IMPROVING ENERGY AND RESOURCE EFFICIENCY IN GREENHOUSE CULTIVATION IN KOSOVO PROJECT

DELIVERABLE # 2: ASSESSMENT OF RENEWABLE ENERGY TECHNOLOGIES & HYDROPONICS IN KOSOVO GREENHOUSE OPERATIONS

May 29, 2019

This report was produced for review by the United Agency for International Development. It was prepared by Agritecture, Subcontractor, and Crimson Capital Corp., Prime Contractor.

IMPROVING ENERGY AND RESOURCE EFFICIENCY IN GREENHOUSE CULTIVATION IN KOSOVO

DELIVERABLE # 2: ASSESSMENT OF RENEWABLE ENERGY TECHNOLOGIES & HYDROPONICS IN KOSOVO GREENHOUSE OPERATIONS

Consortium Members:	Crimson Capital Corp. (Prime Contractor) Agritecture (Sub Contractor)
Purchase Order No.:	72016719P00003
Contracting Officer Representative:	Besa Ilazi
Project Director:	Megan Falvey

TABLE OF CONTENTS

ACRONYMS

CEA	Controlled Environment Agriculture
CO_2	Carbon Dioxide
GIZ	Gesellschaft für Internationale Zusammenarbeit
DWC	Deep Water Culture
GH Operator	Greenhouse Operator
ITP	Innovation and Technology Park
ha	Hectare
kWp	Kilowattpeak
MAFRD	Ministry of Agriculture, Forestry and Rural Development
m^2	Meter squared
NFT	Nutrient Film Technique
pH	Potential of Hydrogen
PV	Photovoltaic
USAID	United States Agency for International Development
VET	Vocational Education and Training

BACKGROUND

The Improving Energy and Resource Efficiency in Greenhouse Cultivation in Kosovo program (the Program) is a USAID-funded, 13-month long project that is designed to research and bring to light improvements in technologies for greenhouse cultivation in Kosovo and how to finance them in two primary areas: (1) Renewable Energy Technologies; and (2) Hydroponics; in a format that is accessible, practical and usable for Kosovo's greenhouse operators.

The hypothesis is that if technologies for reducing energy costs, reducing natural resource use (energy/water) and improving energy reliability in greenhouse production in Kosovo are better understood by greenhouse operators, combined with a better understanding of how to finance these technologies, then greenhouse operators in Kosovo will be more likely to uptake these technologies and the overall efficiency of greenhouse production in Kosovo will be improved.

The Program will:

1. Conduct an overview, sampling 10 greenhouses in Kosovo
2. Develop an assessment of application of renewable energy technologies and hydroponics in Kosovo
3. Develop Optimal Technological Packages for the 10 greenhouses sampled
4. Create a Toolkit for greenhouse operators in Kosovo of technologies for renewable energy and hydroponics, providing practical guidance on potential options for how to source financing for these technologies
5. Provide support to select greenhouse operators in accessing finance
6. Produce a Study Report compiling data and information gathered from activities 1-5 above

During the period March 4-16, 2019, project experts conducted on-site, field-based research at 10 greenhouse operations in Kosovo, in order to better understand the technologies currently used by greenhouse farmers in Kosovo and the challenges they face in their greenhouse operations. See Program Deliverable # 1 for further details.

This report covers item # 2 of the Program, an assessment of renewable energy technologies (specifically, solar and biomass) and hydroponics for greenhouse operators in in Kosovo. It provides an overview of renewable energy (solar and biomass) technologies appropriate for Kosovo greenhouse operators and also provides an assessment of the potential for using hydroponic systems in greenhouse operations in Kosovo.

RENEWABLE ENERGY TECHNOLOGIES

Renewable Energy (RE) technologies implemented in greenhouse operations can decrease energy inputs needed from the electrical grid and/or from fossil fuels, while improving energy reliability. RE technologies can be used to heat and cool the greenhouse environment, in addition to running mechanical equipment. It is important to note that Kosovo implements a net metering scheme. Net metering allows owners of renewable energy systems to use excess electricity produced to offset their bills. However, even with net metering in place, the capital costs of RE technologies can be prohibitive for the average farmer in Kosovo without financial assistance.

The Ministry of Agriculture, Forestry and Rural Development (MAFRD) of Kosovo offers cost-shared grants to eligible farmers for installation of renewable energy technologies. Commercial financing is also available through financial institutions. Both of these options are covered in more detail in the Toolkit.

SOLAR

The integration of ***solar photovoltaic (PV) panels*** can provide long-term operational savings and reliability to greenhouse farmers. PV systems include several components:

Component	Description
Solar Panels	Absorb and convert sunlight into electricity
Inverter	A mechanism that converts Direct Current (DC) to Alternating Current (AC)
Racking	Panels are mounted in racking which is placed on the ground or roof angled for the optimal degree of sun exposure
Performance Monitoring	To verify the performance of the PV system
Storage Options	Batteries can be installed to store excess energy

Table 1: Components of a PV System

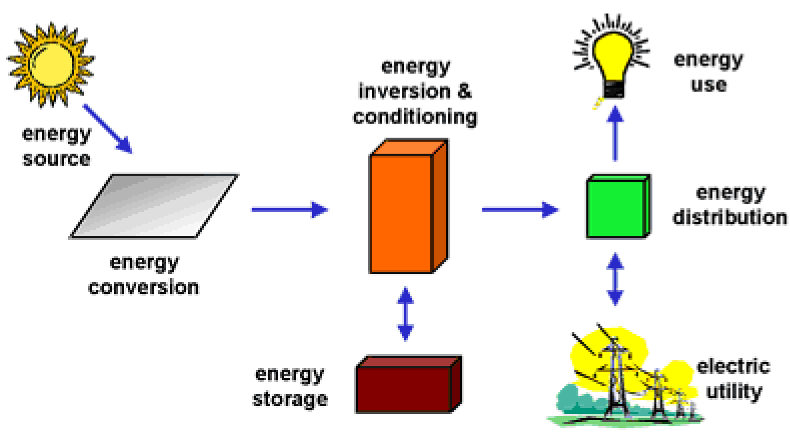

Figure 1: Main photovoltaic system components[1]

[1] http://www.fsec.ucf.edu/en/consumer/solar_electricity/basics/how_pv_system_works.htm

Currently, the capital costs per kWp installed of solar PV in Kosovo ranges from €850 - €1,100, depending on the technology/producer. If the system is off grid (battery system), then the price per kWp installed is roughly is €1,500 - €1,700. Operational costs are minimal; usually, no operational costs are calculated for small projects. Energy outputs are contingent on the location of the project site and the solar radiation. In Kosovo, energy output is estimated to be between 1200-1400 kWh/m2/annum.

Solar thermal for heating greenhouses in combination with biomass heating (used to heat water accumulation tanks during the night, when no solar energy is produced) also warrants consideration. The capital costs of such a hybrid solar-thermal / biomass heating system would be roughly €17,000 with operational costs (pellets or biomass) running roughly €1,000 per season, sufficient for heating a greenhouse of 1,000 m^2.

BIOMASS

Biomass heating in greenhouses can provide an environmentally sustainable and reliable heating solution for commercial greenhouse operators. Globally, common types of biomass fuel include corn, small grains, prairie grass pellets, and wood pellets. In Kosovo, wood pellets are the most common form of fuel used in biomass heaters. Wood pellets are biofuels made from typically made from compacted sawdust and related industrial wastes from lumber mills and manufacturers of wood products.

The current capital costs for purchase and installation of a biomass heating system in Kosovo runs about €10 per m^2. Depending on the type of pellet used, operating costs would be in the range of €1,600-€2,000 for the season, assuming 8-10 tons of pellet used (sufficient for a greenhouse of 1,000 m^2).

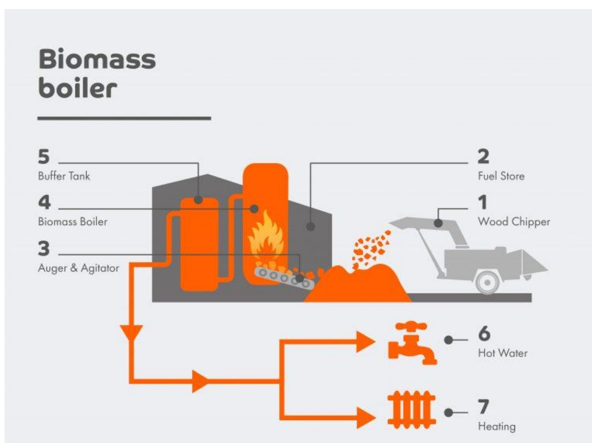

Figure 2: Example workflow of Biomass heater/boiler[2]

The companies listed in Table 2 below provide a range of biomass heating and solar solutions for greenhouse operators in the Kosovo.

[2] https://www.bamfordsyeovil.com/renewables/biomass-boilers/

VENDORS OF RE TECHNOLOGIES

Below is an overview of some of the more prominent solar PV and biomass stove vendors / installers / manufacturers in Kosovo. Other vendors may be preferential depending on specific needs of farms and project budget.

Name	Location	Products/Services Offered
Elen	Kosovo	Complete Solar Solutions Solar panels Battery Storage Power Inverters Backup Generators Engineering, Procurement, and Construction Financing
Eng House	Kosovo	Central heating systems using Biomass
Enrad LLC	Kosovo	Pellet Stoves Boilers
Green Energy Technologies (GET) Group	Kosovo	Solar Panels (PV and Solar Thermal) Central Heating Systems using Biomass
Italterm	Kosovo	Central heating systems using Biomass Solar Thermal Systems
Jaha Group	Kosovo	Solar panels Battery Storage Power Inverters Off & on grid Solutions * Jaha Group also manufactures solar panels
Muqa Solar	Kosovo	Solar Hot Water Heaters Solar Room Heating Collectors Pump Stations Freshwater Modules Heating Modules
Swiss Pelet	Kosovo	Wood pellet production Retail of pellet stoves
Termoluli	Kosovo	Solar Thermal System Central heating systems using Biomass
Termoteknika	Kosovo	Central heating systems using Biomass
Thes-Ari	Kosovo	Wood pellet production

Table 2: PV Solar and Biomass Energy Companies

OBSERVATIONS ON RE TECHNOLOGIES

Table 3 illustrates which of the 10 GH operators surveyed had solar PV or biomass heaters installed on their farm.

GH	Operator	Solar PV	Biomass	Notes
1	Halim Baftiu	10 kW System - €12,000	No	N/A
2	Izet Kastrati	No	No	If financing were available, then would purchase heating system for seedling production and ventilation equipment
3	Nexhat Morina	2.5 kW with batteries Total Cost: €4,500 Farmer paid €3,000 MAFRD provided a grant of €1,500	No	Solar PV system used to power well pump
4	Regjep Kryezi	2.5 kW System with batteries Total Cost: €6,000 MAFRD provided a grant of 60%	No	Solar PV system used to power well pump. Disconnects battery so it is not stolen and to take to other fields to power pumps in each place.
5	Ekrem Duraku	No	No	Would use RE for heating of seedlings
6	Armend Krasniqi	No	No	Plans to install solar panels in the future for house and greenhouse (for irrigation) Water heater for house - PV System
7	Nasim Morina	No	No	Interested in solar but cannot afford it (estimated at €4,000 for his operations)
8	Ylber Kuqi	No	No	N/A
9	Ismajl Doraku	No	No	N/A
10	Selmon Shala	2.5 kW System - €4,000 40% paid by farmer and 65% financed through a grant from MAFRD	Yes	Solar PV used for pumps. Biomass heater not used due to operational costs and inefficiencies.

Table 3 Solar PV & Biomass Systems by Greenhouse Operator

Regarding Solar PV, four of the greenhouse operators visited had Solar PV systems installed. These operators noted that the systems provided substantial operational benefits (both energy reliability and cost savings), but that they were only able to purchase the equipment with the support of grants from MAFRD. The majority of operators interviewed are interested in pursuing solar PV solutions, but only with financial support.

None of the greenhouse operators visited are currently using solar thermal systems for heating greenhouses.

Figure 3: 2.5 kW Solar PV System – GH 3

Figure 4: 2.5 kW Solar PV System – GH 10

Regarding biomass heating, only one greenhouse operator visited had a biomass heating system onsite. However, due to the high operational costs and inefficiency of the system, it is rarely used. Biomass heating solutions can be a good option for heating for greenhouse operators located in areas of unreliable electricity or heating options. However, if biomass heating solutions are not properly installed and a reliable source of biomass fuels not secured, this heating solution will be inefficient and expensive.

Figure 5: Unused biomass heater – GH 10

In terms of application of RE technologies at the 10 greenhouse operations surveyed, one immediate energy need observed which could be addressed by RE was the lack of ventilation equipment in the greenhouses surveyed. A renewable energy solution that greenhouse farmers could implement is horizontal airflow fans and ventilation to exhaust excess heat and humidity, especially during the summer months. PV Solar panels can serve as a source of electricity to operate exhaust fans, airflow fans, irrigation pumps, and any other mechanical equipment that requires electricity.

HYDROPONIC SYSTEMS

Globally, there are numerous types of hydroponic technologies. Theoretically, all of these could be imported and implemented in Kosovo. This report focuses on the hydroponic technologies that would be most practical to use in Kosovo, based on the major crops cultivated by the greenhouse operators.

Table 4 illustrates the main crops observed in Kosovo greenhouse operations and corresponding hydroponic system options:

Crop	Hydroponic System Options
Lettuce	Nutrient Film Technique (NFT), Deep Water Culture (DWC), Ebb & Flow
Tomatoes (Vine)	Drip (Slab or bucket)
Cucumbers (Vine)	Drip (Slab or bucket)

Peppers (Vine)	Drip (Slab or bucket)
Melons (Vine)	Drip (Slab or bucket)
Strawberries	Drip (gutter), Tower
Spinach	DWC (not recommended due to pythium disease)
Seedling Production	Ebb & Flow

Table 4: Main Crops in Kosovo Greenhouse Operations & Hydroponic Systems Options

SOIL-BASED CULTIVATION VS. HYDROPONIC CULTIVATION

It is important to understand the difference between soil-based cultivation and hydroponic cultivation since they are very different and there are often misunderstandings surrounding both methods of cultivation. While there are many differences between the two systems, one critical difference is the concept of "the buffer". When cultivating in soil, the soil has certain properties. Some examples of the key properties are the soil temperature, drainage characteristics and oxygen level, pH and nutrient levels. While these characteristics can be adjusted in soil culture, it is not easy to do because the soil being cultivated is connected to the earth. Soil acts as a massive *buffer* to fluctuations. In hydroponic cultivation, the situation is the exact opposite. All the elements described above are controlled by humans (in combination with natural processes) and the buffer of the system is very small. Any changes made by the operator (good or bad) will take effect very quickly and can cause crop loss much more quickly than in soil based systems.

For this reason, hydroponic systems are often referred to as Controlled Environment Agriculture (CEA) because, without the buffer of the earth, they rely on very stable environmental conditions to be successful. CEA can be defined as any agricultural technology that enables the grower to manipulate a crop's environment to the desired conditions for increased crop performance. CEA technologies include greenhouse, hydroponics, aquaculture, and aquaponics among others. Controlled variables include air and water temperature, humidity, pH and electrical conductivity of the soil/substrate/nutrient solution, ambient CO_2 levels, speed of air movement, light spectra, quantity and intensity received by plants, and other variables.

Hydroponic systems require a substrate or grow medium since they don't use soil. A material such as coconut coir, pumice, perlite, rockwool or clay pebbles is used to provide support to plants in a hydroponic growing system. The substrate also allows for proper aeration and access to nutrients.

Rockwool | Oasis Grow Cubes | Coco Coir Slab

Figure 6: Examples of substrates for hydroponic systems

HYDROPONIC PRODUCTION SYSTEMS

Nutrient Film Technique (NFT)

Description	A hydroponic cultivation technique wherein a very shallow stream of nutrient solution is re-circulated past the bare roots of plants in a watertight gully, also known as channels.
Crop Example	Lettuce, herbs
Pros	Lots of oxygen, quite, high density, lightweight
Cons	Not resilient to power failure, set planting density, more equipment needed, very thin buffer, root zone temperature management

Figure 7: Lettuce growing in a commercial NFT system

Deep Water Culture (DWC)

Description	A hydroponic method of plant production by means of suspending the plant roots in a solution of nutrient-rich, oxygenated water.
Crop Example	Lettuce
Pros	Simple, resistant to power failure, accommodates large root mass, easy to scale, variable density, constant water temperature
Cons	System weight, low oxygen retention, water level management

Figure 8: Leafy greens being grown in a DWC system

Ebb & Flow

Description	A hydroponic method of plant production by means of flooding the root zone in a solution of nutrient-rich water, allowing for oxygen in the air for roots as well as allowing reduction in water use.
Crop Example	Lettuce, Seedlings
Pros	Simple, high oxygen levels, accommodates large root mass, quiet, easy to scale, variable density
Cons	System weight, water level management, multiple points of failure, root zone temperature management, power failure resilience

Figures 9: Ebb and Flow system in a greenhouse

Figure 10: Multilayer ebb & flow system ideal for seedling production

Drip (Slab or Bucket)

Description	A hydroponic method of plant production by means of drip irrigation through a porous substrate that holds the root zone. Irrigation water drains into a channel and is returned to a main reservoir for re-circulation.
Crop Example	Tomatoes, Peppers, Cucumbers, Strawberries
Pros	High oxygen levels, accommodates large root mass, quiet, easy to scale, variable density, allows for specific plant treatments
Cons	Multiple points of failure, difficult to set up

Figure 11: Drip hydroponics- slab

Figure 12: Drip hydroponics - bucket


Figure 13: Strawberries growing in a gutter based drip system

Tower System

Description	A hydroponic method of plant production by means of sprinkler or shower type irrigation, which wets root systems on the inner surface of a vertical cylinder. Tower systems may each have their own reservoir or connected to a central reservoir.
Crop Example	Lettuce, Strawberries
Pros	High oxygen levels, accommodates large root mass, easy to set up, attractive, make use of vertical space
Cons	Expensive, no density variation, hard to clean, hard to observe roots, hard to automate, not commercially proven for strawberries


Figure 14: A vertical tower system from Germany

OPERATIONAL COSTS OF HYDROPONIC SYSTEMS

Costs of hydroponic systems vary greatly depending on a number of factors and it is very hard to estimate costs without a specific site under consideration. Factors that will influence project price include:

- System size
- Site conditions upgrades required- plumbing, electrical, ventilation, structure, etc.
- System complexity

Table 5 below illustrates "ballpark" purchase costs for hydroponic systems, exclusive of any applicable shipping costs or customs duties. Operational costs will be comprised of labor, electricity and inputs such as seeds, substrates & fertilizers. These costs will vary on a site-by-site basis.

Crop & System	**Costs**	**Labor Requirements**	**Other Costs**
Strawberries/ Drip / Gutter	€6.5 linear meter gutter, plus growing container. Irrigation lines cost €0.35-0.5 per meter. Supports for the gutters cost €2-4 each & spacing is required every 1.33 meters. The total cost is approximately €10 per linear meter of system. Source: Magan-Mak, Macedonia (Mapal System)	1 person per 700 m^2	Additional cost for substrate, rhizomes, central reservoir, pumps, sensors, controllers, filters, etc. These costs will be based on the number of plants and system design.
	Generic system costs €2.06 linear meter gutter €0.35 linear meter irrigation	1 person per 700 m^2	Additional cost for substrate, rhizomes, central reservoir, pumps, sensors, controllers, filters, etc. These costs will be based on the number of plants and system design.
	NGS (Spain) offers a complete system for strawberries. Cost is €73,000/ha with 100,000 plant sites. They also offer an oscillating system which costs €192,000/ha with 200,000 plant sites. Minimum size 0.5 ha	1 person per 700 m^2 1 person per 350 m^2	Rhizomes, substrate & fertilizer
Lettuce / Strawberries Tower	Aponix (Germany)[3] 0.1 ha greenhouse	Varies by crop and quality of production	Plants/ Rhizomes, substrate & fertilizer

[3] Note: these vertical tower systems are used commercially for lettuce, but have not been used commercially for strawberries.

	333 towers 2.1 m tall (each tower) 142 plant sites per tower €178,400 Note: these tower systems are used commercially for lettuce but have not been used commercially for strawberries	required, time of year, etc. Likely 1 person per 25-35 towers	Central reservoir, pumps, sensors, controllers, filters, etc.
Lettuce / NFT	Generic System €38-75 per SQM bedspace	1 person per 140-180 m^2 bedspace	Plants/ Rhizomes, substrate & fertilizer Central reservoir, pumps, sensors, controllers, filters, etc.
	NGS (Spain) offers complete systems for lettuce. Cost is €150,000 per ha for a static system with 165,000 plant sites. In greenhouse, with appropriate climate control, 8-10 harvests per year. They also offer a mobile system where cultivation rows slide. This system costs €240,000 per ha with 225,000-240,000 plant sites. Minimum size 0.5 ha		Plants/ Rhizomes, substrate & fertilizer
	Complete systems offered by Magan-Mak (Macedonia): €55 per m^2 (0.1 ha) €49 per m^2 (0.2-0.9 ha) €45 per m^2 (1.0 ha or larger)		
Lettuce / DWC	Generic System €40-90 per m^2 bedspace	1 person per 160-200 m^2 bedspace	Plants/ Rhizomes, substrate & fertilizer Central reservoir, Pumps, Sensors, Controllers, Filters, etc.
Lettuce / Ebb & Flow	Generic System €38-75 per m^2 bedspace	1 person per 140-180 m^2 bedspace	
Vine Crops / Slab	Generic system costs €2.06 linear meter gutter €0.35 linear meter irrigation	Varies by crop & season	Additional cost for substrate, rhizomes, central reservoir, pumps, sensors, controllers, filters, etc. These costs will be based on the number of plants and system design.
	Generic system costs €9-13 per linear meter including gutters and slab/substrate.		Additional cost for plants, irrigation, central reservoir, pumps, sensors, controllers, filters, etc. These costs will

			be based on the number of plants and system design.
Vine Crops / Bucket	€30-50 per m^2 bedspace		Additional cost for substrate, rhizomes, central reservoir, pumps, sensors, controllers, filters, etc. These costs will be based on the number of plants and system design.
Vine Crops / NGS	NGS (Spain) offers complete systems for vine crops. Cost is €55,000/ha for a static system with 15-30,000 plant sites.		Plants/ Rhizomes, substrate & fertilizer
Seedlings / Ebb & Flow	These systems have the following main components: rack, lights, trays, reservoir & pumps. Other optional components are heating pads, timers, sensors/controllers. The main cost driver is the lights & sensors / controllers. For a more affordable system, fluorescent lights are recommended. €400 - €1,000 per system.	Seeding is time intensive. Once plants are in system, little work is needed.	Seeds, Substrate, Flats & fertilizer

Table 5: Ballpark costs for hydroponic systems

VENDORS OF HYDROPONIC SYSTEMS & COMPONENTS

Below is a list of vendors located in the U.S. and Europe that could be suppliers of required hydroponic materials. Other vendors may be preferential, depending on specific needs of farms and project budget.

Name	Location	Products
NGS systems	Spain	Proprietary cultivation systems
Meteor systems	Holland	Racks for strawberry cultivation
Aponix systems	Germany	Tower systems
TAP systems	Various	NFT systems for lettuce
CropKing Inc	US	NFT, Bato Bucket
AmHydro	US	NFT, Bato Bucket, Slab
D-light	Holland	Seedling System
Grow Pact	Holland	Community Seedling System
Balkan Greenhouse	Macedonia	Fertilizer, Substrate, Greenhouses

Magan Mak	Macedonia	Distributor of systems for multiple types of hydroponic systems for various crops

Table 6: US & European Hydroponic Equipment Vendors

OBSERVATIONS ON HYDROPONIC SYSTEMS

For a market for hydroponic vegetables to exist, four elements are required:

1. Farms willing to use hydroponic means of production and invest in these technologies
2. Availability of suppliers of hydroponic equipment and inputs
3. Trained individuals to operate hydroponic facilities
4. Consumer demand for hydroponic produce

Converting to Hydroponic Technology

The research conducted in Kosovo included discussing with10 greenhouse operators their experience, knowledge, and interested regarding hydroponic cultivation, as summarized in the table below.

GH	Operator	Knowledge / Experience with hydroponics	Interested
1	Halim Baftiu	Has seen facilities in Germany & Macedonia. Interested in trying hydroponics but money is an issue.	Yes
2	Izet Kastrati	Has seen 2 hydroponic facilities both of which were not functional. One was in a greenhouse damaged by a snowstorm and the other was not financially viable due to the high cost of inputs and shut down. He has heard that yields can be high using hydroponics but that the investment is high. He is open to trying.	Yes
3	Nexhat Morina	Mamusha is home to the only hydro operation in Kosovo, which failed. He has seen successful hydro operation in Greece for lettuce. He thinks that in Kosovo it is very difficult because of lack of knowledge and expertise to have successful operations	No
4	Regjep Kryezi	Has seen in Turkey. Not interested in trying because it is too expensive.	No
5	Ekrem Duraku	Would be interested in seeing an agricultural demonstration area in Mamusha or other place so that he could go and learn. He is interested based on what he has seen on the internet but feels that there is a large gap between the technology available in Kosovo and reaching that level.	Yes
6	Armend Krasniqi	Has knowledge of hydroponic systems and operations but doesn't believe that it can be profitable in Kosovo.	No
7	Nasim Morina	Has knowledge and wants to implement a tower-based system for strawberries in his greenhouse. He sees a vertical system as providing more density than a gutter system. He has researched hydroponics and also visited in Holland.	Yes

8	Ylber Kuqi	No knowledge	No
9	Ismajl Doraku	No knowledge	No
10	Selmon Shala	Has visited facilities in Macedonia and Holland. Seems to be satisfied with current operation.	No

Table 7: GH operator knowledge of hydroponics

Of the 10 greenhouse operators interviewed, four are potentially interested in pursuing hydroponics. Only one operator seems serious about trying hydroponics on his own (GH 7). Two operators would be interested in trying hydroponics if capital expenses were not an issue (GH 1, 2) and one operator (GH 5) is interested in learning at an agricultural training facility.

As a comparison, all operators interviewed as part of this project were interested or very interested in insect screening for their greenhouses, yet none had taken the initiative to install it. The main reason given is the expense. The cost and complexity of insect screening is very small compared to that of a hydroponic installation so it is unlikely that these operators who feel only slightly motivated/interested in the idea would take action on it without any sort of economic incentive.

Based on research conducted by the Team, there are no functioning commercial hydroponic-based operations in the country. One facility was setup in Mamusha approximately three years ago for tomato production, but it is currently not operating. It appears that the facility was not successful due to a lack of knowledge of facility operators, but without having access to details about facility economics, production, etc., it is hard to determine exactly what went wrong.

Figure 12: Shuttered hydroponic facility in Mamusha

Availability of suppliers of hydroponic equipment and inputs

The team is not aware of any suppliers of commercial scale hydroponic equipment in Kosovo. One hobby hydroponics store was discovered in Pristina, but that serves a different market. The closest supplier is Magan-Mak, located in Skopje, North Macedonia. Magan-Mak is capable of supplying all equipment for hydroponic production. They source the majority of their equipment from Israel, which has very reputable equipment. Many suppliers exist in other European countries such as Holland and Spain. Additionally, the team is aware that there are suppliers in Turkey because all the equipment for the failed operation in Mamusha was sourced there. Equipment can also be sourced from the US, although having European suppliers, especially for replacement parts, would be advantageous, in case of operational emergencies.

Trained individuals to operate hydroponic facilities

While technology is an integral part of hydroponic facilities and production, technology cannot operate hydroponic facilities alone. As discussed earlier in this document (regarding the level of buffer in soil vs. hydroponic systems), hydroponics is an exact science and the lack of a buffer means that things can go wrong very quickly and easily. For this reason, a highly trained and experienced individual is required to manage a successful hydroponic facility. The failed facility in Mamusha did not appear to have a trained operator (it was run by family members). It is not clear if this was due to a lack of funds to hire this person, a lack of available talent, or the impression that it was not required.

It is not clear that there is an existing talent pool to operate hydroponic facilities available in Kosovo. According to agricultural expert Dr. Ismet Babaj, there are no courses offered on hydroponics or soilless culture at the agricultural departments at the universities in Kosovo, nor is there any hydroponic equipment at the campuses for testing or learning.

Hydroponic Farming at Kosovo's Doorstep

Located in Bogdanci, North Macedonia, Badzo Farm is the closest successful, commercial-scale hydroponic farming operation. The company started with hydroponic production of tomatoes and cucumbers in 2009, and now operates 18 hectares under hydroponic cultivation, using Israeli hydroponic equipment. The company engaged an international consultant during the start-up phases of its hydroponic operations.

Professor Dr. Astrit Balliu, in conjunction with Dr. Glenda Sallaku, at the Agricultural University of Tirana in Albania, offer a course on soilless production methods to approximately 30 students per year. The course outline was reviewed and the course content is an excellent way to prepare technical staff for operating hydroponic greenhouse systems.

Consumer Demand for Hydroponic Produce

Setting up hydroponic production is much more capital intensive than establishing field production on a per hectare basis. Operating costs of hydroponic production can be comparable or even lower than field production, depending on crop, location of production, scale, labor rates, amount of automation, etc. Because the initial costs are higher, hydroponic crops cannot compete with traditional conventional production and require a different market. Potentially viable markets for hydroponic production are the following:

- Consumers willing to pay more for higher quality of produce
- Consumers willing to pay more for cleaner/unsprayed produce
- Urban consumers willing to pay more to "know their farmer" in DTC (direct to consumer) business models
- Restaurants that want to partner with local farms and feature them on their menu
- Produce cultivated during gaps in the conventional production calendar
- Production of high value crops that can't be cultivated in outdoor production systems
- Produce cultivated for export

Do any of these markets exist in Kosovo? While it is not clear that they exist now, it appears that several are developing. While visiting farms, anecdotal evidence was observed that leads the team to believe that these markets will develop in the near future. This anecdotal evidence includes:

- The restaurant industry seems to be developing very robustly in Pristina and there may be opportunities for restaurants to partner with local farms that have similar values. These farms could, in turn, produce specific crops for these restaurants, and get a higher value. In theory, both parties win since the restaurant gets a premium for the food because of the story associated with it; and the farm wins because they sell at a higher value due to the direct relationship. These relationships must be cultivated (no pun intended) between the restaurant and farm and will take time to develop. The team visited AgroSerra farm on March 16, 2019 in Mitrovice. Gani Hajzeri, the farm owner and operator, grows tender salad mixes for restaurants in Pristina and other locations. He has been working to develop these relationships for many years and believes that the future is bright but it will take patience.

- There also seems to be a developing sector of younger consumers who have the financial means and desire to pay a premium for higher quality produce. It is obvious that Pristina is developing rapidly as a city. The new real estate will bring higher income individuals to these locations and they will likely have the means and desire for higher quality produce.

In short, the potential for the markets addressed by hydroponic production are directly linked with the economic development of Kosovo. Understanding these economic projections will better predict the probability of the development of these markets.

FINAL OBSERVATIONS & RECOMMENDATIONS

- There is a well developed solar and biomass industry within the Kosovo region that can provide local RE technological solutions to farmers.
- Solar solutions can provide a reliable source of electricity and long-term operational savings for farmers. However, the capital costs of these systems can be prohibitive. A community/shared solar installation could potentially distribute the costs over several farmers and this will be further explored.
- Biomass heating solutions can provide affordable and long-term operational savings for farmers, but the source of biomass fuels and sizing of equipment must be properly evaluated for a farmer/operator to receive the benefit. It could be useful to install a demonstration system to help determine the fuel and sizing requirements that would meet local conditions.
- Hydroponic technologies can increase production and provide a higher level of control over the quality of produce. However, similar to the renewable energy technologies, the high capital costs of these systems can be a barrier for farmers. In addition, hydroponic facilities require highly trained operators. Of the 10 greenhouse operators we surveyed, none had experience with or knowledge of hydroponics. For a successful introduction of hydroponics in Kosovo, there should simultaneously be efforts to develop the market for higher quality produce (both domestically and for export) and to develop the technical capacity of greenhouse operators in the region. There would be a benefit to installing a demonstration hydroponics facility for training purposes and determining the further requirements for Kosovo. Prime Contractor Crimson discussed the possibility with GIZ of installing a demonstration hydroponics facility in one of the buildings of the Innovation and Technology Park (ITP) being implemented at the former German KFOR base in Prizren. The ITP is planned to support entrepreneurship, ICT, agriculture, VET and non-formal education, science and research, and tourism and culture. Sub-contractor Sub Contractor Agritecture confirmed that the building was suitable for a self-contained (room within a room), working hydroponics system that could be used for training as well as producing high value products year round. As the ITP moves forward, we will continue discussions with GIZ.
- Most of the farmers interviewed, and most farmers in Kosovo, are older and are not very tech savvy. They are also quite conservative and tend to be committed to traditional farming. It will

be important to attract the younger generations into agriculture to explore both new crops and markets, and also new methodologies and technologies.

- In order to attract younger people into agriculture, it will be critical to provide training and capacity building in the most modern methods and technologies, including RE and hydroponics. It would be helpful to implement agricultural training centers in main growing areas in Kosovo to overcome the knowledge and skill gaps, especially with the new technologies. The plan for ITP in Prizren includes just such a center. This center could include training on the utilization of solar PV, solar thermal, biomass, hydroponics, etc.
- Agricultural training centers should be set up in the agricultural areas of the country. These centers will provide both training and inspiration to the area farmers. One component of the training can be hydroponics. Trials should also be conducted at these facilities with new crop varieties, new methods of production and different pest management strategies.
- Kosovo has opportunities to develop an agritourism sector, which includes hydroponics. Creative applications of hydroponics may be a viable means of implementation. This restaurant in Iceland is a good example of agritourism: https://fridheimar.is/en/tourist-services.

U.S. Agency for International Development
Mission in Kosovo
Ismail Qemali Street, No. 1
Pristina, Kosovo 10130
Tel: +381 (0) 38 243 673
Fax: +381 (0) 38 249 493