Draft report

Aghali Smart Village Project

Building a better
working world

1. Background

2.1 Smart Village concept

The Smart Village concept is based on supporting rural areas and communities and developing capacities by adopting innovative and sustainable concepts and solutions. In Smart Villages, the traditional and new infrastructural systems and services are enhanced with ICT and innovative approach benefiting the rural residents and businesses operating in these areas. The smart villages' best practices entail innovations which provide a higher quality of life, better standards of living, improved public services, and sustainable use of resources by minimizing the environmental impact and providing new opportunities for rural value chains.

There is no uniform, one-fits-all solution for the Smart Village development while the integration of certain components differs case-by-case as the goals set by the governing bodies or municipalities depend on the specifics of each region, e.g. climate, location, infrastructural links, prevailing economic activity, agricultural potential etc. Alternatively, such solutions are also based on the major employment of the residents and directed to boosting the existing local businesses.

Figure 1: Smart Village strategy development basis

2.1.2 Case studies around the world

Table1: Comparable best practices of Smart Village concept		
Location	*Project background*	*Innovations and results*
Die Stanz, Austria	▸ 1,850 Residents ▸ Area at 77 km^2 includes 130 homes, 2 churches, 7 restaurants, and social service centers, but predominantly consists of forests at 83% ▸ Duration 8 years, since 2014	• 50% of goods are from local producers. • Village applied renewable energy technologies (biomass, PV, hydro and windmills) for electrification and heating and established renewable energy community
EcoVillage at Ithaca, New York, USA	▸ 100 Homes, 220 Residents clustered on the site in three neighborhoods, each neighborhood is a housing cooperative ▸ Duration of construction is over nearly 20 years ▸ Residences are privately owned and contain the amenities of conventional homes. Residents also have access to extensive common facilities (open space, community gardens, play areas and a community center) ▸ Area includes homes on 61 km^2, 80% of the land (708 km^2) used for natural areas, wildlife habitat, and two working farms	• Sustainable agriculture solutions and farming cooperatives • Net-zero energy approach using renewable energy generated electricity and heating • Imitated entry to the private vehicles and promotion of car sharing and carpooling. There are walking and cycling paths for residents.
Sochi, Russia	• Total building site area is 595,047 m^2 • The project planning is completed and approved in 2021 • The master plan includes: a beach area and a new marina. Called Marina City, it will be a business and innovation center for business and leisure with conference facilities, high-end hotels, vibrant nightlife, Design and Innovation Museum and a Yacht club; three different routes (The Lanes, The Boardwalk and The Green Wave)	• The plan of Sochi Smart City preserves sustainable technology, digitalization and use of renewable energy sources for the business and leisure areas. • Innovative approach considers community engagement and stability in social services provision for the residents of the city.
Oberrosphe village Hesse, Germany	▸ 240 households ▸ The project was launched in 2007 after 2 years of planning and investment collection ▸ By 2020, 50% of all households signed up to get their energy from the community heating scheme based on using local wood energy. ▸ Total amount of investment through state and EU grants and private investors is EUR 3.7 million	• Village developed renewable energy produced energy use using photovoltaic power and a combined heat and power (CHP) plant. The heating coop now purchases the waste heat from that CHP plant to provide about 50% of its heat needs. • About 700 tons of carbon emissions are saved annually.

Sources: https://enrd.ec.europa.eu/sites/default/files/enrd_publications/tg6_smart-villages_sv-green-deal-bill-slee.pdf, https://www.smartrural21.eu/, https://www.unstudio.com/en/page/15292/sochi-waterfront-concept-masterplan

2.2 Current situation

Being an energy-rich country, the Republic of Azerbaijan emerged as a major regional energy player after restoring its independence in early 1990s. Over the period of transition from the Soviet system, Azerbaijan experienced may challenges primarily because of the first Karabakh war and further occupation of the high historical and economical value region with agriculture being one of the key revenue sources. The country’s territory covers an area of 86,600 sq. km.

With the occupation of Zangilan since 29 October 1993 the region became inaccessible, forming over 8,000 sq. km security belt and leaving Nakhichevan region separated from the main part of the country. The territories of Karabakh and the adjacent 7 districts remained isolated with constant violations of the ceasefire until it escalated to a full-scale Second Karabakh war in September 2020, resulting in peace agreement between Azerbaijan and Armenia signed on November 9, 2020 with Russia acting as a stabilizing intermediary party. With this agreement Azerbaijan returned its de facto power and issued a plan of deliberation of the territories. According to the decree "On the New Division of the Regions of the Republic of Azerbaijan" (July 7, 2021) a new division on 14 economic zones was established, where Zangilan district is a part of East Zangazur economic region.

The Government of Azerbaijan (GoA) allocated major funds for the reconstruction of the liberated territories. Over 2 billion of manats (AZN) was allocated for the infrastructural restoration projects in the region for the safe resettlement of the displaced population. The main goal of these investments is to support the return of the internally displaced people (IDPs) to their historical homeland. With a total population of over 10 million, 10% of the country's population were forcibly displaced from their areas of settlement in the early 1990s during the first Karabakh war. Despite these turbulent events of Azerbaijan's early independence period, the economy started picking up its upward trend with total gross output of agriculture rising from 726.8 mln. AZN in 1995 to 9,163.4 mln. AZN in 2021. In Azerbaijan the private farms and small household-scale agricultural activity prevails over the industrialized, enterprise type at 8,277.5 mln. AZN gross output in 2021, as opposed to 885.9 mln. AZN for agricultural enterprises in the same year (data source: stat.gov.az).

In terms of improving its energy consumption patterns Azerbaijan adopts an international approach as part of the "European Union (EU) Neighboring Countries" within EU4energy initiative program. Despite the law "On the Efficient Use of Energy Resources and Energy Efficiency" which will come into force in July 1, 2022 focused on principles of regular energy audit and accreditation of non-residential buildings, the Law establishes a baseline for similar approach for the residential buildings. One of the main targets set by a state heating energy distributor and supplier Azeristiliktechizat OJSC is to improve residential energy efficiency (EE) standards by increasing number of centralized heating network linked buildings. Currently only 15.8% of country is supplied with central heating with 25.4% in urban (predominantly Baku) and only 3.8% in rural areas (2021, Annual household survey report of The State Statistical Committee of The Republic of Azerbaijan: stat.gov.az).

2.3 Traditional village in Azerbaijan

After Azerbaijan proclaimed its independence from the USSR in 1991 the intra-economic ties collapsed, thereby causing stagnation in the agricultural sector. Introducing new type of socio-political system led to a systemic transformation and application of the reform policies, such as the Land Reform Act (1996) which established a new program of agrarian reforms shifting from the collective to individual farming. Azerbaijan completed its transition from a socialism-influenced, agriculture-led economy to an independent, modern industrialized country with the prevalence of heavy industries such as oil and gas and petrochemistry.

Azerbaijan has a high agricultural development potential due to the beneficial geographical position and other environmental factors, such as climate, soil fertility etc. Throughout history, the rural population of the country has maintained high labor productivity in this area, which indicates its readiness for further development in this sector. Despite that, more than 53% of total population still reside in urban areas. This is causing higher urban population density, thereby investments in the reconstruction of rural regions of Azerbaijan may also potentially cause lowering an overpopulation distress in urban areas and ease the infrastructural congestion issues as well.

Starting from the early 2000s, the GoA has been pursuing the goal for developing the rural areas through regional investment programs. Despite that, rural areas are considered in distress compared to the urban ones in relation to the primary needs supply and infrastructure. According to the annual report for 2021 year issued by The State Statistical Committee of the Republic of Azerbaijan (SSC) (data source: stat.gov.az):

- Only 76.7% of rural households are connected to water supply network
- 9.9% of people have no inhouse bathroom
- 86.1% use carbon-emitting timber or gas fueled oven for heating and cooking

- 97.5% are linked to the public gas network

In some distant villages people use compressed gas cylinders (48.6%) because they have no or limited access to a centralized gas network. This is highly hazardous in terms of indoor household safety and emitting environment. There is no municipal waste management system, as well as public engagement in awareness campaigns in rural areas. Deficiency of waste infrastructure and basic waste management awareness, lower education level - all these factors are causing uncontrolled waste dumping, littering, open-pit burning, which cause toxic emissions, groundwater, and soil contamination, and eventually causing high damage for public health and local ecosystem. Untreated wastewater is discharged to sewer pits or directly to the water bodies because of no central sewerage systems and insufficient number of wastewater treatment plants in rural areas.

Most of the rural population is predominantly self-employed at 43.8% (2020 year) in agriculture, due to limited employment opportunities. This is triggered by predominant gaps in education, especially for women as a sensitive social group in these areas. Lack of digitalization as well as limited health care and other public services cause barriers to social and economic mobility of rural households. Poor road infrastructure and lack of municipal support in supply system is causing low engagement of rural areas in the main sectors of the country productivity. As a result, these factors are causing high youth unemployment of rural areas and further migration of the young generation to the cities.The situation in the labor market is also complicated by the large number of IDPs. IDPs receive social support and have access to free higher education which supports their access to be active in the labor market. Additional to housing concessions, the GoA also established Social Development Fund for IDPs (SFDI) for small-scale infrastructure reconstruction within the areas of IDPs residence.

2.4 Zangilan Smart Village Project information

The implementation of smart city/smart village projects in liberated regions of Azerbaijan is a part of "The National Action Plan for 2020-2022 for the Promotion of Open Government 2020-2022", approved by the Decree of President Ilham Aliyev on February 27, 2020.

Smart City and Village concepts in Azerbaijan have specific requirements which are based on the President's decision, dated April 19, 2021. The approach for reconstruction of de-occupied territories of Karabakh and Eastern Zangazur economic zone is to apply Smart infrastructure practices throughout the region. Aghali village of Zangilan was selected as a pilot project within this reconstruction approach covering a total area of 110 hectares.

The challenging aspects for such reconstruction cases include the absence of any infrastructure, local workforce, and sparce or lacking data on climate and historical pollution. Despite those predicted challenges, the GoA decided to establish a foundation for an innovative strategy for the development of Karabakh, and East Zangazur economic region, in particular. The working group tasked with the construction of Smart Villages in the region consists of representatives of key operational sectors of municipal planning (i.e. energy, economy, agriculture, transport and high-tech and other), and the targets set for the group include the following:

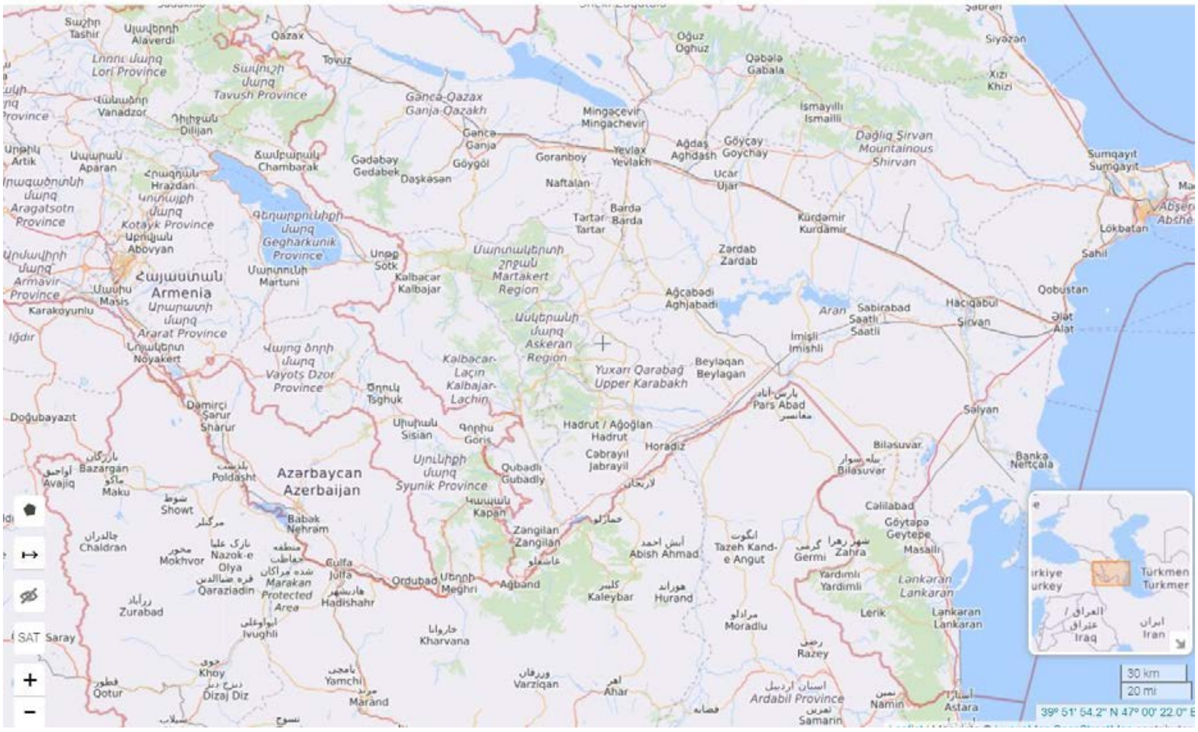
- Improve the quality, safety, and efficiency of social services
- Ensure the effective use and management of available resources for services by applying ICT;
- Boost socio-economic and agricultural productivity and efficiency
- Create new income opportunities in the overall value chain
- Improve the quality of decision-making and management

2.4.1 Zangilan Smart Village geographical location

Zangilan district is located in the south-west of the Republic of Azerbaijan on the border with Armenia and Iran, on the line of the Baku-Julfa-Nakhichevan main railways and highways and poses significant strategic importance.

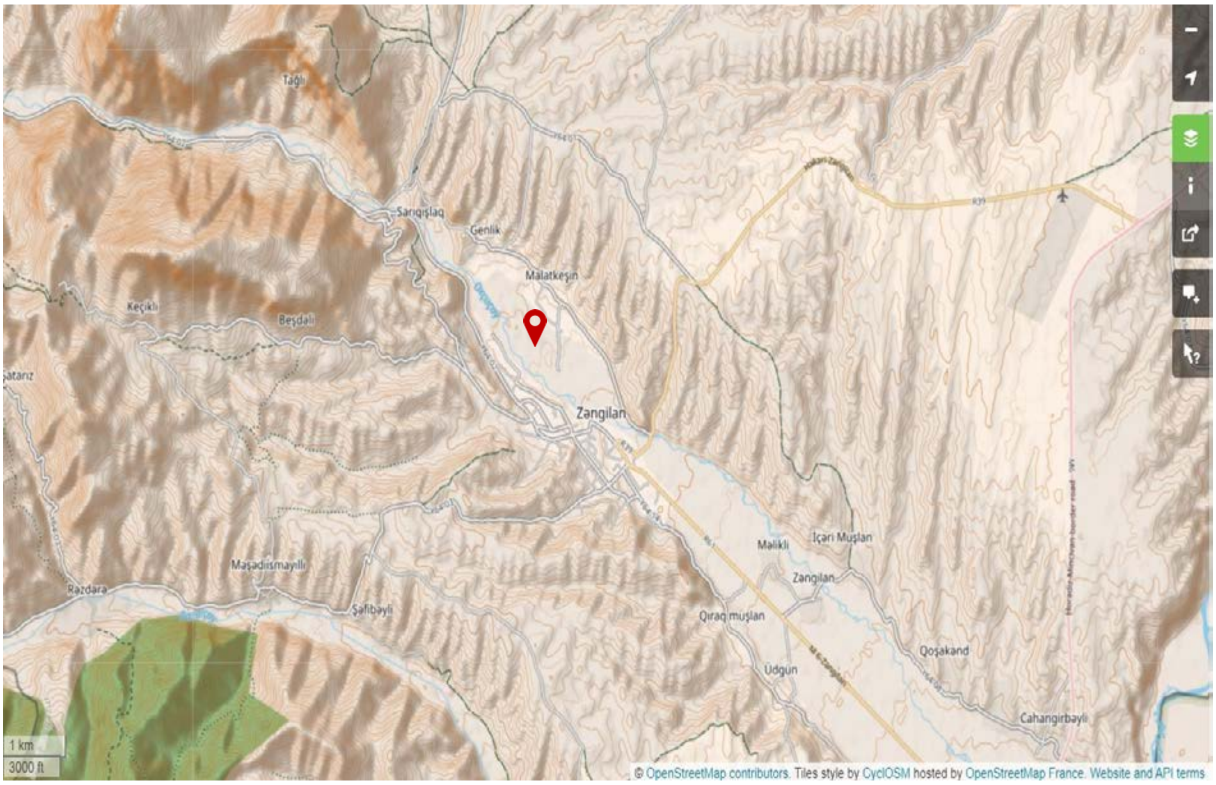
Due to its geographical location, climatic and soil characteristics, historically Zangilan boasts unique natural landscapes and diverse ecosystems. The area is located in the medium and low mountainous areas. The relief structure of the area is rugged and undulating terrain. From the north-west, the Bargushad mountain range (mountain Susen, 1,304 m) wedges into the territory of the region, descending, forming between the rivers Bazarchay and Okhchuchay a gentle plain Ag oyug (altitude 400-600 m). In the northeast, the slopes of the Karabakh mountain range, descending towards the Araz and Kura, pass into the mountain lake Geyan.

Map 1. The position of Zangilan district



Source: OpenStreetMap

Map 2. The position of Aghali village area in Zangilan district



Source: OpenStreetMap

2.4.2 Zangilan Smart Village project's infrastructure

The Company's strategy for Aghali Smart Village project in Zangilan is based on the 5 main components:

- Develop residential sector and the service infrastructure
- Create sustainable labor market in agricultural industry
- Provide innovative approach and solutions in the social services
- Establish principles of smart agriculture
- Supply the village with heat and electricity generated from the alternative energy sources

Key challenges

- The local population of Zangilan was displaced for a period of 30 years. Local population from the area are primarily from the upper-age group. The youth born outside of the area adapted in the areas of their new residence, usually Baku and environs. Since they primarily reside in urban areas it will be challenging for young generation to adapt back to rural life.
- Unexploded ordnance and munition hazards in the pasture areas surrounding the village due to the demining activities in the region.
- High level of pollution, damaging soil fertility, destruction of ecosystem and biodiversity due to the three-decade occupation, military presence and uncontrolled contamination by the occupying forces requiring environmental restoration.
- Poor economic ties in the district area with the neighboring countries while restoration and construction work in the region are in the process.

Main assets and opportunities

- As the region is of high interest for the country residents as well as foreigners after the liberation, it has a potential to develop local tourism.
- Embracing renewable energy technologies such as solar energy and hydro due its location with favorable conditions.
- Promoting synergy in economic sectors (agriculture/farming, energy production, manufacturing, social infrastructure, and other services).
- Introducing new paradigm for rural development with a high potential to promote this type of approach for the rural development at a national level.
- Successful implementation of the current project can become a good precedent for developing similar projects in the country, attracting investments to the country as well as improving environmental and social conditions in Azerbaijan.

2.4.2.1 Dwellings

Zangilan Aghali Smart Village Project is the first Smart village project in the country. The planned residential area of the village is 119 ha with 200 residential and 4 administrative dwellings, as well as two educational facilities - a school and a kindergarten. There are three types of residential houses to be constructed for 1000 residents:

Table 2: Types of buildings in the Aghali Smart Village

Type of the dwelling	*Design*	*Number of dwellings*	*Capacity, people per dwelling*
Residential			
Type 1	*Detached one story houses*	*80*	*4*
Type 2	*Detached one story houses*	*80*	*5*
Type 3	*Detached two story houses*	*40*	*6-7*
Educational			
School	*Two story building with underground level*	*1*	*360*

Kindergarten	One story building with underground level	1	60
Public			
Municipal/administrative	Two story building	4	40

Based the expected number of residents, proposed dwellings are considered sufficient. Moreover, positioning of the residential houses considering solar orientation can provide additional environmental benefits by reducing energy demand for heating and cooling.

Building envelope materials

The construction materials used for outer shell of the buildings are considered energy efficient and have appropriate insulation level. The main material used for the dwellings walls is Thermoblock. The envelope solutions are the same for both residential and public buildings type. Thermal characteristics of the materials are obtained from the project owner and are given in Table 3.

Table 3: Building envelope specifics

Structure	Thickness, mm	R value, $W/(m^2 \cdot {}^\circ C)$	U-value, $W/(m^2 \cdot {}^\circ C)$
Walls	0.33	3.99	0.25
Floor	0.31	2.94	0.34
Ceiling	0.43	2.98	0.34
Window	0.02	0.44	2.28
Door	0.03	0.82	1.21

Energy and water needs

The energy and water consumption specifics for each type of the dwelling is given in the Table 4 that are also certified by the relevant governmental entity, the State Agency on Construction Safety Control under the jurisdiction of the Ministry of Emergency Situations of Azerbaijan.

Table 4: Energy and water consumption by each type of the buildings given per building type

Building type	Energy needs for space heating, kWh/season	Electricity needs, kWh/year	Cold water needs, m^3 per day	Hot water needs, m^3 per day
Residential building Type 1	7,777.62	1,794.38	350.0	150.0
Residential building Type 2	9,520.73	1,955.70	437.5	187.5
Residential building Type 3	11,075.58	2,323.20	262.5	612.5
School	104,415.15	18,082.50	2,880.0	1,260.0
Kindergarten	88,586.71	78,002.94	4,200.0	2,100.0
Administrative building 1	27,895.58	26,920.56	915.0	475.0
Administrative building 2	27,895.58	26,920.56	369.0	287.0
Administrative building 3	27,895.58	26,920.56	369.0	287.0
Administrative building 4	27,895.58	26,920.56	388.0	522.0

Space heating technologies include using electrode boilers “Krepish Gradient” for 200 houses. The manufacturer claims that compared to traditional electric heaters (TEHs), these units produce the same amount of thermal energy by consuming on average 50% less electricity. At the same time, traditional stove firewood/pellets will be also installed to guarantee additional method of space heating and cooking that is more traditional for local residents. This method also implies that residents can consider electricity economy when needed, particularly during the cold winter days.

The water needs will be met by the artesian wells. Hot water for residential buildings will be provided through the solar thermal technologies installed at each house.

Table below demonstrates the solutions and key characteristics of the technologies used for meeting residents' energy and water needs.

Table 5: Solutions used in the project.

№	*Infrastructure Components and Facilities*	*Description*
1. Economic Infrastructure		
1.1 Energy		
1.1.1	HES (636 kW)	Archimedes Plant consisting of 3 generators with installed capacity of each 212 kW. Annual production capacity is 5.5 million kWh.
1.1.2	Solar power plant with installed capacity of 325 kW	The most modern 455 W photovoltaic panels.
1.1.3	Solar collectors (200 units installed capacity of 400 kW)	Evacuated tubes solar collector from INCI Systems manufacturer.
1.1.4	Gradient electric boiler (200 pieces)	Based on reports obtained from the manufacturer's test results, and compared to traditional electric heaters (TEHs), this unit produces the same amount of thermal energy by consuming an average of 50% less electricity.
1.1.5	Wood stove	Stove that meets the needs of the kitchen and heating. Operates on firewood/pellets.
1.1.6	Smart distribution network	240 subscribers in the village will be equipped with smart meters. Smart meters wirelessly transmit information on energy consumption, external interference and accidents to data collectors installed on 11 transformers located in rural areas, and data from data collectors is sent to the dispatch center. An additional advantage of the meter is that operating and maintenance costs are very low and eliminates the need for additional manpower to collect information on subscribers' energy consumption. The device provides the necessary database for various analyzes, protecting information on energy consumption for up to 10 years.
1.1.7	Electric charging stations for cars	The village waste will be transported by electric garbage truck and the truck will be filled at the electric charging station. Given the fact that in the near future, traditional vehicles will be replaced by electric cars, the importance of these points will increase sharply.
1.2 Road		
1.2.1	Bicycle paths	13.6 km of bicycle roads planned to be built in the village. This solution has a positive impact on the environment and ecology, but also reduces health costs as a result of its benefits to human health. The United Nations HEAT (Health and

		Economic Assessment Tool) software has been calculated to reduce cycling deaths and its economic impact. In addition, research has shown that riding a bicycle instead of a car for 10 km a day will prevent the emission of 720 kg of greenhouse gases per year.
1.3 Telecommunications		
1.3.1	Information and Dispatch Center	It is designed to monitor, collect and process data from power plants, in general, the network, as well as information received from surveillance cameras and meteorological observation stations. If necessary, it will be possible to intervene in the operation of power sources, pumps, switches and other devices by direct interference. The center is of great importance in ensuring the efficient use of the power grid and other systems, making better decisions by analyzing the data and preventing the occurrence of potential accidents, including failures, and minimizing the effects of system failures.
1.3.2	Automatic meteorological observation station	The most important of these elements, the meteorological observation station, is a tool that helps the rural population to plan their daily and economic activities by providing real-time and accurate data on weather information. Thanks to the accurate information provided by this station, statistical analysis can be carried out and future-oriented agricultural planning can be carried out. This, in turn, will boost economic development with increased productivity.
1.4 Water Supply, Dam, Canal and Sewage System		
1.4.1	Smart home (purified) drinking water supply network	Due to the installed smart water meters, information on water consumption, interference and leaks is immediately sent wirelessly to the data center via light meters. The device provides the necessary database for various analyzes, protecting information on energy consumption for up to 10 years.
1.4.2	An artificial lake for irrigation, entertainment and electricity	Due to the recreational areas to be developed around the lake, the opportunity to engage in canoeing, kayaking and other sports activities, in particular, will increase the opportunities for tourist activities. The water collected in the lake will be a necessary source of water for the operation of the hydropower plant. In addition, lake water will be used to irrigate the surrounding fields. Due to the contact of water with air, the amount of oxygen will increase and contribute to the biodiversity of the lake.
1.4.3	Pressure pools for water supply	Efficient use of relief
1.4.4	Water canals and lines within the village for irrigation	The relief-adapted irrigation system is designed to be used without the need for additional power sources
1.4.5	Sewage network	The relief-oriented sewage system is designed to be used without the need for additional power sources.
1.4.6	Wastewater treatment plants	Wastewater treatment will provide 63,875 cubic meters of technical water per year, which could be used to irrigate the common green areas of the village.

1.5 Waste Management		
1.5.1	Waste management, sorting and transportation	Garbage bins installed for waste sorting will be transported to the destination by an environmentally friendly electric garbage truck.
2. Social Infrastructure		
2.1 Accommodation		
2.1.1	200 energy efficient dwellings (80/80/40)	Thermoblocks were used in the construction of the outer walls of the houses in the Smart village project, and energy-efficient insulation materials were used in the construction of the ceilings and floors. These solutions allow buildings to become more energy efficient than traditional buildings. Thus, it results in a reduction of energy used for space heating.
2.2 Education		
2.2.1	A fully equipped energy efficient school for 360 students	Thermoblocks were used in the construction of the outer walls of the houses in the Smart village project, and energy-efficient insulation materials were used in the construction of the ceilings and floors. These solutions allow buildings to become more energy efficient than traditional buildings. Thus, it results in a reduction of energy used for space heating. Opportunity to organize online teaching.
2.2.2	60-bed local fully equipped energy-efficient kindergarten	Thermoblocks were used in the construction of the outer walls of the houses in the Smart village poject, and energy-efficient insulation materials were used in the construction of the ceilings and floors. These solutions allow buildings to become more energy efficient than traditional buildings. Thus, it results in a reduction of energy used for space heating.
2.3 Organization of administrative and other services		
2.3.1	4 energy efficient office buildings	Thermoblocks were used in the construction of the outer walls of the houses in the Smart village poject, and energy-efficient insulation materials were used in the construction of the ceilings and floors. These solutions allow buildings to become more energy efficient than traditional buildings. Thus, it reulsts in a reduction of energy used for space heating.
2.4 Tourism, Entertainment, Recreation and Sports		
2.4.1	Construction of recreation and active recreation areas around the artificial lake	Effective leisure and development of tourism business.
2.4.2	Construction of a fountain and a park in the center of the village	Effective leisure, holding mass events Attracting tourists.
2.4.3	Landscape-recreation	Improving the well-being of residents and attracting tourists.