AMERICAN UNIVERSITY OF BEIRUT

ASSESSING THE VIABILITY OF VERMICOMPOSTING IN LEBANON ON COMMUNITY LEVEL: WARHANIEH CASE STUDY

by

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A thesis
submitted in partial fulfillment of the requirements
for the degree of Master of Science in Environmental Sciences Program
of the Interfaculty Graduate Environmental Sciences
(Ecosystem Management)
of the Faculty of Agricultural and Food Sciences
at the American University of Beirut

Beirut, Lebanon
April 2015

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ACKNOWLEDGMENTS

First and foremost, I would like to express my love and gratitude to my family for their continuous support throughout my entire journey. To my father, Radwan, who always encourages me to follow my passion and dreams, and provides me with all the needed resources to pursue my studies at the American University of Beirut. You were the one who believed in my potential and offered me the best education, and you were right, education is the most powerful asset anyone could have. My deepest gratitude and warmest affection goes to my wonderful mother, Diana, who was always there to cheer me up and stood by me throughout the good times and the bad. You were the source of motivation and perseverance, you were my support system, my guardian angel from the beginning to the end, and you did the impossible to provide me with the best atmosphere for completing my graduate studies. I am indebted to my whole family, my elder brother Wassim, my younger brother Mouen, and younger sister Sarah, thank you for your love, patience, care and immeasurable support.

My profound appreciation goes to my brother Mr. Wissam Abou Dargham for supporting me spiritually throughout the years. You have constantly gave me the motivation to perform to my maximum potential and taught me to never give up. I am eternally grateful for your presence in our life. This thesis is just the beginning of my journey.

My utmost appreciation goes to my friends, who stood by my side and against all odds are still present in my life, those I consider my true friends. Jinan, you have always been a true sister and a loyal friend, people like you are rare to find. I'm extremely lucky to have you in my life. To my lovely sister Zeina, you are a unique friend, a friend for life. I would like also to thank all of my friends who have touched my life in different ways.

I would like to sincerely thank my advisor, Professor Salma Talhouk, for her guidance and confidence in me. Beside my advisor, I would like to thank the rest of my thesis committee: Professor Rami Zurayk, Professor Ibrahim Alameddine, Professor Ali Chalak, and Professor Mohammad Abiad for their insightful comments.

My extended thanks go to the University of California Davis for funding my study.

I would also like to thank the AUB libraries and the graduate council for offering helpful tools and resources that assisted me in writing my thesis.

Last but not least, I would like to express my wholehearted thanks to the community of Warhanieh, my dear village, and thank each and every individual who participated in my study. I really appreciate and value your love, trust, and generosity throughout the entire study period, which was an unforgettable experience. Because of you the final year of my master degree was the best and most interesting of all. Because of you, vermicomposting is

going to progress and grow in Lebanon. This research would not have been possible without your help and cooperation.

AN ABSTRACT OF THE THESIS OF

Nada Radwan Ghanem for Master of Science in Environmental Sciences
Major: Ecosystem Management

Title: Assessing the Viability of vermicomposting in Lebanon on Community Level: Warhanieh Case Study

This study is a case study that aims to assess people's perception and attitudes towards vermicomposting in Lebanon. For this purpose a direct field application of vermicomposting at household level was carried out in Warhanieh, a rural community in the Chouf region.

Two vegetable crate boxes tied to each other were used to develop a small vermicomposting unit which allows for the lateral movement of worms from one container to the other. The unit is made of readily available and cheap material and it is practical in that it reduces the direct handling of worms. Briefly the first container is filled with bedding material (soil), worms, and kitchen waste and it is covered with cotton material. Once the waste is fully digested by the worms, bedding and kitchen waste are added to the second container causing the worms to migrate towards fresh food source.

Thirty six households volunteered to test the experimental vermicomposting unit. In addition, a contingent valuation study was conducted involving 200 households to assess the attitude of village residents towards vermicomposting and towards home sorting of waste. Furthermore, the study assessed people's willingness to pay additional tax to fund the construction and operation of a large scale vermicomposting facility at the municipality level.

These findings revealed that participating residents were enthusiastic about their involvement but they preferred that vermicomposting of organic waste be managed at the municipality level. The setup of large scale vermicomposting systems did not prove financially feasible while small scale household units established in home gardens are beneficial.

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I dedicate this work to my family and to Dr. Sami Makarem whose presence in my life and teachings have touched my heart and changed me, May your soul rest in peace.

I will always keep in mind your famous quote “The scourge of knowledge is vanity”.

CHAPTER I

INTRODUCTION

Vermiculture is defined as the process of composting organic waste using earthworms to produce vermicast, also known as worm casting or worm manure (Sinha et al, 2010). Earthworms used in vermiculture are red wigglers or Eisenia foetida. Earthworms are hermaphroditic, meaning that they both impregnate each other at the same time, and they have both male and female sex organs. Yet, it still takes two worms to reproduce (Ndegwa & Thompson, 2001). Vermicompost serves as a humus rich soil amendment (Nagavallemma 2004, Blouin et al 2013). Unlike conventional composting, vermiculture composts organic materials more quickly and does not generate offensive odor, which makes it convenient for indoor home composting. Compared to other organic fertilizers, vermicompost was shown to have better fertilization potential (Kumar Srivastava et al., 2011). This was established at the 20% ratio of vermicompost in potting mix, and gave significant results which varied from increased number of branches and leaves, to increased root and shoot length, and number of flowers and pods. vermicompost also improves soil quality in terms of water holding capacity, disease suppression, porosity, microbial composition and abundance, and porosity (Adorada, 2007, Blouina 2013).

Vermicomposting has been successfully produced and used in many developed countries and is considered an important technology to be applied on a household level, and on larger municipality level scale (Purkayastha 2012). Vermicomposting is appealing because it is faster than the traditional composting methods, requires less space, and is odorless. It helps in getting rid of municipal organic waste (Sim and Wu 2010).

Vermicomposting is still new to Lebanon and the chances for it to prosper are directly linked to whether people would accept to work with earthworms or not. A previous study by S. Moledor (2014) concluded that one obstacle for the progression of vermicomposting in Lebanon is the negative perceptions towards earthworms and waste collection.

This study addresses social issues surrounding vermicomposting, it looks into people's perceptions towards the technology. Chapter II of this thesis introduces the study area; Chapter III addresses the direct field application of vermicomposting at the community, and the change in attitudes. Chapter IV discusses the contingent valuation study made at the community to assess the people's willingness to pay to construct and operate a municipal scale vermicomposting facility that treats the community's organic waste; Chapter V is a feasibility study that compares small-scale home vermicomposting to large-scale municipality level vermicomposting. Conclusions and recommendations are presented in chapter VI.

CHAPTER II
DESCRIPTION OF THE STUDY AREA

A. Warhanieh: a rural Lebanese village in Mount Lebanon

Lebanon is an Arab country that lies on the Eastern shores of the Mediterranean. It has an area of 10,452 km^2 with only 2730 Km^2 dedicated to agriculture. It has a population estimated at 4.4 million people out of which 9.2% work in agriculture (Ministry of Agriculture, website source accessed on 25/02/2015). In addition to its narrow coast, the country's landscape is roughly divided into three main units, the Mount Lebanon Range, the Bekaa valley, and the Anti-Lebanon Mountains running parallel to the Mediterranean Sea (Wally, 1998).

Warhanieh is a rural village in the Chouf region that has a land area of approximately 6.0 km^2 and is situated at higher elevations of Mount Lebanon ranging from 1000 m to 1150 m. Although Warhanieh is only 52 km away from Beirut, the village's geographic location away from main roads, lends itself towards isolation; like many villages in Lebanon, the infrastructure of Warhanieh has yet to be completely developed. Roads were first built in the 1950s. The first car followed in the 1960s, incidentally owned by a foreigner. Construction of a water network commenced in 1960 to 1962; prior, villages depended on two springs for household use. A sewer network was constructed in 1988 (Ghassan Ghanem, head of municipality). The municipality of Warhanieh estimates that the current population at 2,000 residents. With 350 households in the village, an average of 5.7 people resides in each household. Of these, an estimated 65 households live

in cities and are part-time residents of the village and reside there during weekends and summer break (Ghassan Ghanem, head of municipality). With respect to level of education in Warhanieh, local authorities indicate that illiteracy has been eradicated since 1990. The village has one public elementary school which has experienced a decline in enrollment; as income levels in the village have increased, a growing number of families chose to enroll children in private schools located outside Warhanieh. Beyond elementary schools, students must attend elsewhere, usually in larger villages 15 km away from Warhanieh (Kamel Ghanem, village Moukhtar).

In 2007, Batal et al. (2007) estimated that the average income level for Warhanieh and two other nearby communities at 943,379 LL or 629 USD (exchange rate 1,500 LL for 1 USD) per month and unemployment rate of 25 to 35 percent.

Like most mountain villages in Lebanon, the landscape of Warhanieh is steep and has the capacity to harbor diverse natural resources suitable for agricultural land use (Rachid, 2007). Terrain ranges from 800 to 1300 meters, where the lowermost elevations run along the Nahr al-Safa (Safa River), a primary agricultural water source. The Nabaa al-Safa (Safa River) located to the northeastern side forms a natural village boundary. The primary source of income and employment in Warhanieh is the agricultural sector (Kamel Ghanem, village Mokhtar). Warhanieh has two basic agricultural areas, an upper area and a lower area. Primary crops grown in Warhanieh include apples, apricots, olives, and vegetables, listed in order of importance and these have been grown continuously in the lower agricultural area since the 1950's. Other crops are also grown in Warhanieh, including peaches, cherries, persimmons (kaki fruits), prickly pears, nuts, and others (Osmat

Ghanem, large landowner, farmer). To help enhance livelihoods, vegetables were introduced in Warhanieh in conjunction with apple orchards, in the 1950s. This practice is not done for biodiversity or income diversification. Rather, these farmers elect to plant vegetables in their home gardens for their own household use. Primary crops include cucumbers, tomatoes, mint, and beans.

Local farmers indicated that lands were once fertilized solely using animal manure. Today, this manure continues to be used to a limited extent; fertilizers are generally preferred.

Cultivated areas in Warhanieh primarily rely on Nabaa al-Safa (Safa River) for irrigation. Water is diverted from Nabaa al-Safa a short distance downstream (see Appendix 12) from its spring source, where outflows are estimated to range from 0.3 m^3/sec in November to 2 m^3/sec in April (Dia & Jach, 1992). From the diversion canal, water is then pumped via a pumping station, to reach an extensive concrete canal network which then flows via gravity. From this canal network every farmer redirects water to flow to his/her land. Water then flows via furrows that pass through the terraced landscape (see Appendix 12). Farmers report that lands are watered every 15 to 20 days from May through September each year.

Similar to many villages in Lebanon, Warhanyeh residents no longer practice agro pastoralism which is declining in Lebanon, partly due to recent conflicts and government focus on the industrial sector versus the agricultural sector (Abou Zeid, 2007; Chalak & Sabra, 2007; Zurayk, 2000);

In contrast, few farmers still practice beekeeping as part of the holistic agricultural practices to maintain crop sustainability through pollination. Honey and other products are normally for household use only. At present, four beekeepers maintain hives in selected areas in and around the village, collecting and selling bee products as part of their livelihoods. According to local accounts bee keeping was at its highest in the 1960s when there were 15 beekeepers and each reportedly had up to 40 hives. This number was significantly reduced to four due to bee disease, and subsequent losses to bees and their hives.

B. Selecting Warhanieh as a prototype village

Considering that farmers are primary beneficiaries of vermicompost production and use, the target community for this study was one that was rural with an active agricultural profile (Ninawe, 2008). However, these characteristics could apply to many rural village communities in Lebanon. Another priority during the selection process was the ability to document 'real' attitudes and perception change in the community (Duncan and Ridley Duff, 2014). Vermiculture may be regarded as bizarre for the Lebanese and similar to other environmental projects that face resistance, the results were not guaranteed to be positive (Devine-Wright, 2007). In addition to all the above mentioned reasons, the nature of the participatory work to be carried out required continuous follow up. So, the decision was made to conduct the study in the community of the researcher as it fulfilled most requirements. Letiecq and Schmalbauer (2012) indicated that being an insider is important when attempting to engage with communities to facilitate communication, and develop

meaningful university community partnership. Furthermore, the location of Warhanieh in close proximity to Nabaa al-Safa (Safa River) makes it ideal for ensuring a continuous supply of local earthworms near river banks to the participants throughout the entire study period.

Figure 1 Agricultural land in Warhanieh

CHAPTER III

APPLICATION OF VERMICULTURE AT COMMUNITY LEVEL AND PERCEPTION CHANGE TOWARDS EARTHWORMS

Vermiculture is widely used across the globe with wide range of benefits (Sim and Wu 2010, Ansari 2007, Adorada 2007, Purkayastha 2012). India is the main producer and largest exporter of vermicompost in the world. In addition, the Unites states is also known for producing and using vermicompost products at several states such as Oregon, California, New South Wales, Washington, North Carolina, and others. The U.S is considered the largest importer of vermicompost from India. Other countries that produce vermicompost at a large scale are France, Canada, Italy, Japan, Malaysia, Cuba, Australia, Ukraine, Indonesia, Estonia and several others. In addition to selling the fertilizer, firms sell worms for small scale applications. Iran has started investing in vermicompost production and now has more than fifteen industries. Also, academic institutions in Iran are dedicating special attention to the science behind this process and many studies and publications are available regarding this subject (Majlessi et al., 2012). In Turkey, there are at least five industries for vermicompost production one of them produces liquid vermicompost known as vermin-tea (Sherman, 2014).

Vermicompost and earthworms are used to remediate contaminated soil. For example, in India a major soil contamination with toxic heavy metals was amended by adding vermicompost and worms followed by planting maize to monitor the levels. After a short period, they recorded only traces of heavy metals (Sitton, 2010). India also has the

single largest vermicompost company in the world "VermiCo" (Bogdanov, 2013). Vermicompost enterprise for rural women is popular in India, Philippine and others in which medium scale vermicomposting units are managed by women. Countries such as Philippine use vermiculture projects for community development, and social economic improvement (Adorada, 2007). Vermicomposting is also used for municipal solid waste management, and it was first established in Holland followed by England, and Canada. Later on, it was applied in USA, Italy, Philippines, Thailand, China, Korea, Japan, Brazil, France, Australia, Israel, and Russia (Sinha & Agrawal, 2010).

Lebanon is one of the 22 Arab countries located in the Middle East region. Despite the fact that many innovative projects are being implemented in the Arab world to promote sustainability and eco-friendly activities, vermiculture projects are still absent or not reported (renewables & User, 2013). There is only one company that produces vermicompost located in Dubai, UAE (Guardian of Earth), however there are no available information on its production rates, number of customers, and its location.

This study was carried in order to introduce vermiculture at the household level and examine the social dimension of vermiculture including people's perceptions and attitudes towards it.

A. Methodology

1. Designing the Vermiculture unit

In a previous study by S. Moledor (2014), vermiculture units were developed out of readily available plastic vegetable crates. The advantages of these units are that they are cheap that are made of readily available materials. However, upon the completion of the

study, two disadvantages were identified, mainly the lack of practicality especially at the harvesting stage, and the poor ergonomic potential. After waste was degraded by worms, these were harvested manually; the process was time consuming and not suitable for community intervention. These points were addressed in the current study, whereby modifications were made to the units before approaching the community. The resulting new units consisted of a two crate setup and minimized the need to handle worms.

The new setup consisted of two compartments made of two vegetable plastic crates, attached to each other with screws. A cut was made to the adjacent sides, removing the centers, and keeping only the frame to keep them attached as one unit. The opening between the two compartments was covered with a cotton cloth to keep the worms from moving from one compartment to the other. With this set up, the worms stay in the first compartment for a period of one month until the food waste is completely transformed into vermicast. Then the cotton sheet is removed to expose worms to light and encourage them to migrate to the other compartment, filled with food waste, and covered to keep the interior environment dark, contrary to the conditions in the compartment where the vermicast was produced. To maintain high humidity, the sides of the crates were lined with recycled lint material. This was supposed to ensure optimal humidity and absence of flies.

2. Public introductory seminar

The project team organized a public seminar at the village on May 27 and all villagers were invited to attend, whether farmers or not. During this presentation the team

introduced vermiculture, relayed past experimental findings, and explained the planned participatory research (Appendix I). At this early stage the study objective and proposed methodology were presented to the residents, and they were asked to contact the resident researcher in case they were interested in taking part of the study. At the end of the presentation, some asked questions on technical aspects of vermiculture, while others indicated that they are accustomed to see lots of earthworms when they plow the land. Others said that they notice that chicken are a big fan of earthworms. Samples of vermicompost were distributed to all attendees to familiarize them with the texture of the product and highlight the fact that it is odorless. More than 70 men and women attended the public seminar and the participants included farmers, housewives, entrepreneurs, university students, and even teenagers (see Appendix 3). An information sheet was circulated amongst those interested in participating in the study; 29 registered their names during the seminar.

Each household that chose to participate in the study was given the prototype for free, and trained on the following:

- How the system works and what is the theory behind the set up.
- What to feed and not to feed the worms
- How to monitor and assess the progress of the process
- What are possible reasons for failure, and how to prevent and mitigate problems

Participants were asked to give their feedback and recommendations on the overall method, and they were encouraged to suggest ways to improve the system and trouble shoot problems. Most importantly, they were expected to collect the organic waste generated

from their own household, conduct the vermiculture process by themselves, and consult on a regular basis with the resident researcher who was available, on site, during weekends and by phone on weekdays.

Following the seminar, 29 units were prepared at the American University of Beirut, in the Eco Unit of the Faculty of Agricultural and Food Sciences (check Appendix 2) and distributed to participants a week later. Written instructions about what to feed the worms and what not to feed them, was placed on each unit along with the resident researcher's contact information (Appendix 2)

3. Visit of Permaculture expert to the village

In September, the project team, in partnership with an international NGO supporting farmer to farmer exchange, organized another public seminar led by a permaculture and vermiculture expert consultant. Although the invitation was open to everyone the main attendees were the project participants. The permaculture expert shared his farming experience and highlighted the importance of vermicompost 'tea' which is known for its high nutrient content. The resident researcher contributed to the translation of the presentation session and the question and answer session (check Appendix 10 for presentation material and pictures). The expert showed images of the vermiculture system installed on his farm, discussed the size, the steps of installation, and the byproducts being vermicompost and vermin tea. Attendees were surprised to hear that the juice excreted from the process is also beneficial to the plants. The expert showed images of tomato plants and other trees that he grows with vermi-tea, in order to emphasize its real effects in terms

of crop quantity and quality. Attendees were interested to meet a foreigner who applies vermicomposting as well. A nice interactive atmosphere dominated the seminar, where everyone was engaged in the discussion which took longer than planned (check Appendix 10 for pictures). Many questions were asked, people wanted to make sure that the technique was really giving positive results, and that's what the expert confirmed. In addition, we discussed the concept of a closed system in agriculture; its benefits were explained and discussed.

4. Setting up Vermiculture units in the households

a. Phase one (June 2014) – a failed attempt

Each participating household was asked to collect their organic kitchen waste for a period of 7 days. Red wigglers Eisenia fetida were provided for free from two sources, (1) American University of Beirut FAFS Eco Unit where worms were raised, and (2) the Nabaa al-Safa (Safa River) bank located near the village. The resident researcher scheduled an appointment with each household and together, they set up the units, placed the collected organic waste inside one of the compartments, and added around 400 grams of worms. The participants were then given one to one instructions on how to monitor and adjust humidity; if the bin was dry, they were asked to spray some water to keep it moist. Three weeks later the study was discontinued because the worms in all units died. Factors that may have contributed to the collapse of the set up included high temperature, high moisture, and lack of ventilation. Furthermore, it was also thought that the worms collected directly from the river may have experienced a shock, either during collection and transportation, or in the set up due to the rapid change in environment. The following

changes were made; remove insulation material from the sides of the boxes, add bedding material (soil), and protect worms from stress during harvesting. Possible reasons for failure were presented, modifications to the methodology were explained, and the participants were informed that the experiment will be launched again in one month period.

b. Revising the methodology on campus and setting up trial units

During this phase, which lasted one month (July 2014), prototypes were set up at the resident researcher's house. Bedding was added, lining was removed from the sides and kept only at the bottom and on the top to keep flies away and maintain darkness inside. Worms were collected from the Nabaa al-Safa (Safa River), rinsed with fresh clean water, and added to three starter containers filled with organic material. At the same time, another group of earthworms was placed in clay pots containing bedding material. Clay pots provide a cool and convenient environment for the worms to live in. The number of pots was 36, the same as the number of participating households, so that the components of each single pot are later given to one household. After one month, worms in both the mother bins and in the clay pots increased in size and multiplied.

c. Setting up vermiculture units in the households using revised methodology (August-December, 2014)

In the third and last phase, in order to standardize the model, participants were asked to collect only 1Kg of kitchen organic waste. After one week, the resident researcher went to every household and set up the units. Lining material at the sides was removed,

bedding material was added, and a clay pot filled with red wigglers was empties on top of of the organic waste and covered. The bin was monitored for a period of one month then the participants were asked to prepare the adjacent compartment to make it ready for worm migration; new bedding material was added, as well as 1Kg of organic material. The bin was also kept covered on top. When all the organic material in the first compartment degraded into Vermicast, the cotton sheet separating the units was removed, and the worms migrated within few hours to the compartment with fresh organic material. The cotton sheet was put back in between, in order to prevent worms from returning to the initial bin. At every house, the resident researcher performed all the phases of the process herself. After that, participants were asked to proceed on their own. This rotation occurred four times before completing the study.

B. Results

Following the failure of the first phase in June, 2 out of 29 participating households dropped out of the study. One the other hand, nine additional households joined at the beginning of the 3rd stage. The total number of participants in the study was 37; those who continued until the end period were 34 households.

1. Description of people's reactions and feedback

The residents of Warhanieh were open to the initiative and appreciated to the fact that a resident from their village was conducting the study and that they were part of the

process. The interest in the material that was distributed during the initial public seminar can be shown in the following anecdote: A couple of weeks following the seminar, the resident researcher was stopped by a women and asked for the 'black fertilizer' that was distributed. The women explained: "I saw the basil that my neighbor grows have become healthy and their odor reached my house. So I asked her what had happened, what did she add to them that made them special? She said that she added from the fertilizer that you distributed in the seminar last week. Can you please give me a sample? I wasn't able to attend but I really want to try it!"

Other comments made by people were related to the fact that a 'university student' was actually working with 'dirt' and handling worms and she was neither afraid nor disgusted. This was interesting to the residents who commented that young people of the age of the resident researcher refuse to work with the land and consider it less prestigious than modern lifestyle. Many times, people commented to the resident researcher that it was the first time a university student from Warhanieh does something beneficial to her/his community, and that they wish others would do the same. Another comment that illustrates the adult community's interest was made by a woman as follows: "Look at you, how you hold the worms! I'm older than you and don't dare to do that! …" The oldest farmer (65 years old) among participants insisted that he will support the resident researcher's work until the end, and that he supports any individual who genuinely wants to help the villagers and develop the community of Warhanieh.

Participants communicated their feedback to their neighbors and relatives. By the time the project closure was due, all members of the community had gone through four vermiculture 'cycles', and they were happy to know something new others are not aware of yet, which can be shown in the following anecdote: During the final stages of the study, a woman told me that she is explaining to her visitors about the vermicomposting project and showing off that she is taking part in it. What she liked the most is that when she talks, no one can interrupt her, because it's a new idea and they just sit and listen to her.

2. Perception and attitude change

Perception among women was different at the beginning. Some were anxious to deal with the worms, whereas others were suspicious, but tended to enjoy working with the worms at a later stage. During the trials and tests, participants became more engaged in the process when they saw the worms growing and multiplying in numbers. The worms became the subject of the morning and evening conversations in town. They discussed with how the worms move and how they hide and go to the bottom of the bin once the cover is opened and light strikes. Women were eager to use the vermicompost on their plants and vegetables, whereas men wanted a larger scale production to use it in their farms. Their final conclusions and recommendations were positive and encouraging; everyone enjoyed the experience and wanted to spread it to others. Below are some of the comments made by participants that reflect their perception and attitudes towards the project:

Dalal: “I was worried at first when I heard about the project, I wanted to help Nada but the idea was new. The worms that nada provided us with were small, but as I started adding food wastes and taking care of them, their numbers started to multiply fast and they grew bigger and became healthier. Once I was putting the lettuce as it is without chopping it, and Nada took it back from the bin and chopped it into smaller pieces. This caught my attention and since then I always chop the waste into smaller pieces before adding them to enhance their degradation. I’m happy with the results. I never imagined myself holding worms, but now I can easily do so. It is amazing how the worms use the food waste we generate to produce a valuable product to our garden. I really wish everyone tries it because the process is very easy and the product is beneficial. What I liked the most is that you shared with us an important technique that you know in the lab, but no one of the framers knows. It is very important to couple lab experiments with infield application, to share and disseminate the knowledge across communities.”

Jouhaina: “It is a weird idea! That’s why we were very excited about it. We were eager to try it and see what the results would be. Dealing with the worms is very easy for us, they are domestic creatures especially that we raise many animals such as chicken, ducks, birds, cats, dogs and turtles. Worms can be raised like any other animal; the process is simple, clean, and beneficial at the same time.”

Sheikha: “We have large agricultural land and we don’t use chemical fertilizers nor pesticides. We use goat manure and compost as fertilizers; for insects we spray a homemade solution that is a mixture of olive oil, garlic, and hot pepper. Your project is very successful. We are taking good care of the worms, adding food waste, and keeping them in optimal conditions. We will use the vermicompost for plants and herbs in our home garden. God bless you and be with you. We support you in whatever you want to do.”

Sohaila: “It was the first time we hear about the idea of vermiculture and we loved it! We started applying vermiculture and obtained great results from the first round. We produced vermicompost and used it on vegetables and garden plants. The results were amazing. As you can see, there is a difference of 6 cm in the leaf length of lettuce planted with vermicompost versus without vermicompost. I was surprised that after adding vermicompost to my garden plants in November, the spring blooming gardenia bloomed in November and gave nice glowing flowers with extraordinary fragrance. I recommend this technique to everyone and I hope every house in the village applies it.”

Wissam: “We are making use of the organic kitchen waste to produce healthy crops. I would like to produce it at a larger scale.”

Kamel: “It is good soil amendment. Studies proved it to be very effective and beneficial on many aspects as reduced irrigation, better crop yields, and better quality.

Being a rich soil amendment, producing it locally will reduce the farming cost of purchasing chemical fertilizers. We were born and raised in Warhanieh, our ancestors were farmers, we are farmers, and our children will continue to practice farming. vermiculture is a great tool. What else would a farmer want! vermiculture is a new idea and I believe it is going to flourish and with the help of the municipality, we want to produce it on a large scale."

Nashaat: "The project is very important. It helped us get rid of the kitchen food wastes. At the beginning I was disgusted from the worms. But this changed after I witnessed their high efficiency in transforming whatever I add to the bin into valuable vermicompost. It was a great experience! We found the idea very appealing since we own large agricultural land and it generates high amounts of organic waste (vegetables and fruits). Using earthworms to transform this waste into a useful product that can be applied back on our land implies maximizing our profit and minimizing our loss in the least expensive way. Even though sorting the waste requires additional time, but having to deal with living creatures makes the process enjoyable. I believe that the demand on this technique will increase tremendously in the future."

Nazih: "This project is international, it is very important. We are taking good care of the worms, keeping them in the shade during the hot summer days, and in warm places during cold winter. However, the 5 Kg of vermicompost I'm producing now won't help me

because I'm a large land owner. I participated in the project to support you and try the new technique, but we need incentives to be able to continue and help researchers in further field trials. If they don't give us incentives, we won't participate later on."

The experience with children was more emotional and oriented towards exploring earthworms for the first time, by watching them as they move and trying to hold them with care in order not to harm them.

Amir, A 10 year old kid ran away screaming out of disgust the moment he saw me holding earthworms with bare hands. It took him less than a minute to come back running after me racing to the bin to watch me as I open it to add the worms. He kept screaming every time he saw a worm. But I kept talking to him all the way, telling him stories about the worm, explaining how it moves, how it eats, and how it changes color as it moves. He was staring at me and as I finished my words, he gazed at me and said: "Wow, you are a scientist!" I also told him that it won't bite him if he touches it. At that moment, he started mocking the idea and asked ironically: "Who would I touch the worms? Is anyone in the village touching them?" I said:" Yes, many children your age already held them". He was surprised and instantly requested to touch them. During the first trial, he started screaming even before his finger touched the worm. But during the second time, he held it with bare hands. I finished checking on the bin. I Left and he stayed playing with the worms. As I said goodbye to his grandparents, I saw him running back home and explaining to them what I told him about the worms. I heard him saying: I saw the most beautiful thing ever! A worm can change its color!"

Rami is a cute 6 year little boy and his younger brother were watching me while I was harvesting worms from the large bin to distribute to other households. They stared for some time before Rami requested confidently to hold the worm. I gave him some instructions on how to hold it, do not to squeeze, hold it softly, make sure you don't hold it for long or else it will dry and die, if it moves make sure to adjust your hand so it stays attached to it. He nodded and opened his hand to hold the worm, and he did, very gently. His smile grew wider as it moved all over his hand. His younger brother felt jealous and wanted to hold it as well (figure 20 in Appendix 3). And they started to fight over it; Rami wants to keep it while Rabih wants to try and hold it. I made sure not to give him another worm, to see how they will behave. As soon as Rabih grabbed the worm and felt proud of himself, their friend came and started to ask what is the creature that they were holding. Both explained for him that it is an earthworm. He wanted to hold it as well. But the surprise was that Rami and Rabih became very worried that their friend will harm the worm if he held it, so they refused to pass it to him. After insisting, Rabih gave it to him while Rami kept giving him instructions on how to hold it and made sure he returned it back to the bin before it dried.

One of the participants mentioned towards the end of the study that the first time she saw the resident researcher handling earthworms without wearing gloves; she got very disgusted and took a shower directly after the researcher left her home. This same woman now handles the worms with bare hands. She also indicated that it was an extraordinary

experience for her, as she never imagined that one day she would hold an earthworm. She used to kill them if they appeared in the soil.

One of the participating women was able to save the worms in her bin during the first trial. She saw few earthworms in her garden while plowing, and wondered why the worms are active in her garden, whereas they are dying in the bin. Then she decided to add soil to the bin and collected some worms from her garden and added them to the bin. The few worms grew and multiplied in the presence of soil. In the third phase the resident researcher gave her a new bin to apply the new methodology. She ended up having two well-functioning bins.

C. Discussion

Although vermiculture was not known in the village of Warhanyeh the study showed that in the span of few months residents became receptive to the idea and some participants even supplied their neighbors, who recently became interested in vermiculture, with earthworms and helped them design their bins. The community was engaged in all phases of the study. Everyone wanted the project to succeed. Driven by their interest to see the "resident researcher" succeed in her research they were willing and proud to be the pioneers in applying this technology. Even in the beginning when the method failed, their reaction was very unique mainly because they owned the process; if it fails it means they failed, and they wanted to succeed (Rabinowitz, 2014). In addition, they trusted the resident

researcher and believed that the knowledge that was disseminated is true and they were eager to experience the results by themselves.

The four main principles in community based participatory research, according to Potvin et al (2003), were met in this study. First, community members were integrated as equal partners. During the opening seminar, the ultimate goal of the study was clearly communicated which is to improve the health of community members, improve soil quality, which will be reflected in the quality and quantity of crop yields, and that Warhanieh will be the first village to apply this technique in Lebanon. These goals are direct benefits to the community, people supported them and chose to participate, which made them collaborates in this research. And the university was ready to help them apply a technique for their own benefit. Second, the study integrated intervention and evaluation. As observed in the failing stage, the participants came up with interventions and recommendations to overcome problems and proceed with the project. The third principle was organizational and programmatic flexibility through the continuous follow up on the study participants and results, in addition to organizing the workshops and seminars for making sure the community is well convinced with the technique. Fourth, the project was a learning experience for everyone, which was the best part of this study. Participants continued to practice vermicomposting after closing the study, which indicates that they are applying out of interest and awareness of its importance as soil amendment and solid waste management strategy. Most of the participants asked for bigger vermicomposting units that can tolerate larger volume of organic wastes.

D. Conclusions

This study as a whole met its objective and people's perception towards vermiculture was assessed as well as the practicality of the vermiculture set-up. The process has the potential to change how people deal with the environment. It made them notice the un-noticeable creature living under the soil, and appreciate its role in maintaining a healthy ecosystem. The approach to the community which was based mainly on respect, humbleness, love, and most importantly based on trust was accepted by all and these facilitated communication and help develop a rapid and meaningful university community partnership. Based on people's request it would be beneficial to design larger household vermicomposting units that can tolerate higher amounts of organic waste.

CHAPTER III

CONTINGENT VALUATION TO ASSESS THE PERCEPTION, ACCEPTABILITY AND WILLINGNESS TO PAY OF VERMICOMPOSTING

Vermicomposting is being promoted in many countries due to the wide range of benefits it possesses. Vermicomposting provides solutions in agriculture for poor soil quality (Munnoli et al, 2010; Singh et al, 2008; Atiyeh et al, 2000; Edwards et al, 2010; Aroncon et al, 2005). Moreover, it is an effective tool for community development (Shivakumar et al, 2009; Purkayastha, 2012; Roseland & Soots, 2007) besides being a strategy for solid waste management (Clarke, 2000; Singh et al, 2011; Tognetti et al, 2007). As a technology, vermicomposting has been successfully used in some developed countries for years (Karousakis & Birol, 2008). Vermicomposting is appealing because it is faster than traditional composting methods, requires less space, and creates unrecognized odor (Sinha, 2010; Shouchet, Bhatiz and Jain, 2014). Considering that solid waste management is a major concern in Lebanon, vermicomposting can contribute to the alleviation of this problem. Actually, the resulting nutrient-rich compost end product from vermicomposting is an environmentally sound amendment that enriches soil for plant growth which will directly be reflected on the health of the population. However, in Lebanon, there are no tangible estimates of the community acceptability of vermicomposting and there is no observable market data contrary to other European and North American countries (Doherty & McKissick, 2000; Sherman, 1997; Munroe, 2005). The following study adopts

contingent valuation (CV), defined as a survey-based technology for non-market environmental valuation (Baarsma, 2000).

A. Objectives

The study's objective was to estimate the acceptability of vermicomposting in a village community with a farming background, and to gauge the community's willingness to pay (WTP) for setting up a municipal vermicomposting facility to manage part of the village organic waste and to assess whether there is variation across different socioeconomic and attitudinal profiles.

B. Methods and materials

1. Contingent valuation

In order to start an environmental project, public acceptance is a necessary step to be able to implement the theory in the field (Baarsma, 2000). Therefore, a contingent valuation survey was conducted in Warhanieh - Chouf to assess public's willingness to pay through payment card options ranging from $0 to $31. Payment card is a widely used elicitation format for CV (FAO, 2001). Many studies are available on the use of contingent valuation in waste management, for example in Malaysia; CV is used to estimate the WTP of households to improve waste collection systems (Afroz & Masud, 2011). Another study done in Ghana assessed the demand of farmers for compost (Danso, Drechsel, Fialor & Giordano, 2006).

a. Questionnaire development

The aim of this study was to investigate the attitudes and perceptions of Lebanese citizens towards vermicomposting and to test the viability of this method at a rural village where agriculture is widely practiced. All the benefits of vermicompost were explained to residents of Warhanieh village through a public seminar.

Willingness to pay (WTP) was elicited from respondents by means of an increase in municipal taxes in exchange for this new service. The face-to-face survey (Copies of the survey and the consent form in both Arabic and English are attached to appendices 4, 5, 6 and 7) provided information on whether the community in Warhanieh would accept the concept of vermicomposting and whether they are ready to apply it if the required resources were available.

The questionnaire was developed and adjusted to fit Warhanieh. Pilot-testing was done prior to the field survey; several focus group meetings were held at both the university and the village levels, with specialists and with local farmers, to test the survey. The survey was approved by the university's Institutional Review Board (IRB). The final version included a consent form followed by five sections tackling 1) major environmental concerns 2) contingent valuation exercise 3) further questions about current farming practices 4) demographics and 5) observation of the household situation. All questions were closed ended of two types, either multiple choices or ranking questions see Appendix 6 for the questionnaire.

C. Household interviews

The survey was conducted face-to-face in Warhanieh between November and December 2014 by means of a pen-and-paper questionnaire. A team of surveyors was trained to deliver the questionnaire in such a way to minimize interviewer bias. Only one individual from each available household was surveyed. The sample was selected by means of convenience sampling, if no response was received when knocking at the door, the household was skipped. The target group consisted of the males and females residents of Warhanieh, aged between 18 and 64 years old, and fully or partially responsible of the household budget and expenses. Interviews took approximately 30 minutes apiece. The number of households approached was 200 households, out of which 144 (72%) took part in our study while 51 (28%) refused to participate. The participants were informed of the purpose of the research following protocols agreed by the IRB university ethics committee. Consent was sought through both verbal and written communication see Appendix 4 and 6. It was made clear that participants could withdraw at any time. Those who completed and in recognition of their time and effort were given a souvenir which is a mug with the AUB logo and the name of the village printed on it (check Appendix 8).

D. Results and Discussion

1. Sample characteristics

In Warhanieh, the results show that 47% of villagers use chemical fertilizers while 34% use organic fertilizers. Goat manure is preferred over the other types of organic fertilizers. None of the farmers use compost. Relative to Lebanese agricultural villages,

Warhanieh's level of education was considered high, with the absence of illiteracy and up to 33% of household heads with university degrees. The detailed sample characteristics are mentioned in the table 1 below.

Table 1 Characteristic of the sampled population in Warhanieh during the Survey

Variable	Level (%)
Males	57% (83)
Females	43% (61)
Respondents educated with university degrees	33%
Stay in the village regularly	76%
Income: ➢ of low income $800 and below ➢ of middle income $800-1500 ➢ of high income $1500 and above	 40.6% 34.03% 25.37%
Household size: Small Big	 43.75% (63) 55.56% (80)
Farming: ➢ use only organic fertilizers ➢ use goat manure ➢ use cow manure and less than 1% use poultry	 31% 32% 22%
Think that solid waste disposal and management problem is a priority	31%
Strongly disagreed with the statement that solid waste disposal was done safely and environmentally safe.	25%
Think that vermicomposting is very interesting	76%

The number of university educated people is 33% which is significantly high compared to other rural villages. In addition to that and as previously stated, illiteracy was completely eradicated in Warhanieh since 1990. It is remarkable that 31% of the people use organic fertilizers which imply that there is a great deal of environmentally good practices.

Meanwhile, 31% of people think that solid waste disposal and management is a priority and 25% believe that solid waste disposal is not done safely which gives urgency to proceed with vermicomposting. High level of interest in vermicomposting was recorded (76%) which is encouraging and further supports this study.

2. Warhanieh Face to Face Survey

It was hypothesized that the willingness to pay and acceptability of vermicomposting will be affected by age, gender, income, education, and the type of fertilizers used. Particularly, it was expected that i) an increase in income will increase people willingness to pay for vermicomposting, ii) as the level of education increases people's willingness to participate and pay for vermicomposting increases because they can better understand the benefits of the product, iii) younger people will be more willing to pay for vermicomposting, and iv) people that use organic fertilizers will be more willing and accepting to pay and participate.

3. Model Estimates

a. Willingness to pay responses

People were asked if they would accept to pay an additional tax to the municipality to install and run a vermicompost production facility. Also, people were shown a sample of vermicompost and asked whether they would accept to pay for vermicompost as a soil

improver, in addition to other questions. For the analysis, we chose the multiple linear regression with square root transformation for the WTP. Multiple linear regression with square root transformation equations are as follows:

$$Yi = \alpha + \beta_1 X_{i1} + \cdots + \beta_p X_{i,p} + \varepsilon_i$$

$$\sqrt{cost} = \alpha + \beta_1 x_{i1} + \ldots + \varepsilon$$

Based on this mean function, expected willingness to pay is explained by educational level, income level, age and gender.

Variables	Coefficients	Std-Error	t-value	P-value
Income 800 – below	1.3767	0.2682	5.133	$1.27e^{-06}$ ***
Willing to do vermicompost at their house	0.4315	0.2430	1.776	0.07861 .
Income $ 800-1500	0.4612	0.2711	1.701	0.09181 .
Income above $1500	0.9954	0.3300	3.017	0.00319 **
People Educated with a university degree	0.8441	0.2811	3.003	0.00333 **
People who use organic fertilizers exclusively	0.4904	0.2353	2.084	0.03951 *

Figure 2 Model estimates for WTP

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

N: 144, Multiple R-squared: 0.2506

p-value: $7.217e^{-06}$

Table 2 presents our model estimates which has an acceptable R-squared of 0.25. The variable income, education, and organic fertilizers practice exclusively were

significant and positively correlated with WTP. This model explains 22% of the variables in the data.

The results confirm the factors that are commonly linked to WTP; these factors are income, education, and organic fertilizers practice. The other factors such as gender and age are not significant. In Warhanieh, people who are willing to do vermicompost at home are willing to pay $1.37/hh/month more than the average WTP, while people with university degree are willing to pay $3/hh/month more. Besides, people who use organic fertilizers exclusively have $1.5/hh/month higher willingness to pay. In addition, as the income increases above $1500 the willingness to pay will increase by $3.7/hh/month.

The average willingness to pay an additional tax for implementing a vermicomposting facility in the village is $7.4 per month. Few people said that they are ready to pay $35 as a tax in a month in case the project is well done and having beneficial outcomes. In general everyone was satisfied with services of the private company that is currently managing the solid waste collection management in the village, Chouf. While very few of those of higher income class didn't like the idea and sometimes refused to fill the survey from the very beginning as they believed that this issue has nothing to do with their living or work. People were glad to participate in filling the survey and they were really interested in the idea of vermicomposting and using earth worms. Many people used chemicals to sustain their income from farming though they believe it's not healthy.

Some of the visited houses said that they do not really grow crops, however, for them it is a good idea that others start using vermicomposting instead of chemical fertilizers. Others did not have any objections as long as there will be transparency in the

municipality's work and there is continual monitoring. In general, all respondents were ready to be contacted for the next steps in case their assistance was needed.

The WTP in Warhanieh (US$7.4/hh/month) was half the WTP of people from the pilot testing survey that covered different regions (US$14/hh/month). This can be attributed to many factors; mainly the sample of the regional survey was mostly comprised of university students who are characterized with high education level and low income level. In addition the Cedar Environmental firm mentioned earlier that it is charging less ($4), meaning that even if the existing WTP ($7) for vermicomposting decreases, the aforementioned firm can still cover the expenses and gain profit.

b. WTP estimates for different profiles

Looking into other scenarios is helpful for giving a wider view of possible WTP with changing variables of income, willingness to do vermicomposting at home, education, and use of organic fertilizers exclusively. Table 2 shows how the willingness to pay changes with different profile characteristics.

Profiles of people of different characteristics	Average cost
Profile of a person of Income less than $800	
Income is less than 800, ▪ Abstains from vermicomposting at home, ▪ Does not hold a university degree, ▪ Does not use organic fertilizers exclusively	$ 1.9/hh/month more than the average WTP
Income level less than 800, ▪ Has a university degree, ▪ Willing to do vermicomposting at the household, ▪ Uses organic compost exclusively,	$9.8/hh/month more than the average WTP
If this same person did not go to the university	WTP decreases $4.59/hh/month.
For the person who is in the income is less than $800, ▪ Did not go to university, ▪ Not interested in doing vermicomposting at home	➢ the willingness to pay decreases by $6.39/hh/month
Profile of a person of Income above $ 1500	
Income level above $1500, ▪ Has a university degree, ▪ Willing to do vermicomposting at the household, ▪ Uses organic fertilizers exclusively	Willing to pay is $17/hh/month more than the average WTP.
For this same person if he was not interested in doing vermicomposting at the household	Willingness to pay decreases by $3.38/hh/month.
If this same person is ▪ Not interested in vermicomposting, and ▪ Did not go to the university.	His WTP decreases $7.2/hh/month.
If this same person is ▪ Not educated, ▪ Not interested in doing vermicomposting at his house, ▪ Does not use organic compost exclusively.	His willingness to pay decreases by $ 11.49/hh/month.

Figure 3. Estimated WTP for different profiles

c. Estimating the Logit model

In order to compare the characteristics of the people who prefer the municipality to do the vermicomposting versus those who prefer doing it at the household level, the logit model was used.

Logit model log transformation equation:

$\eta i = \text{logit}(\pi i) = \log (\pi i / 1 - \pi)$

Variable	Estimate	Std. Error	z value	Pr(>|z|)
Income $800 - below	0.8804	0.2885	3.052	0.00227 **
Income $800 - 1500	-0.7578	0.4064	-1.865	0.06224 .
Income $1500 - above	-1.4065	0.4534	-3.102	0.00192 **

Figure 4 Participants who chose to do vermicomposting at their homes

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '

Based on table 4, it was found that the probability to participate in vermicomposting at home for someone of high income more than $1500 is 37%. While the probability increases to 71% for a person of low income less than $800. For the people of middle income, 800 to 1500 the probability is 50%. It can be concluded that people who have higher income are less likely to do vermicomposting at home.

Variable	Estimate	Std. Error	z value	Pr(>|z|)
Income $800 - below	2.5649	0.5189	4.943	7.68e-07 ***
Income $800 - 1500	18.0011	2532.9101	0.007	0.994
Income $1500 - above	-0.1978	0.7961	-0.248	0.804

Figure 5 Participants who prefer that the municipality handles all the process

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

However, almost 90% of the people prefer the municipality to handle the project (estimates from table 5). But when it comes to implementing the technology at the household level the percentage drops. On the other hand, people that have low income tend to have a higher acceptance to do it at home, and as the income increases their willingness drops. While people who want to do it at home tend to be of lesser economic means, and the people who are the least to do it are the people of high economic means. And what was found is that paying people money to do it does not change a lot their willingness to participate. As such it would be important if we were to increase the acceptability of the product, to invest in raising the level of education of farmers through workshops and certification programs. However, future programs targeting the spreading of this technology should bear in mind that even educated people, once their income increases to a certain level their willingness to do it at their household will decrease. People were highly interested in vermicomposting and eventually almost all wanted the municipality to handle the process.

E. Conclusions

This study revealed that residents of Warhanieh, even those of low economic classes, are willing to adopt vermicomposting at household level. This may be due to the fact that the majority are full time or part time farmers and they see the end product as beneficial to their activity. The results also show that the residents were aware of the importance of solid waste treatment and environmental initiatives with a considerable willingness to pay for these types of projects. Although this study focused on a farming community it would be interesting to expand it to a larger geographical area that will encompass the whole of Lebanon. Therefore, it would be interesting to investigate the WTP and perception of urban dwellers which allows us to compare rural versus urban settings. But the question remains whether a large scale facility is feasible and doable especially when talking about continuous daily flows of municipal organic waste.

CHAPTER IV

FEASIBILITY STUDY VERMICULTURE APPLICATION ON LARGE SCALE VERSUS SMALL SCALE

Many studies show that vermicomposting can be used as a tool for improving economic status in rural settings (Purkayastha 2012). However, it is not yet proven if this applies to Lebanon in the absence of an established market for vermicompost. To provide baseline information regarding the economic feasibility of vermicomposting in a rural community in Lebanon this study compares the value of small scale vs large scale vermicomposting.

Solid waste in Lebanon is managed by a private company that gets paid per ton of waste from the government. This company manages the waste in the capital Beirut and in Chouf – Mount Lebanon. Compared to other towns Warhanieh which is located in the Chouf region does not have a pressing waste management problem. However, based on a village wide survey the majority of residents agreed that solid waste was not disposed of safely and did not take into consideration the environment. For the city of Beirut, waste disposal is a pressing problem due to the fact that the only landfill to dump the waste is Naameh landfill which was put up to work in 1997. The landfill was intended to close after six years of establishment, however it has been functioning for 17 additional years and has received five times more waste than its designed capacity per day (Zaatari & Sidahmed, 2015). Naameh is a residential area and people are complaining and suffering from the negative effects of the landfill. Increased number of cancer cases and pulmonary problems

are detected, in addition to high air pollution levels and noise pollution because of the site incoming and outgoing trucks. On top of that the unpleasantodors and flies generated from waste worsen the living conditions. Dwellers have been protesting for many years asking for the closure of the landfill (The Daily Star, 2015). However, not until this year the government has seriously dealt with the problem after a major crisis in this sector that lead to the accumulation of the waste in the streets for more than one week. Protestors from across Lebanon stood together claiming a fast and effective mitigation for the problem. The final suggestions presented by the minister of environment in the Lebanese government were 1) opening landfills in other towns 2) incinerators (Al Kantar, 2014). However the area of Lebanon doesn't tolerate opening other landfills, and incineration can be a real threat to health if air quality wasn't well monitored, especially that we lack a functioning air monitoring system although the plan, equipment and hotspots were defined in a study that was done in collaboration between the United Nations for Environmental Protection, the American University of Beirut and the University Saint Joseph.

In light of the above, many studies and public calls are made to adopt solid waste sorting and recycling at the source, vermicomposting can contribute to this strategy.

A. Cost

1. Large scale application

The project would involve some basic costs as the opportunity cost of the land for the installation of the facility, transportation and collection of the waste, employees and equipment to run the facility. Costs are dependent on the size of the facility which is

determined based on the volume of waste it should handle (Bogdanov, 2004). Besides, if vermicomposting is to contribute significantly to waste management, then the process must be sustained throughout the year. Based on this, the internal environment should be optimized through installing air conditioning system to control the temperature, and humidity.

a. Construction Costs

In Lebanon the average organic waste production per household per week is estimated at 3Kg. According to a study done by Visvanthan in 2005, 20 tons of household waste is vermicomposted in France every day and this requires 1000 to 2000 million earthworms and produces 400 tons of vermicompost and 10 tons of earthworms (Visvanathan, et al., 2005). In the case study of Warhanieh, if we follow the same ratios, an estimated 300 households would produce an estimated 6 tons of organic waste per month. This amount of organic waste produced per month requires 12 tons of earthworms as they reportedly consume half their weight every day (Sinha, Herat, Valani & Chauhan, 2009). So on a scale of 6 tons, 12 tons of earthworms will produce 0.8 tons of vermicompost and 0.02 tons of earthworms. The area required to carry the process is 1.22 Km^2 or 1,228,898 m^2 which is costly to buy and difficult to find especially in rural areas because land is considered an important asset. Figure 1 summarizes the costs of operating a large scale vermicomposting facility.

Earthworms double in number every 60 days given optimal conditions of temperature, moisture, and feeding material. If earthworms don't get physically damaged they can live up to 220 days. They need 4 to 6 weeks to become sexually mature. On

average worms produce 3 cocoons every week and produce 300 to 400 young worms during its lifecycle (NC State University, 2015), Eisenia foetida species have a maximum net reproduction rat of 10.4 worm per week (Dynes, 2003). They are sensitive to light and prefer to live in the dark (Sinha, Herat, Valani & Chauhan, 2009). Eisinea fetida, the earthworm found in Lebanon and used in this study is known of its ability to survive extreme conditions such as soil toxicity and heavy metal pollution (Satchell, E., 1983). However, treating organic waste on a municipal level high amounts are needed which becomes expensive where 6 tons of earthworms will cost $1,111,131. Although their numbers will multiply but this amount should be available to initiate the process and guarantee that the 6 tons of waste will be treated and converted to vermicompost on time since there will be a continuous flow of waste to the treatment facility.

Water should be available on site all time, for water is used in preparing the bedding and keeping the earthworms moist. The water sources available in villages are either spring water or the water supplied by the government. These are not enough and keeping the process going will require additional water sources which can be delivered to the site in cisterns. However water availability is decreasing in Lebanon and the government has already initiated several campaigns to direct the use of water. vermicomposting technique is important because it improves the environment and protects its resources. That's why it is not environmentally safe to have a large scale vermicomposting facility.

Other costs involve construction of the facility, which need to be indoors to make sure it functions throughout the year. Materials and equipment for building the facility: this

involves cement blocks, wood, metal shelves and others. In addition to the cement and concrete building, the interior structures should be designed to hold the municipal waste and at the same time provide the adequate environment for the worms to live in. These costs will be invested once at the beginning before starting the process. This will include also installation of air conditioners to regulate the temperature.

The size of the facility will determine the cost. In other words the quantity of organic waste to be treated which varies based on the number of households in each village.

b. Operational costs

Monitoring equipment to control the environment inside the facility (ex: log, pH meter, and others) will be needed. Also tools to perform tasks and distribute the waste across the compartments such as shovels to mix and ensure aeration inside the beds are needed as well.

At least 6 workers should be present on site to aid in waste disposal and distribution across the worm beds. Moreover, there is the cost of collecting waste from households and transportation to the site. It is mainly the fuel and truck maintenance, in addition to the salary of 2 employees who are going to perform this job.

c. Maintenance Costs

The cost of maintenance is minimal, mainly the worm population should be kept in check, and any decrease should be compensated. Truck maintenance, tools and equipment is necessary.

d. Additional costs in case of major crisis

In case the worms died or disappeared for reasons such as increase or decrease in temperature, dryness or increased moisture, invasion of ants, harmful insects, or chicken which are known to be direct threats to earthworms, high costs will be incurred. The worms should be purchased and added immediately to control the process or else many additional problems will prevail some of which are offensive odors, attraction of flies, waste leachate, increase of harmful bacteria and microbes on site (Bogdanov, 1996). The waste will be piled and the facility will reach its full capacity in less than two weeks. For that reason usually facilities are designed to account for emergency situations for example an additional compartment for treating waste used only in case of cleaning or defects in the process (Galante, Aiello, Enea & Panascia, 2010). However, if such thing is to be applied, the area of the facility will have to double, which is not feasible and almost impossible in the Lebanese model.

Land

- should be allocated away from residential area, its size depends on the scale of the facility
- The larger the required land the more expensive it becomes.

Water

- Should be continuously available on site, most of the time it is bought in cisterns.

Earthworms

- 12 tons of worm are needed for treating 6 tons of food waste in one month period
- 12 tons are sold for $ 1,111,131 (One pound of worms is sold at $42)
- 12 tons will require an area 1.228 Km2

Construction Material

- Cement blocks, concrete, wood, metal shelves and others are needed.
- Interior structures should be designed to hold the municipal waste in optimal conditions, so the installation of air conditioners and others are required

Tools and Equipment

- Monitoring equipment to control the environment inside the facility (ex: log, pH meter, and others
- Tools to perform tasks and distribute the waste across the compartments such as shovels

Collection and Transportation of waste

- Salaries for 2 employees responsible for collection of waste and driving the collection truck
- Truck maintenance and fuelcosts

Operation

- 6 workers should be present on site to aid in waste disposal and distribution across the worm beds

Additional costs in case of crisis

- Purchase of earhtworms
- offensive odors, attraction of flies, waste leachate, increase of harmful bacteria and microbes on site.

Figure 6 Costs of large scale vermicomposting

2. Household level application

Carrying vermicomposting at the household level is considered cheap since the installation and operation costs are minimal. In my study we used plastic vegetable crates, bedding material (soil), cotton sheets to cover the top, and earthworms.

Since the size of the setup is relatively small, enough to manage organic waste of a single household, the needed amount of earthworms ranges between 400 to 500 grams as a starter. Knowing that worms multiply fast, the vermicomposting process will sustain itself by itself. Figure 3 shows the steps for preparing and installing the household bin which is easy and cheap. Therefore, household application is prefered over large scale because it involves less costs.

Figure 7 Stages of household vermicomposting

B. Benefits

1. Economic Benefits

a. Large scale

Profit from large scale facilities takes time and is not immediate especially with the absence of vermicompost market to sell the product it is not guaranteed. Moreover, the cost will be divided on the households and is considered high for rural communities. In addition, it is not safe to depend solely on vermicomposting to manage the waste of an entire community due to the high risk of failure because earthworms are sensitive creatures and are subject to many threats. Besides, even if the municipality was able to cut the organic waste out of the stream, it won't save the money charged by the government for waste management because the amounts are reduced automatically from the municipality balance before reaching its treasury. This prevents the municipality from saving the money to do developmental projects in the village that could benefit the community. This is the major drawback of the large scale application. This model was found not feasible because the money invested will not be returned neither through selling the product due to the absence of market, nor by the deducted municipality tax. People will have to pay additional tax for implementing the whole project from A to Z, while their municipality tax doesn't decrease and the municipality will not be able to offer them in return beneficial projects that address their needs.

b. Small scale household

Economic benefits in small scale vermicomposting are very low. The production rate is low and there is no market to sell whatever is produced. Thus Vermivcomposting will not be applied for its economic feasibility, but rather for its ecological, environmental, and health benefits which will be discussed below. So people and farmers are recommended and encouraged to produce and use vermicompost for its benefits on ecology, health, and local food security. These are the added values that distinguish vermicompost from the rest of the existing fertilizers.

2. Ecological Benefits and increased crop growth

Vermicomposting is an alternative method for improving soil fertility. It is highly recommended in home gardening practices. Vermicompost is stabilized and is the byproduct of the interaction between earthworms and organic material in the presence of soil or bedding material (Fernández-Gómez, Díaz-Raviña, Romero & Nogales, 2013). The worms excrete a powerful fertilizer called vermicompost. Known as the black gold, vermicompost has many benefits to the ecology. Many studies show that vermicompost provides high soil porosity and high water holding capacity which contribute to aeration, water drainage and resistance to erosion (Domínguez, 2004; Weber et al., 2007; Adhikary, 2012; Bachmann and Metzger, 2007). This prevents nutrient runoffs during storms and irrigation thus sustains the groundwater clean from contamination and eutrophication problems (Chaudhary, Bhandari and Shukla, 2004). Besides, vermicompost regulates the soil pH levels; if the soil is acidic mixing it with vermicompost will increase the pH

towards 6 or 7 which is the optimal. It does the same when the soil is basic; vermicompost decreases the pH to the optimal level (Chaudhary et al, 2004; Bhandari and Shukla, 2004). Another important feature is that it suppresses plant diseases by providing certain nutrients that increase the plant's natural resistance to pests and fights plant microbial diseases, insects and parasites (Biradar et al., 1998; Rao, 2002; Ramesh, 2000; Noble and Coventry, 2005; Termorshuizen et al., 2006; Arancon et al., 2003)

In addition to all the ecological benefits, vermicompost is important for producing healthy fresh food. It is known that using vermicompost enhances the smell, color, taste, and keeps the quality of flowers, fruits, vegetables, and grains (Sinha, Agarwal, Chauhan, Chandran & Soni, 2010). It stimulates plant flowering and seed germination, thus increasing the flower number and biomass (Arancon et al., 2008). It is also rich in biochemical substances and organic carbon which play an important role in soil fertility. Worm casting has ten to twenty times higher microbial activity of beneficial microorganisms than that present in the soil and other organic matter which promote plant growth, stimulates shoot and root development (Edwards et al., 2004; Adhikary, 2012; Tomati and Galli, 1995; Nardi et al., 1988; Graf and Makeschin, 1980; Dell'Agnola and Nardi, 1987). Moreover, the humic material present in earthworm vermicompost, that is the form of completely mature compost that reaches the stable state and is used by horticulture specialists to regenerate soils, increases hormonal activity which in-turn induces root growth (Canellas et al., 2002, Zandonadi et al., 2006; Canellas et al.; 2002; Zandonadi et al., 2006). Many studies show that vermicompost have higher nutrient availability because it transforms the nutrients present in soil from insoluble to soluble

which makes it available for plants (Scott, 1988, Adhikary, 2012; Edwards and Burrows, 1988). Thus it increases nutrient uptake by plants and also regulates the release of nutrients into the soil by chelation where it only releases the amounts required by the plant (Kabir et al. 1998; Cavani and Mimmo, 2007; Adhikary, 2012). A study done by Lazcanoa and Domínguez (2011) shows that adding a mixture of 25% vermicompost and 75% inorganic fertilizer to plants made significant greater increase in plant height and crop yields compared to 100% inorganic fertilizer. Many other studies are done prove that vermicompost increases crop yields which is a great incentive to users especially farmers as it will have a positive impact on their profit (Adhikary, 2012; Ansari, Ismail & others, 2008; George, Pillai & others, 2000; Jelin, Dhanarajan & Mariappan, 2011; Blouin et al., 2013). All these characteristics contribute to healthier plants, increased crop productivity and quality of food which is directly linked to better health and improved farming profit.

Figure 8 Lettuce planted by one of the volunteers during the study period at the same timing shows different growth results: without using vermicomposting (top) with vermicompost (bottom)

3. Environmental Benefits

The benefits of vermicompost extend beyond improving ecology, supplying nutritious foods, and promoting healthy lives, to environmental benefits. vermicompost is defined as the use of earthworms to transform organic waste into fertilizer of high quality. It recycles back the nutrients into the soil and treats waste at the source which is the most effective strategy to solid waste management. Reducing waste generation eventually reduces the community's ecological footprint. In addition it reduces ground and surface water pollution and eutrophication problems as a result of reduced use of chemical

fertilizers (Fernández-Gómez, Díaz-Raviña, Romero & Nogales, 2013), because of its ability to control the release of nutrients into the soil based on the plant's need for it.

Not to mention the benefits that include increased landfills size because of reduced volume of waste dumped in it, reduction of the use of Fertilizers by at least 50% which saves money and protects the environment, and finally possible profits from selling Vermicompost.

C. Warhanieh interviews

1. Ecology and livelihood practices in Warhanieh

Soils in Warhanieh are porous which are distinguished by high infiltration rates, low moisture retention, and poor fertility due to limited organic matter and nitrogen (Aulakh & Bijay-Singh, 1997). To compound matters, when crops are harvested, nutrients are moved from the soil, leaving it depleted (Bijay-Singh et.al, 1995). Although fertilizers may help to increase crop yield, excessive usage may negatively impact the ecosystem, affecting other resources like water (Aulakh & Bijay-Singh, 1997; Bijay-Singh, et al., 1995).

Synthetic fertilizers were first introduced in Warhanieh fifty years ago. Most farmers rely on fertilizers to increase crop yield. Because of cost, applications may be restricted to every other year (Kamel Ghanem, Moukhtar). However, there is a general belief that fertilizer quality has declined, suggesting the nutrient composition has decreased. Studies have revealed that lack of confidence in these chemicals have resulted

in farmers using 20 to 30 percent more than label recommendations despite cost (Farajalla & Khoury, 2007).

2. Home gardens

Family production systems whether called kitchen, home, or backyard gardens, are the oldest known production system (Marsh, 1998). Large or small in area, home gardens provide security to households by diversifying its sources of livelihood and by making them less vulnerable to external factors as food shortage. House gardening isn't necessary practiced by those of low income, but mainly by the households which have access to the needed resources such as water for irrigation, land, and labor (Marsh, 1998). Studies show that the successful household food security strategy would be to focus on the micro rather than macro level. In other words, it's to focus on the household not on the government, ministries, and municipalities. Home gardens are also important because they provide ecological niches for many insects, and function as conservation areas for beneficial organisms (Marsh, 1998).

Although people use chemical fertilizers and pesticides in their farms, yet at their home gardens they apply only animal manure and spray some plants with a mixture of water and ashes to fight insects and worms to reduce the use of pesticides. People believe that organic gardens are their only source for healthy and fresh food. The gardens have wide diversity of vegetables and fruits; especially the smallest gardens because they force people to group many different species in small numbers. While big gardens allow multipurpose use of the area and gives space to more diversity of plants, small gardens are

managed in a way that allocate space for the plants which constitute the highest portion of their diet. Even landless families tend to cultivate in containers. Daily practices in Warhanieh during the summer season involve harvesting the vegetables directly from the garden to prepare the food for the family to eat them fresh and healthy. Outsource purchase is very low, home gardens provide almost all the needed food products.

Figure 9 Aerial view of Warhanieh

The image in figure 15 shows the old village clustered at the middle, the area around it was a community garden. The residential area in Warhanieh doubled in size between 1970 and 1978 and took over the community garden. However, the houses built around the old village portray the individualistic lifestyle where each household has its own garden (check Appendix 13). Home garden vegetation has two purposes, decorative and functional. Even in small gardens people manage to plant both types of plants. Land is

always dedicated for planting vegetables and herbs, while ornamental plants in pots and placed outdoors and indoors, in narrow spots, on garden stairs, home stairs, and on balconies. Fragrant trees and plants are usually planted in the garden or in pots in close proximity to the house's main entrance. Larger gardens provide more space for wider range of plants. Processing fruit, vegetable, and dairy products is part of the village heritage practiced by almost all housewives where they prepare products in the summer for local consumption in winter season. Processed food constitutes a significant portion of the winter diet, some of the products include: jam, juice, salad dressings, tomato paste, grape molasses, mulberry and rose syrup, kushk, pickles, dried fig, apricots, grapes and others (see figure 6).

Figure 10 Home gardens in Warhanieh

a. Absence of gardens

Houses without kitchen gardens plant the food for local consumption in their large agricultural lands that are located away from the residential area. These houses represent 25% of the households which constitutes the old clustered village. Although if we look at the map in figure 5 they might seem more in number, but each home in the old village have burst into more than one household dispersed in the extended village area. Only the first

generation of aged families inhibits them, or in some cases one of their children. People without access to land next to their home plant only ornamental evergreen plants, flowering plants, and fragrant herbs in pots and place them indoors or on their balcony as shown in figure 7 a and b, and figure 8.

Figure 11 a)Decorative plants on narrow balconies b)Vegetables planted in plastic pots

Figure 12 Many planted pots to keep the greenery near the house

b. Garden area up to 500

Households surrounding the old village are open to the external land, and have house gardens of maximum area of 500 meters. In addition households that lie under the steep mountain have limited access to land but still manage to plant their vegetables in small land slots which constitute their kitchen garden. These households combined represent another 25% of total households. In gardens of maximum 500 meter area, people plant several kinds of fruit trees, one or two of each kind mainly cherry, fig, apple, or peach. They also plant variety of vegetables. Depending on the preference of each family and the main constituents of their diet, planted food varies between zucchini, parsley, and mint, herbs like endive, cucumber, lettuce, eggplant, tomato, radishes, green onions, garlic,

kidney beans, broad beans, and green beans. In addition they plant flowers, fragrant trees, and evergreen plants as shown in figure 9 and 10 below.

Figure 13 Small home garden where flowers, parsley and herbs are planted

Figure 14 Small piece of land is plowed and planted with vegetables for home consumption

c. Garden area from 500 to 2000 meter^2

The remaining 50% of households have enough space surrounding their houses reaching 2000 meters, but not everyone cultivates the entire area. Usually people assign certain section for kitchen gardening while the rest is designed to offer a nice view to the house. The kitchen garden area varies from one household to the other depending on personal preference and whether the owners are permanent or seasonal dwellers. Seasonal residents are less likely to have large kitchen gardens because they need more attention; in addition, most of the time, living outside the village changes the food lifestyle and makes them more dependent on purchase than growing their own food. However, seasonal residents constitute a small percentage. When land is available, the type and amount of food grown increase. Some people grow up to five different kinds of grape vines, more than one kind of fig trees (figure 11). Besides, people grow mulberry, green hummus, apricot, akidnaa tree or Indian apricot, and strawberries. In addition to all the other vegetable products mentioned in the earlier section on small home gardens, however in the case of larger gardens, people have the opportunity to grow relatively higher amounts based on their need. Moreover, people choose to grow watermelon, Cantaloupe melon, and some alien species such as kiwi and others.

Figure 15 Households with hanged vine at the main entrance

There are certain types of herbs that almost all households grow such as basil and oregano which are used in the main traditional dishes as added flavors, and sweet woodruff which is used to makes flavorful tea. In addition, they grow medicinal plants like sage, fennel, and rosemary which are used to treat stomach and headaches. These plants require little space as they are intended for local use and can be planted in small plastic pots. However, in gardens of area more than 500 meters, people plant them in higher quantities to serve as decorative and fragrant plants.

Interviews with people from Warhanieh revealed that the community cares about its diet and that people are in a continuous search for environmentally friendly and organic practices which will eventually make it easier for them to adopt vermicompost.

D. Vermicompost as circular-economy solution

Instead of sending the organic waste to landfills or to incinerators, recycling it back into the soil contributes to closing the system and reducing energy loss as clarified in figure 12 below. Vermicomposting at the household level in home gardens connects people more to the environment especially the new generation who is slowly abandoning farming practices and adopting the urban lifestyle. Vermicompost is highly demanded because of the above characteristics and since it is odorless and of good visual aesthetic. Besides it requires little space as shown in figure 2. If people consume home grown products of longer shelf life compared to the market purchases foods, it further prevents rotting and flies which help eliminate unnecessary offensive odors throughout the vermicomposting process. In addition to this, as discussed earlier Vermicompost will help regenerate the soil and improve its quality in terms of porosity, water holding capacity, and ph. Moreover it contributes to better food quality by increasing nutrient availability and uptake, flowering, and yields. Using Vermicompost at home gardens supports the families' health and wellbeing.

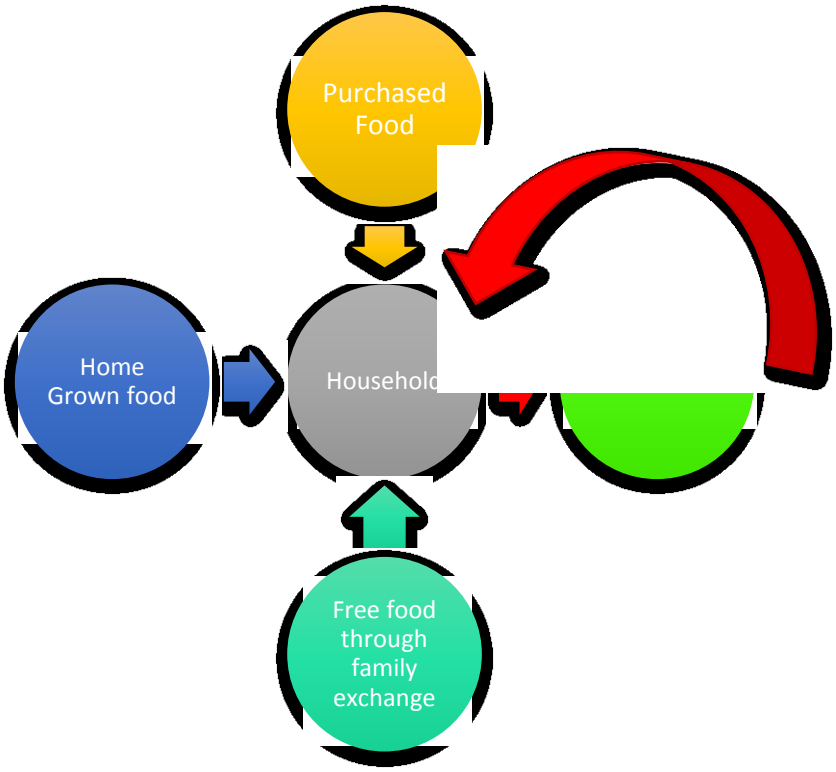

Figure 16 Household closed system – recycling back energy outputs

E. Conclusions

This study shows that in Lebanon the profit from selling homemade vermicompost as well as upgrading to municipal scale vermicomposting facility is low, meaning that money is not the main driver for adopting vermicompost. However, vermicomposting should be demanded for the ecological benefits it possesses, as well as the nutritious food products it produces. In addition, its contribution to closing the system by recycling the energy back into the system through processing the organic kitchen waste back into the soil makes it a powerful tool for alleviating the level of environmental awareness and

socioeconomic status of rural families. All this further contributes to local food security which is becoming a pressing need in the current period. Vermicomposting at the household level is the most cost effective approach that will guarantee the continuity of the practice, and spreads its benefits to wider population. Our study is trying to help people consume nutritious food and promote healthy behaviors. On the other hand it is recommended, in case it is to be applied on a large scale, to establish horticultural and agricultural markets, well-trained sales staff, and a network of delivery and distribution facilities. Moreover, designing vermicomposting units for different sizes of home gardens would facilitate the application of the technology at different settings and increase its practicality which in turn increases the demand for its use.

CHAPTER VI

CONCLUSIONS

Vermicomposting technology has a promising future in Lebanon. This study succeeded in building bridges between scientists and village residents. The success of the project may have been due to the fact that the village has a relatively high education level, the villages are sensitive to their environment, and they were positive about collaborating with a local resident researcher. It is not known, however, where vermicomposting would be equally accepted in other rural villages or in cities. Although willingness to pay to establish a vermicomposting facility for managing the municipal organic waste was relatively high, the study revealed that it may not be economically feasible to install a large scale vermicomposting facility at the village. One reason being the absence of tax incentives; currently there is no mechanism that enables the deduction of the municipal tax on solid waste management from the total government tax for reasons related to the type of contract between the government and the company managing the waste in the Chouf area. Similarly vermicomposting at the household level did not prove to be profitable either especially in the absence of a vermicompost market. The findings suggest, however, that for owners of home gardens, vermicomposting at household level is beneficial in gardening as it reduces the need for synthetic fertilizers and pesticides. In this context, vermicomposting at household level contributes to local food security.

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APPENDIX

Appendix 1. The Presentation of the Introductory Seminar Given to the community at Warhanieh

تربية الديدان لإنتاج السماد
Vermicompost

تنفيذ دراسة ماجستير في بلدة الورهانية

د. سلمى تلحوق
ندى غانم

عودة الى الدورة الطبيعية

الجامعة الأميركية في بيروت

معلومات عامة

- الديدان مخلوقات ليلية لا تحب التعرض لضوء الشمس.
- تعيش في التربة وخاصة أثناء النهار ، تأتي لسطح التربة فقط للتغذية في ساعات المساء.
- عندما تحفر الديدان في الأرض للراحة خلال ساعات الصباح الجافة فإنها تسمح للهواء بالدخول في التربة. هذا الهواء يساعد بشكل كبير في عملية نمو جذور النباتات.
- الديدان تأكل المواد العضوية وتلقي الزوث أو الزبل. يمكن أن تصل كمية الزبل من الدودة الواحدة الى طن سنويا، والتي تساعد على الحفاظ على التربة غنية وخصبة.
- هذا الزبل يحتوي على:
  5 أضعاف النيتروجين،
  7 مرات أكثر فسفور،
  11 مرة أكثر البوتاسيوم،
  1000 مرة أكثر بكتيريا من المواد التي تتناولها دودة الأرض في البداية.

الجامعة الأميركية في بيروت

الديدان ماذا تأكل؟

- مثل الدجاج، الديدان ليس لديها أسنان تستعمل حبوب التربة لطحن ما تأكله في إمعائها.
- عندما تمطر تصعد الديدان إلى سطح التربة بسبب عدم وجود ما يكفي من الأوكسجين
- ليس لها عيون، ولكنها تستشعر الفرق بين الظلام و الضوء.
- الديدان تتنفس الهواء مثلنا تماما، ولكن عبر جلدها الرطب، لذلك إذا جفت الديدان تختنق.
- لا يمكن معرفة ما إذا كانت دودة ذكرا أو أنثى لأن تكوينها يضم الجهازين الذكر والأنثى

الجامعة الأميركية في بيروت

أشخاص عاديين ومن مختلف الأعمار
يقومون بتربية الديدان لإنتاج السماد













الدول المنتجة: الولايات المتحدة الأميركية، فرنسا، كندا، الهند، الفلبين، تايلاند، أستراليا، كوبا، أوكرانيا وغيرها.

الدول المجاورة:

- إيران لديها أكثر من 15 معمل لإنتاج ال Vermicompost
- تركيا بدأت حديثاً بإنتاجه واليوم تملك قرابة 5 معامل

تربية الديدان لإنتاج السماد
Vermicompost

هو عبارة عن عملية تحويل النفايات العضوية عبر إستخدام دود الأرض وتحويله إلى سماد بعيد التوازن للتربة مما يزيد الإنتاج الزراعي.

يحتوي على غذاء للتربة بنسبة تتعدى النسبة الطبيعية الموجودة في السماد العضوي بخمسة أضعاف.

ما هي فوائده الأخرى؟

<u>على المزارعين:</u>

تخفيض كلفة الإنتاج من خلال تدني إعتماد المزارع على الكيماوي

إرتفاع إنتاجية التربة بسبب تحسن نوعيته

محاصيل ذات نوعية أفضل و إنتاجية أكبر

مصدر دخل إضافي للعائلات التي تنتجه وتبيعه

<u>على البيئة:</u>

لا تعود النفايات مصدر تلوث بل مواد أولية قيمة لتعزيز خصوبة التربة

دراسة في ال AUB أثبتت فعاليته على النباتات

بقدونس Parsley

من أسفل إلى أعلى: 0%, 5%, 15%, 25%

روكا Rocca

من اليمين إلى اليسار: vermicompost 25%, 15%, 5%, 0%

تطوير نموذج
تربية الديدان لإنتاج السماد للتطبيق على الصعيد المنزلي

◄ فمنا بتطوير نظام التخمير لتجنب أي ملامسة بدود الأرض.
حيث يضاف دود الأرض في الشهر الأول، و ينتقل بمفرده بين الصندوقين.

◄ يشغل مساحة أقل.

◄ يكون الصندوق بوضعية ثابتة.

◄ تكون عملية الحصاد سهلة لا تتطلب جهد.

تطوير نموذج
تربية الديدان لإنتاج السماد للتطبيق على الصعيد المنزلي

لقد تم تطوير النموذج على عدة مراحل:
أكياس القمامة البلاستيكية،
الأواني البلاستيكية المستخدمة في الزراعة،
الأواني الفخارية،

صناديق الفاكهة البلاستيك،
المنسوجات

الدراسة الأولى في بتلون – صيف 2013

المنهج التطبيقي للدراسة

1. تعرب النفايات العضوية (خضار, فاكهة, نفل قهوة,أكياس شاى) بشكل يومي, لمدة سبعة أيام من أول كل شهر من حزيران إلى تشرين الثاني. كما يضاف إليها خليط من ديدان الأرض والتراب.
2. توضع النفايات يومياً في الصندوق المخصص للتخمير الذي يقدم مجاناً من الجامعة الأميركية في بيروت.
3. يجب أن يغطى الصندوق دائماً, يفتح فقط عند وضع النفايات.
4. عند إنقضاء السبع أيام يترك الصندوق في المكان المخصص له خارج المنزل.
5. عند إنقضاء أول شهر, تكون قد إنتهت عملية تحلل النفايات.
6. في الشهر الثاني , نبدأ بوضع النفايات بالصندوق الملاصق, و لمدة سبعة أيام متواصلة.
7. في الشهر الثالث، نزيل السماد من الصندوق الأول و نضع مكانه النفايات العضوية لمدة 7 أيام.

الهدف من الدراسة

- تطبيق التقنية على مستوى القرية الريفية
- تقييم فعالية الجهاز المعتمد
- تقييم مدى تقبل الناس لهذه التقنية عبر ملئ إستمارات خطية

اللجنة التحكيمية:
الدكتورة سلمى نلحوق،
الدكتور رامي زريق،
الدكتور إبراهيم علم الدين،
الدكتور علي شلق،
الدكتور محمد أبيض.

على الراغبين بالمشاركة في تطبيق التقنية تسجيل أسمائهم كي يحصلوا على الجهاز بالإضافة إلى كتيب الإرشادات.

سوف يتم متابعة المشاركين عن كثب للإجابة عن أية أسئلة والمساعدة عند الحاجة.

شكراً لحضوركم

Appendix 2. Distribution of vermicomposting units with the information sheet to the volunteers at Warhanieh.

Figure 17 the researcher while preparing the vermiculture set-ups at AUB (to the left), final set-up (to the right)

Figure 18 Figure showing the units piled in Warhanieh waiting to be distributed

After the introductory seminar units were distributed on people who volunteered to participate in the study.

Figure 19 Distributing the units on volunteers

Appendix 3. Collection of Photos showing the infield vermicomposting Application in Warhanieh

Figure 20 During the introductory seminar samples of vermicompost was distributed to all attendees and all the study stages and methodology explained.

Pictures taken during my routine follow up on the vermicomposting process inside the household bins. One can notice that each participant placed the bin in a special and different location that provides the best conditions required for the survival of the earthworms.

Figure 21 During the first trial, it shows how the unit was fully lined with cotton sheets


Green Food

Figure 22 Introductory seminar in Warhanieh on May 28, 2014, part of the attendees (to the left), the resident researcher (to the right)

Figure 23 The researcher with a farmer checking the vermiculture bin

Figure 24 Children (Rami and Rabih) holding an earthworm for the first time

Appendix 4. Contingent Valuation Survey Consent Form in Arabic as Approved by the Institution Research Board (IRB)

استمارة موافقة

ان الغرض من المشروع البحثي الحالي هو دراسة الجهوزية لتحمّل تكلفة نقل انتاج السماد العضوي في قرية تحت مسؤولية البلدية، مقابل الجهوزية لتطبيق تقنية انتاج السماد العضوي على المستوى الأسري كوسيلة من وسائل إدارة النفايات وتحسين التربة.

أنتم مدعوون للمشاركة في هذا المشروع البحثي الذي أجرته الجامعة الأميركية في بيروت لأنكم من " الو رهانية" ، القرية الزراعية الريفية التي اخترناها لإجراء المشروع البحثي الخاص بنا.

إن مشاركتكم في هذه الدراسة البحثية هي مشاركة طوعية. بامكانكم اختيار عدم المشاركة. وفي حال قررتم المشاركة فيها بامكانكم الإنسحاب في أي وقت. كذلك، لن تتعرضوا لعقوبة إذا قررتم عدم المشاركة في هذه الدراسة أو الانسحاب من المشاركة في أي وقت.في حال رفضتم المشاركة أو قررتم الانسحاب من الدراسة فهذا لا ينطوي على أي عقوبة أو خسارة من الفوائد لهذا الموضوع ، وكما أنه لن يؤثر على علاقتكم مع الجامعة الأميركية في بيروت.

ويشمل الإجراء تعبئة استطلاع يتطلب حوالي 30 دقيقة تقريباً. ستكون إجاباتكم سرية. ولن يتضمن الاستطلاع معلومات من شأنها أن تحدد هويتكم بغية المساعدة في الحفاظ على سريتها. سيتم استخدام نتائج هذه الدراسة لأغراض علمية فقط، ويجوز تبادلها مع ممثلي الجامعة الأميركية في بيروت. وسيتم رصد سجلات البحث ويمكن مراجعتها دون انتهاك السرية.

إذا كان لديك أي أسئلة، مخاوف أو شكاوى حول البحث يمكنك الاتصال:
بالدكتورة سلمى ن. تلحوق، أستاذ في قسم تصميم وإدارة النظم الإيكولوجية
معاون عميد كلية العلوم الزراعية والأغذية
عضو مؤسس لمركز AUB حماية الطبيعة - الجامعة الأميركية في بيروت ، شارع بلس،
صندوق بريد 11-0236 ، رياض الصلح 1107-2020، لبنان
هاتف: + 961-1-374374 تحويلة 4508/4578
فاكس: + 961-1-744460

تمت مراجعة هذه الدراسة وفقاً لإجراءات مجلس المراجعة المؤسساتي للعلوم الإجتماعية والسلوكية (IRB) التابع للجامعة الأميركية في بيروت حول الأبحاث التي تتعلق بالمواضيع البشرية. إذا أردت الاتصال بشخص ما مستقلة عن الفريق البحثي لأسئلة، مخاوف أو شكاوى حول البحوث؛ أسئلة حول حقك كمشارك؛ للحصول على المعلومات؛ يمكنك الاتصال أو البريد الإلكتروني IRB على العنوان التالي:

صندوق بريد 11-0236 F15 رياض الصلح، بيروت 1107 2020 لبنان
هاتف: 00961 1 374374، تحويلة: 5445
الفاكس: 00961 1 374374، تحويلة: 5444
البريد الإلكتروني: irb@aub.edu.lb
الخط المباشر: 000961 1 738024

فاكس مباشر: 738025 1 000961

في حالة مشاركا الأميين، سوف يكون حاضرا شاهد مستقل عن فريق البحث أثناء عملية التوافق وسوف يوقع على استمارة الموافقة.

وينبغي أن يكون المشارك :
أي من الذكور الإناث الذين تتراوح أعمارهم بين 18-64 .
سكان الورهانية.
كليا أو جزئيا مسؤول عن كسب دخل الأسر و / أو اتخاذ القرارات.

يرجى تحديد اختيارك أدناه.
تشير عبارة "موافق" إلى:
• أنك قرأت المعلومات الواردة أعلاه
• أنك موافق طوعاً على المشاركة
• أن عمرك لا يقل عن 18 سنة

تشير عبارة "غير موافق" إلى عدم رغبتك بالمشاركة في الدراسة البحثية.
☐ موافق
☐ غير موافق

توقيع من أجريت معه المقابلة :_____

توقيع فريق البحث _____

توقيع الشاهد_____

التاريخ : _____

الوقت: _____

وسيتم إعطاء المشاركين نسخة من استمارة الموافقة.

Appendix 5. Contingent Valuation Survey Form in Arabic as Approved by the Institution Research Board (IRB)

استبيان مسحي بشأن تقييم الجهوزية لتسديد الثمن واعتماد التقنية

تاريخ المقابلة: _____
اسم المقابل/المستجوب: _____

القسم الأول

أ. المخاوف الرئيسية:

أ.1 على مقياس من 1 إلى 5 ، حيث أن 1 تعني مقتنع جداً و 5 غير مقتنع مطلقاً، رجاءً ما هو مستوى اقتناعك لما يلي؟ رتب القطاعات المذطورة أدناه من الأكثر أهمية إلى الأقل أهمية (1 إلى 5)

	مقتنع جداً (1)	مقتنع إلى حد ما (2)	لا مقتنع ولا غير مقتنع (3)	غير مقتنع إلى حد ما (4)	غير مقتنع مطلقاً (5)	قم بالترتيب بحسب القطاعات (1 = الأكثر أهمية 5= الأقل أهمية)
التخلص من مياه الصرف الصحي						
الحصول على مياه شرب نظيفة						
جمع النفايات الصلبة والتخلص منها						
الوصول إلى وسائل النقل العام						
الإمدادات الكهربائية						

أ.2 على مقياس من 1 إلى 5 ، حيث أن 1 تعني موافق جداً و 5 غير موافق مطلقاً، إلى أي درجة توافق على كل من البيانات ؟

	موافق جداً (1)	موافق إلى حد ما (2)	لا موافق ولا غير موافق (3)	غير موافق إلى حد ما (4)	غير موافق جداً (5)
أ. هناك مشكلة انزعاج بشأن التخلص من النفايات الصلبة في هذه المنطقة					
ب. يعتبر التخلص النهائي من النفايات آمناً ومقبولاً حالياً من الناحية البيئية					

ج. تملك البلاد نظام جيد لإدارة النفايات					

أ.3 هل تعلم إلى أين يتم أخذ النفايات بعد نقلها من منطقتك؟
أ) نعم
ب) كلا

أ.4 هل أنت قلق حول ما إذا كان التخلص النهائي آمن ومقبول من الناحية البيئية؟
أ) نعم
ب) لا

القسم الثاني

ب. التقييم الطارئ

ينتج عن الأسر من خلال أنشطتها اليومية (الطبخ، الزراعة، الخ ...) الكثير من المخلفات الصلبة (مثل بقايا الخضروات، نفايات الفناء، المخلفات الزراعية بعد الحصاد الخ ...). وقد تنشأ عن هذه النفايات، إذا لم يجر حسن إدارتها والتخلص منها، مشاكل في النظافة العامة (الذباب، الروائح الكريهة، القمامة في الشوارع ... الخ) والصحة (مثل سرطان الرئة، والأمراض الميكروبية الخ ...). وقد سلّطت الأحداث التي جرت في مكب الناعمة مؤخراً الأضواء على جميع المشاكل المتعلقة بسوء إدارة النفايات الصلبة. بالإضافة إلى ذلك، نوعية التربة في لبنان في حالة متدهورة، وبالتالي تصبح المحاصيل المنتجة ذات قيمة غذائية منخفضة، الأمر الذي يؤثر على صحتنا بشكل مباشر.

يستند انتاج السماد العضوي على أنواع محددة من ديدان الأرض (الحمراء) لتحويل النفايات الصلبة العضوية (مثلا من بقايا الطعام) إلى سماد عضوي عالي الجودة يمكن استخدامه بدلاً من الأسمدة الكيماوية لتوفير مواد غذائية أربع مرات أكثر للمحاصيل المزروعة مقارنة بالسماد، وكذلك بدلاً من المبيدات في السيطرة على آفات المحاصيل، الأعشاب الضارة والأمراض.

هناك طريقة واحدة فعالة للحد من المشاكل المذكورة وهي "انتاج السماد العضوي باستخدام الديدان" التي يمكن تطبيقها وفق المقاييس الصغيرة والكبيرة في العمليات الزراعية. وهذا سيفيد المجتمع بطريقتين:

(1) في الحد من المشاكل الصحية والنظافة العامة المذكورة أعلاه و (2) في الحد من اعتماد المزارعين على الكيماويات الزراعية (مثل الأسمدة، المبيدات الحشرية الخ ...) التي قد تلوث مصادر المياه والإمدادات الغذائية والتربة لدينا بطرق مضرة بصحة الإنسان والبيئة.

تستعمل طريقة انتاج السماد العضوي باستخدام الديدان على نطاق واسع في الوقت الحاضر في أوروبا وأمريكا الشمالية. أما في الهند، ساهمت مبادرات انتاج السماد العضوي في حماية البيئة، التنمية الاقتصادية المحلية، وتعزيز الرفاهية الاجتماعية للمجتمعات المشاركة. وهي تطبق حديثاً في تركيا وإيران التي تملك 5 و 16 مرافق إنتاج على نطاق واسع.

لم تطبق هذه التقنية في لبنان حتى الآن. إلا ان تطبيقها على نطاق واسع يتطلب التكاليف. وهذه تشمل جمع النفايات واختيارها، النقل، إنشاء مصنع لإنتاج السماد، إنتاج السماد العضوي وتوزيعه على المزارعين المحليين. يمكن تطبيق هذه الخطة على مستوى البلديات حيث ستكون مسؤولة عن العملية برمتها. لذا بهدف تمويل تلك المبادرة وزيادة رأس المال المطلوب، يمكن للبلديات فرض الرسوم على الضرائب البلدية التي تدفعها الأسر في نطاق ولايتها.

ب.1 إلى اي درجة تعتقد أن انتاج السماد العضوي أمر مثير للاهتمام؟
أ) مثير جدا للاهتمام
ب) مثير للاهتمام إلى حد ما
ج) إنه مضيعة للوقت. لا أعتقد أن البرنامج سينجح
هـ) لا يساوي شيئا بالنسبة لي

ب.2 (إذا كانت الإجابة نعم) هل ترغب في استعمال السماد العضوي باستخدام الديدان بدلاً من السماد؟
أ) نعم
ب) كلا

ب.3 هل ترغب بانتاج السماد العضوي باستخدام الديدان في منزلك كي تنتج الأسمدة الخاصة بك؟
أ) نعم
ب) كلا

ب.4 لو كانت تلك المبادرة متوفرة لدى البلدية في منطقتك، إلى أي درجة ستكون مستعداً لتحمّل رسوم الضرائب الإضافية شهرياً كي تدفع ثمنها وتجعلها ممكنة؟

يرجى اختيار مبلغ من القائمة أدناه يناسب بشكل تقريبي استعدادك لتحمّل ضريبة إضافية.

				□ $0
□ $1	□ $8	□ $15	□ $22	□ $29
□ $2	□ $9	□ $16	□ $23	□ $30
□ $3	□ $10	□ $17	□ $24	□ $31
□ $4	□ $11	□ $18	□ $25	□ $32
□ $5	□ $12	□ $19	□ $26	□ $33
□ $6	□ $13	□ $20	□ $27	□ $34
□ $7	□ $14	□ $21	□ $28	□ $35

<u>الردود الاحتجاجية (لماذا لن تدفع)</u>
أ) لا يمكنني تحمّل الدفع حالياً
ب) ليس عدلاً أن تنتظروا مني الدفع
ت) أعارض البرامج الحكومية الجديدة
ث) يجب أن تدفع الحكومة لهذه العملية
ج) أعتقد أن هذا البرنامج سوف يفيدني لكن يمكن للآخرين أن يدفعوا
ح) لا أؤمن بانتاج السماد العضوي باستخدام الديدان
خ) غيرها: حدد.....

ب.5 هل ترغب بانتاج السماد العضوي باستخدام الديدان في منزلك لو كنت قادراً على تحقيق إيراد من 3 دولار لكل 500 غ ؟
أ) نعم
ب) كلا

ب.6 هل تقوم حالياً بفرز النفايات الخاصة بك؟
أ) نعم ، جميعها

ب) نعم، جزء منها
ج) كلا..... انتقل إلى ب.6.1 و ب.6.2

ب.6.1 (إذا كانت الاجابة على ب.5 هي ج) هل ستقوم بالفرز إذا دفعت لك البلدية 5$ في الشهر؟
أ) نعم
ب) كلا

ب.6.2 (إذا كانت الاجابة على ب.5.1 هي ج) إذا تقاضت البلدية منك رسم 5$ لعدم الفرز، هل ستبدأ بالفرز؟
أ) نعم
ب) كلا

ب.7 هل تفضل أن تتولى البلدية عملية انتاج السماد العضوي باستخدام الديدان؟
أ) نعم
ب) كلا

ب.8 إلى كم فئة تفضل أن يتم الفرز؟
أ) الفرز غير مطلوب..... (انتقل الى السؤال التالي)
ب) 2 (المواد القابلة للتدوير، المواد غير القابلة للتدوير)
ج) 5 (ورق، زجاج، معادن، بلاستيك، غيرها) ---- (تذكر أن هذه تتطلب مساحة أكبر في منزلك)

ب.9 كيف تفضّل أن يتم الفرز؟
أ) الفرز المنزلي
ب) جمع النفايات غير المفرزة عن الرصف كي يتم فرزها لدى مرفق البلدية

ب. 10 كم مرة تفضل أن يتم جمع النفايات؟
أ) مرتين في الاسبوع
ب) 4 مرات في الاسبوع

القسم الثالث

ج. أسئلة إضافية

ج.1 هل تملك أراضي؟
أ) نعم
ب) كلا.....انتقل إلى القسم الرابع

ج.3 ما هي المساحة الإجمالية للأرض التي تملكها؟

_____

ج.3 ما هي نوع الأسمدة التي تستخدمها؟
أ) كيميائية
ب) عضوية

ج.4 أي نوع من الأسمدة العضوية؟
ا) ماعز ب) بقر ج) دواجن د) سماد

القسم الرابع

د. الخصائص السكانية

د. 1 تحديد الأسر:
أ) رب الأسرة
ب) زوجة رب الأسرة
ج) غيرها..... يرجى الشرح.....

د. 2 الجنس
أ) ذكر
ب) أنثى

د.3 كم عمرك؟
أ) 18-24 ث) 41-50
ب) 25-30 ج) 51-68
ت) 31-40 ح) 69- وما فوق

د. 4 هل تعيش في القرية؟
أ) بشكل منتظم
ب) في الصيف
ج) في الشتاء
د) بشكل موسمي/في العطل

د.5 ما هو مستوى تحصيلك العلمي؟

□ لم أحضر المدرسة على الإطلاق	□ معهد أو جامعة - BSc
□ مرحلة ما قبل المدرسة	□ معهد أو جامعة - MSc/PhD
□ الابتدائية	□ تعليم عالي- مهني/فني (مثلا TS/LT)
□ المتوسطة- عامة	□ غيرها:_____
□ المتوسطة- مهنية	□ لا أعلم/أرفض الإجابة
□ ثانوية- عامة	
□ ثانوية- مهنية/فنية (BT/LP)	

د.6 ما هي أعلى درجة علمية متوفرة في هذه الأسرة؟

□ لم أحضر المدرسة على الإطلاق	□ معهد أو جامعة - BSc
□ مرحلة ما قبل المدرسة	□ معهد أو جامعة - MSc/PhD
□ الابتدائية	□ تعليم عالي- مهني/فني (مثلا TS/LT)

□ المتوسطة- عامة	□ غيرها:_____
□ المتوسطة- مهنية	□ لا أعلم/أرفض الإجابة
□ ثانوية- عامة	
□ ثانوية- مهنية/فنية (BT/LP)	

د.7 ما هو مستوى دخل الأسرة؟ (كافة مداخيل الأسرة حتى لو كان أحدهم يعمل في الخارج)

□ $0- 500 $	□ 1.600 $ - 2.000 $
□ $600- 800 $	□ 2.100 $- 3.000 $
□ $900 - 1500 $	□ 3.100 $ وما فوق

د.8 في أي قطاع تعمل؟
أ) خاص
ب) عام
ج) غيرها: حدد.....

د.9 كم تنفق شهرياً على الأسرة؟

□ 150$ - 200$	□ 900$- 1500 $	□ 3100$
□ 300 $ - 400 $	□ 1600 $- 2000 $	
□ 500$ - 800 $	□ 2100$- 3000$	

القسم الخامس

هـ. الملاحظات

هـ.1 حالة المنزل:
أ) جديد ب) قديم

هـ.2 حجم المنزل:
أ) كبير ب) صغير

هـ. 3 حالة الأثاث:
أ) متواضعة ب) عالية الجودة

هـ.4 وضع الأثاث:
أ) أثاث كامل ب) أثاث جزئي

"شكراً لمساهمتكم في هذا المسح"

و. 1 إذا كان هناك حاجة للحصول على مشورة إضافية منك، هل بامكاننا الاتصال بك مجدداً؟
أ) نعم
ب) كلا

ندى ر. غانم : nrg02@mail.aub.edu

6. Contingent Valuation Survey Consent Form as Approved by the Institution Research Board (IRB) in English

CONSENT FORM

The purpose of this research project is to study the willingness to pay for carrying vermicomposting in a village under the responsibility of the municipality, versus the willingness to apply the Vermincomposting technique at the household level as a waste management and soil betterment method.

You are invited to participate in this research project conducted by the American University of Beirut because you are from the rural agricultural village "Warhanieh" the village we chose to conduct our research project.

Your participation in this research study is voluntary. You may choose not to participate. If you decide to participate in this research survey, you may withdraw at any time. If you decide not to participate in this study or if you withdraw from participating at any time, you will not be penalized. Refusal to participate or deciding to withdraw from the study will involve no penalty or loss of benefits to which the subject is otherwise entitled and neither will it affect their relationship with AUB.

The procedure involves filling a survey that will take approximately 30 minutes. Your responses will be confidential. To help protect your confidentiality, the surveys will not contain information that will personally identify you. The results of this study will be used for scholarly purposes only and may be shared with American University of Beirut representatives. Research records will be monitored and may be audited without violating confidentiality.
If you have any questions, concerns, or complaints about the research you can contact the
Professor Salma N. Talhouk
Department of Landscape Design and Ecosystem Management
Associate Dean, Faculty of Agricultural and Food Sciences
Founding Member, AUB Nature Conservation Center
American University of Beirut Bliss Street, PO Box 11-0236
Riad El-Solh 1107-2020, Lebanon
Tel: +961-1-374374 ext 4508 /4578
fax: +961-1-744460.
This research has been reviewed according to American University of Beirut Institutional Review Board (IRB) procedures for research involving human subjects. If you want to contact someone independent of the research team for questions, concerns, or complaints about the research; questions about the subjects' rights; to obtain information; you can call or email the IRB on the following address:

American University of Beirut
PO BOX: 11-0236 F15
Riad El Solh, Beirut 1107 2020 Lebanon
Tel: 00961 1 374374, ext: 5445
Fax: 00961 1 374374, ext: 5444

Email: irb@aub.edu.lb
Direct Line: 000961 1 738024
Direct Fax: 000961 1 738025

Participant should be:

Any male of female aged 18-64;
Resident of Warhanieh;
Wholly or partially responsible for the household income earning and/or decision-making.

In case of illiterate participant, a witness independent of the research team will be present during the consenting process and sign the consent form.

If the above criteria apply, please select your choice below

"Agree" indicates that:

you have ready the above information

you voluntarily agree to participate

you are at least 18 years of age

“Disagree” indicates that you do not wish to participate in the research study.

- ☐ Agree
- ☐ Disagree

Interviewee’s signature: _____

Participant’s signature: _____

Witness signature: _____

Date: _____

Time: _____

Participants will be provided with a copy of the consent form.

Appendix

7. Contingent Valuation Survey Form in English as Approved by the Institution Research Board (IRB)

SURVEY QUESTIONNAIRE FOR ASSESSING WILLINGNESS TO PAY AND ADOPT
Date of interview: _____
Name of interviewer: _____

Section I

A. Major Concerns:

A.1 What is your level of satisfaction for each of the following on a scale from 1 to 5 where 1 is strongly satisfied and 5 is strongly dissatisfied? Rank the sectors that you think are more important (from 1 to 5).

	Strongly Satisfied (1)	Some-how Satisfied (2)	Neither Satisfied nor dissatisfied (3)	Somehow dissatisfied (4)	Strongly dis-satisfied (5)	Rank by sector (1=Most important 5=Least important)
Disposal of waste water						
Access to clean drinking water						
Solid waste collection and disposal						
Access to public transportation						
Electricity Supply						

A.2 To what degree do you agree with each of these statements on a scale from 1 to 5 where 1 is strongly agree and 5 is strongly disagree?

	Strongly agree (1)	Somehow Agree (2)	Neither agree nor disagree (3)	Somehow disagree (4)	Strongly disagree (5)
. There is a problem of nuisance from solid waste disposal in this area					
. Final disposal of waste is currently environmentally safe and acceptable					
. The country has a good waste management system					

A.3 Do you know where the waste is taken after it leaves your neighborhood?
a) Yes
b) No

A.4 Are you concerned about whether the final disposal is environmentally safe and acceptable?
a) Yes
b) No

Section II

B. Contingent Valuation

Through their everyday activities (cooking, farming etc…) households produce a lot of solid waste (e.g. vegetable leftovers, yard waste, agricultural residues after harvest etc…). This waste, if not properly managed and disposed of, may create public hygiene (flies, bad odors, rubbish in the streets etc…) and health (e.g. lung cancer, microbial diseases etc…) problems. Recently, the events in the Naameh landfill brought to light all the problems of bad solid waste management. In addition, soil quality is deteriorating in Lebanon, thus the produced crops are of low nutritional value which directly affects our health.

vermicomposting is relying on specific types of earthworms (red) to convert organic solid waste (e.g. from food leftovers) into high-quality organic compost that could be used instead of chemical fertilizers to provide four times more nutrients to grown crops

compared to compost, and also instead of pesticides in controlling crop pests, weeds and diseases.

One effective way of reducing the mentioned problems could be "vermicomposting" which can be applied at both small and large scales of farming operations. This would benefit the society in two ways: (1) reducing the public health and hygiene problems described above, and (2) reducing the reliance of farmers on agrochemicals (e.g. fertilizers, pesticides etc…) that may contaminate our water sources, food supplies and soil in ways that are harmful to human health and the environment.

vermicompost use is widespread nowadays in Europe and North America. In India, vermicompost initiatives have contributed to environmental protection, local economic development, and enhanced social wellbeing of the participating communities. It is newly applied in Turkey, and Iran which have 5 and 16 large scale production facilities.

In Lebanon, this technology is not yet practiced. Yet to implement this technique on a large scale, costs are involved. These include waste collection and selection, transportation, setting up a compost production facility, production of the organic compost and its distribution to local farmers. This could be done at the level of municipalities where they would be in charge of the whole process. Therefore to finance such an initiative and raise the necessary capital, municipalities could collect levies on municipal taxes paid by household within its jurisdiction.

B.1 How much do you think vermicomposting is interesting?
a) Very interesting
b) Somehow interesting
c) It is bizarre; I don't think the program would work
e) Not worth anything to me

B.2 (If Yes) Would you like to use vermicompost as a fertilizer?
a) Yes
b) No

B.3 Would you carry out vermicomposting at your household to produce your own fertilizers?
a) Yes
b) No

B.4 If such an initiative were in place in your municipality, how much would you be willing to incur additional tax levies per month in payment for it and to make it possible?

Please choose an amount from the below list that best approximates your willingness to incur extra tax.

- ☐ $ 0

☐ $ 1	☐ $ 8	☐ $ 15	☐ $ 22	☐ $ 29
☐ $ 2	☐ $ 9	☐ $ 16	☐ $ 23	☐ $ 30
☐ $ 3	☐ $ 10	☐ $ 17	☐ $ 24	☐ $ 31
☐ $ 4	☐ $ 11	☐ $ 18	☐ $ 25	☐ $ 32
☐ $ 5	☐ $ 12	☐ $ 19	☐ $ 26	☐ $ 33
☐ $ 6	☐ $ 13	☐ $ 20	☐ $ 27	☐ $ 34
☐ $ 7	☐ $ 14	☐ $ 21	☐ $ 28	☐ $ 35

Protest Responses (Why They Would Not Pay):

a) I cannot afford to pay at this time
b) It is unfair to expect me to pay
c) I am opposed to new government programs
d) The government should pay for it
e) I think this program would benefit me but other people could pay
f) I don't believe in vermicomposting
g) Others: specify _____

B.5. Would you carry out vermicomposting at your household if you were able to generate a revenue of 3 dollars per 500 grams?

a) Yes
b) No

B.6 Do you currently sort your waste?

a) Yes, all the waste
b) Yes, part of the waste
c) No --------- Go to B.6.1 and B.6.2

B.6.1. (if the answer to B.5 was c) Would you sort if the municipality pays you $5 per month?

a) Yes
b) No

B.6.2. (if the answer to B.5.1 was c) If the municipality charges you a fee of $5 for not sorting, would you sort?

a) Yes
b) No

B.7. Would you prefer that the municipality handles the vermicomposting?

a) Yes
b) No

B. 8. Into how many categories do you prefer the sorting to be done?

a) No sorting required ----- (Go to next question)
b) 2 (recyclables, non-recyclables)

c) 5 (paper, glass, metals, plastic, other) ----- (Remember that this will occupy more space at your house)

B.8. How do you prefer the sorting to be done?

a) Home sorting

b) Curbside collection of un-sorted waste to be sorted by the facility at the municipality

B.10. How many times do you prefer the collection of waste to be done?

a) 2 times per week

b) 4 times per week

Section III

C. Further Questions

C.1. Do you own lands?

a) Yes

b) No ---- skip to section VI

C.2. What is the total area of the land you own?

_____

C.3. Which kinds of fertilizers do you apply?

a) Chemical

b) Organic

C.4. Which kind of organic fertilizers?

a) Goat b) Cow c) Poultry d) Compost

Section IV

D. Demographics

D.1 Household identification:

a) Head of household

b) Spouse of head of household

c) Others please describe _____

D.2 Gender

a) Male

b) Female

D.3 How old are you?

a) 18 – 24 d) 41 – 50

b) 25 – 30 e) 51 – 68

c) 31 – 40 f) 69 - above

D. 4 Do you live in the village:
a) Regularly
b) In Summer
c) In winter
d) Occasionally/ vacation

D.6 What is your level of education?

- ☐ Never Attended
- ☐ Pre-school
- ☐ Primary
- ☐ Intermediate – general
- ☐ Intermediate – vocational
- ☐ Secondary – general
- ☐ Secondary–vocational/technical (BT/LP)
- ☐ College or University – BSc
- ☐ College or university – MSc/PhD
- ☐ Tertiary – vocational/technical (e.g. TS/LT)
- ☐ Other:_____
- ☐ I Don't Know/refuse to answer

D.7 What is the highest education degree received in this household?

- ☐ Never Attended
- ☐ Pre-school
- ☐ Primary
- ☐ Intermediate – general
- ☐ Intermediate – vocational
- ☐ Secondary – general
- ☐ Secondary–vocational/technical (BT/LP)
- ☐ College or University – BSc
- ☐ College or university – MSc/PhD
- ☐ Tertiary – vocational/technical (e.g. TS/LT)
- ☐ Other:_____
- ☐ I Don't Know/refuse to answer

D.8 What is the household income range? (All incomes of the family members even if have someone working abroad)

- ☐ US$ 0 – US$ 500
- ☐ US$ 600 – US$ 800
- ☐ US$ 900 – US$ 1500
- ☐ US$ 1,600 – US$ 2,000
- ☐ US$ 2,100 – US$ 3,000
- ☐ US$ 3,100 and Above

D.9 In which sector do you work?
a) Private
b) Public
c) Others

D.10 How much do you spend per month on the household?

- ☐ $ 150 – 200
- ☐ $ 300 - 400
- ☐ $ 500 – 800
- ☐ $ 900 – 1500
- ☐ $ 1600 – 2,000
- ☐ $ 2,100 – 3,000
- ☐ $ 3,100 – Above
- ☐
- ☐

SectionV

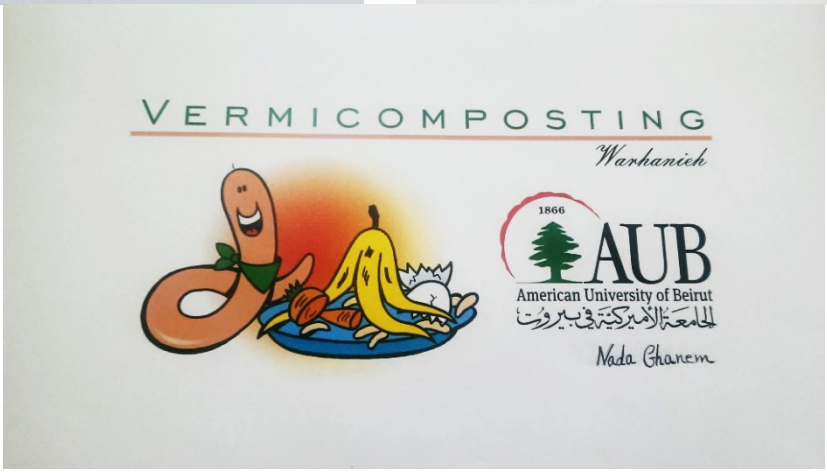
E. Observations

E.1 House situation:
a) New b) Old
E.2 House size:
a) Big b) Small
E.3 Conditions of the furniture:
a) Modest b) High quality
E.4 Furniture Situation:
a) Fully furnished b)Semi furnished

"Thank you for your contribution to this survey."

F.1. If there is a need to seek your advice further, may we contact you again?
a) Yes
b) No

Appendix 8. Distributed mugs on the households that agreed to Participate in the Survey



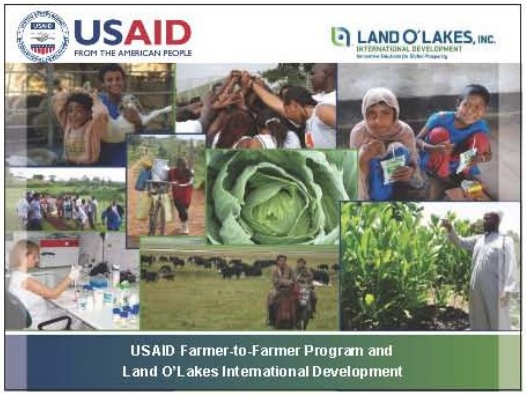
Appendix 9. Pictures taken during the surveying in Warhanieh

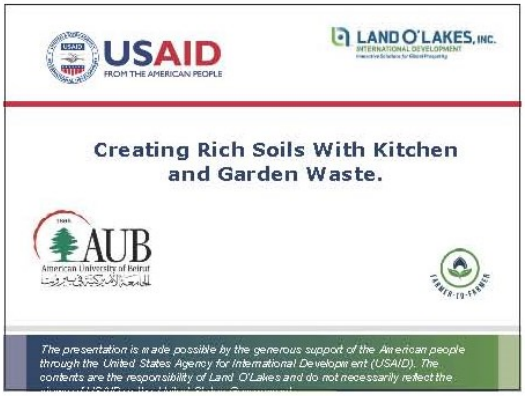
Pictures taken with two of the participants in the survey, the lady in the lower photo was preparing tomato paste at her home garden.

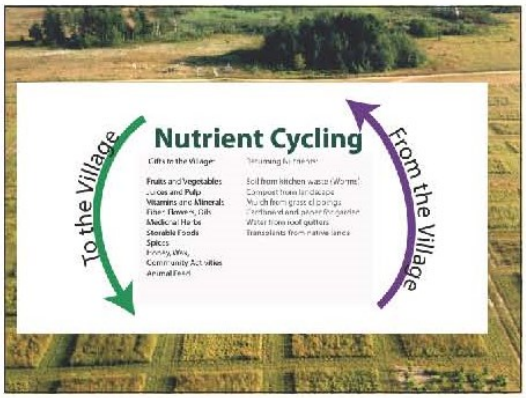
The team that helped me in conducting the surveys at the village are Mohammad, Nour, Rawan and Amina. They said the experience in Warhanieh was unique and developed their communication skills. They were surprised to notice that almost all the households expressed their love to the resident researcher. As they told me that some people did not want to participate in the survey but when they knew it was for my project they changed their minds and welcomed them. Also they met some people who were leaving their home in a hurry and when they told them it's a study for me, they came back

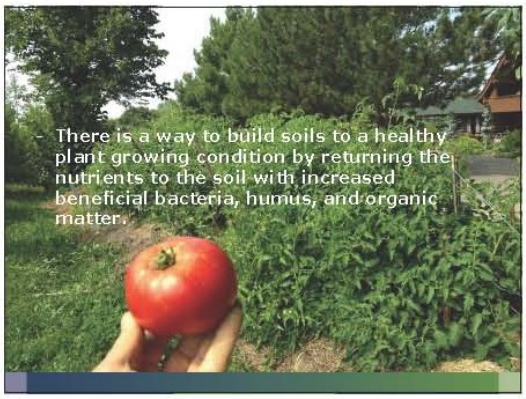
in and answered the whole survey. A lovely old lady who refused to participate insisted on the surveyor the instead of ticking “Do not want to participate” he writes on her survey sheet a statement to express her love to me. It said: “My dear Nada I love you very much but sorry I cannot participate in the survey”. The surveyors also appreciated the generosity of Warhanieh people, they used to come back with their pockets and hands full of different kinds of food.

Appendix 10. The Presentation Given by the Expert Dan Halesy at workshop Warhanieh







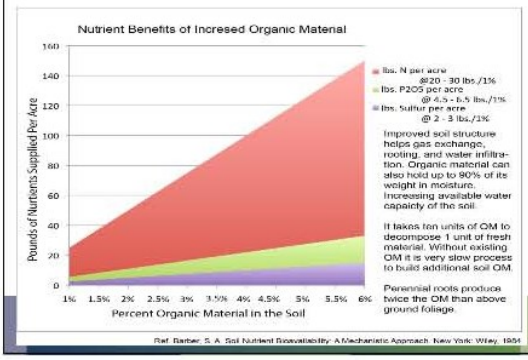


Composting

- **Taking plants and piling them up in stacks to decompose.**
- **Issues:**
  - It takes a lot of plants to create a pile that will heat up for decomposition and the heat that will kill disease and pests.
  - Large areas need to be used for static pile composting.
  - Smaller areas can be used if someone turns the soil every few days. Its labor intensive.
- **This is good and is done all over the world, yet there is another step that creates biodiversity and a stabilized source of nutrients.**

An alternative is to use earth worms to accelerate the process and have choices.

1. **make the nutrients available for *immediate* use for the plants with Worm Tea**
2. **Make soil additives that create long-term time-released fertility, increased beneficial organisms, and biodiversity with worm castings.**
3. **Increase the amount of raw waste processed by growing more worms.**
4. **Grow more food in smaller spaces**



Ref. Barber, S. A. Soil Nutrient Bioavailability: A Mechanistic Approach. New York: Wiley, 1984

This is called Vermiculture

Using the ecological functions of the soil organisms that already exist, to return to the soil the nutrients ready for plant use, that we harvested for our use.

This way:

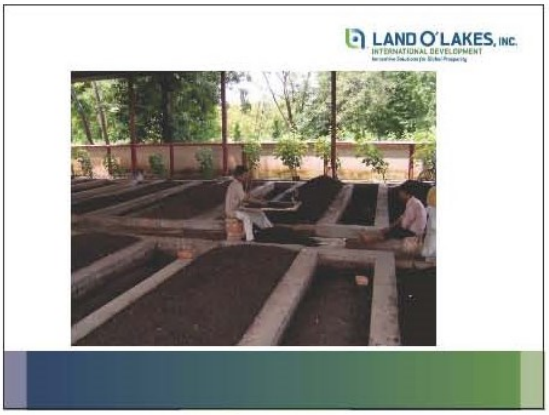
- we build a resilient soil resource.
- we use a system supported by nature.
- we use organic materials otherwise wasted.
- we rebuild depleted soils with living capital.

So what are the benefits of vermiculture?

- To increase the ***carrying capacity*** of the soil.
- To build soil as natural capital, a valuable asset, not to be eroded.
- Close the loop on nutrient cycling so our soil becomes richer each year, even after a harvest.
- Build a resilient source of nutrients held in the soil by the cycling of microorganisms.
- Reduced waste on the landscape
- It creates a valuable product for those not able to create it.

Vermiculture Systems

- **Lateral Worm Beds for harvesting worm castings**
- **Vertical Worm Beds for collecting worm tea.**
- **Row beds to propagate worms for sale or feed.**




ENDOGEIC
- rich soil feeder
- topsoil (A) dweller
- no pigmentation
- horizontal burrows
- small size
EPIGEIC
- litter feeder
- litter dweller
- pigmented
- no burrows
- small size
ANECIC
- litter + soil feeder
- soil dweller
- dorsally pigmented
- extensive vertical burrows (permanent)
- large size

Figure 25 Seminar in Warhanieh for sharing experience with the permaculture expert, it shows part of the participants

Appendix 11. The visit of the professor from University of California Davis to Warhanieh

Professor Pramod Pendey from University of California Davis at the middle. I took him to the study area (Warhanieh) where we visited few households of those that participated in my study. Showed him the household vermicomposting setups and explained the way it works. Professor Pendey expressed his interest in my work and thought it was very important. Also, he was happy with the interaction with people of Warhanieh and the positive feedback on the project. Participants were very generous in offering food, fruits, and desserts. They explained to him how they take care of the worms and what they feed them, also they shared with him their experience with earthworms and how this project changed the way they view them. The visits were informal, friendly, and short.

Appendix 12. Description of the irrigation system at the agricultural land in Warhanieh, Chouf

Figure 26 Figure 1 Diversion canal from the Nabaa al-Safa (Safa River)

Figure 27 Irrigation canal pumping station

Figure 28 A farmer opens a diversion valve

Figure 29 Furrow for irrigation

Appendix 13. Maps showing the evolution of residential area in Warhanieh and the change towards an individualistic lifestyle.

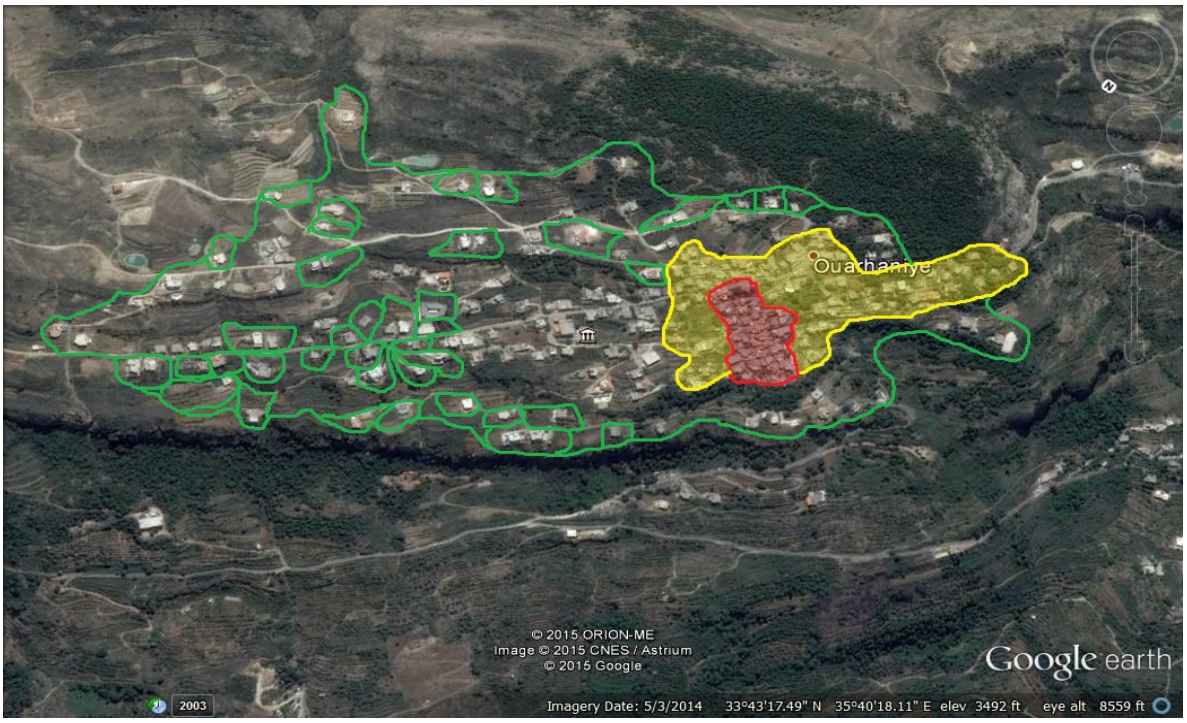


Figure 30 The evolution of the residential area in Warhanieh

Red zone represents the old village where there are no home gardens

Yellow zone represents the semi old region with home gardens of maximum 500 meter

Green zone is the newly expanded village with large home gardens