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Smart Cities in Postwar Karabakh

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Infrastructure plays an essential role in addressing societal needs and climate change policies. The methods and materials used during construction can have an impact (positive *and* negative) on both climate change mitigation and adaptation as well as in engineering a more inclusive society. There is a noticeable shift towards cleaner and sustainable infrastructure worldwide, as countries aim to move closer to fulfilling their net-zero emissions pledges. To achieve net-zero emissions by 2050, an estimated \$139 trillion investment in infrastructure will be needed worldwide.

The global infrastructure business has enormous growth potential. By 2050, around 75 percent of infrastructure across the globe will be

under construction. This growth is likely to be accompanied by a spike in the global green infrastructure market, which is predicted to reach €10 trillion by 2030.

The fact that infrastructure accounts for 79 percent of global greenhouse gas emissions highlights the importance of investing in green infrastructure worldwide.

Azerbaijan has identified specific goals and targets related to the fight against climate change and diversifying its energy mix to include 30 percent mix of green or renewable energy sources by 2030. The government has linked the country's future economic development to the non-hydrocarbon sector, which has grown in the past few years at a more rapid rate

as compared to the hydrocarbon one. Contributing to this higher-growth sector is the application of environmentally friendly technologies, clean energy, waste recycling, and measures to rehabilitate polluted lands.

One of Azerbaijan's priorities is the restoration of the environmentally- and physically-devastated territories liberated during and in the wake of the Second Karabakh War. The plan is to turn Karabakh into a net zero-emission zone by 2050. The government puts special emphasis on the establishment of sustainable and smart cities and villages, with one of the motivating factors being mitigating and adapting to climate change.

To accomplish its goals, Azerbaijan has launched a reforestation campaign in Karabakh and built the country's first smart village; other villages and entire cities are being reconstructed as we speak. Moreover, to fulfill its voluntary commitment to reduce greenhouse gas emissions by 40 percent by 2050 (and already by 35 percent by 2030), Azerbaijan has been massively investing in increasing its wind and solar capacity in liberated Karabakh.

To that end, the Ministry of Energy has signed an agreement

with BP on the final investment stage of "Project Shafag," a 240-MW capacity solar power plant in the Jabrayil district of the liberated East Zangezur region. With Masdar, a UAE government-owned renewable energy company, the Energy Ministry has signed a two-pronged Implementation Agreement, the first part of which will develop a 1 GW utility-scale onshore solar and wind energy mega-project, including in Karabakh and East Zangezur; the second will develop green hydrogen facilities producing 2 GW of energy from offshore wind sources.

Moreover, to tackle issues like pollution and climate change, as well as to boost the overall quality of life in the liberated territories, green infrastructure can be a game-changer by enhancing environmental sustainability, improving community well-being, and creating more livable cities.

Considering that green infrastructure investment in Karabakh will create more added value, since the infrastructure and urban-rural settlements are being built from scratch, the integration of green infrastructure development into existing policy frameworks is vital.

As a key element of smart cities and the green transition, green

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infrastructure development can be boosted through proactive, long-term asset management strategy and investment to meet climate change targets. If green infrastructure development is both properly integrated into policy frameworks and implemented successfully, it can offer services that a functioning society needs: heat, power, mobility, clean water, waste management, and digital communication. It may also facilitate change by raising standards of living, lowering inequality, raising productivity, and promoting environmentally friendly results.

Therefore, this essay examines the opportunities and importance of integrating green infrastructure development into smart urban planning of the cities being constructed in liberated Karabakh. Furthermore, it addresses different investment and finance methods for green infrastructure in Karabakh by drawing attention to successful cases around the globe. The overall objective of the essay is to provide analytical support in the application of the sustainable smart city concept in Karabakh and turning the region into a green zone.

Policy Framework

The aftermath of the Second Karabakh War, which resulted in the end of the Armenian occupation of 20 percent of Azerbaijan, has accelerated the need to rebuild the towns and villages in the liberated areas. During the 30 years of occupation by Armenian forces, the region's infrastructure – including cities, towns and villages and historical places, schools, kindergartens—was completely and systematically destroyed.

In seven cities (Fuzuli, Jabrayil, Zengilan, Gubadli, Shusha, Aghdam, Kalbajar, Lachin), numerous urban settlements, and about 400 villages, complex reconstruction projects on an unprecedented scale began to take place. Days after the end of the war,

Azerbaijan began undertaking reconstruction projects with the aim of returning IDPs to their places of origin with all deliberate speed—by late 2026, more than 150,000 citizens are projected

to return to populate the liberated areas. So far, the country has spent approximately \$10.2 billion on construction and restoration work

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in the liberated territories, with Finance Minister Samir Sharifov indicating that the number is expected to reach \$11.1 billion by the end of 2024. In 2021-2022 as Aliyev stated on 2 March 2024 at the Summit-level Meeting of the NAM Contact Group, Azerbaijan spent \$4 billion on building smart cities and smart villages.

In short, Baku sees the development of modern and smart cities and villages as a solution for regional development and population resettlement in newly liberated regions.

The country has adopted an umbrella document titled “Azerbaijan 2030: National Priorities for Socio-Economic Development” that puts forward a strategic vision of maintaining a high-quality and clean ecological environment. One of its priorities—titled A Clean Environment and a Country of ‘Green Growth’—calls for the efficient use of resources and envisions the establishment of green spaces and the efficient harnessing of water resources.

To that end, Aliyev signed a decree on transforming not only the liberated areas (the Karabakh and East Zangezur regions) but also Azerbaijan's Nakhchivan exclave into “green energy” zones. All told, these three regions make up about

25 percent of the country's territory. “The creation of “green energy” sources in these regions will benefit the entire [South Caucasus] region,” said Aliyev in a speech that commissioned the Khudafarin hydroelectric complex and inaugurated the Giz Galasi hydroelectric complex on the Araz River in May 2024. This envisions leveraging Karabakh's abundant renewable energy potential. The wide spectrum activities include electricity generation from renewable sources, energy efficiency improvements, adoption of electric vehicles, installation of solar panels on buildings, solar-powered LED street lighting, and smart energy management. Waste energy management is also a key component of the green energy zone initiative.

By using advanced technologies, smart cities optimize resource use, incorporate smart city management systems, and transition to renewable energy sources. Taken together, these represent significant steps towards building sustainable cities in Karabakh and other parts of Azerbaijan.

Smart city and green zone policy frameworks operate mostly independently of each other in the liberated areas; however, serious outcomes can be achieved by their integration. The development

of green infrastructure can be an essential part of both the smart city concept and the overall push towards a green transition to provide integrated solutions for complex urban city challenges while improving resilience.

Green Infrastructure

Green infrastructure is the combination of infrastructure elements with natural elements and multifunctional green spaces. It involves integrating nature-based elements into urban planning and development as an interconnected network of green spaces that are controlled and intended to provide a range of environmental, social, and economic advantages. These places include community and tenement plots, individual gardens, urban wetlands, green walls and roofs, and urban parks.

Green infrastructure offers opportunities for carbon capture, temperature regulation, flood, wind speed, stormwater runoff reduction, and food production. Such networks envisage the application of ecosystem-based approaches in various areas such as energy grids, drainage systems, communications, and transportation to increase productivity, save costs, and adapt to climate change

Experts have established six main categories by which to assess the success of smart cities. They are: *one*, energy efficiency and environmental sustainability; *two*, transportation and mobility; *three*, participation and city governance; *four*, people; *five*, buildings; and *six*, city economics. The smart city policy framework aims to support effective operational networks in the city and aid in decision-making by utilizing technology, data, and information platforms. Considering that the smart cities idea focuses on building resilient cities with appealing living spaces and implementing integrated, sustainable solutions, the application of green infrastructure elements into urban planning is win-win solution for cities.

Despite the promising prospects of sustainable city planning and green infrastructure, the road to sustainability is fraught with challenges. Green infrastructure projects are frequently impeded by financial constraints. These projects frequently face competition from more conventional grey infrastructure solutions that do not provide additional co-benefits. In addition, green infrastructure necessitates long-term planning, with the benefits not being realized in the short term, which makes it difficult to attract investment.

The Importance of Green Infrastructure Investment

The realization of infrastructure projects is crucial to the successful economic development of Azerbaijan's liberated areas. There, residential and non-residential complexes adhering to advanced urban planning guidelines are being established; with the integration of smart city and smart village concepts, the modernity of infrastructure will be ensured. This will also cover the establishment of an efficient waste management system and the restoration of social service infrastructure. Considering its environmental, social, and economic benefits, green infrastructure development is crucial for restoring life to Karabakh and East Zangezur.

Green infrastructure investment will play a key role in promoting sustainable development not only by contributing to economic growth through job creation and boosting local industries, but also from a climate change perspective, as carbon emission reduction, climate resilience, sustainable land use, economic and social co-benefits,

the promotion of green cities, and long-term climate adaptation.

One of the most direct benefits of green infrastructure investment is the reduction of carbon emissions. By prioritizing renewable energy sources like wind and solar, the Karabakh region can significantly decrease its reliance on fossil fuels. This transition not only lowers greenhouse gas emissions nationally, but also contributes to Azerbaijan's efforts to combat climate change.

As green infrastructure encompasses energy-efficient buildings that consume less energy, fewer emissions will be produced. This dual approach of increasing renewable energy use while enhancing energy efficiency will position the Karabakh region as a proactive participant in global climate action.

Beyond emission reductions, green infrastructure investments can enhance the region's resilience to the adverse impacts of climate change. Effective water management is a key component of this resilience strategy. As climate change leads to more frequent and severe weather events, green

The realization of infrastructure projects is crucial to the successful economic development of Azerbaijan's liberated areas.

infrastructure solutions provide essential protection against such impacts. Moreover, investing in green spaces, such as urban forests and green belts, helps preserve and enhance biodiversity. Diverse ecosystems are inherently more resilient to climate change, offering a natural buffer against environmental instability.

Sustainable land use is another critical area where green infrastructure investments can have a profound impact. Reforestation and afforestation projects, for example, play vital roles in sequestering carbon, improving air quality, and stabilizing local climates. In regions like Karabakh, where land degradation is a concern, such initiatives can enhance the region's overall environmental health. Additionally, promoting sustainable agricultural practices through green infrastructure investments can improve soil health, increase crop resilience to climate extremes, and reduce the carbon footprint of food production. These practices not only support environmental sustainability, but will also contribute to food security and rural development in the Karabakh region.

The economic and social co-benefits of green infrastructure investments further strengthen the case for this approach. One of the most significant advantages will be job creation. The development of green infrastructure can generate employment opportunities in sectors such as renewable energy, construction, and environmental management. This will not only provide a stimulus to the local economy, but it will also support a just transition to a greener economy and, in turn, ensure that

Healthier communities are more resilient to climate-related challenges, creating a virtuous cycle of environmental and social well-being.

communities are not left behind in the shift towards sustainability. Additionally, green infrastructure investments will improve air and water quality, reducing health risks associated with pollution and extreme weather events. Healthier communities are more resilient to climate-related challenges, creating a virtuous cycle of environmental and social well-being.

Promoting green smart cities through infrastructure investments is another essential aspect of addressing climate change in the Karabakh region. Green cities prioritize sustainable living by incorporating public transportation,

energy-efficient buildings, and ample green spaces into urban planning. These elements contribute to lower carbon emissions and an improved quality of life for the Karabakh residents. Moreover, green smart cities are better prepared to adapt to the changing climate.

Green infrastructure will also support long-term climate adaptation in the Karabakh region. Unlike traditional infrastructure, which may become obsolete or require costly upgrades as climate conditions change, green infrastructure is often more adaptable and resilient. This longevity reduces the need for frequent resource-intensive maintenance and ensures that the infrastructure can withstand the test of time, even as the climate continues to evolve.

Four Funding Options

For the realization of the aforementioned green infrastructure projects, achieving socio-economic development targets, and promoting green cities and long-term climate adaptation in the Karabakh region, innovative green financing mechanisms should be utilized. Despite the benefits, however, green infrastructure often faces funding gaps.

Public budgets may prioritize traditional infrastructure over green projects; thus, increased investment is necessary to bridge this gap and create sustainable, resilient cities. While public funding is essential, this is not a panacea: private investment is also crucial. Across the G20 countries, private-sector-led infrastructure investments has remained below 0.2 percent of GDP, while studies suggest that 5.0 percent is needed.

Middle- and low-income countries rely heavily on nonprivate players (e.g., the public sector and development banks) for infrastructure financing. Newer financing tools like green bonds, impact investing, and public-private partnerships (PPPs) offer innovative ways to fund green infrastructure. In such ventures, governments, development banks, and private investors act as important collaborators to mobilize capital for green infrastructure projects.

For the successful implementation of green infrastructure projects, policy support is also essential. Governments should prioritize and incentivize green investments through relevant regulation and support mechanisms. In this part of our paper, we will examine four innovative green infrastructure funding options for the Karabakh

region, including PPPs, syndicated loans, green bonds, blended finance, drawing on best practices from other countries.

PPPs offer a viable financing mechanism for green infrastructure projects in the Karabakh region. PPPs involve collaboration between the government and private sector companies to finance, develop, and manage infrastructure projects. This model leverages the expertise and resources of private entities while sharing the risks and rewards between the public and private sectors.

The UK has successfully used PPPs for green infrastructure projects, particularly in the area of renewable energy. The UK's Offshore Wind Programme benefited from PPPs by attracting significant private investment while allowing the government to retain a stake in strategic assets. The program has resulted in substantial increases in renewable energy capacity, demonstrating the effectiveness of PPPs in financing green infrastructure. Brazil also has a well-established PPP program, with successful examples in the transportation, energy, and water sectors. The regulatory framework governing PPPs in Brazil ensures transparency, risk-sharing, and project viability. Engaging stakeholders

ensures inclusive decisionmaking and diverse perspectives which fosters buy-in and minimizes conflicts. Brazil conducts consultations during project planning and environmental impact assessments.

In the context of Karabakh, PPPs could be used to fund renewable energy projects, such as solar or wind farms, as well as sustainable urban development initiatives. A state entity could provide initial capital, regulatory support, and land, while private companies could bring in the necessary technology, expertise, and additional financing. This approach could accelerate the deployment of green infrastructure while minimizing the financial burden on the state.

The second green financing mechanism is what bankers call syndicated loans. This involves a group of banks or financial institutions coming together to provide large loans to fund significant infrastructure projects. This mechanism can be particularly effective for financing large-scale green infrastructure projects that require substantial capital investment.

In India, syndicated loans have been used to finance large-scale solar energy projects. The Rewa Ultra Mega Solar Park in Madhya Pradesh, one of the largest solar

parks in the world, was partly funded through syndicated loans. This approach allowed for the sharing of risk among multiple lenders while providing the necessary capital to advance the project. The Lake Turkana Wind Power Project in Kenya, one of Africa's largest wind farms, was financed through a syndicated loan involving international and local financial institutions such as the African Development Bank and the European Investment Bank. This syndicated loan structure allowed for the pooling of resources and risk-sharing among multiple lenders, making it possible to fund the \$680 million project. The successful implementation of this project, which now supplies about 15 percent of Kenya's electricity, highlights the effectiveness of syndicated loans in financing large-scale green infrastructure in developing countries—a model that could be replicated in Azerbaijan.

In its Karabakh region, syndicated loans could be used to finance major green infrastructure projects such as renewable energy plants, smart grids, or large-scale water management systems. By involving multiple financial institutions, the region could access larger pools of capital while distributing the financial risks, making it easier to fund ambitious projects.

A third financing mechanism is green bonds. These are debt securities issued to finance projects with environmental benefits, such as renewable energy, energy efficiency, and sustainable land use. Green bonds have gained popularity as a green finance tool because they attract environmentally conscious investors and can be issued by governments, municipalities, or corporations.

The Netherlands issued government green bonds in 2019, attracting investments of \$6.68 billion for climate change adaptation programs, renewable energy projects, and railway infrastructure. The Netherlands has a strong commitment to sustainability and innovation and the government actively promotes green initiatives. Nigeria's green bond was a landmark achievement in Africa, signaling the country's commitment to sustainable development and climate action. The bond not only helped finance critical green projects, but also set a precedent for other African states to follow. It showcased the potential for green bonds to attract both local and international investors in developing countries, supporting the financing of environmental initiatives in regions with pressing climate challenges.

In the context of Karabakh, issuing green bonds could provide a steady stream of funding for a variety of green infrastructure projects, such as reforestation initiatives, sustainable urban planning, and renewable energy installations. By issuing green bonds, the region could tap into global capital markets and attract investors interested in supporting environmental sustainability. There are indications that something like this could be in the works—unconfirmed reports indicate two Azerbaijani banks, in partnership with the Astana International Financial Centre’s Green Finance Centre, will issue green bonds by the end of the year, perhaps during COP29—but it is unclear whether the bonds will focus on Karabakh. Either way, this represents a good start and could come to be seen as a proof-of-concept endeavor.

The fourth mechanism is what is called blended finance, which involves combining public and private sector funding to de-risk green infrastructure investments and attract private capital. This approach uses public funds to absorb certain risks, making green projects more appealing to private investors.

In Kenya, what is called the Climate Investor One initiative

blends public and private finance to support renewable energy projects. By using public funds to reduce risk, the initiative has successfully attracted significant private-sector investment, leading to the development of several renewable energy projects across the country.

For the Karabakh region, blended finance could be used to fund projects that may be perceived as high-risk by private investors, such as innovative renewable energy technologies or large-scale reforestation efforts. By leveraging public funds to reduce risk, the region could attract more private capital and accelerate the implementation of green infrastructure projects.

What It’s Really About

To achieve long-term sustainability and meet climate change goals, the Azerbaijani government needs to promote responsive and adaptive infrastructure that requires a combination of financial resources, policies, and technologies in the declared green zones. The need for people-centered urban city models that integrate smart infrastructure with nature-based solutions to solve the social, economic, and

environmental difficulties of cities and other urban areas while promoting health and well-being has been highlighted by referencing a few cases from abroad.

With this in mind, the term “smart city” in Karabakh should neither be interpreted primarily as a technological concept based on the application of information and communication technologies, nor as a collection of techniques for administering or managing a city as a whole or any of its constituent parts, such as its resources, traffic, and population. Integrating smart and green yields the most favorable outcomes in terms of the environment, society, economy, and health, the application of nature-based solutions in Karabakh can reduce disaster risk and strengthen climate resilience.

The integration and effective implementation of green infrastructure and funding mechanisms into policy initiatives for smart cities in Karabakh can result in this part of Azerbaijan becoming an exemplary model for the entire Silk Road region. Karabakh has a unique opportunity to leverage a range of innovative funding mechanisms to support its green infrastructure development. PPPs, syndicated loans, green bonds, and blended finance all offer viable pathways for financing its transition to a sustainable future.

By drawing on best practices from other countries, these mechanisms could be implemented effectively in Karabakh, ensuring that its green infrastructure investments are both financially sustainable and impactful in the fight against climate change. **BD**

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