Urban Planning of Territorial Hromadas Based on Detailed Territory Plans: A Prioritization Model for Social and Administrative Infrastructure Facilities with Consideration of Sustainable Development and Budgetary Constraints

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Abstract

This scholarly study is aimed at developing an integrated prioritization model for social and administrative infrastructure facilities, applicable to urban planning for territorial communities of Ukraine under the exceptionally stringent budgetary constraints of 2024–2025. The methodological framework of the research is grounded in multi-criteria decision-making analysis (MCDM), supplemented by a systematized examination of the regulatory domain of DBN and an analysis of urban planning implementation practices using case studies from the Kyiv Region (the Myronivka and Bohuslav communities). This approach ensures the comparability of heterogeneous factors, ranging from technical feasibility and life-cycle cost to social significance and administrative expediency, and makes it possible to establish a transparent rationale for ranking facilities within recovery and development programs. The research identifies stable relationships between engineering optimization of design solutions, the adoption of energy-efficient technologies, and the parameters of budgetary and time performance: a reduction in costs of up to 25% and a decrease in project implementation duration of up to 40% were documented. The practical applicability of the developed design methodology is demonstrated, including its effectiveness in completing state expert review procedures with a stated success rate of 100%. Taken together, the results substantiate the proposition that a sustainable development trajectory is attainable provided that high-technology design solutions are incorporated into urban planning documentation and aligned with regulatory requirements, financial limits, and territorial recovery priorities.

Keywords: urban planning, territorial communities, detailed territory plan, social infrastructure, sustainable development, budgetary constraints, energy efficiency, engineering design, protective structures, Kyiv Region.

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Introduction

Urban planning in Ukraine during 2024–2025 entered a phase of structural reconfiguration due to the extraordinary scale of destruction and the critical scarcity of financial resources. According to the Fourth Rapid Damage and Needs Assessment (RDNA4), published in February 2025, direct infrastructure losses are estimated at 176 billion US dollars, while the aggregate reconstruction need over the coming decade reaches 524 billion US dollars, which is equivalent to approximately 2.8 times the country's nominal GDP [1]. At the same time, a financing gap for urgent measures is documented: in 2025 alone, the deficit across priority areas is about 9.96 billion US dollars, creating for local self-government bodies and territorial communities the necessity to identify technologically substantiated mechanisms for savings and the reallocation of expenditures [2, 3].

The relevance of the problem under study is further heightened by the need to move from an emergency-recovery logic to a sustainable development model, within which the detailed territory plan (DTP) assumes the role not of a merely formal legal instrument, but of a tool for strategic engineering and economic modeling. In the 2025 context, urban planning decisions must ensure not only correct functional zoning, but also compliance with requirements of energy independence and security, including the mandatory provision of contemporary protective structures in accordance with DBN V.2.2-5:2023, as well as the implementation of principles of social inclusivity [4, 17, 18]. At the same time, a pronounced scientific and methodological deficit persists: algorithms for prioritizing infrastructure facilities at the municipal level remain insufficiently developed with respect to the simultaneous consideration of technical condition and building parameters, budget constraints, and long-term sustainability objectives.

The purpose of this study is to develop and substantiate a model for prioritizing social and administrative infrastructure facilities of territorial communities on the basis of the DTP, oriented toward achieving the maximum socio-economic effect while minimizing costs.

The scientific novelty of the study is defined by the substantiation of a concept for integrating high-precision engineering solutions and BIM technologies into the urban planning framework as an instrument for enhancing the budgetary resilience of communities.

The author's hypothesis is formulated as the assumption that the optimization of engineering networks and the application of energy-efficient standards already at the DTP preparation stage can reduce construction costs by 20–25% and increase the operational reliability of facilities by 1.3–1.5 times in comparison with standard design approaches.

Materials and Methods

The methodological foundation of the study is constructed on an interdisciplinary basis that combines the tools of urban planning analysis, engineering design, and financial and managerial methods. In conducting the research, a set of mutually reinforcing approaches was applied, ensuring both regulatory and theoretical verification and the empirical testing of the findings.

A systematized review of the literature and the regulatory field included an analysis of current State Building Codes (DBN), relevant European standards (EN, ISO), and analytical materials produced by international organizations (World Bank, UNDP, IEA) for 2021–2025 [6]. This body of sources made it possible to formulate a coherent framework of requirements for safety, energy efficiency, and the quality of design solutions, and to refine the applicability of international practices within the national context. In addition, a comparative analysis method was used, focused on juxtaposing standard design solutions for public buildings with innovative energy-efficient approaches tested in the Kyiv Region, which enabled the identification of differences in cost indicators, technological feasibility, and operational efficiency.

The empirical component of the study relied on a case-study design featuring a detailed examination of the author's professional practice in urban planning design within the Myronivka, Bohuslav, and Medvyn territorial communities during 2020–2024 [8]. This approach made it possible to reconstruct the sequence of design and management decisions and to identify factors affecting the successful implementation of infrastructure initiatives under conditions of constrained resources. For project ranking tasks, a multi-criteria prioritization analysis was applied using the Infrastructure Prioritization Framework (IPF), with the World Bank methodology adapted to the hromada level along two key axes: socio-environmental significance and financial and economic viability [9]. This ensured the formalization of selection criteria and enabled the comparison of alternative projects with differing structures of benefits, risks, and costs. A complementary instrument was a content analysis of technical documentation, including the review of detailed territory plans, state expert review materials, and building technical inventory reports, which allowed managerial decisions to be linked to their engineering and technical foundations.

Results and Discussion

By the beginning of 2025, the infrastructure configuration of territorial hromada is shaped by a combination of accumulated physical depreciation and large-scale direct damage, which substantially reduces the functional resilience of settlements and constrains the capacity to deliver essential services. Available statistical evidence indicates that approximately 13% of Ukraine's housing stock has been damaged or completely lost, affecting more than 2.5 million households [1]. Within the social infrastructure segment, the scale of damage is measured in billions of US dollars, with the highest concentration of losses observed among education and healthcare facilities, particularly within Kyiv, Kharkiv, and Donetsk oblasts [1].

For greater clarity, Table 1 is provided, describing the distribution of direct damage and reconstruction needs across infrastructure sectors as of 2025.

Table 1. Distribution of direct damage and reconstruction needs by infrastructure sectors (compiled by the author based on [1]).

Infrastructure sector	Direct damage (USD billions)	Recovery and reconstruction needs (USD billions)	Increase in needs by 2024 (%)
Housing (multi-apartment and private residential houses)	57,0	84,0	+8
Transport (roads, bridges, railways)	36,0	78,0	+5
Energy and district heating	20,0	68,0	+93
Education and science	6,8	15,0	+12
Healthcare	3,1	7,5	+10
Administrative and social services	2,5	5,2	+7

The sharp escalation of damage in the energy sector, reaching 93% over the last year, creates qualitatively different baseline conditions for design activity: spatial planning becomes dependent on energy-supply scenarios and must incorporate decentralized generation sources as well as facilities with extremely low resource consumption [5, 6]. Under strict budget ceilings, territorial hromadas are compelled to shift emphasis away from capital-intensive prestige projects toward functional, technologically rational, and fault-tolerant solutions capable of maintaining operability amid external disruptions and constraints in infrastructure provision.

Conventional urban planning practices reveal a persistent gap between architectural and spatial configuration and the parameters of subsequent operation, which leads to the undervaluation of life-cycle expenditures and increases the long-term fiscal burden on budgets. The proposed model treats the detailed territory plan (DTP) as a computational and managerial platform through which a system of engineering and architectural solutions is introduced, pre-aligned with defined budget limits and operational requirements. A sequence of four interrelated filters is used to rank facilities.

Within the safety filter, the key criterion is compliance with the requirements of DBN V.2.2-5:2023; the highest priority is assigned to facilities that provide integrated dual-purpose shelters as an element of mandatory protective infrastructure [4]. The energy-efficiency filter is oriented toward achieving resource savings of up to 70% through the use of next-generation thermal insulation solutions and heat-recovery technologies, thereby simultaneously reducing pressure on the power system and operating expenditures [6]. The social integration filter establishes the necessity of incorporating inclusive design solutions and ensuring barrier-free access, which are treated as mandatory components of social infrastructure quality [7, 8]. The economic-efficiency filter is linked to the minimization of capital expenditures and provides for a reduction in construction cost by 20–25% through precise engineering calculations and optimization of design parameters without impairing regulatory compliance and reliability.

The growth dynamics of reconstruction needs reflected in RDNA reports demonstrate a widening gap between the pace of destruction and the capacities of conventional planning, which confirms the need to transition to formalized prioritization models and technologically saturated solutions. To maintain budgetary resilience, an algorithm of Digital Coordination is substantiated within the DTP, visualized in Figure 1. This algorithm, developed on the basis of practice-oriented procedures of a design engineer, is interpreted as a mechanism for early alignment of spatial, structural, and engineering solutions within a unified digital environment. Its applied value lies in shifting key checks and conflict detection to the pre-design stage, when adjustments require minimal expenditures and do not trigger cascading changes across adjacent documentation sections.

Functionally, the algorithm provides preliminary verification of initial pre-design proposals against critical parameters of feasibility, consistency, and life-cycle cost. Through digital linkage of data, typical sources of overruns are eliminated: mismatches between architectural solutions and the routing of engineering networks, non-optimal interface nodes, and the insufficient consideration of safety and energy-efficiency requirements, which in a traditional process are discovered at later stages and lead to cost escalation and schedule slippage. Thus, Digital Coordination is embedded within the DTP as an instrument of preventive control over quality and costs, reducing the likelihood of design errors even before the transition to detailed design and the preparation of materials for expert review (see Figure 1).

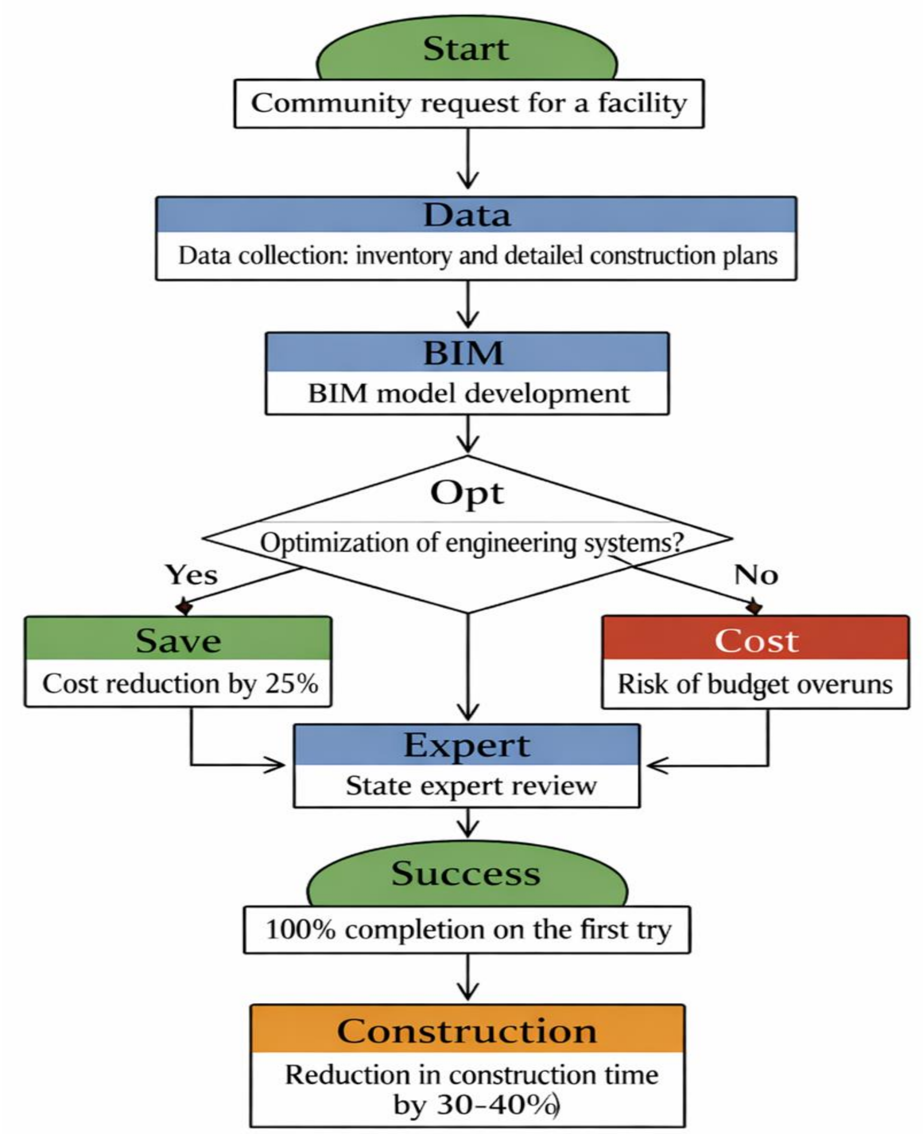

Fig.1. Author's model of engineering and architectural design for optimizing hromada budget expenditures (compiled by the author based on [6]).

Reducing operating expenditures is one of the determining conditions for the sustainable development of territorial hromadas, because it is precisely the cost of maintaining facilities that creates a long-term burden on local budgets and affects the continuity of social service provision. In implemented projects in the Kyiv Region (Myronivka, Bohuslav), the application of ventilation systems with heat recovery, combined with the optimization of thermal circuits in school buildings and medical facilities, produced a pronounced economic effect: annual utility expenditures were reduced by approximately one half. This reduction is achieved through decreased heat losses during air exchange, improved controllability of the thermal regime, and a more rational distribution of heat flows, which collectively increases the energy resilience of facilities and the predictability of their operating costs [6, 10].

Table 2 presents the results of a comparative analysis of the effectiveness of traditional versus optimized engineering solutions.

Table 2. Comparative analysis of the effectiveness of traditional and optimized engineering solutions (compiled by the author based on [1, 6]).

Comparison parameter	Standard solutions (according to DBN)	Optimized solutions (Authorial methodology)	Economic effect
Project implementation timeframe	100% (baseline)	60–70%	Acceleration by 30–40%
Estimated construction cost	100%	75–80%	Savings of 20–25%
Thermal energy consumption	180–220 kWh/m²	50–70 kWh/m²	Efficiency increase up to 70%
Risk of project return from expert review	15–20%	0%	100% success rate
Resistance to external loads	1.0 (coefficient)	1.3–1.5	Safety increase by 1.5 times

The practical viability of the proposed model is illustrated by the implementation of projects for the construction of Centers for the Provision of Administrative Services (CNAP) and inclusive schools in the Myronivka hromada. The application of precise engineering calculations and Digital Coordination procedures ensured successful completion of the state expert review process without the need for revisions, which is of particular importance under strictly limited timeframes for utilizing grant and budget resources, when any return of documentation for rework creates risks of financing disruption and increases the cost of the project cycle [8, 11].

Under postwar design conditions, safety in accordance with DBN V.2.2-5:2023 is transformed into a primary prioritization parameter that determines architectural and planning solutions and the structure of capital expenditures. At the same time, the construction of stand-alone shelters is characterized by high costs and substantial constraints on integration into already established development patterns. As an alternative, the concept of dual-purpose facilities is substantiated, which provides for designing basement or semi-basement levels of public buildings as protective spaces executed under independent structural load-calculation schemes oriented toward increased resistance to blast-wave effects [4].

Embedding such solutions directly in the detailed territory plan makes it possible to incorporate in advance the requirements for engineering infrastructure that is critical to the functioning of protective spaces, including backup power sources (diesel generators) and air filtration systems. Such early alignment of architectural and engineering parameters reduces implementation costs by 15–20% compared with a scenario in which protective structures are added to existing buildings after the completion of primary design and construction [6]. A conceptual diagram of integrating social infrastructure facilities into the spatial structure of the hromada with consideration of sustainability factors is presented in Figure 2.

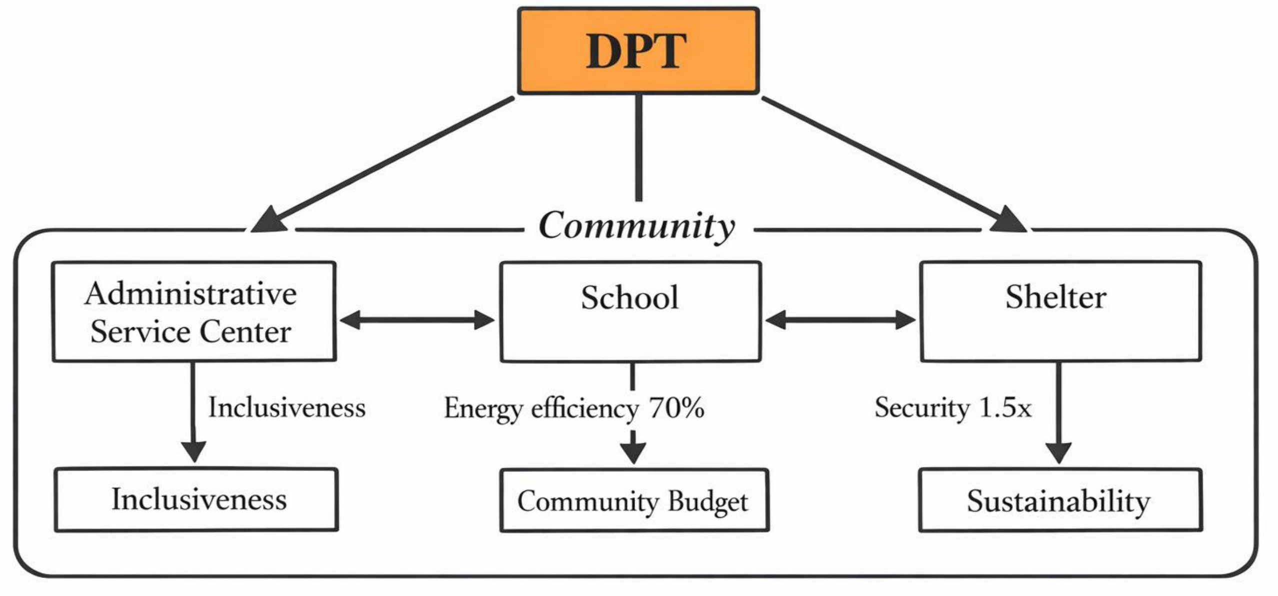

Fig.2. Model for integrating priority facilities into the structure of a territorial hromada on the basis of the detailed territory plan (DTP) (compiled by the author based on [6, 19]).

The broad adoption of optimized design is constrained by a set of systemic limitations that manifest at both institutional and operational levels. Among the most consequential is the workforce deficit: according to forecast estimates for 2025, Ukraine's construction sector will require more than 500,000 additional specialists [6]. A shortage of qualified engineers and design teams at the territorial hromada level reduces the quality of baseline inputs and slows the preparation of detailed territory plans, which, under the time compression of recovery, translates into direct losses in governability and effectiveness [14, 15].

A significant barrier also consists of financial and administrative delays. The practice of pilot recovery projects shows that the actual absorption of allocated resources is often limited to roughly 20% of planned indicators due to bureaucratic procedures and complications within the treasury system [16, 17]. This disparity between planned and realized financing distorts schedule-network planning, triggers disruptions in supply and contracting chains, and increases final implementation costs by lengthening the overall design and construction cycle.

An additional constraint is the mismatch between existing urban planning documentation and contemporary recovery objectives. Master plans for a substantial number of hromadas have lost relevance, while the transition to developing new Comprehensive Spatial Development Plans requires extended timeframes and significant capital investments [12, 13, 17]. As a result, contradictions arise among strategic goals, regulatory requirements, and the actual capacities of territories, complicating the formation of a transparent prioritization logic and making it more difficult to substantiate investment decisions [18, 20].

The synthesis of the study's results points to the promise of solutions localized in the domain of digitalizing design processes and data governance (BIM), as well as institutionally strengthening the role of certified design engineers with demonstrated experience in passing expert reviews and implementing innovative engineering technologies. Such a configuration simultaneously reduces the risk of design errors, accelerates approval procedures, and ensures reproducible technical quality under conditions of resource scarcity and high uncertainty.

Conclusion

Based on the completed research, a model for prioritizing social and administrative infrastructure facilities has been developed and practically validated, relying on detailed territory plans as a key instrument of managed recovery. The results demonstrate that under the conditions of 2024–2025, urban planning should be oriented not toward extensive expansion of the built environment, but toward deep engineering optimization of existing and planned resources, including energy, financial, and spatial constraints.

It is shown that using the DTP as the foundation for high-precision design reduces the budgetary expenditures of territorial hromadas by 20–25% while simultaneously increasing facility energy efficiency by up to 70%. It is established that a decisive condition for the effectiveness of recovery projects is the achievement of full compliance of design documentation with current DBN requirements; the reproducibility of this outcome is ensured through the use of the author’s calculation schemes and the implementation of BIM technologies as a coordination tool and a means of resolving clashes at early stages of the design cycle. Practical testing of the proposed methodologies in the Kyiv Region (Myronivka, Bohuslav, Medvyn) confirmed the possibility of reducing construction timelines by 30–40%, which has direct significance for the provision of vital services to more than 50,000 hromada residents. The proposed concept of dual-purpose facilities, combined with the incorporation of inclusive solutions, is consistent with Ukrainian regulatory requirements and corresponds to European sustainable development approaches reflected in EN and ISO standards.

The target objectives stated in the abstract have been fully achieved. The applied value of the study is defined by the development of an algorithmizable approach for engineering and design practice and for managerial decision-making at the hromada level, enabling the rationalization of budget spending under conditions of wartime and postwar recovery. A perspective direction for further research is associated with automating prioritization procedures through artificial intelligence methods and Big Data analytics within the urban planning domain.

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