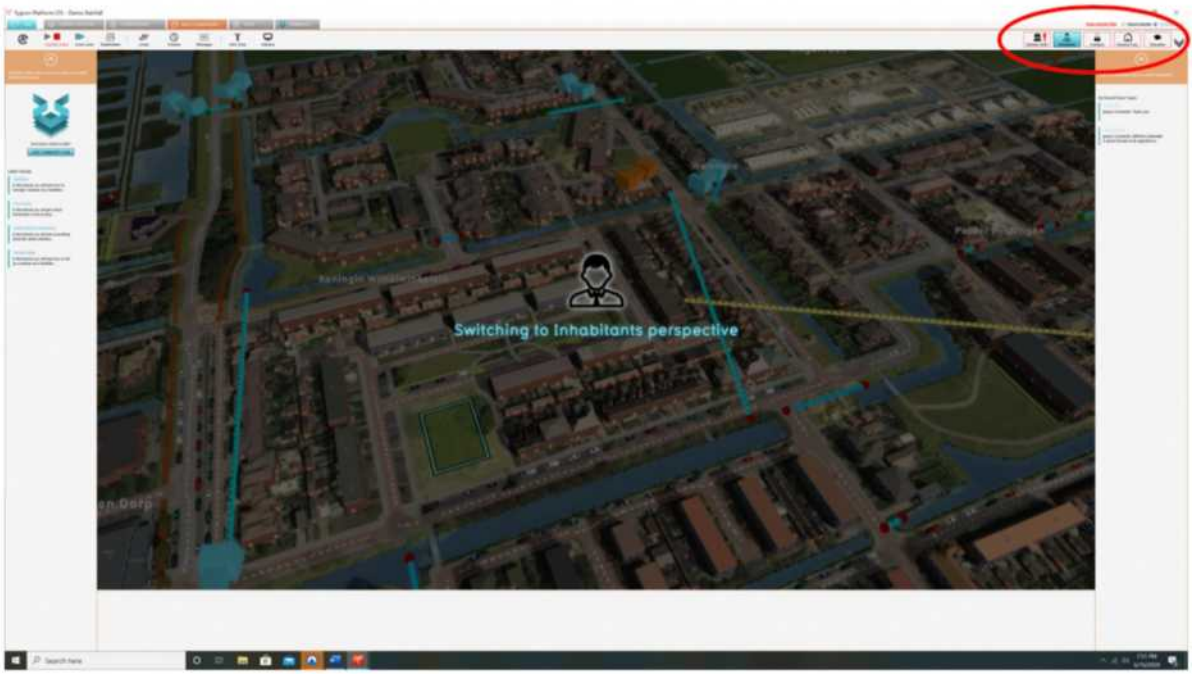


*Figure 10 Switching to a different stakeholder perspective. The stakeholders present in the session are indicated by the icons in the right upper corner of the interface*

The third mode deployment of the software is the *multi stakeholder* mode which is often used as a base for interactive serious gaming sessions. In this mode, multiple users are engaged in the project and each one of them is given a different stakeholder role. The participants of such a session, therefore, are viewing the modelled issue from various perspectives and are striving to reach stakeholder specific goals. Every stakeholder is assigned an objective, budget and is granted the access to specific functions. Every action in the game needs to be made with permission of the other player. That way, in one session representatives of the different groups such as urban planners, municipality and citizens are forced to work together in order to solve a problem. The goal of the whole group becomes more important than the objectives of single stakeholders.

The complexity of the software and the large number of features make it appear to be a black box for users who do not have considerable expertise in the data domain. The software however is supported by a Wiki page, YouTube channel and a forum established by the company where an abundance of tutorials, documentation and webinars are made available to

the users. Every feature of the software as well as its technical foundations are made transparent and accessible for the users. The Tygron forum is a place where the online community of users are invited to share their projects, ask questions and exchange the tips and experiences. The access to the forum is also granted for Tygron's employees which engage daily in the discussions and offer technical advice and solutions to the users. Despite the technical support and extensive documentation of the software operational logic and features, the tool is impenetrable to users who due to their lack of technical literacy are not able to gain sufficient understanding of the operational logic of the tool. The challenge that this user group is confronted with is the risk of trusting in the results and the visualization generated by the software without critically questioning them and acknowledging the fact that they are influenced by a number of factors.

## 4.2 User experience and the consequences of digital twins for the broader social practice

Through the results gained from the interviews as well as the empirical research done during my internship at Tygron I have been able to identify four user groups which correspond to the three layers of the data assemblage, namely the developers, domain experts, policymakers and the citizens. Every user group engages with the tool in a different way and reads the visualizations as well as the data used for the calculations differently which has various consequences understood as challenges and advantages for the broader social practice. Because of the differing degree of data literacy and technical expertise, the tool produces a different type of knowledge per user group.

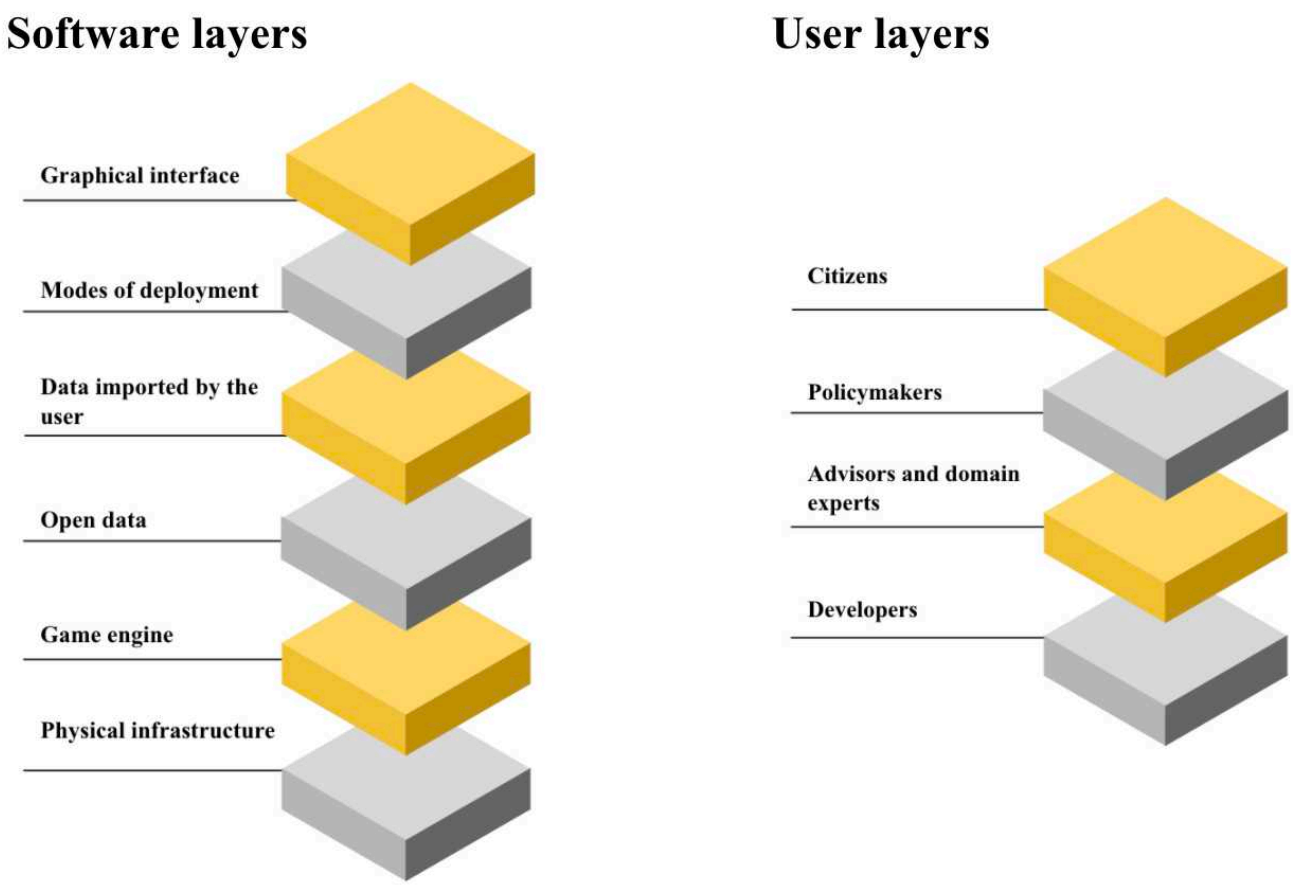


*Figure 11 The Tygron Geodesign Platform data assemblage*

### 4.2.1 Developers

The first user group that I identify while analysing the different user layers of the tool are the developers. They deal with data in its basic form, they see the datasets that the software operates on before it is translated into the graphical representation. The developers have extensive knowledge in the field of data and computer science; therefore, they possess excellent skills in analysing, preparing and managing the data. They are not extensively trained in fields specific to urban planning or public management, but they work closely with other specialists which advise them on that. The developer group is the group who has the insight and the access into the technical structure of the tool, and they are fully informed about the operational logic of it because they decide on how the software is designed on a technical level. That results in them having full control over how the process of translating data into visual representation is design. It is therefore the developers group who has the full understanding of how the different technical levels of the data assemblage such as the data sets, calculation models, game engine

and the interface interact and consequently, how the tool produces and communicates knowledge as well as which factors influence the quality of it.

### 4.2.2 Advisors and domain experts

The second user layer of the data assemblage are the advisors and domain experts who hold expertise in a field closely related to urban planning such as water management, environment or energy transition. Apart from the specialistic field knowledge, the users within this group often have considerable experience and skills in working both with technological innovations as well as with data. Because of their joint expertise, they are very critical about the data used for the calculations performed by the tool as well as results suggested by the visualization of the calculations made by the tool. As it was concluded by several of the interviewees who have introduced the software during interactive workshop sessions (Appendix 2.3, Appendix 2.5), expertise in a specific field as well combined with a strong understanding of data allows the users of this group to ask the right questions and use the right data to retrieve answers. They are also aware of how the data used for the calculations was prepared, what its source is and based on that, they are able to assess the data's quality as well as the quality of results produced by the tool. Unlike the developers, the experts do not have the access to the technical backbone of the software, they do however work on an equal level with both, the data sets as well as the visualization generated based on the data. As it appears from the interviews, the experts are aware of the operational logic of the software to a degree that allows them for designing precise and relevant calculations as well as being critical about the results given by simulation. For that purpose, they create their own calculation models and often work together with the developers to create new functions in the tool which will suit their needs and the issues modelled in the software best. An example of that can be the environmental factors quality scores developed for the Province of Utrecht which indicate if a proposed spatial plan meets the legal standards for a number of indicators such as air quality, noise pollution and traffic (Appendix 2.5).


*Figure 12 Quality scores developed for the Utrecht Province in the Tygron Platform (By Maarten van Helden)*

The advisors and the domain experts work with simulation tools in order to test various scenarios and impact assessments of different urban solutions. Their work is often used in the further steps of the policymaking process as their work is often passed as advice regarding urban plans and policies discussed by the policymakers as concluded by the interviewees (Appendix 2.5, Appendix 2.2). Although it can be concluded from the interviews that the expert user group is reflecting critically about the results of the tool and the degree to which the software can be incorporated in the public management, the deployment of the tool by the expert user group also carries challenges. While making use of the simulation software, the experts only include in the calculations data on the physical environment of the area. The data on the social, political and cultural aspects of the area is not incorporated into the simulation and therefore the results presented by the software are highly limited (Appendix 2.5). As mentioned by Scott, every city, apart from its official structure, also consists of a more disorderly and complex city layer that, according to him, is the condition of the official city's existence (1998, 261). The second city layer is far more complex than the official one as it reveals the unplanned, chaotic movements of everyday life (Scott 1998, 347). Following the thought of Jacobs, the city's order is composed of constant organic movement and change (1961, 50). According to her, the essence of that order is the sidewalk which she compares to an unrehearsed, constantly changing and never repeating itself ballet dance, where the individual dancers compose the whole (1961, 50). Public space cannot therefore be seen as a

uniform, simple and predictable. On the contrary, the city is a living and constantly evolving organism, and making urban plans which do not take the social, chaotic layer of it into account will always fail to meet the real needs and conditions of the city. Therefore, the lack of knowledge about the type of data imported into the tool and the completeness of that data can make the users believe that the, in reality misrepresentative visualization, is the complete representation of the actual state of reality. This in turn reinforces the reductionist approach to governance (Kitchin 2014, 14) which fails to take the underlying social and cultural context into account when managing and planning urban areas. A possibility to become more informed on the social aspects of the area is, as noted by an interviewee (Appendix 2.1), the active incorporation of the citizens into the urban planning processes. The citizens possess extensive knowledge on the social issues of the cities which is crucial in the public management (Appendix 2.1).

Another challenge to the incorporation of simulation tools into the public management domain is the limited access to staff which holds expertise in working with digital twins within governmental organizations. The number of employees competent enough to use the software critically and therefore productively is scarce, therefore the advice they can give using the simulation software on urban planning projects is also limited (Appendix 2.2, Appendix 2.4). As appeared in the interviews, it is difficult to keep expert knowledge within the organization, therefore often when the advisor is present during the creation of urban plans only for a short period of time, upon his departure, his advice is no longer followed and the project is developed differently (Appendix 2.5).

### 4.2.3 Policymakers

The users of the group that commonly works closely with the advisors and domain experts are the policymakers. As can be concluded from the conducted interviews, the objective of this group is foremost the fast and informed decision making. For that purpose, the policymakers often rely on the advice and the estimations provided with the help of digital twins by the advisors who work for institutions specialized in, among others, water management, energy transition or traffic (Appendix 2.2). Common among this group is the lack of tool criticism understood after Van Es et al. as the "critical inquiry of knowledge technologies considered or used for various purposes"(2018, 26). The users of that group perceive the tool, its working mechanisms and its output as neutral and they fail to recognize the complexity of factors that influence the results produced by the software (Appendix

2.2). As the projects have been developed in the tool by advisors who are skilled in using it, they are only confronted with the persuasive, seemingly objective, three-dimensional visual representation of the world and the impact of the proposed changes. The data layer of the tool which consists of the data sets as well as the information about the sources of the data is at this point concealed. Because of the persuasive visualization properties of the software and the lack of data expertise, it appears from the interviews that the users do not critically question the applied calculation models, the quality of data sources or the process of assigning values to, for example environmental scores values Appendix 2.2). Moreover, due to the lack of data literacy, data analytics are often conceptualized within this group as a single process which ultimately results in better decision making. It is however a simplistic approach as policymakers fail to acknowledge that it is in fact a complex process which is influenced by many factors and can be best described as a *data chain* which consists of multiple steps, namely data collection, data preparing, data analysing and, only then, decision making (Janssen et al. 2016, 7). At every step of the process, there are multiple data scientists involved which collect, prepare and analyse the data in a certain way which results in the fact that the data may be incomplete, biased, and as mentioned by Janssen and Kuk deliberately or accidentally manipulated (2016, 374). It is therefore the data and consequently the different parts of the data chain that directly influence the output produced by the tool. Consequently, the visualizations generated by the tool from the input data as well as the decisions that are made based on them, are only as good and complete as the data itself.

As mentioned earlier, the simulation software uses for the calculations data about the physical environment of the cities. It is not yet taking into consideration social data which constitutes an important information layer which provides the social, cultural and political context to the urban planners (Appendix 2.5). Without this information, the representation of the area modelled by the software is far from complete and so are decisions made by being informed exclusively by the tool. As argued by Janssen and Kuk, the context influences greatly the way data is interpreted (2016, 374), therefore concealing such context can result in faulty and misinformed decisions. As can be concluded from the experience gathered by the interviewees during interactive sessions with the Platform (Appendix 2.3), giving advice to policymakers (Appendix 2.2) as well as during serious gaming sessions with the Platform (Appendix 2.1) limitation to the tool is not yet fully recognized by any of the user layers which engage with the tool. The lack of critical reflection upon digital twins in urban planning and policymaking can also be connected to the data culture within governmental organizations.

From the conversations with the interviewed users of the tool who work for governmental institutions it became apparent that their data readiness understood as the "organizational alignment, capabilities and maturity in connection to big data" (Geist 2017, 369) is limited. Municipalities often do not have sufficiently developed data departments (Appendix 2.5, Appendix 2.4). As concluded by the interviewees, the plans to reinforce such departments and invest in their further developments are at this stage only plans for the near future (Appendix 2.4). Without competent employees skilled and trained in the data domain, the advantages of digital, data driven tools for urban planning are limited. Moreover, implementing thesewithin governmental processes and handling them without sufficient data literacy and understanding of the tool can have tragic consequences on the society. In order to be able to make informed, transparent in the thought process decisions, the policymakers and urban planners need to be sufficiently competent and trained in using such tools. They need to be able to understand how such software produces knowledge, what is the quality and the sources of data as well what is the visualisation representative of. Currently, because the data readiness within the governmental institutions is limited, the municipality is forced to hire experts from external organizations which aid the development of urban plans through using simulation software. The incorporation of external parties however, results in higher costs and complicating the decision making process (Geist 2017, 374).

The concern about the lack of critical reflection towards the tool has been raised by numerous interviewees. The interviewees concluded that during interactive sessions where the tool has been introduced to the employees of municipalities and provinces, the participants were initially focused on the convincing visuals produced by the tool and only then in some cases were interested in asking questions about the operational logic of the simulation (Appendix 2.3, Appendix 2.5). The lack of understanding of the system design as well as the increasingly frequent incorporation of such tools in the decision making processes results often in a negative approach to the tool. It is often feared among the users that the tool will replace the human agency in making decisions. A similar concern, as mentioned in previous chapters, has been made by Kitchin who writes in this context about the technocratic mode of governance. He understands it as a data-driven mode of governance in which the world can be understood as a collection of definable and manageable information units (data) which can be measured and analysed in order to make predictions about the real city. Within such a model, all of the city's aspects are measured and monitored like technical problems and therefore they can also be solved and treated as such (Kitchin 2014, 13). Technocratic mode of governance

fails to recognize the underlying cultural, social and economic conditions that shape the city and its problems. Therefore, governance based on tools which produce a fragmented representation of the world fail to treat urban issues at their root. They only deal with the manifestations of these problems (Kitchin 2014, 14).

Besides the challenges and limitations which need to be critically reflected upon, such tools also bring a considerable number of advantages to the urban planning and public management processes. One of such improvements which has been acknowledged by the interviewees, is the fact that the tool reinforces a holistic and spatially informed approach to urban planning and policymaking. According to Strange, urban policymaking, needs to be more spatially informed in order to be successful. The decisions need to be grounded in better understanding of the complexity of particular places as well as their underlying economic, social and environmental context (2018, 27). Strange argues after Harris and Pionocely that a greater spatial intelligence and awareness will result in more effective decision making and will improve the everyday lives of urban communities (2018, 27). Because of the visualization properties of the simulation tools, as concluded by the interviewee, the problems are situated in a context and can be seen in a relation to other elements of the ecosystem (Appendix 2.1). The tool makes it apparent that every change made to the project will have an impact on various aspects of the urban environment. That according to the interviewee, as opposed to the traditional and individual working manner within the municipalities, encourages the policymakers and urban planners to work more collaboratively and make decisions which are discussed from the perspective of multiple experts of various fields (Appendix 2.1). The multistakeholder, game-like mode of deployment of the tool helps to facilitate the discussion and motivate different stakeholders to work together to come to a solution to a problem (Appendix 2.1). Every player is given a different role which can, but does not have to, correspond with the real- life function of the person and is given the task of trying to tackle the spatial problem and come up with a solution from the perspective of their character. In order to come up with an optimal solution, the players need to negotiate, compromise and sacrifice their own personal objectives for the goal of the whole team. The game characteristics such as immersion, identity, interactivity, agency of control, challenge, narrative and feedback have an influence on the attitude change of the players and therefore, motivate them to act in order to tackle real-life problems (Blumberg et al. 2012, 338-340).

The improvement to the work processes that has repetitively been mentioned by the interviewees is the fact that the tool accelerates the decision making process (Appendix 2.2,

Appendix 2.5). Contrary to the traditional model of developing urban plans where every proposed change needed to be calculated by the employees and manually drawn onto two dimensional plans, digital twins allow for immediate calculation of the impact of proposed changes which is visualized by the software almost instantly (Appendix 2.5). The lack of need for continuous evaluation of proposed solutions results in lack of delay in decision making (Höchtl et al. 2015, 23). Moreover, the implementation of big data analytics supports early-warning systems and the possibility to make decisions in real time (Höchtl et al. 2015, 6).

### 4.2.4 Citizens

The last user layer of the analysed data assemblage consists of the citizens. It is important to clarify that in my research I had no access to the actual experiences of the citizens with the Platform. The analysis of this user group is conducted based on the insights provided by the interviewees who work with the software and the citizens in interactive sessions (Appendix 2.1) or those, who have experience in using such tools for civic participation. Through the interviews with the users it becomes apparent that most of the users engaging with the tool agree that game engine based digital twins are a promising tool which can aid communications not only within the governmental organizations, but more importantly it can facilitate dialogue between the government and the citizens . The interviewees agree that such software can definitely be used as a visualization tool to present urban plans to the citizens (Appendix 2.1, Appendix 2.3, Appendix 2.4, Appendix 2.5). The engagement with the tool within the citizens user group, however, is limited only to passive reception of the visual representation prepared with the help of the software by the governmental experts. The citizens lack the data literacy needed to be able to question the representativeness of the visuals as well as they are not critically inclined towards the tool. They do not have the access to the data sets used to generate the visual representation of the plans, and they are not made aware of the technical inner workings of the software. The access to deeper, technical layers of the data assemblage is only granted to the experts who develop urban plans within the tool. Therefore, the citizens who are only faced with the visual layer of the assemblage (the interface of the tool), are inclined to believe that the image is representative and objective. This is problematic because as noticed by Giest, the control and power are held by those who control the data collection and the functioning of the algorithms (2017, 374).

In the context of the new Environmental and Planning act it becomes increasingly important to the government to come up with solutions to engage the citizens more in urban

planning. The new law acknowledges the fact that the citizens are a valuable source of urban knowledge to the government, therefore it encourages the incorporation of citizens in the discussion about urban plans. The incorporation of big data analytics into public management is a good step towards that since as mentioned by Höchtl et al., "big data analytics methodologies will also open the door for a more widespread inclusion of the public at the various stages of the [policymaking] cycle, as it will become easier to better deal with the wealth of collected unstructured information in order to be able to take account of the wisdom of the crowd" (2015, 23).

Another factor that can help evoke citizen participation are the game characteristics of digital twins based on a game-engine. A great deal of interviewed users sees the citizens' possibility to engage with the simulation software in a collaborative, game like mode as a chance to support citizen-government collaboration (Appendix 2.1, Appendix 2.3). As concluded by the interviewee who has considerable experience with leading interactive game sessions for citizens , the multistakeholder mode of deployment of the tool can help the citizens and planners to, in the future, to develop urban plans together and join the expert knowledge with the valuable knowledge of the residents of the cities (Appendix 2.1). It has been acknowledged by the interviewees that such tools foster collaboration and dialogue, but scholars argue that the incorporation of serious games in the urban planning influences the citizens on a much deeper level. According to the Blumberg et al., playing serious games in the public management domain can contribute to the creation of civic knowledge (information justified for informed citizenry), civic conversations (ability to engage in dialogue about civic life), civic attitudes (the ability to empathise with others and make informed decisions about civic issues) and civic behaviours (the ability to take actions which promote the well-being of others) (2012, 341).

# 5. Conclusion

Urban planning is increasingly reliant on the aid provided by digital twins and simulation software. The frequent incorporation of digital tools in public management and urban planning calls for a critical analysis of such software and the assessment on the risks and advantages carried with the implementation of such tools. The critical data studies approach and the critical discourse analysis method combined with the expert interviews allowed me to study the affordances of the tool as well as to conclude that these affordances carry a number

of implications for urban planning and consequently, for the social domain. Studying the tool structurally as a data assemblage allowed me to identify three user layers which typically engage with such software and enabled me to study the implications that such a tool carries per user group. The tool affects policymaking on two user levels. Among the expert uses, it accelerates the decision making process, it provides simultaneous access to multiple information layers, it makes instant assessments of the impact of proposed changes as well as facilitates discussions on urban issues. When deployed within the citizens user group, it helps to visualize the problem and proposed solution spatially as well as it fosters the collaboration and communication between the government and citizens. Although it is the expert and citizen group which implements the software in the urban planning and policymaking processes, a great responsibility lies within the developers user group as the developers are in power to design the operational logic of the system. They create the algorithms and design the features of the software which dictate the way the software works and consequently, they have an influence on the way calculations are made and results are produced by the tool They have the full agency over what affordances are made available which ultimately influences what use cases can the tool be applied to.

As simulation software becomes more popular in urban planning and as the implementation of such tools has the potential to have great consequences on the citizens, they now more than ever before require urgent attention from the media studies field and enquiring such tools not only as pieces of software but also as media objects. Digital twins have extensively been researched within multiple academic fields such as urban studies, data science and computer science. Studying digital urban planning tools from a media studies perspective, however, allows to not only study the technical inner workings of such tools and their effectiveness in urban planning. Investigating such tools as media objects allows us to study the layer often forgotten by the hard sciences, and allows to research the implications that such tools have on society and in this case also, on the citizens. The consequences of datafication of urban spaces has already been an object of enquiry of many media scholars such as Rob Kitchin (2014,2015), Shannon Mattern (2015) and Tracey Lauriault (2014, 2015). The studies on data-driven digital tools conducted within the media studies field, however, do not connect the object of their enquiry with the concept of mediatization, which is especially interesting when analysing software as media objects which operate on data. Mediatization is particularly relevant to studying digital tools as it is a process in which complex concepts such as the urban planning are translated into data which subsequently is visualized and becomes readable through a shared information infrastructure – a media object, in this case study -a digital twin.

Approaching simulation software as a media object therefore allows us to investigate how the complex reality is deconstructed, organized in manageable and quantitative information units (data) and subsequently, how the data is used to reconceptualize the world. Studying digital tools which aid the decision making processes in urban planning through the concept of mediatization reveals numerous challenges that such tools carry which are often concealed in purely technical research projects. It challenges us to ask ourselves, how do these objects reconceptualize reality, how do they produce knowledge and what kind of knowledge is it? What do they conceal, what do they highlight? What do they require from the users qua media and data literacy as well as qua technical skills? How does the different level of expertise influence the degree of critical reflection while engaging with the tool and therefore, how does it impact the interpretation of the results produced by the tool?

The incorporation of simulation software in the urban planning and public management requires a great deal of responsibility from both, companies who develop such software as well as the municipalities who purchase such tools and implement them in their work processes. The technology corporations need to be urged to develop ethical software which will aid good governance and through its design will not produce biased and discriminating results. It is the responsibility of these companies and the developers working for them to make the tool and its operation logic as transparent as possible to the users. Moreover, such tools require the reorganization of work processes on a governmental level. In order to cater to the needs of digital societies and use the tools to the benefit of the citizens, the public management needs to change into one that follows the reassessed principles of good governance (Meijer, Schaefer, Branderhorst 2019, 2). The systems used to aid urban governance need to become transparent and accountable to the public as well as to the public servants who use them in their daily work. In order to ensure that the digital tools are used with full awareness of their implications, the competencies of the employees need to be raised and adjusted on a regular basis (Meijer, Schaefer, Branderhorst 2019, 2).

Digital twins and simulation software are extremely powerful tools which offer a number of promising advantages to policymaking and urban planning; however, the implementation of such tools should not be left without critical reflection. It is crucial that while working with such software, policymakers and urban planners ask themselves questions such as: how can this technology be used effectively? What are the risks involved? What competencies does this tool require from the organization? In order to use the technology to its full potential and for the benefit of the citizens, the users should acknowledge that with the implementation of such tools they need to pay attention to the way governance is influenced.

Just like the technology which moves forward, the governance needs to evolve into governance that supports technical innovations and answers to the needs of datafied societies.

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# Illustration list

# Appendix

## 1. Questions for the interviewees

1. **General questions**
   - What does the platform allow to do that was not possible before without the software?
   - How do the employees of municipalities/ waterboards / provinces react to the introduction of the platform? Do they see such software as a threat or an improvement, and why?
   - Does the deployment of the tool change anything in the work processes of the municipality/ province/ waterboard? If so, in what way?
   - Does the deployment of the tool bring any advantages or disadvantages to the decision making processes? If so, what are they?
   - Are the decisions which are made while using the Tygron platform influenced by the results shown by the software?
   - Are users critical of the tool and the results shown while working with the software?
   - Are there any dependencies or doubts when deploying the tool? If so, how are they tackled?

2. **Questions regarding the institution that the interviewee works for**
   - Does the municipality/waterboard/province have a sufficiently developed data management department to be able to make use of such platform?
   - Do the municipalities/waterboards/provinces have access to highly skilled employees who specialise in the data domain and are able to ask the right questions in order to extract relevant insights from the data?
   - Do the employees working on various projects of the municipality /waterboard/ province have sufficient knowledge about data to be able to use it in order to obtain useful insights?
   - Does the use of the Tygron platform require special preparation of the municipalities/waterboards/provinces (e.g. hiring additional staff to transfer developments plans onto the software or to prepare and collect data)?

- Does the municipality consult experts while using the Tygron platform? Does the municipality consider the expertise of such consultants crucial for working with such software?

**3. Questions regarding the citizens and civic participation**

- Can the platform help to involve citizens in the municipality's work and project? If so, in what way?
- Do the municipalities/waterboards/provinces plan to evoke citizen participation with the platform? If so, how? Is it already done?
- Which forms of deployment of such software are, according to the municipalities/waterboards/provinces best suited for evoking civic participation?
- What is needed qua internal and external work processes of the government, communication and political decision making in order to engage citizens?

# 2. Interview notes

The following notes have been made based on interviews with the users of the Tygron Platform. A number of them has been (and can be in the near future) published as articles of the company's website.

## 2.1 Interview with Hans Wisse – project leader of implementation of the new Environment and Planning Act in the municipality of the Hague and an advisor at Ludanta

14.05.2020

In 2021 the Netherlands will face a major change in environmental laws. The approaching implementation of the Omgevingswet is expected to bring many improvements for the citizens but also requires the reorganization of the work processes of the municipalities and a shift in their approach to city planning. In order to find out what the future of city planning will look like, and in order to see if tools like the Tygron Platform can be important in the process, I reached out to Hans Wisse, a former project secretary of the implementation of the Omgevingswet in The Hague Municipality and an advisor by Ludanta. In his work, he has considerable experience in working with the Tygron Platform as well as in leading Serious Gaming sessions with the use of the Tygron software.

*Spatial planning*

In the light of Omgevingswet, according to Wisse, there needs to be a shift in approach to city planning. Currently, the discussions about urban problems and urban solutions are conducted with limited spatial awareness and with the use of two-dimensional plans. This way, the problems are tackled with little attention to the fact that every problem exists in relation to multiple factors and that every solution to this problem will have an effect not only on the direct issue but also on the environment in which it exists. Policymakers and city planners, according to Wisse, need to start planning three-dimensionally. They need to see the space, which is the subject to their discussion as well as they need to understand the other factors which are tied to the problem that they are trying to tackle. Wisse compares the urban environment to a living organism where one problem treated by a specialist might result in major consequences for other vital organs in the body. Therefore, city planners need to treat

the urban problems holistically, paying attention not only to the immediate issue but also to the effect that the solution will have on other parts of the urban ecosystem.

*Working integrally*

In order for this vision to become reality, it is crucial that policymakers and planners specialized in different domains work integrally. Currently, policymakers are required to make laws and regulations for each domain individually. The cooperation between the different departments is limited yet, in light of the objectives of the new Environmental Act, in order for the city planning to be effective different specialists need to work together.

As Wisse says, such a way of working is a result of the well-established work manner within the municipalities. Switching to a more horizontal, collaborative city planning is a big step that the municipalities are slowly making. In order to make the transition process easier, Hans Wisse says that he searched for a digital medium that would help bring different stakeholders together and be a starting point to productive discussions. The tool that he saw potential in was the Tygron Platform.

With the help of Ludanta, Wisse uses the Tygron software and serious gaming to introduce the municipality workers to a new way of planning the cities. According to him, such a way of deployment of the software is the most approachable way of introducing the new tool. Among the serious games used by Wisse to tackle city-planning problems are the Kijkduin 1 and 2 developed by Ludanta. In the interactive game sessions, different stakeholders are gathered together to debate and to find an optimal solution to a problem. In order to come out with the solution, the game requires the participants to make compromises. The team goal is more important than the goals of the individual stakeholders and in order to reach it, the participants need to negotiate and discuss the issue together. As Wisse says, the Tygron Platform provides the participants with a visual presentation of the problem area and the situation. That way, the area, and the issue discussed become transparent and the stakeholders are provided with a sense of reality. The proposed solution and the discussions held at the table are no longer two dimensional and theoretical. Thanks to the Platform, they come to life and are visualized to the participants. The problems are shown to be a part of a bigger system. It is made clear that they are a part of a web of different, co-existing aspects of the city and therefore, the participants see how important it is that the city-plans need to be made with the joined effort. The Platform provides a safe space for creative thinking, testing, and experimenting with possible solutions without the threat of making mistakes.

*Civic participation*

Currently, the Tygron software is used for gaming sessions for civil servants as well as the citizens. Both groups are however participating separately. According to Wisse, the next step is to use the Tygron Platform to hold discussions at one table with both citizens and the city planners. Municipalities cannot succeed in their work without the input of the citizens. The citizens are the experts that the municipality needs, says Wisse. They live in the area day to day, they are the ones who know everything about the needs and the problems of their city. It is therefore crucial that these two groups work together more closely, and the cooperation between them can be made easier and more effective if supported by tools such as the Tygron Platform.

## 2.2 Interview with Jan Jelle Reitsma- advisor at the Rijnland District Water Control Board

28.05.2020

According to the interviewee, the Tygron Platform brings to professionals many benefits and improvements to their work processes. The results shown by the tool are a result of a detailed and fast calculation. The tool visualizes the problem making it come to life in front of the users. The 3D visualisation and instant calculation of changes that are made in the visualised scenario make Tygron a tool which supports discussion and makes the communication between the stakeholders easier. It places the discussed issue in a broader context and makes its connection with other elements of the ecosystem more apparent. That way, according to the example given by the interviewee, a flood scenario played in the Tygron Platform shows how the water will affect the surrounding area, which roads will be blocked and how many households will need to be evacuated.

According to the interviewee, different user groups with different levels and fields of expertise have different objectives and critiques towards the software. In the interview, he identifies two groups; the experts in a certain domain for example hydrology and energy advisors, and policymakers. The experts focus on the structure of the calculation models used in the software as well as the data that is used to perform these calculations. Because of their expertise in the field, they are sceptical about the accuracy of the results and pay close attention to the data that they use for the calculations. The policymakers, however, are interested in the tool because of the way it visualizes the problem. Such visualization is an aid to their discussions and decision making. They are not critical about the data that is fed into the tool, nor are they questioning the calculation model used in the simulation. According to the interviewee, the policymakers are expecting from the tool fast and accurate calculations without a margin for error and estimation so that they can use the results and use them as an aid to their decision making. In the experience of the interviewee, the 3D visualizations produced by the tool often convince the policymakers that the results produced by the tool are the truthful representation of the reality. Paradoxically, because of the highly realistic 3D environment however, the trust in the truthfulness of the results can also be broken once the user notices that an element of the area looks different than he or she remembers from his real-world experience.

## 2.3 Interview with Henk van Hardeveld, teamleader of Hydrology & Ecology at Waternet

2.06.2020

The questions for the interview with Henk van Hardeveld were posed in relation to his research on the influence of interactive simulations on environmental management.[2] In his research, he tested ISS (interactive simulation system) with real-world stakeholders in multiple interactive workshop sessions, through questionnaires and video recordings of the sessions. The case used for his research was the collective management of Dutch peatlands for which an ISS was developed on the base of the Tygron Platform. The interview evolved around four key issues.

*How to stand the test of critical reflection on the tool and data*

The participants that took part in the workshop were experts in the field and because of their domain knowledge they did not take the results shown by the simulation for granted. The outcome that the stakeholders were often sceptical about was the estimation of costs and profits given by the software. According to van Hardeveld, some of the participants were curious about the data, which was used in the simulation. Because of the tight schedule of the session though, there was little time to explore the actual data sets that were loaded into the tool. However, key settings could be easily adjusted at the start of the session, using the input of the participants. Therefore, the tool was perceived by the participants as credible and legitimate. According to the interviewee, it also evoked trust because the ISS was designed by experts on the Dutch peatlands and because of the fact that the tool is fully customisable.

*How to use the tool successfully*

In the experience of the interviewee, the way to use the tool successfully depends on the level of expertise of the participants in the interactive sessions. A team of participants which consists of only experts will do just fine. They not only have extensive knowledge in the field but are also able to understand the data and the technicalities of the software in a relatively short period of time. Another fruitful possibility is a team which consists of a person who is skilled at using the tool and a person who focuses on the scenario and negotiating a solution.

[2] van Hardeveld, H. A., P. P. J. Driessen, P. P. Schot, and M. J. Wassen. "How interactive simulations can improve the support of environmental management–lessons from the Dutch peatlands." *Environmental Modelling & Software* 119 (2019): 135-146.

From the observations of van Hardeveld, such combination results in effective collaboration within the team. The last type of a team is one that consists of users which are neither familiar with the tool nor experts in the discussed problem. According to the van Hardeveld, the work of such a team is not very fruitful without a proper instruction. Otherwise, the technological aspect of the workshop turns out to be too complicated. In order for the session to be successful, you need to allocate more time to explain the use of the software and the background of the posed problem.

*Reactions to the software*

The interviewee has observed among the participants both enthusiastic and hopeful attitudes towards the software, as well as strong enthusiasm for solving real-world issues with the help of a ISS. According to the interviewee, the informal and friendly atmosphere of the session and the game-like character of the tool contributed, for the most part, to a better engagement in dialogue and negotiations as well as increased the productivity of the participants. The one thing almost everybody mentioned was that they gained a better understanding of the stakes of their opponents. Some even claimed this would be a big help in designing more successful deals in real-world situations. However, the interviewee also warned that real-world application requires more than just organizing one session. If you will use the tool over a longer period of time in a real-world policy process, you may encounter participants who are more sceptical towards the tool. This may also be related to the fact that it would change the work processes that they are used to. According to the interviewee, they may even fear that the new technologies and calculation models are going to replace humans making decisions. However, he does not regard this as very plausible. Instead, use of interactive simulation systems has been shown to enrich decision making in many cases around the world, enforcing rather than replacing the decision makers.

*The advantages of serious gaming for both experts and citizens*

The serious game properties of the ISS are according to the interviewee beneficial to the problem-solving process. The degree of learning amongst the participants is much deeper because they are actively taking actions in the simulation from the perspective of the stakeholder that they are representing. The users are immersed in the experience and the roles that they have assigned and try to communicate between each other and negotiate in order to broker a deal. The serious game mode deployment of the software can according to the

interviewee be also a great tool for civic participation. The combination of data and the three-dimensional interface helps to present the issue to the citizen multidimensionally. It reveals relations between different aspects of the problem such as its causes as well as the impact that it has on the area. The realistic visualisation helps the citizens to identify with the area that is modelled. Moreover, during the interactive sessions with the ISS, the citizens can learn more about the objectives of the other stakeholders engaged in the discussion which helps them understand the complexity of the problem.

Besides the benefits that serious gaming has for citizens in the urban planning processes, van Hardeveld recognises a limitation to such mode of deployment, namely the time. The process of creating an ISS, depending on the complexity of the problem that needs to be visualized is very time consuming and therefore such interactive sessions do not align with the time schedule of many projects. On the bright side, there is at least one notable exception: the ISS that van Hardeveld and his colleagues created is freely available for all users of Tygron software. To underline this feature, they baptized their ISS 'RE:PEAT', and invite all stakeholders in peatland processes around the world the repeat their successful application of the Tygron software.

## 2.4 Interview with senior policy officer, Authorization and Supervision department at the municipality in the Randstad region

9.06.2020

Edward de Wit is a senior policy officer working by the Authorization and Supervision department by one of the big Dutch municipalities. In his work, he is currently using the Tygron Geodesign Platform in a project about nitrogen pollution where he aims to gain insights into the nitrogen deposition caused by the building sites. Having considerable experience in using the Platform, de Wit shares in an interview with Tygron insights on affordances of the software, its' practical applications and the data culture within the municipality.

*Tygron Platform for the Environmental and Planning Act*

According to de Wit, the innovation to the public management that Tygron brings, is of value in the light of the new Environmental and Planning Act which will be put to work in January 2021. One of the aims of the new law is making the spatial laws simpler and more accessible to the citizens. A solution which would help reach this goal is a so called Digitale Stelsel (DSO), a system which would let the citizen to view an area on which he wants to build and show him on a map if his building plans are aligned with the rules posed by the government. Such way of verifying building plans would simplify the long and complicated procedure of applying for building permit. According to de Wit, such shift in the law is only possible once the government possesses the right tools to support such functions. Tygron, among other simulation software is suitable for this purpose. Even though the technical base for such innovations already exists, the government is cautious with handing such tools into the hands of the citizens not only because of financial matters but also because of the possible mistake margin of the calculations and the prediction performed by such software. Therefore, according to de Wit, the incorporation of simulation software in the permit assigning process is a discussion point in the government agenda, but only in distant future.

*Data culture within the municipality*

In the department where de Wit works, there is not so much scepticism about the data used for the calculations in the Tygron Platform. The data which is used for the calculations belongs to the department and is accepted as the truth. In their work, the employees of the Authorization and Supervision department are also making use of the Aerius model developed

by the province, therefore they do not feel the need to verify the data. Asked about the general data culture within the municipality, de Wit says that the institution has at its disposal a general ICT and data department. The municipality has however ambitious plans to strive towards becoming a more data driven municipality. To reach their goals, the municipality had developed an extensive data-strategy for the years 2020-2022. One of the objectives of the innovation programme mentioned by de Wit is that every department within the municipality should have a data specialist who would give advice on data related topics and who would help in preparing the data so that it can be reused by other departments.

De Wit is positively inclined towards the Tygron Platform. According to him, the visualisation properties of the software are impressive, and it is a great communication tool which can support the discussion among multiple specialists from various domains who decide upon the building permits. There is still however, a lot of work that needs to be put into developing of the tool before it can be made available to the citizens. As first, says de Wit, the tool will be used to solving the nitrogen problem and if successful, the municipality will broaden the application of the software to other challenging issues such as the external security, noise and air quality.

## 2.5 Interview with Maarten van Helden- senior sustainable development advisor at the Province of Utrecht

17.06.2020

According to Van Helden, the incorporation of the Tygron Platform into the work processes of the province brought beneficial change to the development of spatial plans. The major advantage of the tool are the visualisation capabilities of the software. The tool can turn a chosen two-dimensional area on the map into a three dimensional interactive model. It can be applied to any area and the user has instant access to multiple information layers (overlays) that can be drawn over the neighbourhood or area. Without the software, any change proposed to the area needs to be first calculated and subsequently, a new map needs to be drawn. This delays the decision process as drawing such plans and making the calculations can take days. The Tygron Platform, however, allows for changes to the plan and assess their impact on the area almost instantly. That way, time and effort can be saved and the decision making and planning process can accelerate.

At the Utrecht Province, the Tygron software is helping Van Helden and his team to develop quality scores of varieties of aspects of the environment. Issues such as noise pollution, air pollution, energy and soil quality are assigned a score from 1 to 10 which gives the urban planners insight into the state of these aspects in the current situation. The scores are calculated by the Tygron software automatically, however the meaning behind the numerical values is decided by Van Helden and a team of specialists which have expertise in various domains related to urban planning. In order for the plan to be approved, all indicators need to be above 6. According to Van Helden, the province is not satisfied with plans which score just above the legal minimum. The advisors are not focusing on what is allowed but they strive to explore which solutions will guarantee the best possible health and living conditions for the people. If certain scores are not satisfactory, the user can take different actions in the platform which could potentially improve the situation and test what influence on the area they will have by running a simulation. According to Van Helden, because of the fact that every decision has an influence on the other aspects of the environment, every issue and every choice needs to be discussed by multiple specialists which are involved in making the urban plans. Even though some scores are impossible to be objectively measured, they are contributing to the discussion because they put the discussed issue in context and provide the planners with a sense of perspective.

While working with the Tygron Platform, van Helden and his team often rely on the assistance of the GIS department within the Utrecht Province which, holding expertise in Geo data, helps them to translate the maps into the software and create custom calculation models. According to Van Helden, even with the help of the GIS department in developing custom solutions catered to the needs of his team, there is need for thought exchange between his team and Tygron as often specialistic features need to be developed in order for the software to support his projects. Holding a partnership with Tygron, Van Helden, his team and the GIS department are in constant dialogue with Tygron and its developers about how the software can be adjusted, and improved, and which features can be added to meet the needs of the users.

Through using the Tygron Platform by multiple various projects within the Utrecht Province as well as in various Dutch municipalities, Van Helden and his team have gained considerable insight on how the employees of governmental organizations react to the software. The visualization properties of the platform evoke positive reactions among the users and make them gain trust in visualized information quickly. It is common that the users are often impressed with the realistic image generated by the software and do not always question the scores and results predicted by the software. Even though not everyone is reflecting upon the calculations performed by the tool and the data fed into the software, there is a considerable number of users who ask good and interesting questions about the inner workings of the tool. According to the observations of Van Helden, the Platform is a tool which aids the discussion and by showing the issue in relation to other aspects to the area, gives context to the discussed problem and motivates the specialists to work and debate together.

From the experience of Van Helden and his team, the advice that they give to urban planners influences the plan initially, however, as they can only join the project for a short amount of time, the plans can develop in a different than the advised direction. As Van Helden mentions, keeping knowledge within the organization is difficult as some small municipalities have limited access to advisors with expertise in the Tygron software. He claims that best results are achieved when the Tygron Platform is incorporated in the planning process right at the beginning of the project. Changing spatial plans halfway usually results in high costs.

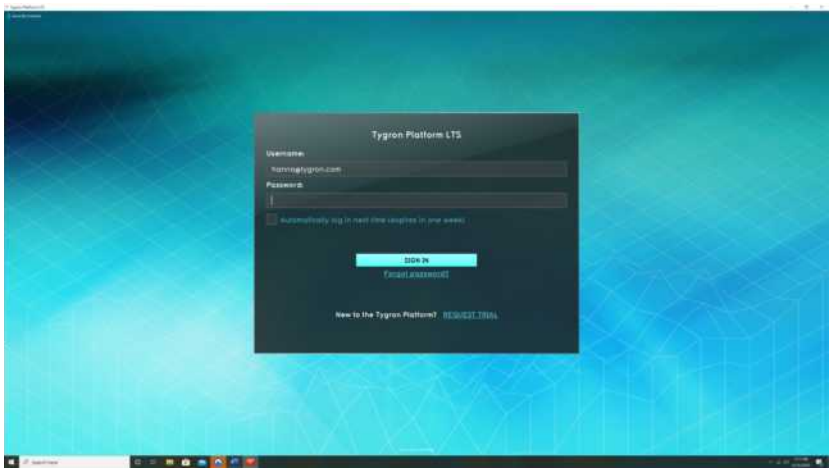
In the interview, Van Helden mentions a number of possible applications of the Platform which might become more common in the near future. According to him, at the moment, little social data is used by the province while working with the Platform. The province has access to basic social data such as the information about jobs and income of the area, it is however difficult to combine it with spatial planning. It is therefore not yet the focus while working with the software. Van Helden indicates however that it might be more

incorporated in the future. Another possible application of the software which is exceptionally relevant in the light of the Omgevingswet (Environmental and Planning Act) is using the Platform as Digital System (DSO) which can inform the citizens about the spatial laws and help to communicate urban plans to them.

# 3. The Tygron Platform - Walkthrough

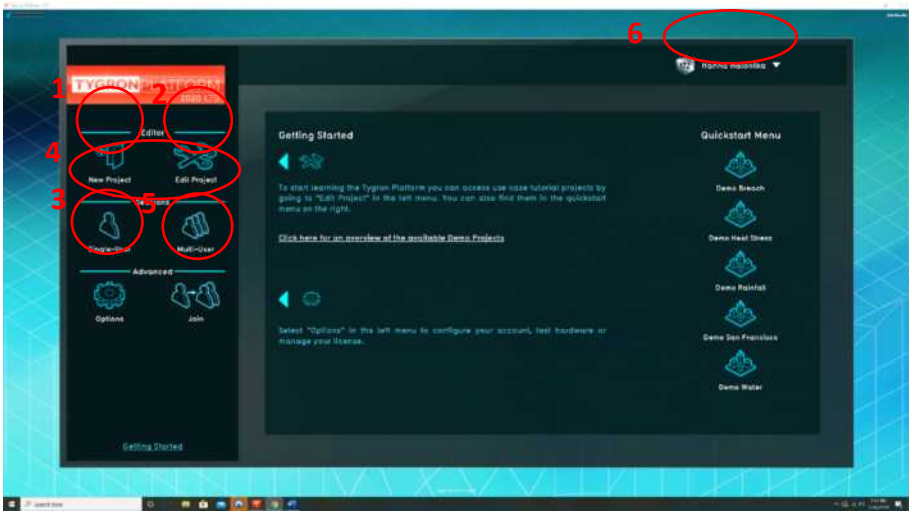
The following walkthrough though the Tygron Platform has been based on a Rainfall tutorial developed by Tygron. The tutorial walks the user through a rain stress demo that the user can access through the platform.

**Home screen**



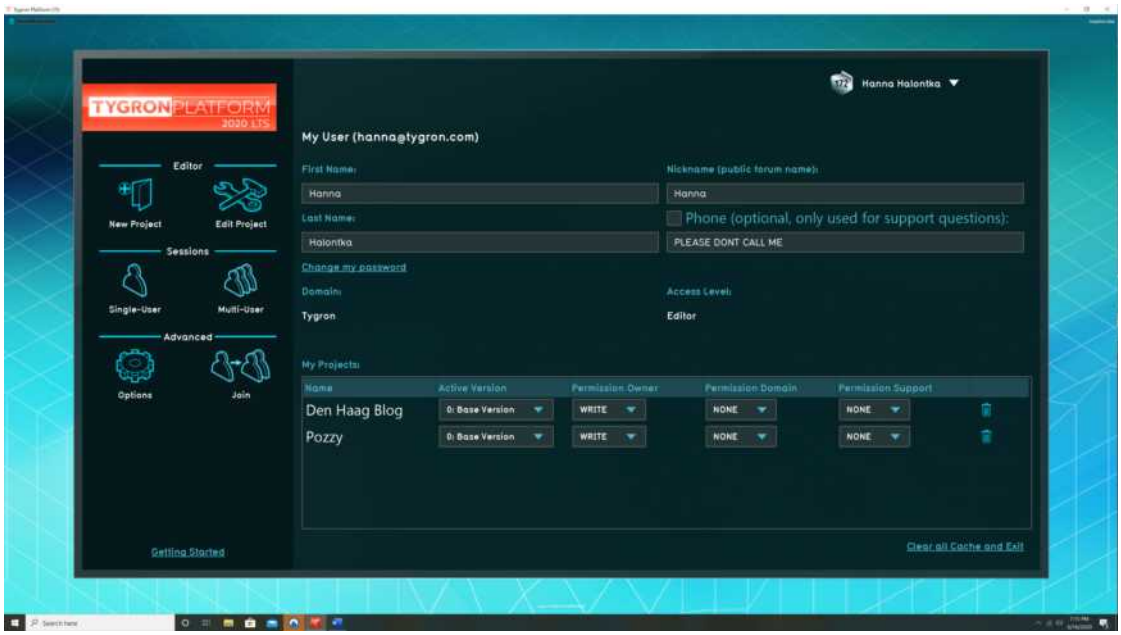

*Signing in screen*

After starting the application, the user comes across a log in screen where he can request a trial version of the software or sign into an existing account with a purchased license.



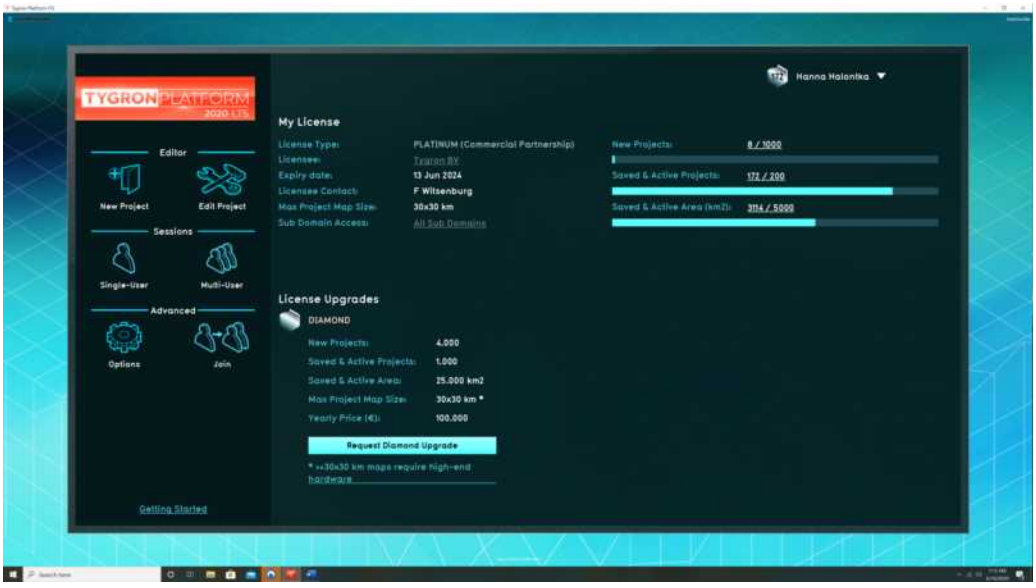

*Home screen. (1) new project, (2) edit project, (3) options, (4) start a session, (5) join a session, (6) user's profile*

Successful sign in brings the user to the start screen where from which he can start a new project (1), edit an existing project (2), change the settings (3), and start (4) or join a session (5) in which a project is edited. From here, the user has the access to the information and settings of the account and the information about the active license (6).



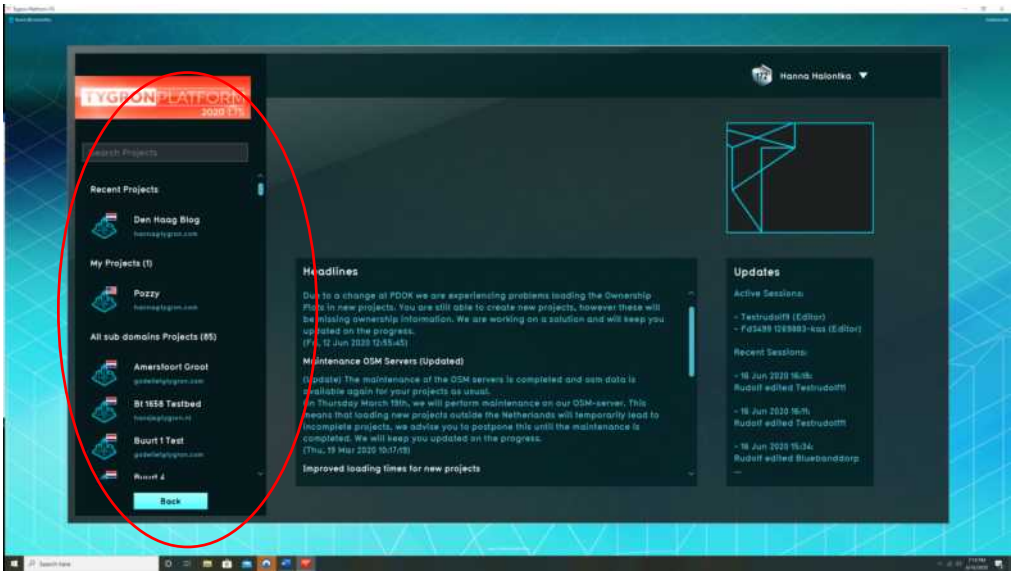

*User screen displaying information about the user's projects and profile*

The "User" screen contains information about the account such as the name of the user, his phone number and the access level that of the account. From this screen, the user is able to change the personal information of the account as well as he can reset his password. This screen also gives insights into the user's projects and allows for deleting them as well as adjusting access settings to the project.




*License screen displaying information about the active license*

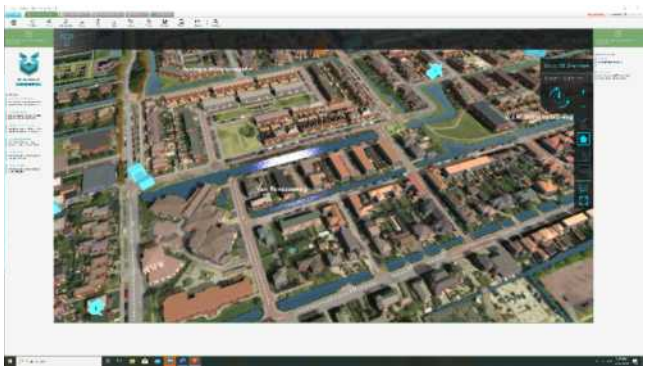
The "License" screen gives the information about the active license type, the maximal project size and the number of projects which still can be created within the purchased license. From here, the user can also request a license upgrade.



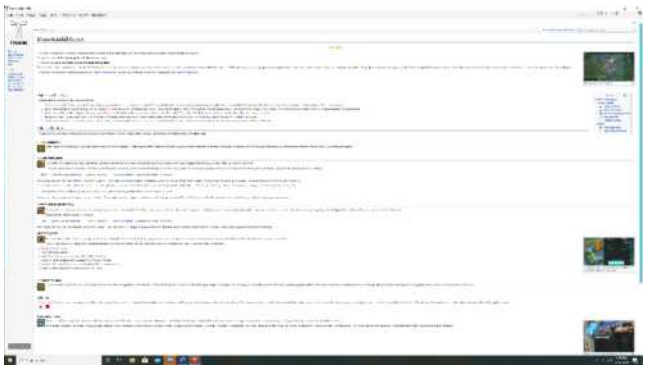

*The project library*

Back at the main screen, the user has the access to all of the projects available to him. He can search for and choose a project at the right panel of the interface and start editing it. From here, the user can access the demo projects which are accompanied by the tutorial published on the Wiki page of Tygron.

**Opening a demo project**



*The editor*



*The tutorial on the Wiki page of Tygron*

After launching the Rainfall Demo project, two windows are open. The first one is the editor where the 3D model of the world is displayed and the second one is the Wiki page of Tygron with the descriptions of various steps that the user can take to explore the demo.


*The structure of the interface. Source: Tygron Wiki page*

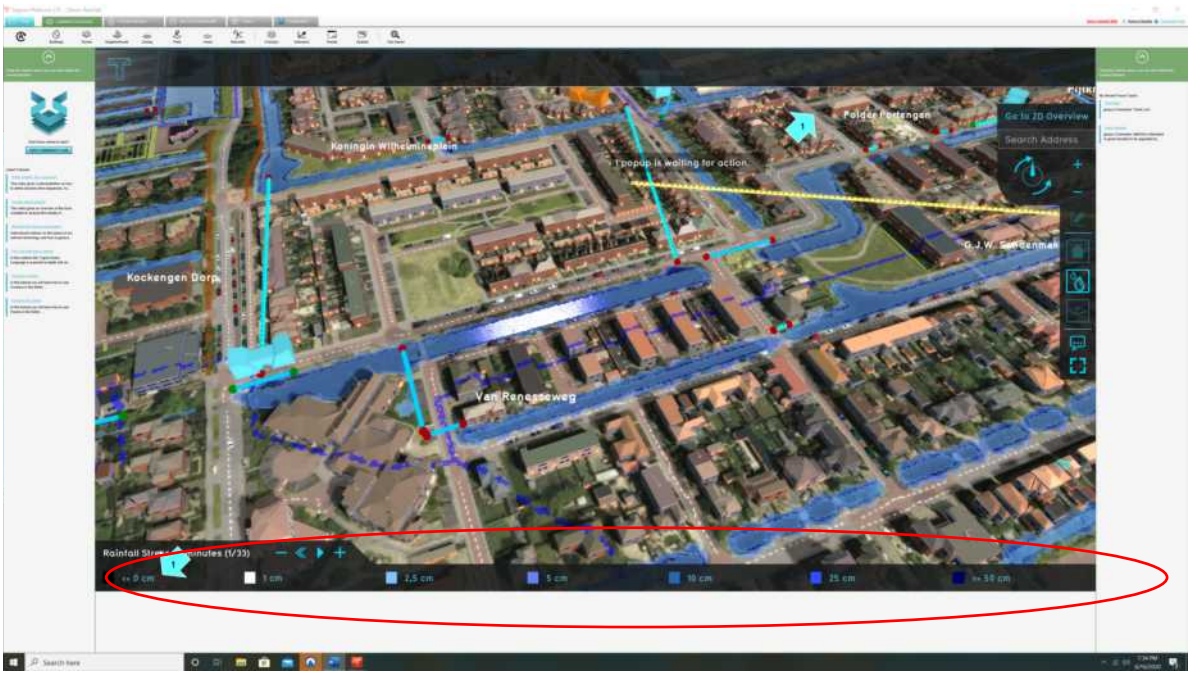
The editor consists of a ribbon in the upper part of the interface the two panels on the right sides of the screen, the bottom panel and the main interface where the user navigates through the visualization. The user can use the arrows on the keyboard or drag the camera around by right clicking and moving around in order to navigate through the world. He can also zoom in using the scroll wheel of the mouse.

**Overlays**

At the right edge of the main interface there is an overlay panel. From here the user can apply different data and calculation layers ("overlays") and "child overlays" which appear on top of the map of the world visualizing additional information about the world.

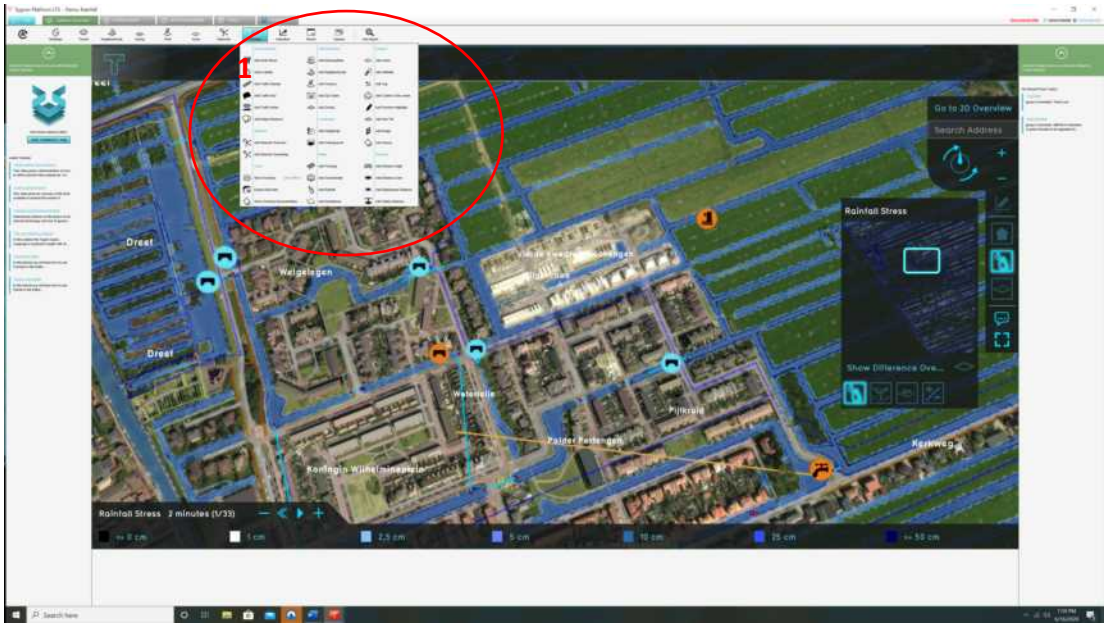

*The overlay panel*

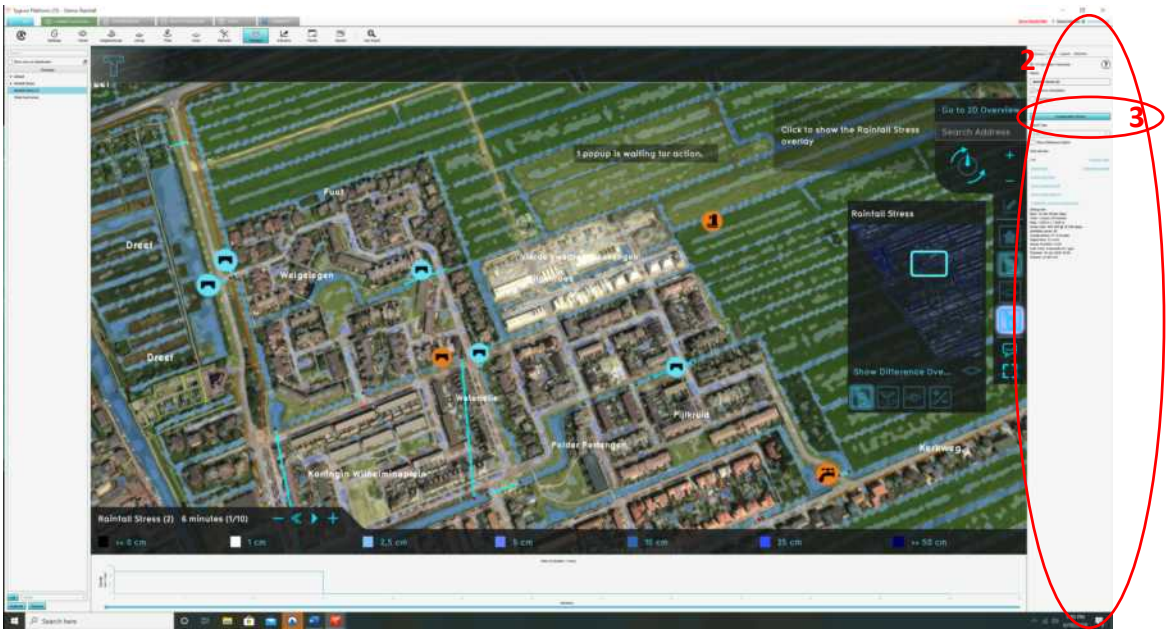
1. Navigation (access to the 2D view, zoom, rotation, searching by address)
2. Measuring section
3. Default state, overlays of neighborhoods, property and zoning
4. Rainfall stress, surface elevation, base typology, manning value
5. Water level areas
6. Show past actions
7. Full screen



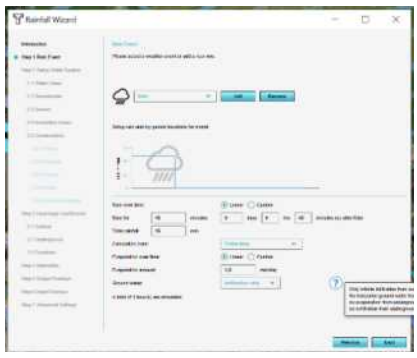

*The applied rainfall overlay and the colour legend with the water level marks*

After applying the Rainfall overlay, the amount of water in the world during the rainfall simulation is shown. Based on the data uploaded to the project, the software calculates the water levels in different areas of the neighbourhood and visualized it with different colours. At the bottom part of the main interface, a grey ribbon is displayed where the user can play the simulation and see how the how the water levels change in time. The different water levels are marked with different colours which are explained in the legend in the lower part of the screen. More overlays can be accessed by the user through the overlay tab (1) placed on the ribbon in the upper part of the interface. Choosing a certain overlay opens a more detailed overlay menu in the right panel (2). From here, the user can open the Configuration Wizard which allows for extensive customization of the overlay (3).

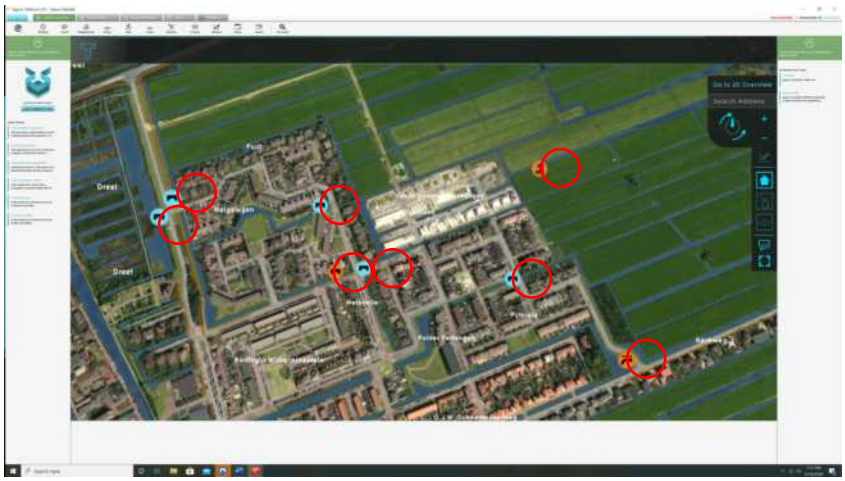



*Configuration Wizard*

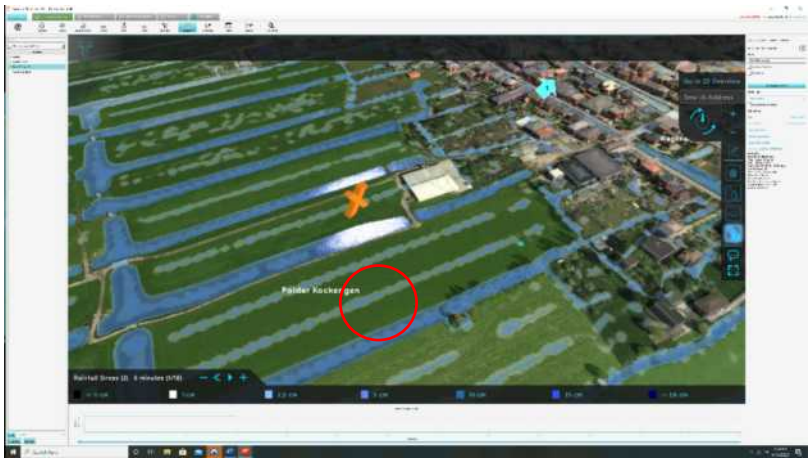



### Points of interest on the map



*Points of interests on the map indicated with pop up icons*

The icons visible on the map while zoomed out indicate point of interests worth exploring. An explanation of the icon and the indicated issue is available after clicking on the icon.



*The cross icon indicating area where the calculation cannot be performed because of lacking data*

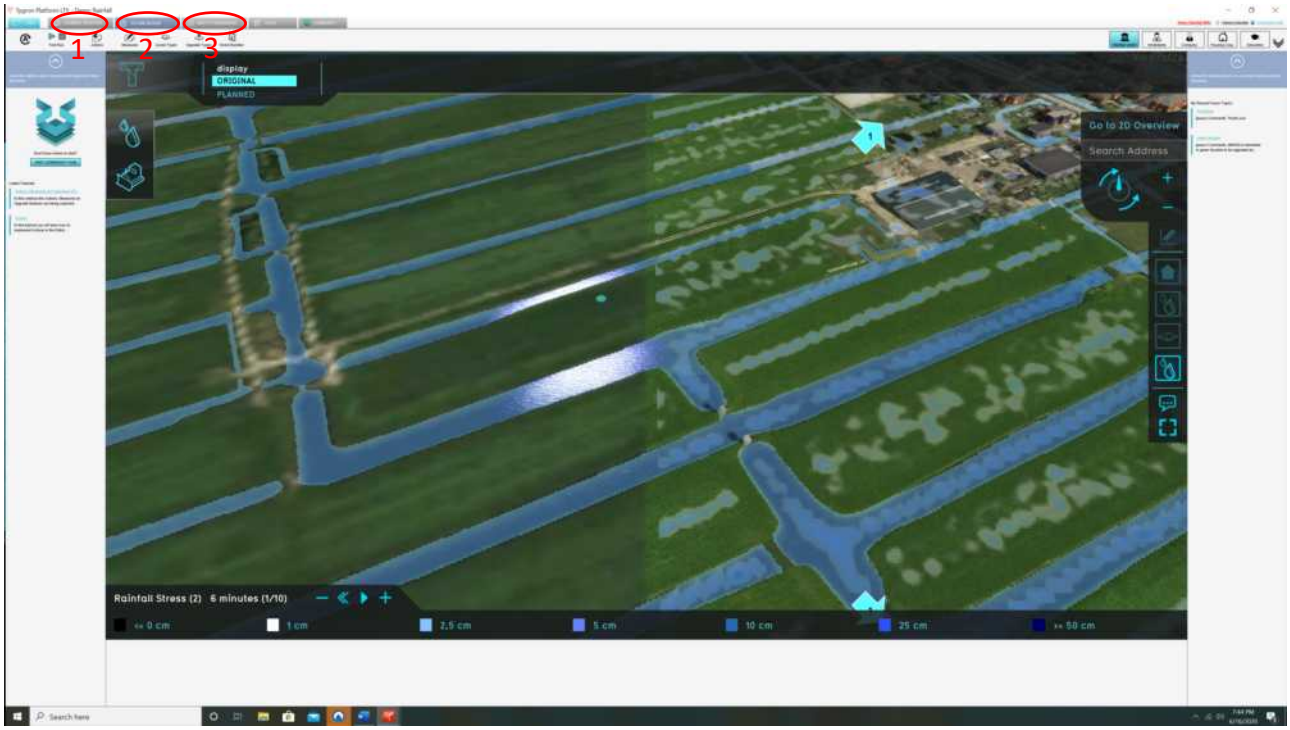
The cross icon displayed on the map indicates an area where no calculations could be performed due to the lack of data. The data used for this project does not cover the whole sections therefore it is impossible to model how the water would flow through. The project can only perform calculations in areas where the data exist.

### The three modes of the deployment

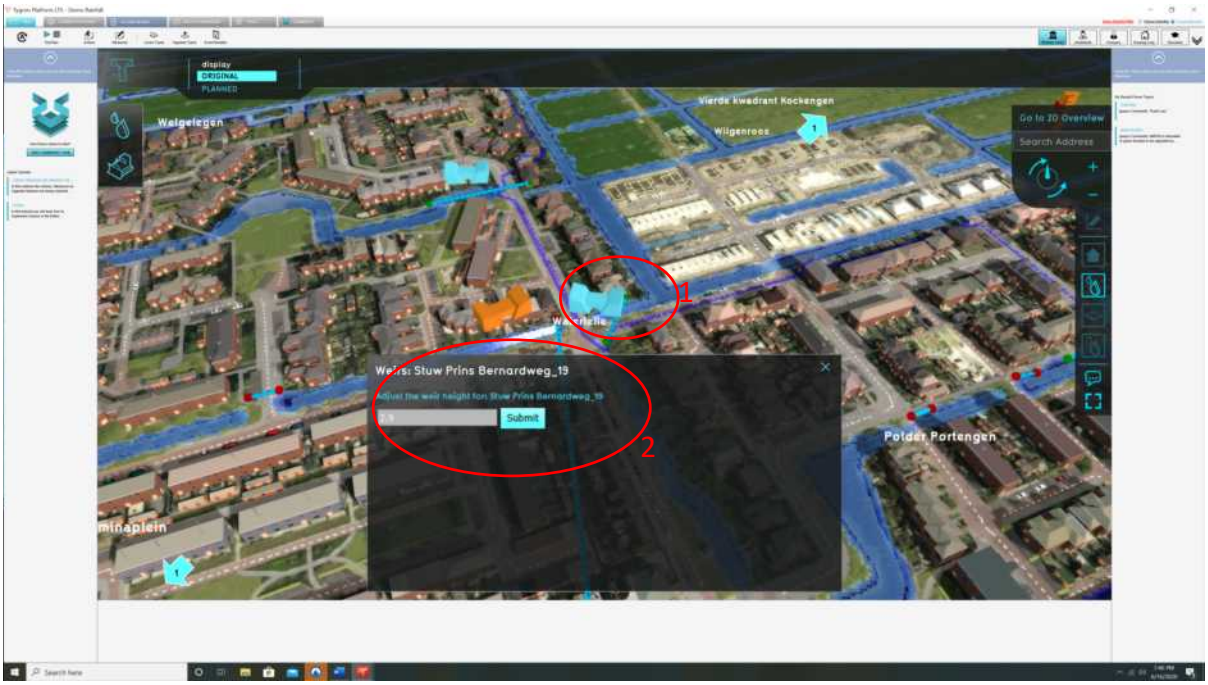
The Tygron Platform has three modes in which the software can be deployed. The first mode, the current situation allows the user to edit, configure and build the project. It is the starting point for any project before a simulation, planning or an analysis can be performed. The second mode is the future design mode in which the user can perform a test run of the actions planned

in the project in order to test possible solutions and plans. The third mode is the multi stakeholder mode which allows for viewing the project from the perspectives of different users engaged in the planning. The users can switch between the modes by clicking on the different tabs on the ribbon in the upper part of the interface.

The Rainfall demo which has been used as the project which this walkthrough is based on explores the features of the second mode of the deployment, the future design mode in which the users can test out different scenarios.

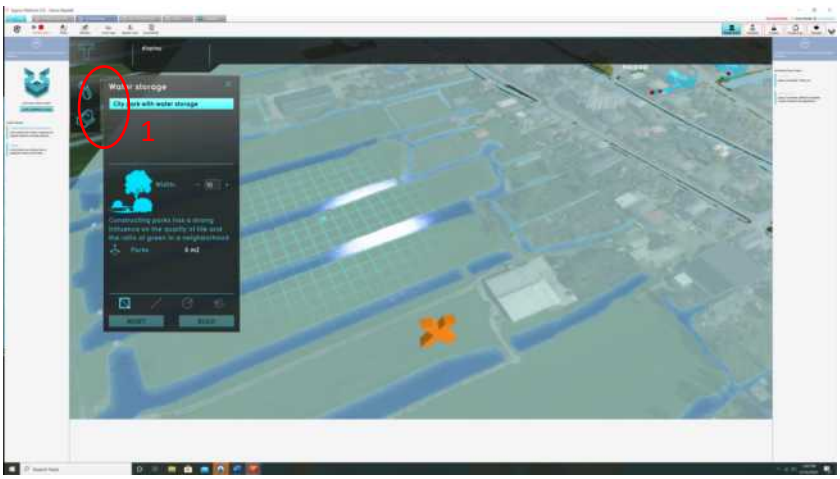



*Modes of the deployment of the Tygron Platform: (1) Current situation, (2) future design, (3) multi stakeholder mode*




*Changing the settings of an element in the future design mode: (1) weir, (2) adjusting the weir's height*

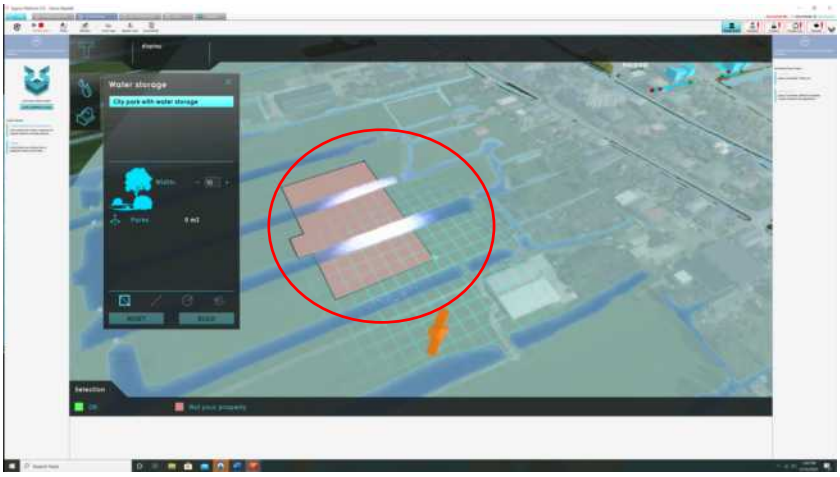
In this mode, after making a change in the settings of a particular element of the world (in this case a weir) , the rainfall overlay will be recalculated, and the new results will indicate how water would act with the weir set to its new height. The user can compare the initial results with the new results predicted by the software by activating the "difference mode" of the rainfall overlay. The overlay will now show where the resulting amounts of water have changed due to the action taken by the user.



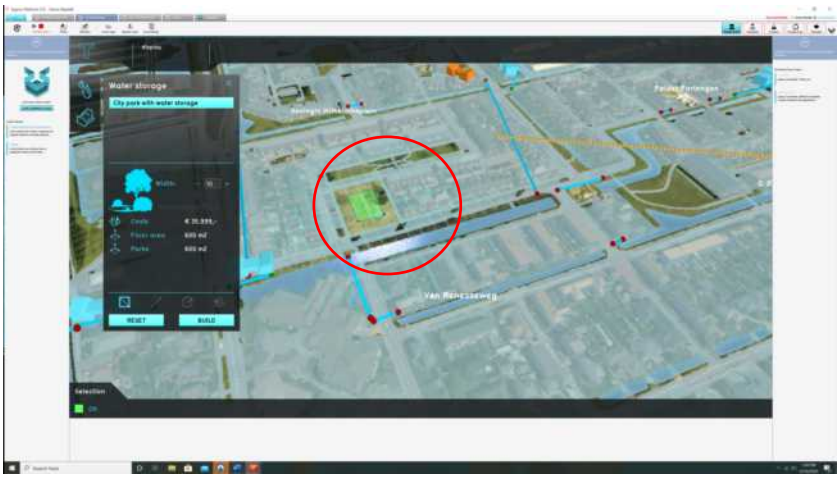

*The action menu activated in the future design mode*

Once the user switches to the "future design" mode, he gets access to the action menu (1) which appears on the left side of the 3D visualization. In the action menu, the user can choose what new element they would like to place in the project. In this case the objective was to build a city park with water storage. The new object needs to be drawn onto the map in a spot which, according to the data that the project operates on, it is permitted to build. In the case of the

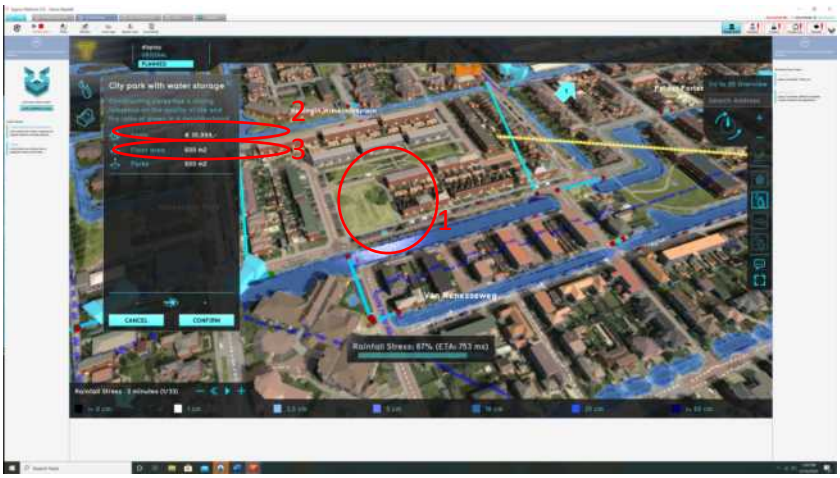
tutorial project, the software gave feedback on which grounds belonged to the municipality. The software will also indicate the costs of the construction as well as its surface in square kilometres.



*The software indicating that building in the area is not permitted as the ground doesn't belong to the active stakeholder*

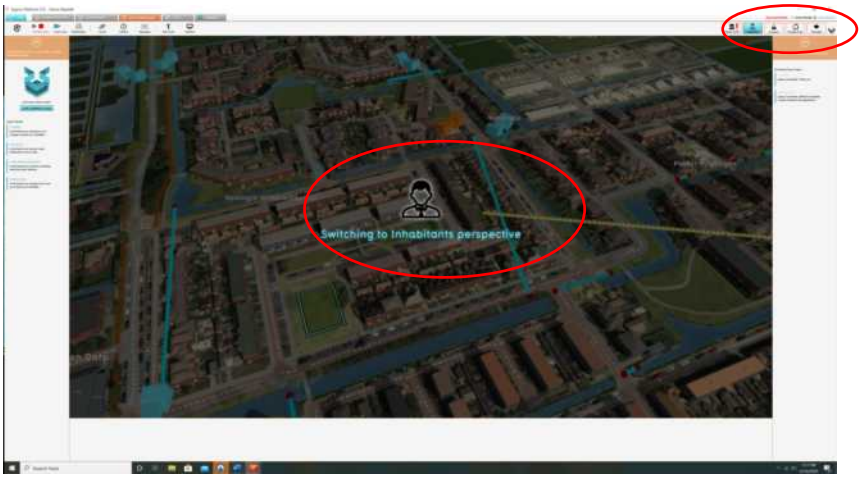


*Accepted building plan indicated in green*




*(1) Completed construction, (2) cost estimation and the (3) floor area value*

The area and the proposed actions can also be viewed in the Platform in the multi stakeholder mode. This mode allows to view the project from the perspective of different users which engage with the software during an interactive serious gaming session. The users represent different stakeholder groups which have different objectives. Each stakeholder needs to communicate with the other users and different actions taken in the simulation need to be first requested and approved by the appropriate stakeholder.




*Switching to a different stakeholder perspective. The stakeholders present in the session are indicated by the icons in the right upper corner of the interface.*