

Entrepreneurial options for capacitive electro dialysis in the West Bank, Palestine

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ABSTRACT

The research conducted within the Palestinian Dutch Academic Cooperation on Water (PADUCO) program confirms that capacitive electro dialysis (CED) has the potential of becoming the next innovation in water purification. It uses less energy (<0.5 kWh/m³) than reverse osmosis (3–10 kWh/m³) and is, in particular, promising for local small-scale use, since it produces clean irrigation or drinking water not continuously, but in batches. The current prototype produces 2 m³/d for irrigation and 1.6 m³ for drinking water. Additionally, research has been conducted on options for entrepreneurship, taking into account a conducive context of required policies and institutions. These to an extent appear to be a condition for a successful introduction. The present publication aimed to research the feasibility of using this CED device for four types of use: irrigation for small farmers and large-scale farmers and small-scale and large-scale drinking water companies that presently use reverse osmosis. Preliminary results showed that medium-sized water companies may most easily introduce the technology and that in the long-term small-scale water companies and small-scale farmers may benefit most from the new technology. A scenario for an improved entrepreneurial approach for drinking water companies and farmers is also developed considering their level of sophistication and the further development of the CED system towards large-scale production (of the CED system itself) and user-friendliness. At present, medium drinking water companies and medium farmers appear to be better positioned for the adoption of the new CED technology, as they produce and operate on a higher level of sophistication. Especially for the small farmers but also for small drinking water companies, more training and support, also with capital investment, is required. This can succeed if government agencies, Non-Governmental Organizations, investors, and other stakeholders align their efforts to that purpose, in this way creating a conducive policy and institutional environment. For the initial introduction of the CED system and in order to make it affordable, introduction for humanitarian purposes, refugees, Bedouins could be the first step.

Keywords: Capacitive electro dialysis; Drinking water; Irrigation water; Entrepreneurship; Farmers; Governance

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1. Introduction

The lack of access to clean water is one of the world's major concerns nowadays. According to UNICEF [1], 2.1 billion people worldwide are suffering from the lack of access to safe water, which threatens public health [2]. Many countries are expected to face severe water problems by 2025; the issue is acute where water shortages already occur. Therefore, guaranteeing clean water for all people is goal number 6 of the Sustainable Development Goals, "Clean Water and Sanitation" [3].

The majority of the water crisis problems are occurring in conflict areas, such as the West Bank, Palestine. Palestine has two major water resources: groundwater, including wells and streams, surface water, and some small portions of rainwater collected in cisterns. Groundwater is the primary source of water for the Palestinians in the West Bank and Gaza Strip, supplying more than 90% of all water sources. The major aquifer systems can be classified into four separate units: the West Aquifer Basin, the West Bank North-East Aquifer Basin, the West Bank Eastern Aquifer Basin, and the Gaza Coastal Aquifer, where the groundwater is much shallower [4]. Surface water resources are primarily represented by the Jordan River and ephemeral wadis basically flowing in three directions: the Mediterranean (Gaza Strip and the West Bank), the Jordan Valley, and the Dead Sea.

1.1. Background of water crisis in Palestine

The clean water crisis in the West Bank causes a gap between the market demand and the supply of clean water, which is about 65 million m³ (MCM) per year [5]. The fulfillment percentages of both agricultural demand and domestic demand are 47% and 77%, respectively [4]. The West Bank domestic consumption is deficient, and only 21% of the Israeli domestic consumption and 28% of the global average [6]. Approximately 64% of the clean water supply comes from local resources and 36% is purchased [5]. The water crisis problems in Palestine are here considered from three different perspectives:

First, the technical problems include sourcing, producing, and distributing. Nowadays, continued extraction of groundwater causes water quantity reduction and the deterioration of water quality. The groundwater in the West Bank has a high chlorine concentration of 250 mg/L, while the nitrate concentration is relatively low, which is 50 mg/L [7]. The quality of the groundwater as a source of clean water is shifting from regular water into saline water, even to be categorized as brackish water, especially in the areas of the Jordan Valley and Jericho [5]. Therefore, the production and distribution of clean water should be modified considering the decreasing quality of water sources.

Second, the governance of clean water in the West Bank, Palestine's condition under the occupation of Israel, made all primary resources restricted for Palestinians, including clean water [5]. Israel controls several valuable sources of water. At the internal Palestinian government level, there is a gap between the water-related strategies and the instruments used, indicating the necessity of the cooperation of public and private sectors [8].

Third, the business opportunities for clean water production in the West Bank should also be considered in the context of introducing a new policy framework for solving the clean water crisis in the West Bank. The combination of high demand and high prices of clean water in the West Bank is creating new business opportunities. Furthermore, competitors in the clean water production business are rare, and thus, this condition also drives the business opportunities for clean water production in the West Bank. This transition, however, needs some support from a conducive policy framework.

1.2. Water purification technology as a promising solution

Desalination is one of the water purification processes that remove the high salinity content in the water resource and produce clean water for domestic and agricultural applications. Removing the impurities in the feed water is not the only characteristic of the water purification system. The other criteria are the affordability for the users and the acceptance considering social and cultural conditions [9]. Reverse osmosis (RO) and capacitive electro dialysis (CED) systems are considered to be water purification systems that match the above criteria. The RO system has a low product recovery ratio (25%–50% of the feed water), and requires post-treatment [10], in addition, typical RO requires energy of 3–10 kWh/m³ [11], while our primary investigations showed that the CED system requires less than 0.5 kWh/m³, due to the use of capacitive electrodes.

On the other hand, the CED system offers desalination technology with a water recovery of 90% and salt mineral selectivity to maintain the desired salt mineral [10]. Even seawater can be used as an input, but considering the time required for desalination of seawater different degrees of brackish water may be preferred. Both CED and RO could be used on a wide range of scales. RO is more suitable for big capacity, for example, above 100,000 m³/d feed water, while CED is feasible for small capacities, such as below 10,000 m³/d feed water [10,11]. Considering the situation in the West Bank, the CED system could be seen as more promising than RO as it could be built in a small-scale capacity and decentralized for avoiding the risk of being abandoned by the Israeli Government.

1.3. Business model and entrepreneurship in the West Bank

According to Osterwalder et al. [12], a business model describes "the rationale of how an organization creates, delivers, and captures value". A viable business model is one of the critical factors in designing new strategic alternatives for the future. It is depicted in the business model canvas, containing nine basic building blocks [12]: customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure. The extended business model canvas is suitable for analyzing the business operations of the CED system in the West Bank. As one of the water purification technologies, the CED system also needs to consider social, cultural, and environmental parameters for developing the appropriate business model in the West Bank [9].

The word “entrepreneurship” is in this research understood as social entrepreneurship, not only about seeking opportunities and minimizing risks, but also about providing new environments for the betterment of society [13,14]. Entrepreneurship in Palestine is mainly embodied in small and medium sized enterprises (SMEs) because 97% of economic units in Palestine are organized as SMEs [15]. The entrepreneurial activities in Palestine mainly focus on the service sector and retailer businesses. Therefore, the opportunities to develop new SMEs in the service sector that provide clean water at an affordable price are ample. The only support for SMEs in Palestine is from the United Nations Relief and Works Agency (UNRWA) and Non-Governmental Organizations (NGOs) [15]. These organizations help SMEs through short-term soft loans with flexible collateral instruments.

The Israeli occupation has affected both the governance system and the business operations in West Bank. Israeli occupation is continuously constructing a rigorous institutional system with enforced inset of a militaristic, architectural, and political apparatus that constrains entrepreneurship opportunities in the West Bank [16,17]. The occupation limits the free access of enterprises, especially SMEs, to resources and market goods or services, which leads to lack of long-term planning due to the uncertainty [18]. Notwithstanding the importance of this context, also limitations and opportunities of entrepreneurship in relation to Palestinian institutions and society are taken into account.

1.4. Research objective

The objectives of this research are formulated into three goals. First, it aims to describe the characteristics of the current CED technology, such as water production, capacity, energy consumption, water recovery, and purification efficiency. Second, it develops a viable business model for the CED system considering the sociocultural context of the West Bank. Third, it analyzes the manifestations of cultural dimensions and social arrangements within the different levels of society in the West Bank and identifies the effect of these different levels on the developed business model of the CED system in the West Bank.

2. Materials and methods

2.1. CED prototype

The prototype under scrutiny was developed by The Palestinian Dutch Academic Cooperation on Water (PADUCO) project (Fig. 1). This prototype has been tailor-designed to process the water sources in Palestine, which mostly consist of brackish water. It is a multi-functional system, both for agricultural and domestic use.

This system has been tested for its technical capabilities in the West Bank, focusing on the capacity, the water recovery ratio, the quality of clean water, and energy consumption. Besides, the affordability for users is determined by the ease of use, the maintenance cycle, the operation costs, and the initial costs. The analysis of the current CED

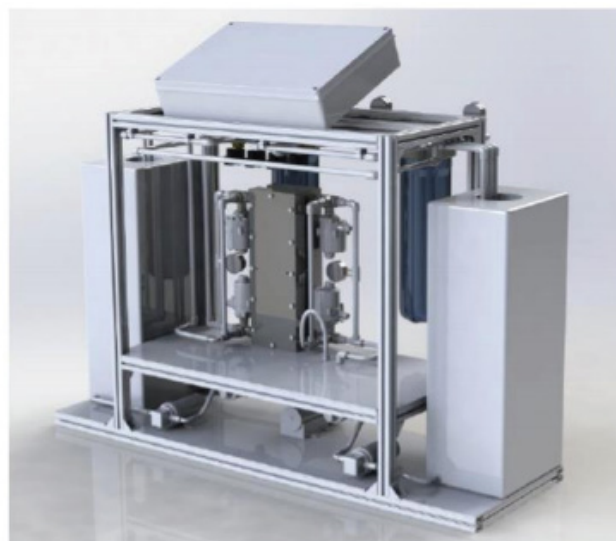


Fig. 1. 3D visualization of the CED system designed by the PADUCO team.

system provided an initial insight into developing a feasible business model for the CED system in the West Bank.

For testing the CED device, synthetic water that simulates brackish water in Jericho, Palestine was prepared with the following characteristics: 3.00 g/L as NaCl, 0.41 g/L $Mg(NO_3)_2$, 0.35 g/L $CaCO_3$, the final pH was 8.00 and electrical conductivity (EC) was 6,200 $\mu S/cm$. CED was operated and monitored for EC and pH for both the treated water and concentrated water, electricity consumption, and pressure across membranes stack. CED system was controlled based on the number of treatment cycles to reach the desired quality of water, in addition to the polarity switch time for the electrodes in the stack for self-cleaning of the system. The system was operated to reach an EC of around 1,000 $\mu S/cm$ for irrigation water and of around 300 $\mu S/cm$ for drinking water.

2.2. Research framework

The research framework has been developed on the base of the social transformation model from [19], which is illustrated in Table 1. The cultural values and institutional conditions are conceptualized by considering six cultural dimensions, selected as the most important ones for doing business from the cultural model developed by Hampden-Turner and Trompenaars [20] and Hofstede et al. [21]. This framework is used to distinguish between two social systems, one system is more oriented on traditional values, and the other system reflects more modern values.

The analysis has been conducted from a multi-level perspective entailing three levels; governance, civil society, and individual enterprises. The analysis was focused on the current status of the three different levels and the impact of each on the business development of the CED system in the West Bank. The Israeli occupation has also been taken into account, which had a strong impact on the governance level and consequently on the policy framework of doing business in the West Bank.

The business model canvas [12] and its extended version [22] were incorporated into the level of individual enterprises for a thorough analysis of the entrepreneurial feasibility of the CED system in the West Bank.

2.3. Data collection

Semi-structured interviews were used for data collection. The interviewees were limited to representatives

from small and medium sized enterprises (SMEs). The geographical distribution of the interviewees was also taken into account in order to enhance the generalizability of this research throughout Palestine. Two types of SMEs have been interviewed in this research, farmers and drinking water companies. The total number of SMEs which participated in this research was eleven, four of them are drinking water companies, and the rest are farmers, as illustrated in Table 2.

Table 1
Research framework adopted from Kroesen et al. [19]

| | System I | | System II | |
|------------------------|-------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| | Institutions | Values | Institutions | Values |
| State | Patrimonialism at the top, granting favors in return for services | Obedience and loyalty, hierarchy, status personalized relationships | Rule of law, universalism, equal access, strong but accountable state institutions | Equal access, transparency |
| Civil society | Closed in-groups, vertical networks, little cooperation | Lifelong solidarity, participation in the traditionalism, uncertainty avoidance | Civil society, open cooperation, changing coalitions (apart from family loyalty and state authority) | Open attitude, shifting alignments and coalitions, multiple memberships, pluralism of opinion |
| Individual enterprises | Family-based, distributed activities, dependent on position and opportunities in the vertical network | Strict command and control, closed in-group ethos, loyalty counts, more than efficiency, synchronic time management | Open labor market, contracts, instrumental working relations, both competition and cooperation between competitors | Individual judgment, professional attitude, initiative, status by achievements, planning and innovation, cooperative attitude |

Table 2
List of interviewees

| Name | Short description | Location | Workers number |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------------------------------------|
| Farmer 1 | Provides groundwater for farmers, use of water pumps by generators, plastic-iron greenhouses, continuously the same products (primarily tomatoes) | Nablus | 2 |
| Farmer 2 | Produces dates and cultivates palm trees, advanced level of technology, ponds, water pumps, packaging machinery | Jericho | 90 (up to 200 during harvesting season) |
| Company 3 | Produces drinking water in cups, RO technology | Ramallah | 4 |
| Company 4 | Produces drinking water in bottles, RO technology | Ramallah | 5 |
| Company 5 | Produces drinking water in bottles, RO technology | Nablus | 4 |
| Company 6 | Produces drinking water in bottles, RO technology | Jericho | 50–100 |
| Farmer 7 | A former farmer who now sells farming equipment, irrigation system, water pump, open field | Jericho | 2 |
| Farmer 8 | Group of farmers who produce horticultural products, plastic-iron greenhouses, water pumps | Jericho | – |
| Farmer 9 | Farmers association produces horticultural and pharmaceutical plants and operates an RO system to irrigate their plantation, NGO financed for common use | West Bank | – |
| Farmer 10 | Produces dates and grapefruits, modern machinery, large scale | West Bank | 7 |
| Farmer 11 | Produces dates and horticultural products, modern machinery, medium scale, plastic-iron greenhouses | West Bank | 15–50 |

An interview questions list was drafted to guide the semi-structured interviews. The first group of questions addressed the business model canvas of SMEs or entrepreneurs operating in Palestine. This group aimed to map the business model of the entrepreneurs. The second group of questions examined the internal business management. This group was designed to identify the quality of management, which was reflected by the behaviors and strategies of SMEs or entrepreneurs. The third group of questions addressed the status of the civil society. This group has the main purpose of analyzing the business networks of SMEs, which include partners, competitors, and supporters. The fourth group of questions was related to the governance system in Palestine. This group aimed to determine the institutional environment of regulation from the side of government bureaucracies and agencies.

2.4. Data analysis

This research was conducted in an explorative-qualitative manner. The method used is called open coding. This method was used to extract relevant information from the interviews. The interview reports were examined using qualitative analysis software, ATLAS.ti. The texts were coded using the topics of the interview questions as the code name. For example, coded data includes innovation, hierarchical structure, water demand, and many other parameters. The open codes resulting from the interview reports were subjected to a thematic analysis. Furthermore, a comparison of all codes was performed by relating codes to each other and by means of triangulation with the results from expert interviews and literature. Collected data and further analysis by Atlas.ti were used to develop the social transformation model illustrated in Table 1.

3. Results and discussion

3.1. Interview results

This section provides detailed information about each interviewee:

- *Small farmer (1)*: the farmer exploited a water pump and sub-rented his land to 20 farmers who did the actual work. He received half of the produce. The products were sold via a middleman. The owner of the well and the farmers appeared to have a somewhat traditional mentality and were not innovating. Also, the customers were served on a repetitive, regular basis via middlemen. The farmer was not busy either finding new customers or introducing new products. Sometimes, a farmer gave up, and another farmer stepped in.
- *Large farmer (2)*: he had a big date farm in Jericho of 3,300 ha, 300,000 date palms, and 13 wells (varying between 100–150 m deep). The salinity of these wells varied between 2,000–14,000 ppm. All wells flowed into three ponds (with a capacity of 350,000 m³ together), so by mixing the water, the average salinity was reduced to an average salinity of 3,000–4,000 ppm, which suffices for the date palms. At eight farms, the business operations were supervised by graduated engineers who were well acquainted with the technology of water purification and all the other technical requirements for the date production. The water demand for date trees was high: one date palm (5 y old) required around 60 m³/y, differing between summer (0.5 m³/d) and winter 0.5 m³/week).
- *Small water supply companies/bottlers (3, 4, 5)*: family-based companies used a small saline well and bottling drinking water after desalination via RO. One of them (3) worked on a somewhat larger scale by producing a large number of cups besides bottles. The two others (4, 5) distributed big 10 L bottles to private customers. All of them were sufficiently professional to deal with the technology. One of them produced 6,000 L/d, and the other 2,000 L/d (5), and in winter-time/the rainy season only 600 L/d (5), in which case customer outreach did not extend beyond the local community, which also caused problems in cost recovery since it was difficult to enforce payment to members of the community one belongs to (5).
- *Big water supply company/bottler (6)*: currently the company relies on a carbon filter, and used heat (90°C), ultrafiltration (0.02 mm), and UV. By using these technologies, clean water could be produced in Jericho, except for the removal of bromide. In the Turkayem Factory they had a nitrate problem, and they have stopped ozone treatment due to bromite > bromate formation. With current treatment technology, they produced 10,000 L/h and produced 6,000 bottles/h (two bottle sizes: 0.5 and 1.5 L).
- *Small farmer (7)*: this was a small citrus farm in Jericho, with an area of 15,000 m² (15 dunams). The well had a 30 m³/h capacity and a salinity of 7,300 ppm. The farmer had received a license for a new well, but within a perimeter of 200 m of the current well. Tests have shown that a new well had the same bad water quality (too saline). The current high salinity was devastating for the citrus trees, so the farm is currently not operational, and the trees were dying. The farmer was from a family that traditionally consisted of farmers. Although he did not show a very innovative attitude he was well acquainted with plant treatment. He also showed a somewhat entrepreneurial mindset in that he is now selling agricultural equipment and making a living from it.
- *Small farmer (8)*: a group of farmers in the neighborhood of Nablus produced horticultural products. Some of them were traditional farmers and legal; others operated illegally and were removed by the Israelis. They faced increasing water problems, and the number of families growing crops decreased from 50 to 15 for that reason. The group had a moderate degree of agricultural knowledge and practices, primarily traditional. Like many farmers, they worked on seasonally based horticulture from September to May due to water scarcity.
- *Small farmer (9)*: A farmers Association had been supported by installing a reverse osmosis water purification system, which was provided with the support of the ministry of agriculture in order to be used by a group of farmers. A special fluid necessary for the RO system could not be delivered anymore, and as a consequence, the system was not in use. The one farmer which was present at the spot, used water from a distant well and

survived by a strategic selection of spices he was growing, which did very well in the market. The farmer was knowledgeable about farming, and he has strategically chosen this product, but he doesn't seem to be that innovating since he was acquiescing in the failure of the RO system.

- *Large farmer (10)*: This was a farmer in dates and grapefruits. The dates were produced by means of protected cultivation; as soon as it got cold in September, the greenhouses were covered. The farmer hired workers per day when there is work, but since he employed the same people time and again, the workforce was quite knowledgeable. He also provided them with some training. The level of work was professional. Since he hired the land himself, he was not positioned so strongly in vertical networks and government relations as Farmer 2.
- *Large farmer (11)*: This was a date farmer in area C along the Jordan River. He sub-rented parts of his farm to local farmers in return for half of the produce. He was professional, showed successful operations, and brought his dates to the market. He used several wells and had rights from before 1967 to do so. He was allowed to replace the water pumps but not to add new wells. He was sub-renting parts of his farm because it was difficult for him to intervene in the case of theft. Since in area C, only Israeli police operated, he could not hand over thieves to them, being an important leader in the Palestinian cause.

3.2. CED prototype technical details

In the CED system sophisticated control and monitoring systems have been incorporated in order to ensure user operations' easiness. This system was operated automatically, allowing the user only to choose and push buttons and then monitor the system running through the online application. The performance of the CED System Designed by the PADUCO team is shown in Table 3.

The well-designed CED system required high capital investment to build and install it since it is a prototype. Only mass production could bring the price down to the price of an average refrigerator or even less. The primary disadvantage of this system for the time being consisted in its price. In the interviews, the capital investment of CED was always considered a significant factor in the choice for a CED system in the West Bank. High investment requires more intense use to cover the costs. Moreover, the requirements from the sociocultural context affecting the implementation of the CED system in Palestine were not yet taken into account in the design of this prototype. The costs of the present system developed for the West

Bank by Water Future is €7,500 for material costs and labor are summarized in Table 4. The costs can be reduced by increasing the scale of production and besides that by reducing the stack price that is at the heart of the system. The price per cubic meter from the CED system is now €3.62/m³ for drinking water and €2.43 for irrigation water (only taking into account the initial investment, energy use, maintenance and depreciation, not operation costs). Production per day of drinking water is 1,600 L, irrigation water 1,800 L.

Despite the disadvantages of the CED system, it has more advantages than RO as mentioned in Table 5.

3.3. Current business model and business environment of SMEs in Palestine

In this section on the basis of the interviews and on-site visits the present business model that is implicitly followed by farmers and drinking water producers is described. The business model describes not so much what they intend to do, but what de facto they were doing. Hereby the extended business model canvas was helpful. It is called extended because as part of the cost structure it also took social and environmental costs into account. A distinction should be made between two types of SMEs in Palestine, pre-sustainable and sustainable (Table 3). Pre-sustainable business models entail SMEs that offer and deliver their value proposition without considering social and environmental benefits. At the same time they operate more along the lines of System I (Table 1), the traditional type. Sustainable business models ensure that companies also take social and environmental benefits into account. They work comparatively more along the lines of System II procedures and values (Table 1). The descriptions in Fig. 2 represent the actual operations of the SMEs in the West Bank.

3.3.1. Key activities of current business model

All SMEs under scrutiny were the owner of their production equipment, and their training activities varied depending on their value propositions and their market segmentation. SMEs 1, 2, 4, 6, 9, 10, and 11 have trained people to work in their specific business operations. Farmer 2 was the only one with a well-developed training and education program for the employees, and it is independent from the help of an external organization. Yet, he helped civil society partners with training and education programs. However, the efficiency of training was different for each SME. Farmer 1 his business, who had trained people in running and managing the well he owns for agricultural use, not operated it very well. He was not informed about their farming activities which only

Table 3
The performance of CED system designed by PADUCO team

| Water products | Conductivity ($\mu\text{S}/\text{cm}/\text{cm}$) | Capacity (L/d) | Energy consumption (kWh/m ³) | Water recovery | Purification efficiency |
|----------------|-------------------------------------------------------|-------------------|---------------------------------------------|-------------------|----------------------------|
| Drinking | 0.3 | 1,600 | 2.65 | 84% | 95% |
| Agriculture | 0.7 | 1,800 | 2.36 | 84% | 88% |

contributed to his business revenue stream. On the other hand, Farmer 2, who had a sustainable value propositions, also had efficient employee training. The operation showed excellent results in production, and he both has a local market and exported the products to 12 countries.

It seems that pre-sustainable SMEs only focus on production activities, while sustainable SMEs are trying to balance production, training, and management activities.

3.3.2. Key resources of current business model

SMEs in the West Bank also had three types of key resources that contributed to their key activities. These were production resources, management resources, and training resources, similar to the categories of their key activities. There were two types of SMEs in this research; the typical production resources for farmers were water, fertilizer, seed, and machinery, and the typical production resources of drinking water companies were groundwater, processing machines, and packaging machines. Following the results founded in the key activities of SMEs in the West Bank, there was a lack of resources for management training and

other training activities. SMEs 2, 6, and 11 were the only SMEs that considered the need of both management training and training of other activities. In short, the key resources of sustainable SMEs have already taken into account the three types of key resources. The pre-sustainable SMEs have only taken into account the key resources used for their production activities.

3.3.3. Key partnerships of current business model

Partners here consisted of the customers, suppliers, and supporters. The relationship of SMEs with their suppliers could be distinguished into two types. The first type entailed a strong, secure, and reliable relationship with the suppliers. This type of relationship was found in SME 2, its suppliers were authorized and professional and they secured the partnership by keeping their agreements. The second type of relationship entailed a weak, unreliable, and insecure relationship. SMEs 3, 4, and 5, the drinking water companies, experienced a monopoly of their raw material caused by the Israeli occupation. Only one company could supply their raw materials for making the

Table 4
Costs and production CED system

| | Artificial Palestine groundwater 6 μS/cm | | Drinking water | Irrigation water |
|------------|------------------------------------------|---------------------------|----------------|------------------|
| | Desired water quality | μS/cm | 0.3 | 1 |
| | Complete system | €/piece | 7,500 | 7,500 |
| | Deprecation | y | 5 | 5 |
| | Energy use stack | kWh/m ³ | 0.5 | 0.33 |
| | | €/kWh in NL | 0.2 | 0.2 |
| | | €/y | 48.24 | 47.52 |
| | Maintenance | €/y | 20,000 | 20,000 |
| | Production | L/uur | 67 | 100 |
| | | m ³ /d (24uur) | 1.6 | 2.4 |
| | | m ³ /y | 482.4 | 720 |
| Present | Costs system | €/m ³ | 2.62 | 2.43 |
| | | €/L | 0.0036 | 0.0024 |
| 100%–25% | Costs system | €/m ³ | 2.72 | 1.82 |
| | | €/L | 0.0027 | 0.0018 |
| 1,000%–40% | Costs system | €/m ³ | 2.17 | 1.46 |
| | | €/L | 0.0022 | 0.0015 |

Table 5
Comparison between CED and RO

| | CED | RO |
|--------------------------------|--------------------------------|----------------------------------|
| Salt removal | Selective | All |
| Pressure | Low | High |
| Electricity | Low (<0.5 kWh/m ³) | High (>2 kWh/m ³) |
| Suitability for brackish water | Suitable | Less suitable |
| Pretreatment | Fewer requirements | High requirements |
| Water yield | Higher (>80%) | Restricted water yield (45%–75%) |








| | | | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Key Partnerships </p> <p><i>Sustainable:</i></p> <ul style="list-style-type: none"> • Strong, secure, and reliable supplier • Free access to customer • Two-way relationship with supporter <p><i>Pre-Sustainable:</i></p> <ul style="list-style-type: none"> • Weak, unsecure, and unreliable supplier • Limited access to customer • One-way relationship with supporter | <p>Key Activities </p> <p><i>Sustainable:</i></p> <ul style="list-style-type: none"> • Production activity • Training activity <p><i>Pre-Sustainable:</i></p> <ul style="list-style-type: none"> • Production activity | <p>Value Propositions </p> <p><i>Sustainable:</i></p> <ul style="list-style-type: none"> • Deliver value propositions accompanying with the awareness on environmental and social impact <p><i>Pre-Sustainable:</i></p> <ul style="list-style-type: none"> • Deliver value propositions without the awareness on environmental and social impact | <p>Customer Relationships </p> <p><i>Sustainable:</i></p> <ul style="list-style-type: none"> • Relationship with buyer • Relationship with employees and citizens <p><i>Pre-Sustainable:</i></p> <ul style="list-style-type: none"> • Relationship with buyer | <p>Customer Segments </p> <p><i>Sustainable:</i></p> <ul style="list-style-type: none"> • Buyer as its primary customer • Employees and citizens as its secondary customer <p><i>Pre-Sustainable:</i></p> <ul style="list-style-type: none"> • Buyer as its sole customer |
| <p>Cost Structure (Financial) </p> <p><i>Sustainable and Pre-Sustainable:</i></p> <ul style="list-style-type: none"> • Fully consider the financial cost structures | | <p>Revenue Streams (Financial) </p> <p><i>Sustainable and Pre-Sustainable:</i></p> <ul style="list-style-type: none"> • Fully consider the revenue streams | | |
| <p>Social Costs</p> <p><i>Sustainable</i></p> | <p>Ecological Costs</p> <p><i>Sustainable</i></p> | <p>Social Revenues</p> <p><i>Sustainable</i></p> | <p>Ecological Revenues</p> <p><i>Sustainable</i></p> | |

Fig. 2. Current status of business model in the West Bank [23].

packaged drinking water. No exact agreement was made during their cooperation. Furthermore, the limited number of well-operated SMEs was making the water supply for most farmers (1, 7, 8, 9, 10, and 11) unreliable which makes them too dependent.

The key partnerships between SMEs in the West Bank and their customers could also be distinguished into two types. The first one is a company that could access the market freely, and the second one had limited access to the market. SMEs 2, 6, and 9 were the only SMEs that could access both international and local markets. Most farmers sold their products through the middlemen in their surrounding area who can sell the farmers' products to the local and international market with often high profits.

The last key partnership was the relationship of SMEs with their supporters, such as NGOs, research institutes, or government agencies. There were two forms of this partnership, a reciprocal relationship, which mutually benefited both parties, and a one-sided relationship, in which one side benefited more. SME 2 is the only SME that was characterized by a reciprocal relationship.

3.3.4. Customer segmentation of current business model

Two types of customers in the West Bank can be distinguished: customers who worked with whatever they have and customers who improved their skills, knowledge, and welfare. SMEs 2 and 6 had these two groups of customers

and both were well developed. SMEs 1, 3, 4, 5, 7, 8, and 11 only served the first group of customers.

3.3.5. Customer relationship of current business model

Two types of relationships between SMEs and customers were found. The first one was the relationship of SMEs with the buyers of their product/service. This relationship had the characteristics of a professional, impersonal, and distant relationship, outside their internal business management. All SMEs maintained their relationships with this group of customers for receiving the orders, receiving the complaints or feedback, and responding to their complaints. A conflict between SMEs and its customer could only be found in Company 5, although it is not known whether also other companies may have had similar problems. Its customers do not pay sometimes, and Company 5 found it difficult to force them to pay. The second type was the relationship between SMEs with their employees and citizens, to be considered as their secondary employees. This second type of relationship was mentioned in the business operations of SMEs 2 and 6.

3.3.6. Channels of current business model

All SMEs used physical distribution channels, for instance, pipes, lorries, trucks, or containers. They also used packaging to deliver their products to the customers.

Since water and dates were scarce products, all SMEs do not put high effort into promoting their products. The last component of this block was the way SMEs distributed or delivered their values to employees and citizens. This component was only found in SMEs 2 and 6 because they were the only SMEs that gave training to their employees and surrounding citizens.

3.3.7. *Cost-revenue model and social-environmental impact of current business model*

This refers to financial, environmental, and social costs. In general, the SMEs operating in Palestine had little awareness of the environmental and social impact of their business operations. Four of the eleven SMEs already showed some awareness on both issues, two farmers (2,11) and two drinking water companies (4,6). For instance, Farmer 2 had a joint program with a university to improve the quality of social life within and outside the region. On the environmental impact, Farmer 2 ensured that there was no negative impact on the environment caused by his business. Company 4 mentioned that it was the only company among its peers in Palestine to have used an environmentally sustainable machine. On the financial part, the cost structure of all SMEs consisted of raw materials, wages, capital investment, maintenance, and marketing. Only SME 2 considered the training and healthcare to belong to its cost structure. The financial revenue stream for all SMEs only originated from their sales of products/services. Furthermore, SMEs 2, 4, 6, and 11 have also taken into account the social and environmental context, which has been discussed earlier.

3.4. *Internal business management of SMEs in Palestine*

In general, all interviewed SMEs were family-based, except for Company 6. The business activities in these family-based SMEs were conducted collectively, and the close relationships among the family members made the information flow easy. Moreover, collectivism was more predominant than individualism in the Palestinian SMEs' internal business management. SME 2 was the only one that had incentives and rewards for the workers who performed more than the usual target.

Two approaches to management and control were observed. SMEs 2 and 6 provided an apparent command structure to the worker who worked under the supervision of a well-educated manager. A high level of professionalism was also observed in Company 6, making the employees independent in their tasks. Company 3 was characterized by little control, and allowed its workers to work at their own pace. However, both companies operated efficiently and show excellent performance. It could be maintained that SMEs in the West Bank were using both a hierarchical and egalitarian-style of management, but mostly the hierarchical was still predominant.

Initiative and planning for future operations was observed in SME 2, 3, 5, 6, 9, and 11. These SMEs were planning to expand their production as well as market coverage. In the case of drinking water companies, there was a lack of business associations, while the farmers already had such

associations, although the growth of these associations was slow.

Based on the analysis above, the SMEs in Palestine were characterized by a mix of various cultural dimensions, derived from two different social systems, traditional and modern (Table 1 System I and System II). Both conventional and modern approaches were found in internal business management, and some SMEs had a more traditional approach, while others had a more modern approach.

3.5. *Civil society in Palestine*

The network of operations of the SMEs was analyzed by linking it to the social transformation theory developed by Kroesen et al. [19] (Table 1). The business operations of SMEs cannot be separated from the context of the civil society. The market conditions for SMEs in Palestine can be considered as unsaturated markets, which easily allow new companies to enter the market, as stated by SMEs 2 and 4. Problems related to the relationship with the customers were identified as payment problems. There were two types of payment problems: the amount and method. For instance, Company 5 experienced difficulty in enforcing payment because of the rules of politeness within the small community served.

More partnerships between companies in the same industry should be initiated because there was a lack of associations that support peer companies to cooperate. According to the explanation of SME 11, most farmers do not cooperate well. Furthermore, most of the farmers, especially in Jericho Valley, often do not use water resources responsibly. The same was the case with the drinking water companies. This showed that cooperation on the level of civil society was not developed to its full potential. There was lack of sectoral development, lack of cooperation between big players like retailers and farmers, often farmers found themselves in a situation of dependency on the middlemen, which showed there was little exchange and a low level of organization amongst the farmers. Access to services and relevant information were often dependent on relationships.

The SMEs' trust in NGOs was relatively low because the result of their training was not optimal. Furthermore, there was no evidence of any improvement resulting from such courses. Thus, the NGOs or other organizations that were willing to help SMEs in the West Bank should first assess how their recipient works, and tailor their courses to the specific needs of the farmers. Agricultural trainings should also not only comprise agricultural knowledge, but also entrepreneurial skills and organizational capacity.

3.6. *The State of Governance in Palestine*

A supportive governance system could improve the business operations of SMEs. A good governance system can produce policies or other instruments to ensure the SMEs work efficiently. SMEs have mentioned different experiences in the license procedures. SMEs 2, 3, 6, and 11 didn't face any problems getting a license from the government. However, companies 4 and 5 experienced a slow process for getting a license. This difference could be attributed to unequal access

to the government for different SMEs. Three different reasons may have caused this inequality. The first one was the slow work pace of the government itself, the second one was the planning activities on the SMEs level, which might have led to the slow process, and the last one was that some companies might have had privileged treatment due to particularism. Still, it was difficult to lay a hand on that. Moreover, the tax was seen as burdensome for most SMEs. Administrative processes were considered as time-consuming.

Regulations produced by the government differed continuously and confused SMEs' business operations. The infrastructure problems found in the operations of the SMEs in the West Bank were mostly about the electricity supply. Furthermore, the road access for Palestinians faces some problems when there was a security check at the Israeli border. The governance issues of SMEs operating in Palestine were also related to the Israeli government. All interviewees argued that they were experiencing the obstacles caused by the Israeli occupation. It seems that these two processes reinforced each other: lack of agency from the Palestinian Authority, omni-presence of control from the Israeli occupants.

3.7. Business environment in the West Bank

The situation in the West Bank is theoretically considered a postcolonial situation. Palestinians, however, are still experiencing the occupation of the Israeli government, which maintains the limitation of several activities. The transition of the business environment values and institutions takes place in a slow pace but still it is the purpose to become a free and developed nation. SMEs' business operations should cope with and support this transition.

Table 6 shows the values and institutions of the business environment of SMEs in the West Bank. It is an adaptation of Table 1 to the Palestinian circumstances, and resulted from the open coding by Atlas.ti and further the thematic analysis of data. Four significant effects were presented in this study. These four effects were chosen because they were decisive factors for the implementation of new technologies in SMEs.

3.8. Effect of the sociocultural and economic transformation in Palestine

In this section the impact and consequences are described of the transition Palestinian society is going through from traditional (System I) to modern (System II) values and institutions (Table 1). Change is taking place, but they need reinforcement, reinforcement of entrepreneurial skills, mutual support in cooperation and in associations, institutions that are efficient and characterized by equal access. This is not only important for the introduction of the CED system, but pertains to any technological innovation to be introduced into society.

3.8.1. Skills gap

According to many stakeholders, Training Courses for SMEs have to cope with a skill gap found in the Palestinian labor market [24]. The empirical data showed that only one

of five companies had well-prepared training courses for their employees. This evidence somehow was related to one of the cultural dimensions [21], uncertainty avoidance and as a consequence lack of initiative. Moreover, training should also cover the production process and the management practices, governance and compliance, and business planning. At the moment SMEs do not want to take risk and demand comprehensive success stories for the latest technology before they are willing to implement it in their business.

3.8.2. Readiness of SMEs on implementing CED

The readiness of SMEs to receive the new technologies varied, and this was related to the level of professionalism of the SMEs on the specific technology [25]. In the beginning, entrepreneurs should be aware and consider the importance of this new technology, such as CED, to their business operations. However, the difference between the new technology and the present core business of the SMEs' could lead to a lack of professional knowledge for the new technology. Of course, this affects their readiness to accept the implementation of new technology [25].

Based on the empirical data, most drinking water companies were willing to implement the new CED technology for producing drinking water. They benefit from their core activities and were already familiar with the complicated water purification system. On the other hand, the second type of SMEs (i.e., farmers) showed a less professional attitude toward implementing the CED system. Moreover, farmers do not own their water wells in most cases, and they often buy water from other parties. Farmers also faced uncertainty because they leased the land for their plantations.

Another consideration of the readiness of SMEs was the capital investment required for implementing the new water treatment technology, which was often burdensome for the SMEs. Furthermore, advanced water treatment technology for desalinating water can only be obtained by big companies and big farmers, with exception of the funding help from NGOs or similar organizations. SMEs can only afford CED technology with funding support from NGOs. Therefore, the readiness of SMEs also their finances should be taken into account.

Knowing the levels of readiness of the SMEs' could help make an appropriate plan for implementing CED technology to SMEs. The program for the CED implementation should be tailor-made. The initial assessment should be done by the organizations that aim to implement this technology so that they know the level of readiness. Then, the plan for implementing the CED can be designed. The essential components that should be considered in that plan are the funding scheme, the CED package, and the complete training plan covering the technology operations and maintenance, governance and compliance, and the business plan. Next, the final step is monitoring and evaluating the running implementation program for this CED.

3.8.3. Emerging association for specific type of SMEs

The evidence from the empirical data shows that most SMEs focusing on water purification technology demanded

Table 6
The ideal-typical of sociocultural and economic description in the West Bank

| | Traditional system | | Modern system | |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | Values | Institutions | Values | Institutions |
| Internal business management | <ul style="list-style-type: none"> • Hierarchical style • Ascribed status • Synchronic time management • Collectivism • Dependent on guidance | <ul style="list-style-type: none"> • Family-based • Responsibilities kept at the top • Top-down decision making • Opportunities in the vertical networks • Employed family members • Lack of innovations • Unclear company goals | <ul style="list-style-type: none"> • Egalitarian style • Achieved status • Sequential time management • Individualism • Professional workforce | <ul style="list-style-type: none"> • Open labor market • Distributed responsibilities • Interactive decision making • Based on horizontal networks and anonymous trust • Selectively employed family members • Continuous innovations • Well-defined company goals • Multiple suppliers • Free access to market • Professional and diverse marketing tools |
| Civil society | <ul style="list-style-type: none"> • Copying behavior uncertainty avoidance • Lifelong solidarity | <ul style="list-style-type: none"> • Limited access to supplier • Limited access to customer • Informal and “Word-of-Mouth” Marketing • Solely competition • Distrust in NGO | <ul style="list-style-type: none"> • Innovative behavior • Initiative • Open attitude | <ul style="list-style-type: none"> • Competition and collaboration • Trust and collaborate with NGO • Freedom of nations • Access to resources • Access to partnership • Free market • Developed infrastructures |
| State of Governance | <ul style="list-style-type: none"> • Particularism • Privileged treatment | <ul style="list-style-type: none"> • Suppressing the occupied nation (Israel) • Keeping control of civil society (Palestinian Authority) • Limited access to resources • Limited access to building a partnership • Monopoly market (Israeli monopolies) • Underdeveloped infrastructures | <ul style="list-style-type: none"> • Universalism • Equal access | |

the establishment of such associations. The associations could boost the business environment and make the introduction of new technology to SMEs easier. Introducing the new technology through cooperatives or associations could avoid the risks of failure in implementing this new technology.

3.8.4. Equal access to resources for Palestinian SMEs

The inequality in sharing the resources in West Bank is widely known. The resources to which the Israeli government limits access for Palestinians are water, land, and imported commodities [26]. The Israeli Government had unfairly limited the number of wells for Palestinians; they even destroyed the existing wells for unclear reasons. Land acquisition was also a major problem in the West Bank. In addition, the imported commodities, big machinery, spare parts, and electricity were monopolized by Israeli companies because of the limitation and strict regulations established by the Israeli Government.

On the other hand, the work of the Palestinian Government should also be monitored, and their performances and responsibilities on several projects should also be evaluated and given feedback. This monitoring and evaluation should be developed to ensure equal access to Palestinian SMEs' resources. The change in the direction to equal access to resources is urgently needed in the Palestinian business environment.

Support from all stakeholders, especially from the Palestinian Government, is required. The feedback cycles between the business environment and the Government will improve Palestinian welfare in the future.

3.9. Feasible business model of CED system in Palestine

The purpose of the business model proposed in this section is to design options for sustainable use of the CED technology in Palestine. Potential users targeted at are drinking water companies and farmers. In the initial phase, the users could also consist of entrepreneurial NGOs or cooperatives. The business model developed here was designed explicitly for CED implementation in the West Bank but applicable to other similar developing countries as well.

3.9.1. Value proposition

The value proposition developed here was based on the sustainable business model canvas. The objective of the value proposition was preparing, producing, and selling environmentally sustainable, socially desirable, and economically feasible agricultural/water products for the emerging market in the West Bank. This should be supported by technical and managerial training for the local employees and their business partners. Medium farmers and drinking water companies are the most suitable companies to first implement this value proposition. These medium farmers and drinking water companies already had an awareness of their business's social and environmental impact. Besides, their level of professionalism was relatively high compared to small SMEs. Although small farmers and drinking water companies were less feasible for the implementation of the CED in their business, they could do so with some support

from NGO-partners and governments. This was in line with the competitive advantage offered by the CED system, which can contribute to the water supply issues in the West Bank because of its high efficiency and small capacity features.

3.9.2. Market segmentation

There is an opportunity in this water market by providing suitable technology that could enhance the water quality and the water produced could be supplied for domestic and agricultural use. The CED system should have the capability to provide water for both domestic and agricultural use. It could enlarge the market coverage and generate more revenue for the user to get a high return on investment as a compensation for the high initial investment.

The broad range of market segmentation of medium companies supports the idea that they are more feasible to become the companies that implement the CED, especially in the initial phase, earlier than the small companies. However, this does not exclude the opportunities for small companies to implement CED in their business. Small companies could cover the high investment of CED by enlarging their market coverage. They could consider using CED for both farming and drinking, like it is the case with the prototype of the CED, which can serve both markets. Small companies would need substantial support and effort from their partners and governments, such as through training and mentoring programs.

3.9.3. Key partnership

The supporters of the CED users are organizations that provide assistance not only in their specific production activities but also in the operation of CED technology to contribute to their specific business activities significantly. However, the support is not limited to technical advice; it also covers financial means, business management and plan, and social-cultural considerations. Suitable supporters for CED users to develop their products and market in the West Bank are NGOs, governments, research institutes, local or foreign universities, and associations. The supporters should also often function as initiators because, in the initial phase, the prototype can only be successfully introduced and sold to the small farmers and drinking water companies through these supporters. The medium farmers and drinking water companies would need less assistance from these supporters than the small ones in the implementation of the CED system because they are already independent.

The suppliers of CED users are the trickiest partnerships because it is known that some machinery suppliers are companies from Israel, that monopolized the market, causing high prices, narrow range of product types, and low amount of supply. Therefore, cooperation with Dutch NGOs or companies could be considered the facilitator to ease the CED user in getting spare parts for the CED system timely for maintenance, etc.

3.9.4. Key activities

The production activities of farmers covered seed selection, land preparation, crop establishment, water management, nutrient management, crop health management,

harvesting, and post-harvest activities. The production activities for drinking water companies consisted of raw water supply, purification processes, packaging, marketing, and distributing. The training activities for both types consisted of training the technical ability, training the managerial activities, preparing the targeted market to sustainable use the water and agricultural products, and developing a complete training program for new entrepreneurs or existing small companies who also want to start integrated farming and water purification SMEs.

Medium companies can conduct training activities in advanced and comprehensive ways because they already provide training courses. On the other hand, small companies are experiencing a lack of training activities. Therefore, the medium companies, both farmers and drinking water companies, are better prepared to implement the CED in their business operations than small businesses.

3.9.5. Key resources

The resources required from the CED user are distinguished into three. Firstly, the resources required for each production facility, such as raw materials, machinery, and labor. A capable and professional internal business management should handle these three main production resources to lead this business to become sustainable, focusing on medium farmers and drinking water companies.

Secondly, the resources required for management activities are labor, offline and online media, which support the managerial activities. An example of offline media is a cozy workplace to gain the creativity and eagerness of its employees, and an example of online media is integrated ICT support for the business management activities, such as implementing affordable enterprise resource planning. Lastly, the resources required for training activities are the employees of each division preparing the training, the equipment and materials required. Medium companies already have these three types of resources at their disposal; in the case of small companies this cannot be expected.

3.9.6. Customer relationships

At present especially small farmers in the West Bank typically sell their products through middlemen. Their relationship to these middlemen is personal. The medium farmers, however, often have bigger networks and produce for larger local markets, also supermarkets, and they sometimes even produce for foreign markets. For both medium and small farmers a more developed market is required. Cooperatives among smallholder farmers can help them to enter larger and more distant markets. Cooperation within the sector, between retailers, NGOs, and government agencies can lead to higher amounts and better quality of production. By means of sectoral cooperation quality standards can be set, shared facilities and support can be organized and especially the production processes of small farmers can be upgraded in order to meet customer requirements, especially from bigger off-takes. As to the drinking water companies a similar course of action is required. The larger drinking water producers showed a more diverse and more developed market; the smaller ones often only operate within the local community.

In both cases improved marketing could provide them with higher revenues in order to cover the costs of higher initial investment. The media used for delivering the marketing message consist of social media, e-commerce, websites, seminars, and workshops. CED users also need physical distribution vehicles to transport the products to their buyers.

3.9.7. Cost structures and revenue streams

The cost structure for CED users included production costs, which covers raw material costs, operation costs, labor costs, maintenance costs, and training costs. Here a distinction is required between the smaller farmers and drinking water companies and the bigger ones. Considering their higher level of capacity, technology, operations and larger market, for medium-sized water companies and larger farmers it is easier to adopt CED technology. The paradox, however, is that CED technology is quite suitable to small-scale production, because the CED system produces clean drinking water or irrigation water in batches. But for the smaller farmers and small drinking water companies it is more difficult to create a revenue from the investment and organize all the training required to accommodate the new technology by themselves. Here government agencies and NGOs may step in to help those smaller companies to get started with the new technology. The need for investment from government agencies and NGOs and international partners and the small-scale of the CED technology, may also make it an attractive technology for humanitarian use in refugee camps or among Bedouins.

There is clearly also an ecological and social revenue coming in with the new technology. The ecological revenue consists in the efficiency of energy use and the decreasing amount of waste compared to other water purification technologies. In the long run a CED system will, if produced on a large-scale, become cheaper than RO technology both in investment and operation. Next, the social revenue expected is the development and upgrading of small farmers and small water companies, the access to clean drinking water and irrigation water by households and smallholders among Palestinians who live in the West Bank.

4. Conclusions and recommendations

On the technical feasibility of the CED system under scrutiny in the PADUCO program it can be concluded that it offers a viable alternative for reverse osmosis especially in use on a smaller scale. The CED system produces in batches, which makes it less suitable for continuous large-scale operation. But its energy efficiency was much higher than the alternative of reverse osmosis. Even seawater could be used, although it was not the most efficient option in terms of energy reduction (with higher rates of salinity the CED system has to run for a longer time). Another reason for considering the CED system as more promising than RO consisted in its ability to be used on a small-scale which made it less sensitive for an abandonment by the Israeli government.

Considering the three levels of individual enterprises – civil society – governance framework (Table 1), which has been used for the research of the entrepreneurial feasibility of the CED system the following can be concluded:

4.1. Individual enterprises

Most enterprises on the West Bank were family owned, both drinking water companies and farmers. Smaller enterprises often were also primarily family operated. This helps to explain a somewhat traditional orientation in business operations and market penetration, with little attention for innovation and on average low entrepreneurial skills. For the small farmers this carried even more weight since, in comparison, drinking water family businesses often operated in the cities and all of them already had to innovate in terms of introducing reverse osmosis systems for production and learn to operate them. Small farmers often rented the land (sometimes for half of the produce), grow crops in traditional ways, were dependent on middlemen. Both drinking water companies and farmers needed training to familiarize them with new technologies, and entrepreneurial strategies. For both, but mostly for the smallholder farmers it is also important to cooperate within the sector, enhance sectoral development, upgrade farming techniques and the quality of the produce in order to meet the market demand. Both internally and externally the market increasingly demands a continuous flow of high quality products. The larger drinking water companies and farmers (often date farmers) already are operating on a higher level of technology, quality and market access. Mostly they are also better positioned in family networks and vertical networks reaching out to the government bureaucracy. Therefore, the larger drinking water companies and farmers could be the first ones to adopt the new CED technology, at least before also smaller companies can gain access to the new technology, as soon as after the first introduction prices drop, due to the larger scale.

Furthermore, it can be concluded that the CED system in its present state is already a viable option for small-scale water producing companies as an alternative to reverse osmosis, which is presently in use. This is especially the case if they produce less than 2000 L of water per day, but even if they would produce more, it is still feasible to install two systems at a time, which is manageable for them. Their business operations would not have to change, even although a large-scale CED system would also suit them well. However, key issues to solve are investment and training.

4.2. Civil society cooperation and governance

The Israeli occupation and the monopolization of important technologies and products puts severe strains on entrepreneurial development. These obstacles for entrepreneurial success are aggravated by the somewhat traditional attitude of the Palestinian Authority, which was not used to and was somewhat suspicious towards initiative from civil society participants and was more inclined towards regulation and control than towards stimulating entrepreneurial development. However, for a conducive institutional and policy environment for entrepreneurial initiatives the cooperation of government agencies, NGOs, traders, retailers, in short, many stakeholders is required. There is an important role for government agencies in organizing infrastructure, setting standards, etc. It is also important and a growing need of farmers and entrepreneurs in general to cooperate

in associations and in sectoral alliances, which should be stimulated as a promising development.

4.3. Role of NGOs and international support

Considering the need of training and upfront investment in the introduction of the CED system first among larger firms, later and most importantly among small drinking water companies and small farmers, the CED system will not make it without support from many NGOs and international stakeholders. First steps in a scenario for introduction are required that will make the number of CED systems produced bigger, production processes organized more smoothly, including consideration of local production and assemblage, in order to lower the costs and make the system more affordable. The application of the CED system for humanitarian purposes in the Palestine Territories for those reasons is a first and ready at hand feasible and necessary option, especially for communities not connected to the grid (=no or unreliable piped water and energy supply), such as the Bedouin communities in the West Bank, and for household purposes in the Gaza Strip. Of course access to a water source is a requirement.

4.4. Future developments

Finally, it can be concluded that future developments of the CED system and future social developments in Palestine can meet halfway and offer several viable business options. The CED system becomes cheaper by production in large quantities and local assemblage. It can be designed for larger amounts of water to meet the requirements for irrigation and the production of clean drinking water. Water scarcity may become an incentive for more prominent farmers to shift their attention toward horticulture. In combination with low productivity, water scarcity will incentivize smallholder farmers to grow and become more entrepreneurial. In the case of smallholder farmers, the current programs to increase production seem insufficient. It is an essential condition for introducing the CED system for smallholder farmers that the farmers' level of technology, investments, and capability increases. The CED system can become a useful component of such an innovation package.

The authors present the following recommendations based on the research and the conclusions.

- The CED system needs to be further developed. The operation should become more accessible and robust and not require much professional expertise to make it useful on the household level. It should be designed to be free of the risk of producing contaminated or not sufficiently treated water.
- The CED system should be designed in different sizes to suit a diversity of circumstances, like drinking water, irrigation of small farmers, households, and middle-size farmers, especially in horticulture.
- It should be researched how the CED system can be produced in larger quantities and assembled locally.
- Production in larger quantities should be explored as a first step for water production by SMEs on the household level for Bedouin communities and refugee camps

and in the Gaza Strip. For this purpose, cooperation with humanitarian agencies should be explored.

- Water scarcity problems may create opportunities for large farmers to shift to water-saving and climate-smart horticultural solutions. It should be explored and researched how the CED system can become part of such a climate-smart agricultural strategy for large farmers, especially in the Eastern aquifer region. Since horticulture requires a lot of manual labor, it may be easier to integrate the CED system operation into the daily activities.
- There is an urgent need to bring smallholder farmers to a higher level of farming, not only in the use of water but also in the use of technology in general, accompanied by growth in investments and capacity growth. It should be researched how a growth path according to the pace and rhythm of the capacity of the farmers may look like and how besides other technical inputs, the CED system can become part of a climate-smart solution for productive smallholder farming.

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