RESCCUE RAF App – Using Technology to Mitigate Climate Change Urban Impacts

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Abstract - **Climate Change (CC) is nowadays one of the most important concerns for urban management. Given its scalability, technology can take an important role to help city managers identify and mitigate specific CC-related problems. Herein, an innovative and user-friendly web application is presented to empower city managers with a tool to cope with CC, giving them detailed information , accessible from anywhere. The usage of this app allows city managers to decide on optimized measures to address vulnerabilities to CC in their city. A methodology of city assessment that goes deep into city services processes, their characterization and interdependencies is behind the app, materialized by the Resilience Assessment Framework (RAF), identifying the specific areas and topics that have higher vulnerability to CC z d. T y' xp d within the app, at multiple levels, using intuitive and interactive chart and tabular information. Given its generic nature, the RESCCUE RAF App can be applied to other cities and take a major role in the urban resilience improvement to cope with climate change effects. Adaptation for other cities requirements can be developed g dm p f w g RAF' classification levels are possible.**

Keywords - Climate change; Resilience assessment; Urban areas;

I. INTRODUCTION

A. City resilience importance and short state-of-the-art on assessment methodologies

Urban areas are complex and dynamic systems, with interacting and interdependent strategic services and assets. Therefore, the management of these areas is complex, requiring involvement of a multiplicity of stakeholders. Potential effects of climate dynamics, such as intense precipitation events, tidal and surge effects or droughts, may significantly affect the strategic services, people, natural environment and economy in these areas. These challenges require an integrated and forward-looking approach to resilient and sustainable urban development [4]. The resilience concept has evolved along time and among disciplines [14], [16]. Herein, urban resilience refers to the ability of human settlements to withstand, recover quickly and adapt from any plausible hazards. Resilience to disruptive events not only refers to reducing risks and damage from disasters, but also the ability to quickly bounce back to a stable state. Besides addressing disaster risk reduction, resilience includes changes in circumstances [1], [14].

Since the cities are dynamic systems and considering the principle of continuous improvement [11], it is essential to undertake regularly the assessment of their resilience and to have the reliable information needed and tools to support this. Different tools and frameworks for resilience assessment have been developed in several fields of study e.g. ICLEI 2010, UN-Habitat CRPT 2013, Rockefeller&Arup 2014, World Bank 2015, UNISDR 2015, EPA 2017 among others [14], [19], [20], [17], [6].

A resilience assessment is necessary for identification of the real needs for resilience improvement, as well as the efficiency and effectiveness of planned or implemented measures. Therefore, assessing current and future resilience constitutes the basis for cities to know where they stand, to support decision on strategies, actions and measures to consider, planning in the long, medium and short terms and assessing progress. In this context, a Resilience Assessment Framework (RAF) was developed [4] within the H2020 RESCCUE project – Resilience to cope with climate change in urban areas [19].

B. Technology importance for city support and for resilience to CC assessment

Technology has been exponentially evolving on recent years, and its capabilities have become essential across innumerous areas allowing resolving tasks in a more efficient way or creating new processes that were not possible without it.

Cities are constantly evolving and have the tendency to increasingly grow and it's difficult to city managers to get detailed information on all the service processes of the cities. Given its size and complexity, cities can benefit

with the use of technology to gather detailed information to cope with CC and to facilitate communication among different involved stakeholders.

In this paper, a general description of the RESCCUE RAF methodology is presented and the overall architecture of the application, its components and user's profile is described. A brief presentation of the use of the application by the cities, in the scope of the RESCCUE project, is made.

C. *A brief overview of the RAF methodology*

The Resilience Assessment Framework (RAF) is an objective driven framework that was developed considering the RESCCUE's scope i.e. urban resilience to climate change (CC), with focus on the urban water cycle. The emphasis is on city, services and infrastructure resilience [3], [4]. Therefore, the RAF purposes are to facilitate an objective-driven resilience diagnosis of urban cities and services; to support decision on selection of resilience measures and the development of strategies to enhance resilience to climate change; to support the development of resilience action plans tailored to each city or to each service, and to track progress over time.

The RAF considers four resilience dimensions [13]: organizational, spatial, functional and physical. The first integrates governance relations and urban population involvement, at the city level. The second, also at the city level, refers to urban space and environment. The resilience of strategic services is assessed in the functional dimension, while the physical dimension focuses on the resilience of their infrastructure. The last two dimensions also allow to know the contribution of each service to city's resilience [3], [4]. The services within the RAF scope are water supply, wastewater, storm water and solid waste management, energy supply and mobility.

The RAF validation involved different stakeholders, representatives of research, city and urban services, allowing incorporating their concerns as well as their own context and reality. To ensure coherence, feasibility and effectiveness of the approach, this framework was applied to three cities Barcelona (Spain), Lisbon (Portugal) and Bristol (UK) by their cities and strategic services managers [3], [4].

The RAF has a tree structure (Fig. 1), where, for each dimension, resilience objectives are defined, translating the ambitions to be achieved in the medium-long term by the city and services. The functional and physical dimensions firstly unfold into sub dimensions (one for each service under assessment). For each objective, key criteria are specified, which express the different points of view through which the objectives are to be assessed. A set of metrics is associated to each criterion. Metrics are parameters or functions that allow undertaking the criterion assessment. By comparing the result of a metric with reference values, it is possible to assign a judgment to the responses, reflecting a resilience development level. The whole assessment translates the resilience maturity of the city or of the service [4] and allows to identify the main strengthens and weaknesses.

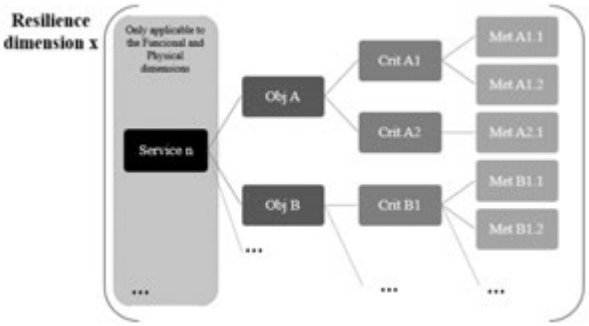

Figure 1. RAF structure (Cardoso and Brito, 2019)

This framework is complemented by the characterization of the city and the services context that frame the interpretation of the assessment results. The main characterization themes are geography, climate, population, economy and governance, built environment and infrastructure, type of customers, components and dimension of services and infrastructures.

II. RESCCUE RAF APP DESCRIPTION

A. *Concept and general description – integrating complexity into simple metrics*

Given its size and complexity, cities can benefit with the use of technology to gather detailed information to support coping with CC. To gather and process this information a web application was developed. RESCCUE RAF App relies on a web framework to facilitate the usage of the RAF methodology in a dynamic and easy-friendly way and able to producing instant results.

Developing a tool to provide such potentialities requires the identification of the necessary requirements. A list of the main requirements and a short explanation for each one is presented below:

1. Simplicity: the application should be the materialization of all the complexity of the RAF structure in a user-friendly web interface without compromising the detail of RAF. The intuitive menus within the application allow that anybody can use the app efficiently.

2. Fast and fluid: the user experience in the app should be fluid and different components of RAF should be dynamically highlighted for quick user understanding. Using client-side web technologies the transitions in the app are fast and fluid.

3. Flexible: depending on user knowledge about resilience assessment, the application should be flexible so the information required and given in the app is adjusted to the user knowledge level. There are three distinct levels of detail of information required to user, corresponding to a relevance level: essential, complementary and comprehensive. The user can alternate between levels at any time according to his knowledge or experience.

4. Customizable: advanced/authorized users should have the possibility of customize components of the application according to their needs and objectives. As administration interface was developed, so authorized users can easily tailor any of the components of the RAF structure to his needs.

5. Instant results: the application should provide instant results after data input from the user. The app uses resources from *Infraestrutura Nacional de Computação Distribuída* (INCD) as computation and storage.

6. Accessible: the access to the application should be made from anywhere using a large range of devices. Relying on a web framework, the app usage does not require any local installation on the user device. The only requirement is a web browser (*Google Chrome* or *Mozilla Firefox*) and an internet connection.

7. Confidentiality: all the data should be confidential; each user needs to be assured that his information in the app cannot be accessed by other users unless he wants to. The app access is made by user authentication ensuring the confidentiality of the data inserted.

The RESCCUE RAF App is integrated as an on-demand online service of the Portuguese Infrastructures Roadmap, under the *Infraestrutura Nacional de Computação Distribuída* (INCD) project. INCD provides the resources for the apps' data computation and storage, and assures its scalability to handle multiple, simultaneous user requests as well as database storage growth.

B. The overall architecture and components

The RESCCUE RAF App can be accessed at http://resccue.lnec.pt/ upon registration. This app has a typical Django web app architecture, containing the Frontend where the user interaction components are and the Backend containing the web framework itself and the application database (Fig. 2).

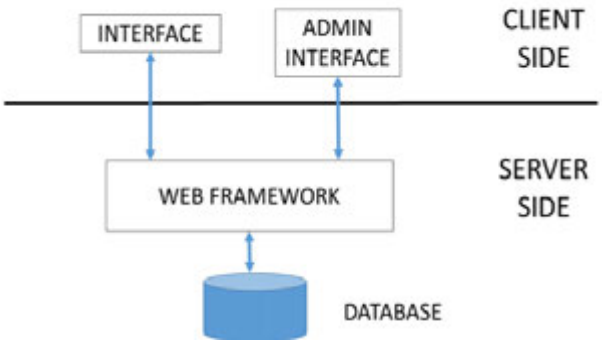

Figure 2. RESCCUE RAF App architecture

- Interface: The application main interface materializes several menus that present to the user RAF structure in a dynamic way. After authentication, the user can manage his previously created studies, insert new information or check results.

Each study takes the user through several categories of information required include among others the historic records of climate-related events and a description of city services and infrastructures. This information is processed on-the-fly and several indicators of the RAF are calculated, organized along resilience dimensions, objectives, criteria and metrics.

After the results generation, these can be explored by the user on the results section of the RESCCUE RAF App. The analysis can be made at different levels, ranging from an overall metric analysis (Fig. 3) to a more detailed analysis of a specific city criteria.

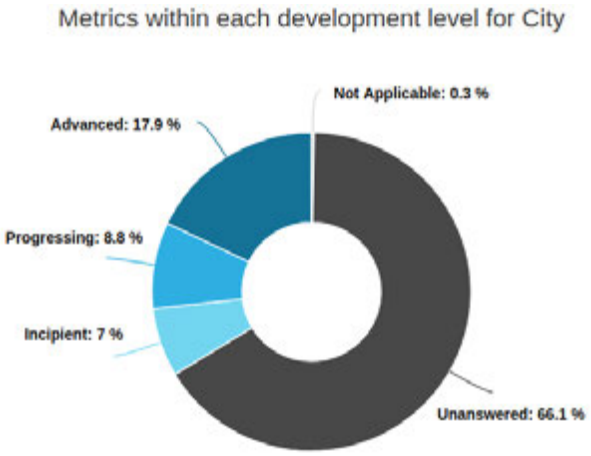

Figure 3. Donut chart with metric overall statistics

- Administration interface: interface where authorized users can customize the application.

There are three major user profiles in this application:

1. IT administrator: admin user with deep understanding of the deployment of the application and all its inherent

processes. Manages users, authentications, uptime of the application.

2. Staff user: users with deep understanding of the RAF and brief knowledge of how the application works. Can customize the RAF structure and the way that app uses to calculate the assessment level in each metric using administration interface.

3. User: only has access to the "main" interface of the app, can create new studies, fill metric with information regarding his studies and check results.

In the admin interface, staff users can customize all RAF components from dimension drilling down until metric. In Fig. 4, one of the menu to assign each service to respective dimension is shown.

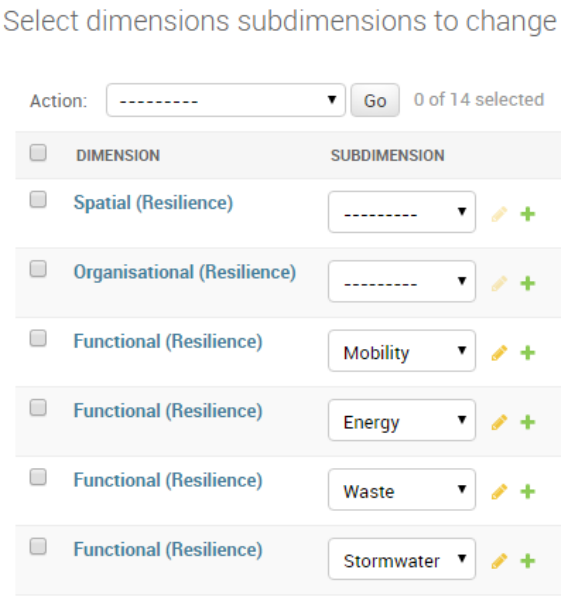

Figure 4. Administration menu of RAF dimensions and services management

Besides RAF structure customization, the methodology of calculation of the assessment to each metric can also be customized.

This customization capacity makes the RESCCUE RAF App, a tool that can be finely adapted to each city type, being it a coastal city with emphasis in water or a high dense populated city where waste management can be an important service to assess.

- Web framework: this component provides access to the application, through web pages hosting the major configurations. The Django Web Framework is used as the development framework of this component taking part of its properties for to a correct behavior of the application.

- Database: The storage component keeps the state of all information in the app. It is accessed by the Web framework to process all the requests made by interface.

III. DEALING WITH THE COASTAL DIMENSION AND FLOODING ISSUES

The city of Lisbon is located at the northern margin of the Tagus estuary, one of the largest estuaries in Europe, being therefore subject to inundation associated with its water levels rising [7]. Water level variability in this estuary is mostly driven by tides and storm surges, the Tagus morphological characteristics promoting tidal amplification [7], [10] and the risk for flooding of its margins [15]. The combination of extreme tidal levels and storm surge conditions has led to several inundation episodes, some of them with very severe consequences. Examples include the February 15th 1941, with high human casualties and property damages [12] and more recently the flood event associated with the passage of the Xynthia storm by the Portuguese coast [8][9]. At a more local scale, the impact of urban drainage has led to severe inundation episodes both at the city of Lisbon [5] and adjacent areas [2].

As this city's results obtained using the app are confidential, we focus here on how the app is prepared to deal with a coastal city and what are the relevant metrics, rather than presenting the real results for the use of the app for Lisbon.

The RESCCUE app can be used by a coastal city's managers to evaluate the city resilience globally and regarding the flooding hazard, since some metrics are hazard-specific. If a city or service intends, the RAF may be used to assess different hazards. In this case, a different RAF study needs to be created for each hazard. For instance, to assess flooding, heat waves, drought and combined sewer overflows, four different studies need to be considered, although they will only differ in the answers related to the CC scenarios metrics. It is possible then to compare and assess the resilience constraints associated to each hazard.

Additionally, for each hazard, the city may have different risk sources/variables associated. For example, flooding might be caused by rainfall or by sea level rise. When answering to the scenarios' metrics for flooding, if there are differences regarding the impacts or consequences that depend on the type of variable, then the answer should be done for the hazard/risk source that causes the most aggravated answer for the metric, and the variable should be specified as a comment to the result.

IV. CONCLUSIONS

Climate change adaptation in cities is a complex endeavor for the multitude of city profiles, adaptation status and services available. Information technologies, in particular based on web tools, can play a leading role in supporting city adaptation and promote a fast adoption of the most relevant options that enhance resilience. RESCCUE RAF App can be a massive step towards into city evolution to cope with CC. Through the

administrator profile, a tailored evaluation system can be built making the app suitable to any urban area. The app is anchored on a structured resilience assessment methodology that helps cities and services to identify the most critical aspects to be improved, supporting a resilience diagnosis and identification of areas for improvement, contributing to a resilient and sustainable urban development. This methodology and its Web implementation can support resilience planning, having a major impact on city managing decisions, and may facilitate communication among different stakeholders, essential requirements to build resilience in a city.

ACKNOWLEDGMENT

RESCCUE has received funding from European Commission by means of Horizon 2020, the EU Framework Programme for Research and Innovation, under Grant Agreement no. 700174. It has also been supported by the Lisboa2020 Operational Program through the INCD project (LISBOA-01-0145-FEDER-022153). This work made use of results produced with the support of the Portuguese National Grid Initiative; more information in https://wiki.ncg.ingrid.pt.

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