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CASE STUDIES

Rehabilitation of Soil through Botanical Gardens as a Practical Interplay Between Learning Spaces and Healthy Places in Urban Environments

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Soils are the primary carriers of heavy metals released into the environment by many different anthropogenic activities. Unlike organic pollutants, which are oxidized, most metals do not undergo microbial or chemical degradation, and their concentration in the soil continues for a long time. Increasing social awareness of the need to adequately address mineral waste to protect the environment has led to increased research in this area. Contemporary trends and the development of technology have revealed numerous methods of cleaning these degraded lands and what would best serve such an area. Based on centuries of historical development, botanic gardens have developed globally leading conservation, research, education, and recreation institutions. Botanic gardens increasingly provide a scientific basis for sustainable use and protection of plant diversity. This research aims to analyze the methods of treatment of these areas, then give a proposal which, in addition to solving a severe problem of this municipality, will become a research and study area for students of various fields related to botany. The investigation line is constructed on: analysis, field research, literature review, data provided by the municipality of Graçanica, interviews, and online surveys. Through this research, we will understand user expectations, spatial preferences, and the intended purpose of the Kosovo Botanical Garden and will convey them through the proposal into a functional concept and present new solutions, modern and practical, in this facility.

Keywords: Healthy places; Educational spaces; Botanical gardens; Healthy design

Introduction

Botanical gardens are a particular category of gardens, distinctive for their scientific grounds, which play an essential role in gathering people and assemblage plants, ensuring inspiring plantings for humans, and assuring plant conservation. These gardens also play a crucial role in meeting human needs and providing welfare. Unfortunately, plant diversity is currently being lost at an unprecedented rate and causing a decline in ecosystem services. The purpose of this study is to create an area where scholars, students, or even citizens, in addition to research and study, will have a place away from the hectic city life with a variety of plants and fresh air. In addition to solving a significant problem for the citizens of the Gracanica municipality, the Jalovina landfill of mineral waste with the endangered soil and constant threat of urban and rural environmental degradation.

The Municipality of Gracanica is located in the central part of Kosovo (**Figure 1**), respectively, in the south of Kosovo capital, Prishtina. The municipality has a rural character with high-quality agricultural land (UN-Habitat Kosovo 2014). The administrative center of the municipality is Gracanica town. The residence area is near the river Gracanka, supplier of the river Sitnica, within the large valley of Lake Gracanica and the industrial waste landfill of Kishnica – Novobrdo, with lead and zinc mining facilities. The territory of the municipality covers an area of 122.25 km. With its convenient location, close to the capital Prishtina, it offers excellent opportunities for the development of Gracanica in commercial and residential trade of prosperous, multi-cultural settlement (UN-Habitat Kosovo 2014).

According to the Kosovo Spatial Plan, the Municipality of Gracanica location is in the designated blue zone of economic development (**Figure 2**). The blue-colored area indicates areas with a population density characteristic of the urban centers, with developed rural areas, high-quality agricultural land, underground natural resources (lignite, nickel, lead, zinc, gold), important archaeological and cultural places, accessible green spaces. At the same time, industry, trade, and services characterize economic activities (Ministry of Environment and Spatial Planning 2010).

General goals of the blue zone are the development of the city network, accessible and attractive access to live and work; Local Economic Development for the support

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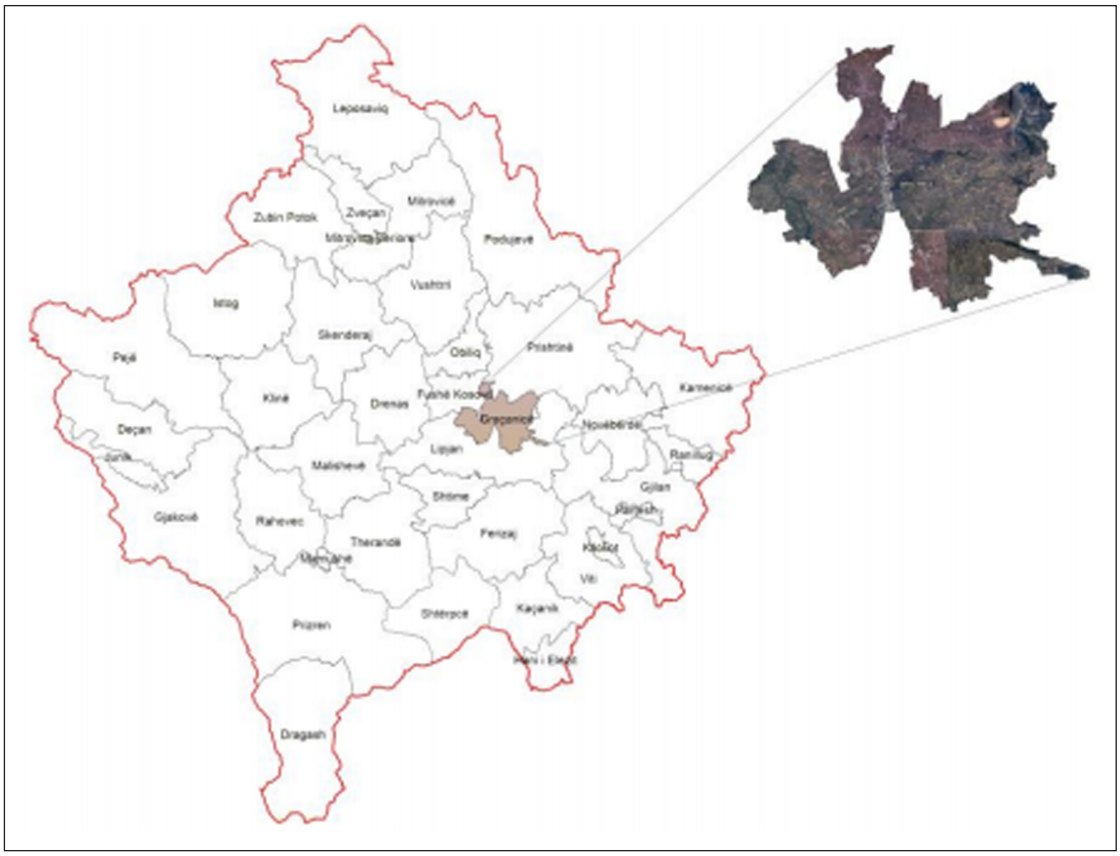

Figure 1: Geographical position of Gracanica.

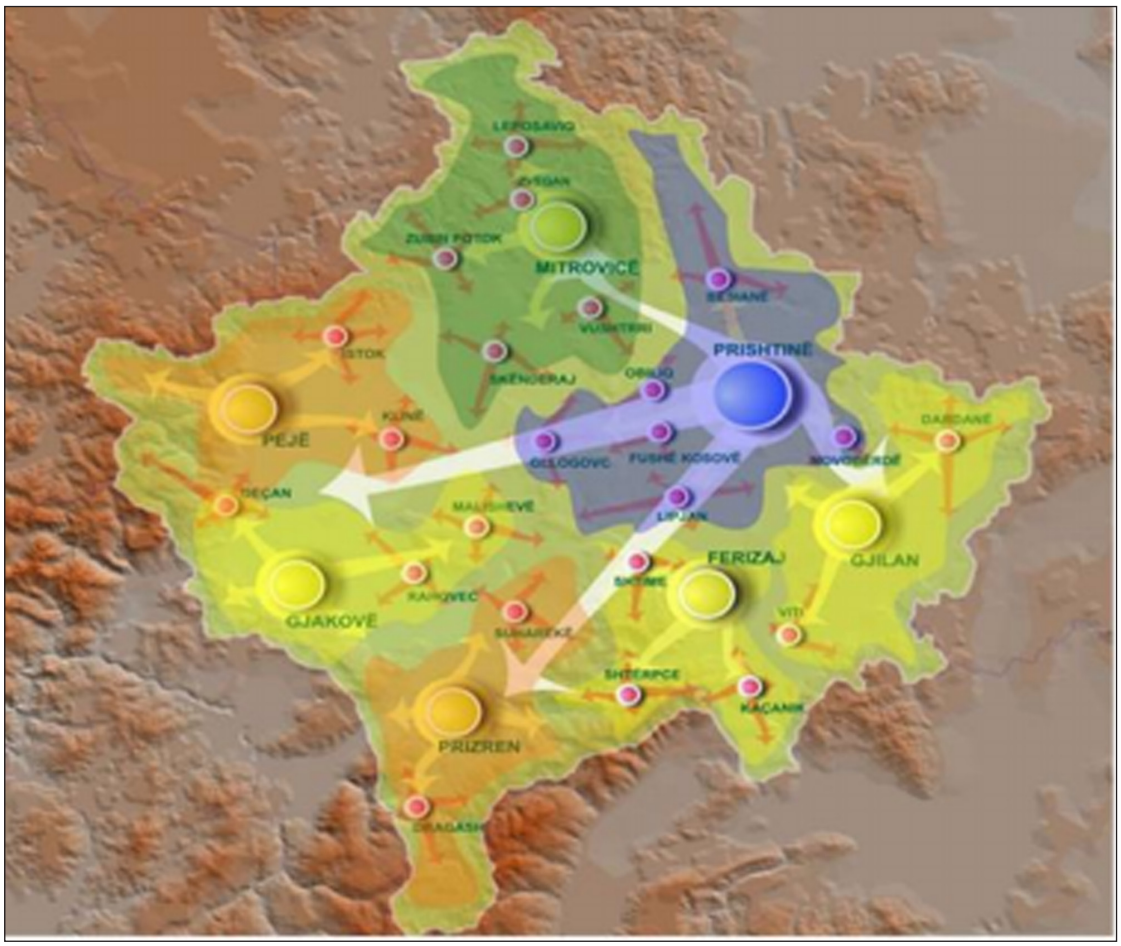

Figure 2: Kosovo Spatial Strategic Development – Blue zone (MESP 2010).

of Kosovo Economic Development; promotion of Triangle of Kosovo Economic Development locations for grouping activities from the spatial aspect, foreign investments, and multinational companies.

According to Kosovo Spatial Development Plan, areas of particular interest should be offered an established development regime. Furthermore, besides other capital investments at the central level, the environmentally polluted areas need to be rehabilitated and used for other purposes, such as industrial waste landfills in Kishnica (Ministry of Environment and Spatial Planning, 2010).

'Jalovina' – landfill of mineral waste of Kishnica

Kishnica mineral waste represents an ecological catastrophe in the municipality and region and the constant environmental degradation threat. Pollution of water, air, and surrounding soil poses a threat to the environment. Since 1965, pollution has caused a risk to watercourses with waste erosion mining, as well as to air through winds that disperse waste dust mining, but also agricultural land in the vicinity where the dumped dust is collected. A report of the international commission on major dams and the United Nations Environment Program has recorded two accidents on the territory of the former Yugoslavia. And one of them is the disorder on the slope of the mine waste in Kishnica (**Figure 3**). The accident occurred in September 1988, when a volume of 10,000 m3 of water spilled above the mining waste dam. Polluted water has flooded the fields and about ten houses. Over-discharge has come from prolonged negligence during waste mining exploitation, while the accident has largely been politicized (UN-Habitat Kosovo 2014). The 'Jalovina' problem dates back to 1965 and is considered the biggest polluter of the environment, not only in these municipalities but much more widely. Materials waste of the Kishnica mine, which has been stored in one place for more than 50 years, are also to pollute the Gracanka River, which flows immediately near Jalovina, the extended heavy rainfall that collects the heavy metals, reaches up to the basin of Black Sea as well. Given the minerals of the Kishnica mine, it is understood that this area contains a considerable amount of arsenic, which in addition to being quite harmful to the ecosystem, is also carcinogenic and very dangerous for human health.

Raising social awareness of the need to treat waste mining to adequately protect the environment has led to increased research studies on this field. Mining activities lead to many negative environmental and socio-economic impacts. Methods such as removing tons of contaminated soil involve years of work and large sums of money. Contemporary trends and the development of technology have revealed numerous ways of clearing this kind of degraded land. According to multiple studies, what would best serve such areas are plants and vegetation. Certain plants have a unique ability to absorb specific chemicals, making them poisonous but 'non-consuming'. Plants in contaminated soil absorb contaminants into their tissues, gradually reducing the amount in the ground until it is safe for humans.

The purpose of this research is to analyze the means of treatment of the Jalovina area by delivering a proposal that will transform into a research and study center for students and scholars of various fields, especially related to botany. After restoring polluted soil, which was once

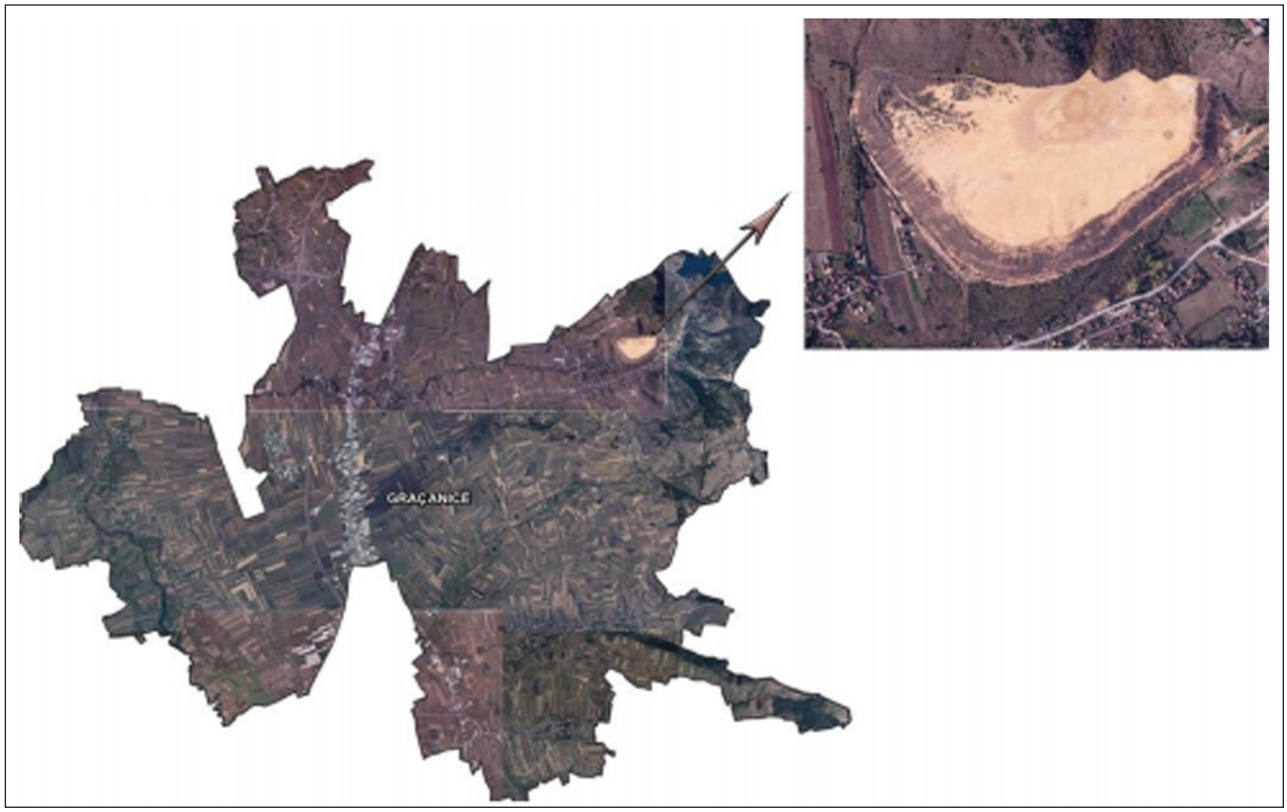

Figure 3: Landfill waste mining in Gracanica.

among the most fertile, it transforms into a botanical garden.

Botanical gardens maintain documented collections of living plants and are usually run by universities or other research organizations. Therefore, the proximity of Gracanica to the capital city would suit the University of Prishtina, as the most prominent public university of Kosovo, for scientific research, conservation, and education. On the other hand, botanical gardens increasingly provide one scientific basis towards sustainable use and preservation of plant diversity. The presence of these spaces that contribute to the well-being of people will help botany scholars a lot in their research and create job opportunities for a large number of them. In addition to research, citizens will have a place that; would provide instructions for home gardening for plant propagation; will be the source of plant supply through sale or exchange, and serve as a getaway from the busy city and stress.

Methodology

The methodology is built on grounded theory as a mixed-methods strategy starting from the quantitative data collected from the understandings of a large number of surveyors. The study later undertakes a more in-depth investigation done qualitatively. The qualitative phase of the mixed inquiry is the principal, while the quantitative method helps identify the areas of concern. The qualitative study involves gathering numerous data and a considerable amount of time spent on the site while attaining information. The instruments for data collection are observation, interview, textual documents, and visual data. The benefit of grounded theory is that it can analyze any data. So the purpose of using the mixed method inquiry is to get a practical, useable, and broad diversity of data to create a concrete cohesive theory of a complete actuality (Basha-Jakupi, Nushi 2017).

Data collection and analysis of the current situation derived from:

1. Municipality of Gracanica – Directorate of Urbanism: offered information about Urban and Municipal Development Plan, geodetic data for the area, other information about this area, such as plot ownership, land use conditions, the buildings stories, the destination of facilities, maintenance of open public spaces, etc.
2. Field analysis: site analysis, space use, activity development analysis, vehicles' and pedestrian movements. Identification of pedestrian and automobile accesses. The most frequented and congested areas, as well as identification of problems with parking, noise, lack of space for activities.
3. Interviews: citizens' opinion of the problems, the daily dissatisfaction with the use of spaces around this area, and their needs and propositions.
4. Survey: electronically distributed questionnaire to the students about their opinions, requests, and needs that they generally have for the premises in the university. The subject of this inquiry was also the Faculty of Biology, Faculty of Agriculture, and Veterinary Medicine students to extract data from their experiences about the importance of the botanical garden.

Following this stance, the primary research hypothesis would be:

> The Botanical Garden will regenerate the soil, create opportunities for various studies in botany, and provide recreational spaces for all.

Applied Principles in The Project

The conception and design of a botanical garden is a unique and rewarding experience, with ecological, cultural, educational, and economic aspects that can last for generations. Therefore, the complexity of the research proposes applying some of the main principles of sustainable design which address issues of the Jalovina area, and test design aspects that matter to planning/building a botanical garden. The main approaches are:

– Treatment of contaminated soils

Metal contaminants are long-lived and toxic to organisms in all parts of an ecosystem, including people. Heavy metals like lead, mercury, arsenic, copper, zinc, and cadmium are poisonous when entering the biological system.

Technologies to correct contaminated soils as physic-chemical remediation techniques usually result in secondary air or groundwater pollution, reduce soil fertility, and make them unsuitable for agriculture. Moreover, the physic-chemicals method is generally very high in cost, limiting their use, especially in developing countries (Muthusaravanan et al. 2018). At the same time, bio rehabilitation has gained attention in recent decades as a growing eco-friendly approach that uses the natural abilities of living organisms to improve polluted soils. Bio rehabilitation among different techniques includes phyto-rehabilitation as a plant-based technology, where raw plant species or genetically modified are used to restore contaminated soil and water resources. The main reason for implementing phyto-rehabilitation are: the possibility of low-cost adjustment; the advantages that are practically possible and publicly accepted; directed by the sun; works with hydrophobic compounds; planting vegetation in one place also reduces wind and water erosion; generates metal-rich recyclable plant waste; eliminate secondary air or water debris (Muthusaravanan et al. 2018). However, given some of its limitations and the level of pollution, such a method would only work on certain parts of the plot. Phyto-rehabilitation could be used where the level of pollution is lowest (more superficial; where plants could clean), while bio-rehabilitation with microorganisms could be used in the rest of the area.

The main elements in bio rehabilitation are microscopic organisms, living bacteria. Microorganisms are ideally suited for the destruction of pollutants because they possess enzymes that allow them to use environmental pollutants as food and are so small that they can reach pollutants quickly. This process aims to stimulate the

microorganisms with the substance nutrients and other chemicals that will allow them to destroy contaminants (National Research Council 1993).

– The flexibility of the design

Flexibility design can tolerate a building to change over time as users need modification. The flexibility of a structure or its design elements displays efficiency despite changes in work requirements. Flexibility depends on the amount of change that occurs and the degree of sustainability of that change. Flexibility is: a) convenience of a building to support multiple functions without changing the architecture itself, it is when the part of the building changes, but the structure does not; b) transformation, which allows the interior or exterior space to change in response to certain stimuli without new constructions. Changes can be permanent or temporary, and c) convertibility by changing the function of a building through a certain amount of construction work. Planning the conversion during the design phase can assess potential future needs, and the time and cost required can be reduced. The resulting changes are often permanent (Sadafi et al., 2014).

– Green walls

As a vertical typology of greenery, where a vertical built structure is intentionally covered by vegetation, it is considered living walls or vertical gardens. It is associated with providing many ecosystem benefits (Medl et al. 2017). Green walls offer an additional layer of insulation that can protect buildings from dense rainwater, which leads to water management and provides a thermal mass. They also help lower the temperature of a building because the vegetation absorbs large amounts of solar radiation. Green walls can reduce energy requirements and clean the air of volatile organic compounds. In addition, vegetation in green walls can help mitigate the effect of heat islands and contribute to urban biodiversity (Gunawardena et al. 2017).

– Green roofs

Vegetative roofs, also known as green roofs, are thin layers of living vegetation installed on conventional flat or sloping roofs. These roofs have great potential for broad use as their sheer convenience makes it inquire for little or no support from the building itself (Miller 2016).

In addition to reducing energy consumption in the building, green roofs are significantly more durable than other roofs. Extensive green roofs have several benefits, such as: provide water flow from storms, erosion, and pollution improve water quality, heat reduction inside the city by cooling and purifying the air, reduce energy consumption, reduce the reflection and sound transmission, give impressions of untouched nature and affect the aesthetics of the home environment (Hashemi 2015).

– Solar panels

Renewable energy is generally defined as energy from natural sources used for heating and direct lighting of buildings, electricity generation, heating and cooling of water, and many other aspects. For example, renewable energy can be from Solar energy, which is for the production of electricity, as well as Geothermal energy, which is for the production of heat energy. Directly and instantly, solar energy converts into electricity without using any fuel (Shinn 2018).

Solar panels made up of multiple solar cells produce electricity from the power that resides in photons of sunlight.

– Collection and utilization of rainwater

Rainwater collection and utilization will preserve water in different structures or surfaces for later use. Traditionally, this involves collecting rain from a roof; instead, rainwater collects from gutters that channel water into the outlet and then into a storage reservoir (Torres 1997).

The earliest stages of the design need the anticipation of sustainable design. The sustainable building system of the botanical garden aims to minimize the environmental impact during the development of the new project. Consequently, creating a building compound that consumes little energy and thus makes it as efficient and ecofriendly as possible.

Conceptual Project Proposal

The concept of the design was outlined after site analysis. Initially, the local architecture was analyzed, more specifically, that of the campus of the University of Prishtina. Where indeed, the dominant effect is given by the iconic building inside the campus, that of the National Library (**Figure 4**), whose main characteristics are the game with volumes and domes, highlighting the expansion of the university premises. The pattern of the steel construction is inspired by the domes spherical shape of the conservatory, which derived from the need for a structure that is resistant to winds and storms, that enables good air circulation and ventilation, has a uniform temperature (ideal for plant growth) and enables maximum absorption of light and heat. Regarding the visitor center, the aim was to merge the architecture into the surrounding landscape by applying green architecture.

The broader situation

The compound was organized so that initially, the northwestern part (**Figure 5**) of the plot will have a garden that expands in proportion to the cleaning of the site from polluters. Knowing that the only drawback of the engineering bio rehabilitation method was the release of a considerable amount of carbon dioxide, this organized area of 7 hectares will clean the air with plants that absorb this CO2 for the process of photosynthesis and in this way will minimize the negative impact on the environment. The designed space allows easily reached access to the garden, and the shape of the garden derives from the shape of the plot. In the western, southern, and eastern parts where the terrain has a noticeable slope, it is intended to plant high deciduous plants to isolate it from the noise coming from the highway (**Figure 6**) and stop the erosion caused by rainfall. The same proportionally reduced space realized as the first intervention stage (**Figure 7**) will be planted with plants that create intimacy within the complex.

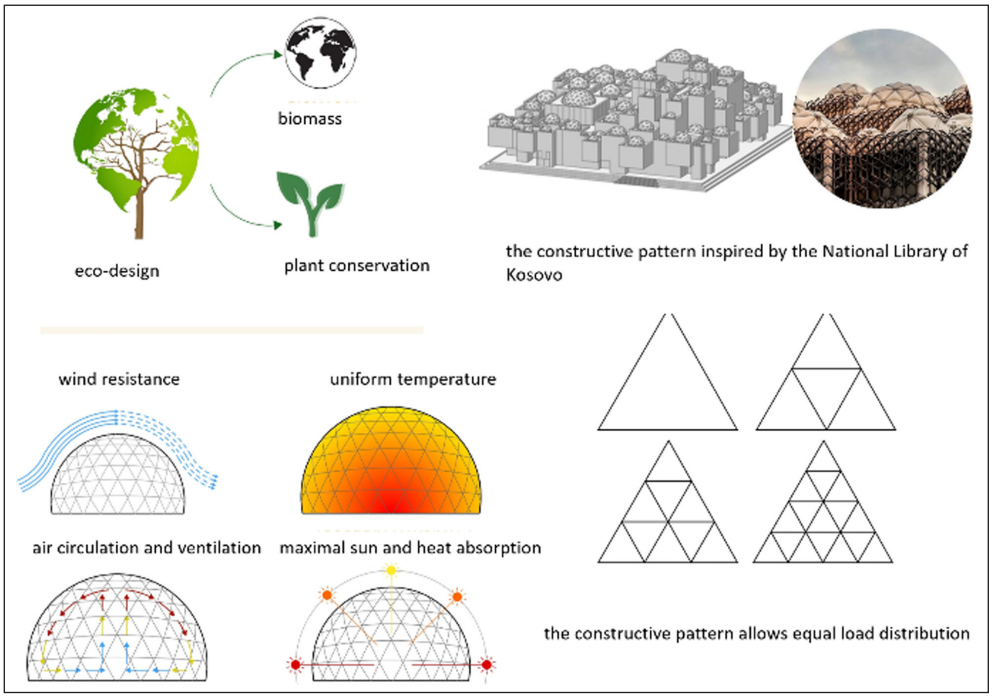

Figure 4: Architecture Pattern (author: D.Hajrizi).

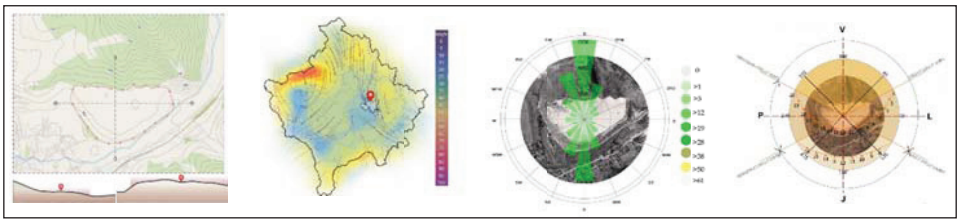

Figure 5: Analysis: a) terrain, b) and c) wind, d) sun exposure (author: D.Hajrizi).

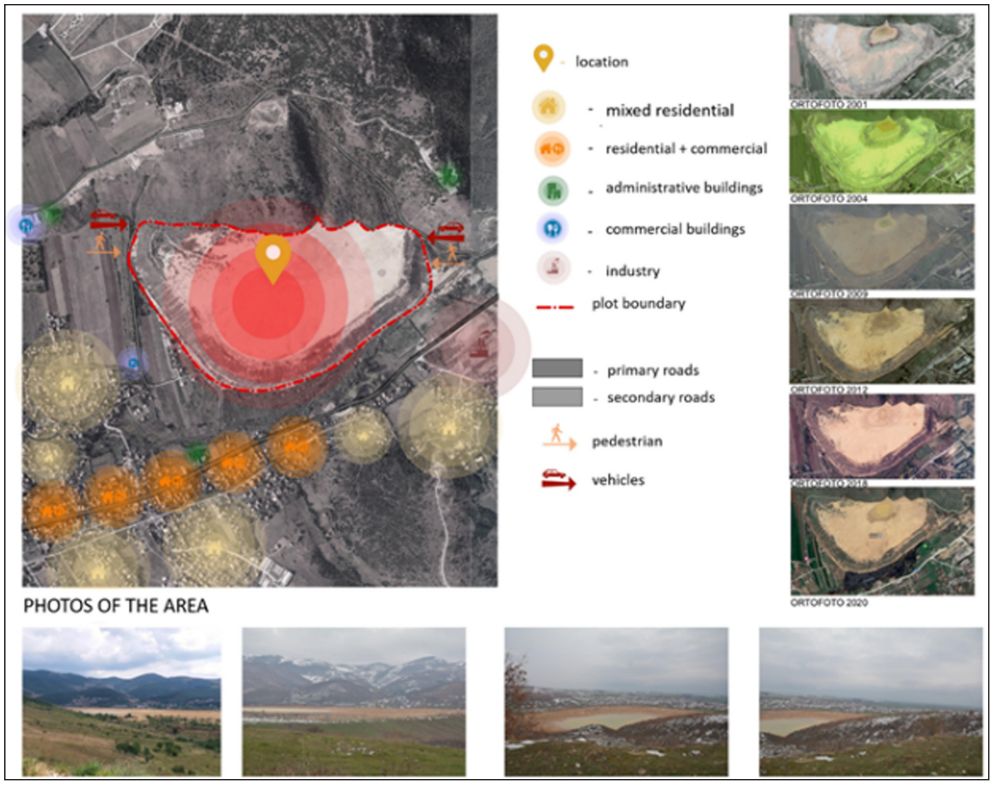

Figure 6: Wider situation of the area (author: D.Hajrizi).

Close-up situation

Shows the organization of the garden (**Figure 8**), characterized by organic forms both in buildings and on the ground floor. On the left side in the north-western part of the plot is the main entrance for visitors, with parking spaces in the buffer zone controlled by the entrance control gate. Also along the road are foreseen bus stops which bring students or visitors from different places. This compound aims to generate revenue and support itself financially, so various forms have been devised to attract visitors. The entrance is for bicycle parking and the bicycle corner for rent, as the surrounding complex has trails for cyclists and jogging. On the north side of the visitor center (building 1), which has open visors on all sides, is the kindergarten so that kids play and parents more easily monitor activity. Next is the garden of herbs and spices. At the bottom is the garden of nutritious plants. Both are placed in these positions due to the proximity to this facility (the restaurant utilizes garden-produced food). Near the herb garden is the so-called low green garden meadow (different types of grass). Furthermore, the Institute for Research and Study has access made by the same path extended to the north of the plot but on the opposite side as it should be more "private" with separate entrances. Between building 1 and 3 is the "maze garden," which are usually bush fences. The shape of this garden is inspired by the unique Dardanian labyrinth of the closed circuit, without visible entrance that in antiquity appears very rarely. It proves a higher philosophical-religious level of its Dardanian creators. Near this garden are the expanded shrub garden and a mini artificial lake representing the garden of aquatic plants.

Free training space is on the southeast and east side of building 3. Farmers and ranchers can use the area; students and researchers can learn more about agriculture; citizens get informed about home gardening.

A flower garden between buildings 2 (Plant Conservatory) and 3 is enclosed by a gallery (width and height of 5m) of hanging plants (mainly flowers). Below this garden is the orchard of fruits and trees sold in the shops at the visitor center.

The most beautiful part of the complex is an artificial "lake" with aquatic plants, circulating building 3 in front of the 'sensory garden.' All senses are activated when entering the 'sensory garden' using different colors, water, fragrant plants, plants that attract birds and butterflies, etc. Opposite building 1 is the plateau space for events (weddings, birthdays, or various holidays).

The fifth facade shows the level quotas, where the total height of the visitor center is 9.5m, while that of the conservatory is 30m. At the top of the visitor center, which is green and usable, there are also south-facing solar panels for maximum sunshine all the time.

Architecture – In terms of architecture (**Figure 9**), the aim was to make the most of sustainable design principles

Figure 7: Project proposal area (author: D.Hajrizi).

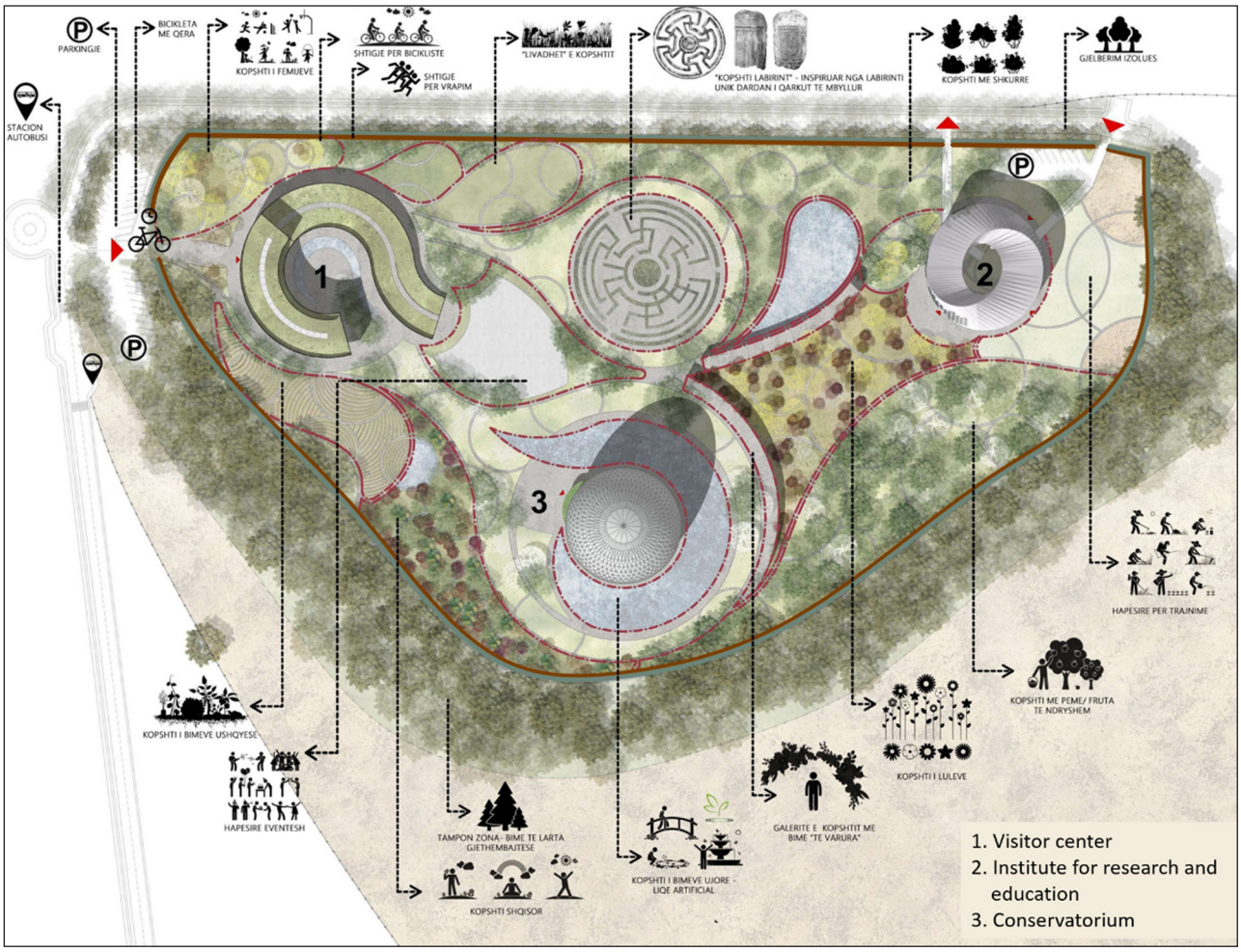

Figure 8: Project proposal (author: D.Hajrizi).

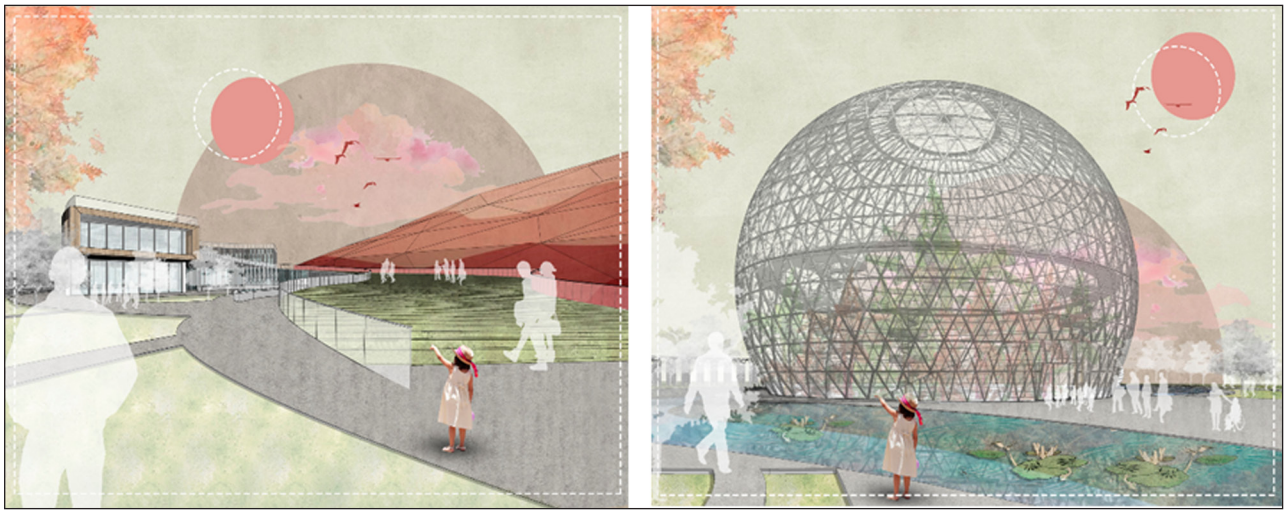

Figure 9: 3D views of the proposal (author: D.Hajrizi).

and minimize the harmful effects on human health and the urban/rural environment. Organic forms, the use of recyclable materials,

The use of solar panels, green walls are the means to an end for a higher level of energy efficiency and imitation of nature. At the visitor center, there are also wooden panels that, in addition to the decorative role, have the possibility of complete closure and play the role of a double thermal insulator. The combination of wood with glass in this building creates the feeling of warmth and closeness but at the same time pleasant transparency and visibility. As for the conservatory, the structural efficiency

of this facility means that it consumes less material than conventional buildings. As for the closed volume, this building has a much smaller surface area than traditional 'box-shaped' buildings, which means that this building has reduced exposure to external temperature changes, which is less costly to heating and cooling the building.

Conclusions and recommendations

Arsenic is a metalloid that causes harm to humans and the environment. However, certain species of prokaryotes can use arsenic (through the process of oxidation or reduction) for energy storage and growth purposes. Therefore, it is essential to remove and reduce this pollutant through various physical, chemical, and biological approaches. Using bio rehabilitation to remove and mobilize pollutants from contaminated soils and waters can be an effective and economical way as many microorganisms degrade these pollutants successfully from the environment.

Field research, and the literature review, revealed most of the study results. Altogether, the identification of the problem defined by the survey gave a lot of information on the issue discussed. At the stage of analysis of similar examples around the world, botanical gardens of different periods helped the compilation of the functional scheme of the complex. In the last stage, the proposal for the botanical garden was given, considering the new concept and the operating system while using impetus from the local architecture.

"Kosovo Botanical Garden" project foresees to improve the student's study conditions and the wellbeing of the citizens but foremost solving a severe problem such as that of the mining landfill of Kishnica.

The design and implementation of such a project will be a significant challenge. Unfortunately, the infrastructure in Kosovo does not offer great opportunities for the realization and functioning of these complexes. Still, it would be best to fund and oversee this project by EU investment or other foreign organizations.

Suggestions for further implications are more detailed research in the region, opportunities to use the latest technology, the inclusion of all stakeholders into a comprehensive discussion related to botany or botanical garden in general.

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Competing Interests

The authors have no competing interests to declare.

References

Basha-Jakupi, A and **Nushi, V.** 2017. International Aid Community, its Presence in the Post-Conflict Reconstruction and Impact on Urban Legacy–Case Study of Prishtina. *Sociologija i prostor: časopis za istraživanje prostornoga i sociokulturnog razvoja*, 55(3 (209)): 315–332.

Gunawardena, KR, Wells, MJ and **Kershaw, T.** 2017. Utilising green and blue space to mitigate urban heat island intensity. *Science of the Total Environment*, 584: 1040–1055. DOI: https://doi.org/10.1016/j.scitotenv.2017.01.158

Hashemi, SSG, Mahmud, HB and **Ashraf, MA.** 2015. Performance of green roofs with respect to water quality and reduction of energy consumption in tropics: A review. *Renewable and Sustainable Energy Reviews*, 52: 669–679. DOI: https://doi.org/10.1016/j.rser.2015.07.163

Medl, A, Stangl, R and **Florineth, F.** 2017. Vertical greening systems–A review on recent technologies and research advancement. *Building and Environment*, 125: 227–239. DOI: https://doi.org/10.1016/j.buildenv.2017.08.054

Miller, Ch. 2016. Extensive Vegetative Roofs. *Whole Building Design Guide*. https://www.wbdg.org/resources/extensive-vegetative-roofs.

Ministry of Environment and Spatial Planning. 2010. Kosovo Spatial Development Plan. http://www.kryeministri-ks.net/repository/docs/Plani_Hapesinor_i_Kosoves_2010-2020_shq.pdf.

Muthusaravanan, S, Sivarajasekar, N, Vivek, JS, Paramasivan, T, Naushad, M, Prakashmaran, J, ... and **Al-Duaij, OK.** 2018. Phytoremediation of heavy metals: mechanisms, methods and enhancements. *Environmental chemistry letters*, 16(4): 1339–1359. DOI: https://doi.org/10.1007/s10311-018-0762-3

National Research Council. 1993. In situ bioremediation: When does it work? National Academies Press.

Sadafi, N, Zain, MFM and **Jamil, M.** 2014. DESIGN CRITERIA FOR INCREASING BUILDING FLEXIBILITY: DYNAMICS AND PROSPECTS. *Environmental Engineering & Management Journal (EEMJ)*, 13(2). DOI: https://doi.org/10.30638/eemj.2014.045

Shinn, L. 2018. Renewable Energy: The Clean Facts. NRDC. https://www.nrdc.org/stories/renewable-energy-clean-facts.

Torres, E, Brito, L and **Marco, J.** 1997. Rainwater harvesting from rooftop catchments. *Source Book of Alternative Technologies for Freshwater Augmentation in Latin America and the Caribbean Unit of Sustainable Development and Environment General Secretariat*, 56.

UN Habitat Kosovo. 2014. Municipal Development Plan, http://unhabitat-kosovo.org/old/repository/docs/3._MDP_Final_eng_2045.pdf.

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