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**Abstract.** Nature-Based Solutions (NBS) are innovative, eco-friendly actions aiming to protect, manage and restore natural or modified ecosystems. Urban areas with NBS provide a healthier environment, which can have positive outcomes for health of the citizens, while positively affects their well-being and Public Health. The aim of this paper is to present the specifications and the design of an artificial intelligence (AI) enabled platform for monitoring the citizens' well-being and public health in areas with NBS. The euPOLIS platform's architecture is designed to measure physical activity and collect health related, as well as, environmental data, from multiple data sources to examine the impact of the NBS in the citizens well-being and Public Health. Data analysis and visualization will be conducted using appropriate services and visualization toolboxes. Future work includes the platform development and evaluation coupled with the analysis of the collected data, using specific criteria to assess the improvement of citizens' well-being.

**Keywords:** eHealth · eCare · Natural Based Solutions (NBS) · Mobile systems · Well-being · Pervasive computing

## 1 Introduction

### 1.1 Nature-Based Solutions (NBS)

According to International Union for Conservation of Nature (IUCN), Nature-Based Solutions (NBS) are innovative, eco-friendly solutions which include actions to protect, manage and restore natural or modified ecosystems [1]. The aim of NBS is to address societal challenges effectively and adaptively, while providing human well-being and biodiversity benefits [1]. NBS can offer a sustainable environmental management using solutions with the aim of “bringing nature into cities” by applying interventions for more

“green” spaces in urban environment, to decrease the ambient temperature and to reduce pollution [2]. Urban areas with NBS could create a healthy environment which can have positive outcomes for mental and physical health of the citizens, while positively affects their well-being and public health [2]. NBS can also be applied for restoring and protecting forests, seas, and coastal areas.

Since 2016, the European Union recognizes the benefits of NBS application in urban environment and a lot of large-scale demonstration projects have taken place in this field [3]. At the same time, the European Union is investing in NBS to achieve economic targets of job creation, growth, and low-carbon technology innovations while protecting the environment [4]. In addition, several NBS have been tested and implemented across the world, to face environmental, health and socioeconomic challenges [1, 2].

## 1.2 NBS Value and Contribution to Climate Management and Health

Multiple studies acknowledge the contribution of NBS to climate change mitigation and to climate crisis management. Specifically, research indicates that the application of NBS can not only create environmental benefits but also have multiple benefits for society against climate change [5]. In addition, NBS seem to decrease the vulnerability of the urban environment and enhance the resilience of cities against climatic change [6]. Scientists advise to include NBS in climate policy and urban planning for affective climate control [7].

In addition to NBS’ contribution to climate control, the effect of NBS is also significant on public health, as living in areas with NBS appears to be related to the reduction of cardiovascular diseases prevalence and mortality [8]. Studies also present the benefits of NBS interventions on citizen’s well-being. Inhabitants seems to be more active in areas with NBS as they increase their daily physical activity visiting “green” sites.

## 1.3 Information Systems, Public Health and Well-Being

Research outcomes indicate that eHealth services, provided by health information systems and mobile health (mHealth) applications, have a positive impact on the improvement of public health [9, 10]. eHealth solutions appear to be valuable to patients with cardiovascular diseases, providing remote care with very promising results [12]. In addition, eHealth and mHealth can be used for monitoring people’s well-being [11–13]. eHealth looks to play a significant role in the well-being of patients with mental diseases as it can provide solutions to support the patients’ needs in a non-clinical environment [14–16].

Currently, there are several health information platforms, eHealth solutions and mHealth applications offer remote monitoring of physical activity, based on data which are recorded by wearable devices [17–22]. In addition, mHealth applications can be used to promote physical activity; people are motivated to increase their activity by setting a schedule to workout, reminders to exercise and specific individual goals [23–25].

The aim of this paper is to present the specifications and the design of a holistic platform for monitoring the citizens’ well-being and public health in areas with nature-based solutions in the context of the euPOLIS EU research project.

The rest of the paper is organized as follows: Section 2, “The euPOLIS Project”, briefly presents the scope of the project and the implementation areas. Section 3, “The euPOLIS Platform”, outlines the specifications and the design of the suggested platform. Continuously, Sect. 4, “Discussion”, presents the intentional usage of the platform, its value, and its contribution to this field of study. Finally, Sect. 5, “Conclusions”, presents a discussion on the proposed platform and future work in the current field.

## 2 The euPOLIS Project

The euPOLIS (Integrated NBS-based Urban Planning Methodology for Enhancing the Health and Well-being of Citizens: the euPOLIS Approach) project [26] aims to regenerate and rehabilitate urban ecosystems, by creating inclusive and accessible urban spaces, focusing on investigating the impact over citizens well-being.

euPOLIS’ scientific and implementation paradigm is based on the Blue Green Solution (BGS) methodology [27] of systemic urban development for sustainability, climate resilience and cost efficiency. The project will address key challenges such as low environmental quality and low biodiversity in public spaces, water-stressed resources, and undervalued use of space. Adopted solutions will be tested in four Front Runner (FR) cities: Belgrade (Serbia), Lodz (Poland), Piraeus (Greece) and Gladsaxe (Denmark). Towards that direction, the project will deploy natural systems to enhance public health and well-being and create resilient urban ecosystems.

One of the main objectives is the implementation of a new urban planning methodology, based on BGS and NBS, enriched with cultural, geographic, and societal aspects of each demo-site. FR cities have different size and climatic characteristics and are situated in different countries in northern and southern Europe. Deployed NBS and monitoring schemes need to adapt appropriately.

Thus, multiple benefits attributed to NBS implementation are expected. Yet, deployment in open public spaces, for enhancing human health and well-being, has many aspects that need consideration, including the type of intervention, appropriate adjustments to the local needs, and monitoring the impact. Additionally, analysis of local micro-climate and environmental conditions will help to identify needs for supportive/complementary measures to be taken in the euPOLIS project.

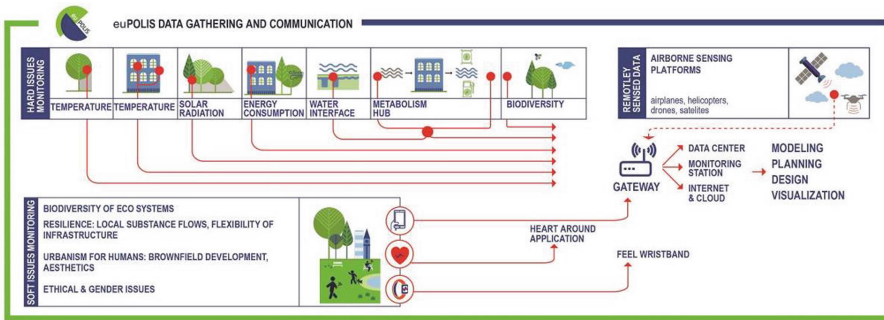
To assess the impact of BGS and NBS interventions on citizens’ well-being and public health, the euPOLIS platform will be utilized based on the user needs as these recorded in the requirements analysis phase of the project.

## 3 The euPOLIS Platform

The euPOLIS platform’s architecture is designed in a way to fulfill the user requirements, as well as to adapt to the ongoing rapid ICT technological progress in the field of personal health and well-being. A dynamic architectural design [28] can support such changes. Specifically, the middleware services are based on the Coodexx platform [29], which enclose a generic database application that can reduce considerably the cost of implementation and maintenance.

The specifications of the proposed platform for monitoring citizens’ well-being in areas where NBS are applied include the collection of citizen’s physical activity and health related data, and environmental data. The euPOLIS platform will be able to collect recorder data from different data sources and other information systems dedicated to specific types of data (see Fig. 1). Figure 1 also illustrates the euPOLIS platform various data sources such as (a) wearable device and mobile software, (b) installed (or going to be installed) cities’ sensors, and (c) any available (or going to be) participatory tools.

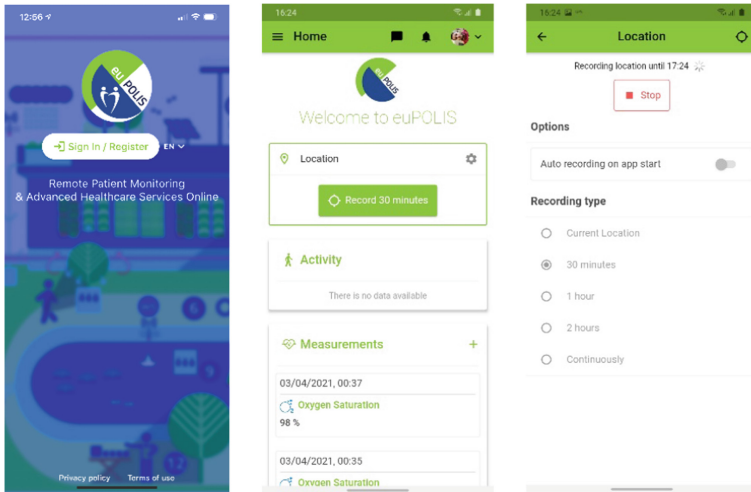
Regarding the collection of citizen’s activity data, an integrated to the euPOLIS platform mHealth application will be used to track the users’ location, to record the date and the time of the visits in the areas, as well as to collect specific user data, such as physical activity (number of steps, daily exercise, walking/running etc.), heartrate, SpO<sub>2</sub>, sleep quality, stress levels and other health related information. Regarding environmental parameters, the euPOLIS platform will be also integrated with environmental surveillance systems to receive data from the demo sites such as, temperature, humidity, wind speed and direction, solar radiation, atmospheric pressure, evaporation, water quality, and air quality.



**Fig. 1.** euPOLIS data gathering, communication and implementations

To collect citizen’s data, the “euPOLIS by BioAssist” [30] mHealth application will be used in combination with a smartphone and a wearable device, such as smartwatch or smartband (see Fig. 2). The aforementioned mobile application is a cross-platform release (available for Android and iOS), and it is compatible with several smart devices and wearables. The users’ physical activity and health data are recorded by the wearable devices and the users’ location is recorded by the mobile application running on the smartphone using the phone’s integrated GPS module. Users can complete health related questionnaires through the mobile application. Both users’ data and their location are transferred to the platform where data analysis takes place to merge and combine the data from the different sources.

To collect the required environmental data, advanced information systems with sensor networks will be installed to gather data from the surrounding environment. The aggregated data from the various integrated sources will be further analyzed to examine the impact of the NBS on the citizens’ well-being and public health.



**Fig. 2.** “euPOLIS by BioAssist” mobile application screenshots

For data analysis and visualization, middleware services will be developed along with an additional visualization toolbox. Specifically, a Data Management System (DMS) will host all related data flows from the different sources. The DMS should support various analytics, accept data from additional sources, and communicate with 3rd party implementations, like simulation or other toolkits. Finally, a visualization toolbox will be used to provide a dynamic interface adjustable to the users’ needs and capable of illustrating various information, stored in the DMS or other integrated information systems, including 3D models, advanced analytics, figures, and timeseries data.

## 4 Discussion

For the design of the euPOLIS platform, a multimodal approach is adopted, capable of providing a vast resource of related data values, spanning multiple categories. Gathered values are paired with location data, facilitating the evaluation of the appropriateness for applied NBS. According to the aforementioned description of the platform, data could be of human nature (e.g., heartrate), environmental conditions (e.g., temperatures), 3D models (e.g., trees), water quality metrics, or any other type capable to facilitate the assessment of implemented NBS. The flexibility of the proposed platform is that individual information systems with sensors can be operated using their software, providing values at any granularity level. The only limitation, on which the euPOLIS project emphasizes, is the capability to access the necessary values using open-source tools.

The mobile app developed in the frame of euPOLIS will be used in combination with wearable devices to support the assessment of the effectiveness and to validate the impact of NBS on public health and the well-being of the citizens. The euPOLIS platform will integrate various data sources, including (a) wearable devices and mobile software, (b) environmental sensors installed in the cities, and (c) available participatory tools, as well as, middleware services and visualization toolkits. The mobile app has been designed

to offer an attractive, multilingual, easy-to-use front-end interface, considering usability and accessibility guidelines, to promote inclusivity and user acceptance. According to the international scientific literature, health information systems have been used before to collect data and to assess the well-being of people and public health [10, 13]. The expected value of the proposed platform is to establish an integrated solution to support decision making based on true world data with minimum user engagement, addressed to urban planners, civil engineers, healthcare and other professionals.

## 5 Conclusions

Urban planners and engineers are integrating nature-based solutions (NBS) to address contemporary environmental, social, and economic challenges. In the context of the EU-funded EuPOLIS project the proposed ecosystem will be developed to examine the deployment of natural systems in the enhancement of public health and well-being and creation of resilient urban ecosystems. The euPOLIS platform stands on the notion of a unified solution, capable to parse, gather, merge, and analyze data from multiple sources, helping city authorities to assess the effectiveness and appropriateness of adopted NBS solutions with regard to bolstering citizens' well-being and public health.

Citizens, city authorities, policy makers, psychologists, sociologists, and communication experts will be engaged in the development of the euPOLIS platform to ensure it is practical and user-friendly, while respecting all relevant privacy issues. The "euPOLIS by BioAssist" application can be used as a health and other data collection tool. The euPOLIS project will aim to regenerate and rehabilitate urban ecosystems to create inclusive and accessible urban spaces. It will address key challenges, such as low environmental quality and low biodiversity in public spaces, water-stressed resources, and undervalued use of space. Future work includes the platform development and evaluation as well as, the analysis of the collected data using specific criteria to assess the improvement of citizens' well-being and public health.

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