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Stakeholder Acceptance of Phytoremediation Technology to Clean-up Agricultural Lands Adjoining Open Municipal Solid Waste Dumpsites: The Case of "Ras el Ein" Dumpsite, Southern Lebanon

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ABSTRACT OF THESIS submitted by:

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for the degree of Master of Science and entitled: *Stakeholder Acceptance of Phytoremediation Technology to Clean-up Agricultural Lands Adjoining Open Municipal Solid Waste Dumpsites: The Case of "Ras el Ein" Dumpsite, Southern Lebanon*

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"Deir Qanoun Ras el Ein" dumpsite, a 20-year-old top priority open MSW dump requiring rehabilitation in Lebanon, sits in the middle of 50 hectares of agricultural lands, cultivated with edible crops. As such, it poses a serious risk of contamination to the surrounding environment, including soil and cultivated crops, as well as a public health risk. As several options have been put forward to rehabilitate the dumpsite, this research targets the surrounding potentially contaminated agricultural lands. Contrary to engineered-based methods, phytoremediation presents low-tech, low-energy, inexpensive and green technology to clean-up and regenerate contaminated soils. This study aims at exploring the factors, which influence phytoremediation acceptability from the perspectives of public, farmers as well as experts. A mixed-methods approach was adopted where quantitative and qualitative research methods were used to address different involved stakeholders. A survey was carried out with 70 residents from "Deir Qanoun Ras el Ein" Municipality. Besides, semi-constructed in-depth interviews were conducted with 13 farmers and seven experts. The study findings have shown that risk perception, trust and values affect public acceptability of phytoremediation. As for farmer's acceptance of the technology, it is similarly influenced by risk perception and trust in addition to benefit perception, provision of livelihood alternative and socio-economic factors. On the decision-making level, phytoremediation acceptability is determined by cost-efficiency, familiarity as well as public acceptance. With the numerous contaminated sites in Lebanon and minimal budget allocations for environmental conservation, phytoremediation could stand out as a feasible approach for remediation in Lebanon.

Keywords: dumpsite, soil, crops, contamination, remediation, phytoremediation, acceptability, residents, farmers, experts.

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List of Abbreviations

MSW: Municipal Solid Waste

GoL: Government of Lebanon

BML: Beirut and Mount Lebanon

MoE: Ministry of Environment

SWTF: Solid Waste Treatment Facility

RQ: Research Question

RP: Risk Perception

PC_RP: Psychological and Cognitive Factors_Risk Perception

PA: Phytoremediation Acceptability

EH_RP: Environmental Health_Risk Perception

V_Ant: Anthropocentric Values

V_Eco: Ecocentric Values

T: Trust

AVE: Average Variances Extracted

VIF: Variance Inflation Factor

WLS: Weight-Loading Sign

ES: Effect Size

USAID: United Sated

EU: European Union

NGOs: National Governmental Organizations

AFD: Agence Francaise de Developpement

1 Introduction

Lebanon, a war-torn country, has yet been struggling to manage its vital sectors, despite the huge investments in post-war reconstruction and rehabilitation plans since the 1990s. Political corruption, sectarianism and lack of strategic oversight have contributed to deficiency in managing vital sectors of the economy, for example the municipal solid waste (MSW) sector. Despite attempts to rectify this situation over two decades, the Government of Lebanon (GoL) has yet to develop a national strategy supported by a robust legislative framework, capable of governing the sector. Meanwhile, the GoL has been relying on extended and inefficient "emergency" and "short-term" plans for MSW management.

The only relatively advanced system employed in the country to manage its MSW is that of Beirut and Mount Lebanon (BML) area and was unfortunately deemed a failure. Outside the BML area, MSW management is characterized by typical "collect and dump" practices (SWEEP-Net, 2014). Municipalities, responsible to collect, treat and dispose the MSW generated under their jurisdiction, generally lack the necessary financial and technical capacity to carry out sound MSW management plans. However, some exceptions of waste management initiatives and facilities exist in few areas with the help of international organizations (SWEEP-Net, 2014).

According to SWEEP-Net (2014), Lebanon's MSW generation rate is estimated at around 2.04 million tons/year and at an average of 0.95 Kg/person/day, with a 1.65% projected annual increase. More than half of the generated waste is organic (52.5%) with a significant number of recyclables including paper/cardboard (16%), plastic (11.5%), metal (5.5%) and glass (3.5%). Around 48% of the generated waste end up in Landfills and 29% in open dumps. Recycling and composting schemes adopted in the country (SWEEP-Net 2014) only represent 8% and 15% of generated waste, respectively. Concerning the medical and industrial waste, around 40% of the infectious waste end up in the MSW stream due to the incapacitated infrastructure to manage and dispose hazardous waste in Lebanon. Unfortunately, this exacerbates the problem of open dumping with hazardous waste ending up in open dumps which often undergo open burning as well (SWEEP-Net 2014).

In 2017, the Ministry of Environment (MOE) and UNDP, with the technical help of ELARD Consultancy Group, prepared a master plan for the closure and rehabilitation of uncontrolled dumps in Lebanon. The plan reported that a total of 617 uncontrolled MSW dumpsites exist on the Lebanese territory, a figure which has increased by 20% since 2011. While 2% of the dumpsites were inaccessible for evaluation, around 55% of these dumps were found to be operational. Regarding the 43% non-operational ones, almost half of them have not yet undergone any rehabilitation plans (MOE, UNDP and ELARD 2017).

Located South of Lebanon in the Caza of Tyre, “Deir Qanoon Ras el Ein” dumpsite, referred to as “Ras el Ein” dumpsite, is one of the biggest non-operational and unrehabilitated open dumps in the country, which also undergoes open burning. It covers an area of 13,000 m^2 with a volume of 300,000 m^3 of waste and forms a hill up to 20 m high (MOE, UNDP and ELARD 2017). While it is not the only dumpsite in the Caza, composed of 66 towns (UOTM 2016), “Ras el Ein” dumpsite remained the main and the largest operational dump for over 30 years. A solid waste treatment facility (SWTF) was put into operation in 2011 in an adjacent town, Ain Baal, to alleviate the pressure on the dumpsite and contribute eventually to its closure. However, besides the inert material, “Ras el Ein” dumpsite continued to receive untreated MSW due to the incapacity of the Ain Baal SWTF to accommodate the quantities generated (Geoflint 2017). Amid massive protests and calls for its closure and rehabilitation from the neighbouring towns’ residents, “Ras el Ein” dumpsite was finally closed down in 2015.

“Ras el Ein” dumpsite used to receive waste from a dozen of municipalities in the district of Tyre as well as a couple of Palestinian refugee camps. Not only was this waste open dumped with no pre-treatment, but it also used to undergo regular open burning. In this context, it poses a serious environmental risk to the surrounding environment as well as a public health risk to the farmers and residents of the adjacent towns. Overlooking the Mediterranean Sea, "Ras el Ein" dumpsite is around 500 meters away from the ancient "Bourak Ras el Ein" or "Ras el Ein Springs" which supply potable and irrigation water to the southern region of Lebanon. Over and above that, the dumpsite sits in the middle of around 50 hectares of agricultural lands cultivated with various types of edible crops. The crops are sold to central markets in three main Lebanese cities, Tyre, Saida and Beirut, which in turn sell the produce directly to the public or indirectly through local shops, supermarkets and street hawkers. Not only does the dumpsite pose a risk of contamination to the adjacent water resources, soil and cultivated crops, affecting human health, but it also raises concerns over the site's cultural and touristic significance, especially that it borders "Tyre Coast Nature Reserve".

"Ras el Ein" dumpsite has ranked seventh among the top 20 priority dumpsites requiring closure and/or rehabilitation for their high impact on the surrounding environment (MoE, EU and UNDP 2017). Indeed, some rehabilitation options have been put forward for "Ras el Ein" dumpsite. These include converting it into a sanitary landfill, a project which has faced some complications and not put in effect yet. However, no rehabilitation plan has been proposed or evaluated to remediate the potentially contaminated soils, cultivated with crops, in the lands adjoining the dumpsite. In fact, little, if nothing, is known about the level of contamination of soil and crops around the dumpsite as no studies have been published yet on that matter. However, in an individual interview at Beirut Arab University on May 23rd, Dr. Borjac revealed interesting finding about the soil's, leachate's and irrigation water quality surrounding the dumpsite. While the study hasn't been published yet, Dr. Borjac confirmed that soil samples hold unacceptable levels of heavy metals including lead (Pb), Arsenic (As), Cadmium (Cd) and Mercury (Hg) at the shallow 30cm top layer.

Open dumping and burning, without any liner system, mixed waste derived from household, commercial, industrial and hospital operations pose inevitable threat to the surrounding environment, including soil contamination (Oluseyi, Adetunde and Amadi 2014). For example, one exposure pathway to contaminants from a dumpsite is rainfall. Precipitation infiltrates through the refuse producing leachate, which percolates through the soil carrying various chemical and microbiological pollutants (Oluseyi, Adetunde and Amadi 2014; Opaluwa et al 2012). Soil, however, acts like a sink, accumulating persistent and non-biodegradable pollutants that can negatively affect the groundwater quality (Obasi *et al.*2017; Njagi *et al.*2017). Numerous studies have shown that soils surrounding MSW dumpsites are contaminated with heavy metals (Obasi et. 2017; Njagi et al 2017; Opaluwa et al 2012; Olayiwolae et al 2017; Ogunyemi, 2003; Kanmani and Gandhimathi 2013). Unfortunately, the absence of regulations and the belief that soils around dumpsites are quite fertile, such lands are often used for agricultural purposes (Oluseyi, Adetunde and Amadi 2014; Opaluwa *et al.*2012). Pollutants present in the soil can be absorbed by the crops and bioaccumulate in the edible parts. Thus, it affects the quality of produce (Olayiwolae *et al.*2017; Ogunyemi 2003) and poses a serious environmental and public health hazard to iys surrounding. Pollutants could be translocated into the food chain and hence affect the health of consumers. As pollutants accumulate in the organs throughout time, it can cause long-term toxic health effects, including cancers, neurodegenerative diseases, and disruption of the endocrine system as well as other physiological processes (Njagi *et al.*2017; Opaluwa *et al.*2012).

Depending on the site characteristics, many soil remediation approaches could be adopted, including physical, chemical, thermal and biological methods (UNIDO 2014). Conventional approaches including engineered-based methods, using physical/chemical methods are indeed rapid and effective (Greger and Landberg 1999; Khalid *et al.*2016). However, besides being very expensive, they have destructive effect on the environment and soil fertility (Greger and

Landberg 1999; Khalid *et al.*2016). Awaiting the needed funds, most contaminated sites are abandoned. Considering an inexpensive and environmentally friendly technology to clean-up the contaminated soil at a site, which have suffered prolonged environmental negligence, is an essential step toward ensuring sustainable future plans in the area.

Among the biological methods, phytoremediation, a plant-based treatment, offers many advantages as a green yet inexpensive remediation technology (Pilon-Smits 2005). Mechanisms of phytoremediation, describing the fate of contaminants in plant-soil system, include pollutant extraction, degradation, sequestration, stabilization, and volatilization (Pilon-Smits 2005). Being solar-driven, phytoremediation is a low-tech and energy-efficient alternative to clean-up contaminated soil, while restoring its quality and structure (Pilon-Smits 2005; Greger and Landberg 1999). Depending on the objective of rehabilitation and the type and concentration of pollutants at a given site, different mechanisms can be employed simultaneously. For example, while organic pollutants can be degraded by plants and microorganisms, inorganic pollutants like heavy metals could be immobilized and sequestered at the soil-root interface and/or within harvestable plant tissues (Pilon-Smits 2005). With the presented features, phytoremdiation was indeed developed to allow remediation to become a more common and inexpensive remediation technique, so that less contaminated sites are left unrehabilitated (Montpetit and Lachapelle 2016).

Several factors are usually considered when deciding on a remediation method. These include site characteristics, contamination type and magnitude, cost, effectiveness, environmental-friendliness, residuals produced, clean-up time required, as well as community acceptance (UNIDO 2014; Lombi and Hamon 2005; Lombi, Wenzel and Adriano 1998). Rapid progress has been observed in investigating the technical attributes of phytoremediation. However, there have been dereliction in research addressing the social and cultural aspects of this technology, characterized by the lack of data and systematic studies to examine in which context it is acceptable (Weir and Doty 2016; Kim 2016; Wolfe and Bjornstad 2002). Despite the many advantages of phytoremediation, knowledge is not available yet on how community members perceive phytoremediation and what factors potentially influence its acceptability (Stauffer 2014; Kim 2016). Indeed, stakeholder acceptance of phytoremediation contributes significantly to the method's implementation feasibility and viability (Weir and Doty 2016; Kim 2016).

1.1 Aim, Objectives and Research Questions

The aim of this research study is to explore the factors, which affect stakeholder acceptance of the application of phytoremediation to clean-up the potentially contaminated agricultural soils surrounding "Ras el Ein" dumpsite. Besides the latter's potential impacts on the surrounding environment and public health, the vital economic, touristic, cultural and historical underpinnings of "Ras el Ein" area, all have contributed to choosing this site as a case study. Scarce findings from literature were put together to understand how different factors play a role in phytoremediation acceptability on this site. The study adopted an integrated approach to address the perspectives of residents, farmers and experts, as each is considered to play an integral role in phytoremediation acceptability. The findings of this study contribute to this growing topic of research and provide insights to what might influence the acceptability of a new green technology in such a unique setting where different stakeholders are involved.

The overarching research question (RQ) of this research study is:

> RQ: *What are the factors which affect the acceptance of the application of phytoremediation technology, to clean up the potentially contaminated agricultural soil surrounding Ras el Ein Dumpsite, among the public, farmers and experts?*

Below are more detailed research questions addressing each of the involved stakeholders:

> RQ1 (Public): *What is the impact of risk perception, values and trust on the public acceptance of phytoremediation application on the agricultural lands surrounding "Ras el Ein" Dumpsite?*

RQ2 (Farmers): *How do the farmers, working on these agricultural lands, perceive the risk that the dumpsite poses to the surrounding environment, including soil quality and cultivated crops, as well as public health?*

RQ3 (Farmers): *What factors do influence farmers' acceptability of the application of a green technology, namely phytoremediation, to clean-up the potentially contaminated soil?*

RQ4 (Experts): *What factors do influence the decision-making process of the selection of soil remediation methods and, in particular, phytoremediation in Lebanon?*

To achieve the aim and answer the different research questions, a list of objectives has been detailed below, specifying the research question number and associated objectives.

Objective 1-RQ1 (Public): Design and administer a survey with the residents of "Deir Qanoun Ras el Ein" municipality.

Objective 2-RO2and3 (Farmers): Conduct semi-constructed interviews with the famers cultivating the agricultural lands surrounding "Ras el Ein" Dumpsite.

Objective 3-RQ4 (Experts): Conduct semi-constructed interviews with experts who are acquainted with remediation plans in Lebanon as well as green technologies, including phytoremediation.

1.2 Main Findings

The findings of the study suggest that risk perception, values and trust affect public acceptability of phytoremediation. As for the factors influencing farmers' acceptance of the technology, these also include risk perception and trust in addition to benefit perception, provision of livelihood alternatives and socio-economic status. On the decision-making level, factors like cost-efficiency, familiarity precedent by knowledge and experience as well as public acceptance of the phytoremediation is essential for its acceptance and application on a given site.

1.3 Thesis Outline

Following this introductory section, this thesis comprise five more section as follows. Section 2 presents the literature review of relevant studies on public acceptability and the factors influencing it with regard to different involved stakeholders. Next, section 3 outlines the methodology followed by the researcher to answer the detailed research questions and meet the objectives of the study. Afterwards, section 4 displays the main results generated from the employment of qualitative and quantitative research methods to explore the topic. Section 5 includes the discussion of the results where they are further explained and put in context to answer the overarching research question and thus contribute to achieving the overall aim of the study. Finally, section 6 wraps up the study with a conclusion that summarizes the main findings and suggests recommendations for further related research work.

2 Literature Review

This section presents the theoretical foundation for the concepts covered in the study. It provides an insight into the research studies published on the acceptability of phytoremediation and influential factors.

1.1 Acceptability of Phytoremediation Technology

Among the remediation approaches for contaminated sites, phytoremediation is a relatively new and promising technology representing a green yet inexpensive alternative. Despite its benefits, phytoremediation application has been quite limited (Weir and Doty 2016). While this can be attributed to unfamiliarity with phytoremediation, it has been as well associated with stakeholders' disfavour of the method, including the public and experts executing the projects (Weir and Doty 2016). This could be mainly due to the fact that phytoremediation is a slow approach to decontamination, which could take years for the site to be ready again for re-development. However, stakeholders' approval of the remediation method is essential for the selection, adoption and implementation of remediation plans on contaminated sites. Therefore, assessing their acceptance of phytoremediation is significant in this sense.

1.1.1 Public Acceptance of Phytoremediation

According to Gupta *et al.* (2011), the socio-political context of each site plays a role in social acceptability of a new technology, like phytoremediation (Weir and Doty 2016). In their paper about the social acceptability of phytoremediation technology, Wolfe and Bjornstad (2002, p.429) emphasizes that phytoremediation decision-making "is a social process informed by scientific and technical information, rather than a science- or technology-driven process". They add that the social acceptance of phytoremdiation may differ between one site and another. This highlights the importance of evaluating site-specific factors and involved stakeholders, which influence acceptability, at a given site (Wolfe and Bjornstad 2002; Weir and Doty 2016). Risk perception (Janmaimool and Watanabe 2014; Stauffer 2014; Weir 2015; Weir and Doty 2016; Kim 2016; Grasmuck and Scholz 2005), trust (Weir 2015; Grasmuck and Scholz 2005) and values (Weir and Doty 2016; Weir 2015; Wolfe and Bjornstad 2002) were mostly cited among the influential factors on public acceptability for phytoremediation. These factors will be explained in detail in the following sections.

1.1.1.1 The role of Risk Perception

Risk could be defined in different ways depending on the context it applies to, with no single definition being the correct one (Fischhoff 1984). Mainly, two components of risk prevail among different available definitions which are the “probability” and “magnitude” of the harm, considered to be threatening to humans and what is valuable to them (Bodemer and Gaissmaier 2015; Hohenemser, Kates, and Slovic 1985). The perception of risk is defined by Sjöberg, Moen and Rundmo (2004, p.8) as the “subjective assessment of the probability of a specified type of accident happening and how concerned we are with the consequences”. Other definitions show an additional dimension for risk perception. Pidgeon *et al.* (1992; 89) defines risk perception to be “people’s beliefs, attitudes, judgments and feelings, as well as the wider social or cultural values and dispositions that people adopt, towards hazards and their benefits”. By this, a strong emphasis has been placed on the social and cultural aspects contributing to public risk perceptions, rather than on merely individual processes (Bodemer and Gaissmaier 2015). Being socially constructed, risk perception understanding varies between one community and another depending on the culture and individuals themselves (Weir and Doty 2016). Bianco *et al.* (2008) assumes that people’s perception of risk is impacted by the information received and processed from past experiences, media, literature as well as their community members, including family and friends (Bianco *et al.*2008; Lin *et al.*2018). Risk perception understanding also varies between the public and experts. Whereas the experts perceive risk as the expected mortality rates, lay people connect risk to outrage and potential health impacts (Weir and Doty 2015; Sandman 1987).

Many theoretical models have been designed to assess risk perception (*Weber et al.* 2001). While it is more of a dynamic social process, different factors from different paradigms could impact risk perception in different settings (Janmaimool and Watanabe 2014). In the context of environmental health risk perception, it is important to account for the social and emotional factors affecting lay people's risk perception (Janmaimool and Watanabe 2014).

The psychological and cognitive factors have been expressed as part of the psychometric paradigm, introduced by Fischoff (1978), which are controllability, experiences, perceived benefits and concerns (Janmaimool and Watanabe 2014). Lay people may perceive high risk when they are unable to control certain hazards (Slovic 1987; Fischoff 1984; Slovic, Fischoff and Lichtenstein 1980). Besides, previous experiences with the risk could shape, positively or negatively, public perception depending on pervious exposure to environmental risks. As for perceived benefits, it has been noted that this factor has negative relationship with lay people's risk perception, commonly associating highly beneficial activities with low risk (Alhakami and Slovic 1994).

Compared to the existing literature on risk perception, those correlating risk perception to the acceptance of a green technology scarcely exit (Weber *et al.* 2001; Stauffer 2014; Weir 2015; Weir and Doty 2016; Prior and Rai 2017). Understanding people's perception of risk can help predict public response to new technologies (Slovic 1987).

1.1.1.2 The Role of Values

According to Thompson and Barton (1994), public concern, support and engagement in pro-environmental behaviour is driven by two motives or values, namely anthropocentrism and ecocentrism. The two values are not mutually exclusive although they are positively correlated together (Weir 2015; Bjerke and Kaltenborn 1999). Both orientations explain people's engagement in pro-environmental behaviour, which often demands sacrifice or at least inconvenience with taking some actions. While people with both orientations show a pro-environmental attitude, the difference lies in the motives being supportive for environmental conservation. Anthropocentrism represents individuals' primary concern for their own well-being and as long as the environment serves this purpose and fulfils their human needs, it shall be conserved. On the opposite, ecocentric people appreciates the environment for its own intrinsic value and considers that conservation shall happen even if it demands sacrifice on their behalf. In this perspective, Thompson and Barton (1994) proved positive correlation between specifically ecocentrism, among environmental values, and pro-environmental behaviour, which sometimes demands sacrifice of some human-centric values (Thompson and Barton 1994; Weir 2015; Weir and Doty 2016).

In a study about public attitudes toward phytoremediation of contaminated soils, Weber *et al.*(2001) have concluded that the long-term environmental advantages of the technique are what primarily influenced acceptability of the technique. However, it is not discussed in the literature whether phytoremediation falls under pro-environmental behaviour, in terms of ecocentrism and anthropocentrism. Not until 2016, Weir and Doty, explored the role of pro-environmental behaviour and phytoremediation acceptability under the theme "values", encompassing anthropocentrism and ecocentrism scales of Thompson and Barton (1994). In their study, ecocentrism uniquely predicted phytoremediation acceptability among other factors like risk perception. This finding has also reflected the work of Thompson and Barton (1994) that ecocentrism impact pro-environmental attitude and thus phytoremediation could be considered to fall under pro-environmental behaviour (Weir and Doty 2016).

As part of the PACT framework, environmental values comprise an important component within the "constituent" dimension (Wolfe and Bjornstad 2002). Values of the involved stakeholders influence phytoremediation acceptability and adoption as a remediation technology. Specifically, this happens at the level of the dialog, which usually happens upon adopting a phytoremediation technique at a given site. Distinguishing core values from trade-off in the context of negotiations could have effect on this technology's acceptance (Wolfe and Bjornstad 2002).

1.1.1.3 The Role of Trust

Trust resembles a significant determinant for social acceptability of a new technology (Gupta *et al.* 2011; Gilding and Critchley 2003). In the context of remediation, this factor has an influential role. Not only does trust impact the application of a future remediation plan, but it is as well relevant to previous ones. The success of previously implemented remediation projects has significant impact on the acceptance of previously planned ones (Weir and Doty 2016). In this sense, public trust in the party executing the remediation project predicts a lot about the employment of the investigated method and associated public acceptance (Weir and Doty 2016; Shindler and Brunson 2004; Siegrist and Cvetkovich 2000). Especially when people are not quite knowledgeable about the risk, trustworthiness of the responsible parties for carrying on the remediation plan is essential (Shindler and Brunson 2004). Trust has been proven to be an indicator of how people assess a technology based on its risks and benefits (Siegrist and Cvetkovich 2000; Prior and Rai 2017). In this sense, it is important for lay people to trust the parties promoting a remediation technology (Prior and Rai 2017).

Wolfe and Bjornstad (2002) acknowledged the role of trust in the acceptability of phytoremediation in particular. As part of the community's social context, distrust of involved organizations, especially those connected with previous failure or disappointment, could make their promotion for phytoremediation less credible. In this perspective, phytoremediation would become socially unacceptable, due to these past interactions rather than some attribution to its technical features (Wolfe and Bjornstad 2002).

1.1.2 Experts' Acceptance of Phytoremediation

The prohibitive cost of employing conventional remediation technologies underpins abandoning contaminated lands instead of remediating it (Montpetit and Lachapelle 2015). For this, experts and researchers have been putting enormous effort to develop low cost and efficient remediation techniques, such as phytotechnologies (i.e., bio- and phyto-remediation). However, the process of adopting of a new technology is quite influenced by several factors (Roupas 2008). According to Arthur (1990), besides cost and institutional-related factors, cognitive biases, including familiarity with some technologies, could represent a "lock-in" regardless of the technology's efficiency (Montpetit and Lachapelle 2017). This is what Montpetit and Lachapelle (2017) describes as the "bias toward the status quo". Consequently, it becomes quite hard for new technologies, no matter how advantageous they are, to feature on the practitioners' agendas.

According to Montpetit and Lachapelle (2017), in the field of soil contamination, it seems that experts are biased toward conventional techniques, including excavations and off-site disposal or treatment. This has been attributed to the impact of practitioners' experience and familiarity with these methods. In relation to phytoremediation, in particular, experts seem to be reluctant to adopt such a new technology even in contexts where it fits best. Even when provided by clear cut scientific evidence, their attitudes toward this technology change only mildly. Despite the growing literature on the applicability of phytoremediation on various soil conditions, professional experts seem to still have little knowledge on the technology because of their same preference for conventional methods (Montpetit and Lachapelle 2015). And, even when exposed to knowledge, "status quo bias" seems to be well "sticky". This means that acceptability of the technology is not very much enhanced by increased experts' access to scientific knwoledge, preferring to stick to what they are familiar with (Montpetit and Lachapelle 2017).

Besides, when their actual judgement is at stake, experts could even “resist initiatives to make the policy environment friendlier to phytoremediation” (Montpetit and Lachapelle 2015, p.668). First, this would gauarntee their commissioning of the project by private owners and gorvernments, who usually refer to experts assuimg they have relevant expertise to choose, oversee and implement a remediation plan. Second, this is attributed to the close personal and professional ties these practitioners have with the industry investing heavily in the machinery and equipemnt needed for conventional methods, as the commonly recommended and applied approach (Montpetit and Lachapelle 2015).

Indeed, soil contamination and remediation is a dilemma at the policy level. Montpetit and Lachapelle (2016) have correlated the decision-making process with the knowledge that experts possess, which is, however, mediated by their values. In other words, experts possessing or accessing specialized knowledge about remediation technologies are more likely to provide valid judgements on best-fit model, as values would have less role with that. Unfortunately, it is “unlikely that science makes the actors automatically update their preferences in a way that would make phytoremediation more acceptable” (Montpetit and Lachapelle 2015, p.669).

3 Methodology

This chapter presents the methodology used to meet the objectives of the study, answer the research questions and contribute to achieving the overall aim. First, it provides an overview about the study area and highlights the research questions. Next, it outlines the research methodology framework and accordingly the research methods employed as well as how they have been constructed and utilized to collect the intended data. It finally depicts the data analysis methods and the ethical considerations of the research study.

3.1 Study Area

On the coastal plain of Tyre, “Ras el Ein” dumpsite is located under the jurisdiction of “Deir Qanoun Ras el Ein” municipality, southern Lebanon. In addition to the town of “Deir Qanoun Ras el Ein”, divided between “Deir Qanoun” and “Ras el Ein” regions, the municipality includes the town of “Sammaaiye”. At an average altitude of around 100m above sea level, this municipality covers an area of 802 hectares (CAS 2005). The population of “Deir Qaoun Ras el Ein” is estimated at around 4000 inhabitants of which only 2000 inhabitants permanently live in the municipality (UOTM, 2011).

“Ras el Ein” region encompasses a large agricultural plain, called “Jaftalek Ras el Ein”, extending along the Mediterranean coast. Besides the area’s agricultural production, it is well-known for ancient water resources, including “Ras el Ein Fountains” which are 5000-year old springs located about 500m away from the dumpsite. Besides the economic significance of the “Jaftalak”, it is actually part of “Tyre Coast Nature Reserve”.

I think we should briefly repeat here why we have chosen this site for the study, just like you did in the Intro.

3.2 Research Questions

The overall research question for this study is the following:

RQ: *What are the factors which influence the acceptance of the application of phytoremediation technology, to clean up the potentially contaminated agricultural soil surrounding Ras el Ein Dumpsite, among the public, farmers and experts?*

To address each stakeholder group, more detailed questions were formulated below:

RQ1 (Public): *What is the impact of risk perception, values and trust on the public acceptance of phytoremediation application on the agricultural lands surrounding "Ras el Ein" Dumpsite?*

RQ2 (Farmers): *How do the farmers, working on these agricultural lands, perceive the risk that the dumpsite poses to the surrounding environment, including soil quality and cultivated edible crops, as well as public health?*

RQ3 (Farmers): *What factors do influence farmers' acceptance of the application* of a *green technology, namely phytoremediation, to clean-up the potentially contaminated soil?*

RQ4 (Experts): *What factors do influence the decision-making process of the selection of soil remediation methods and, in particular, phytoremediation in Lebanon?*

3.3 Research Design and Methodology Framework

A mixed methods approach, employing both quantitative and qualitative research methods was used to cover the different target groups addressed in this research study. The target groups are the residents, farmers and the experts. The below diagram 1 showing how the research questions connect to each target group along with the different research methods employed to target these stakeholders. Q3 needs to be connected to farmers.

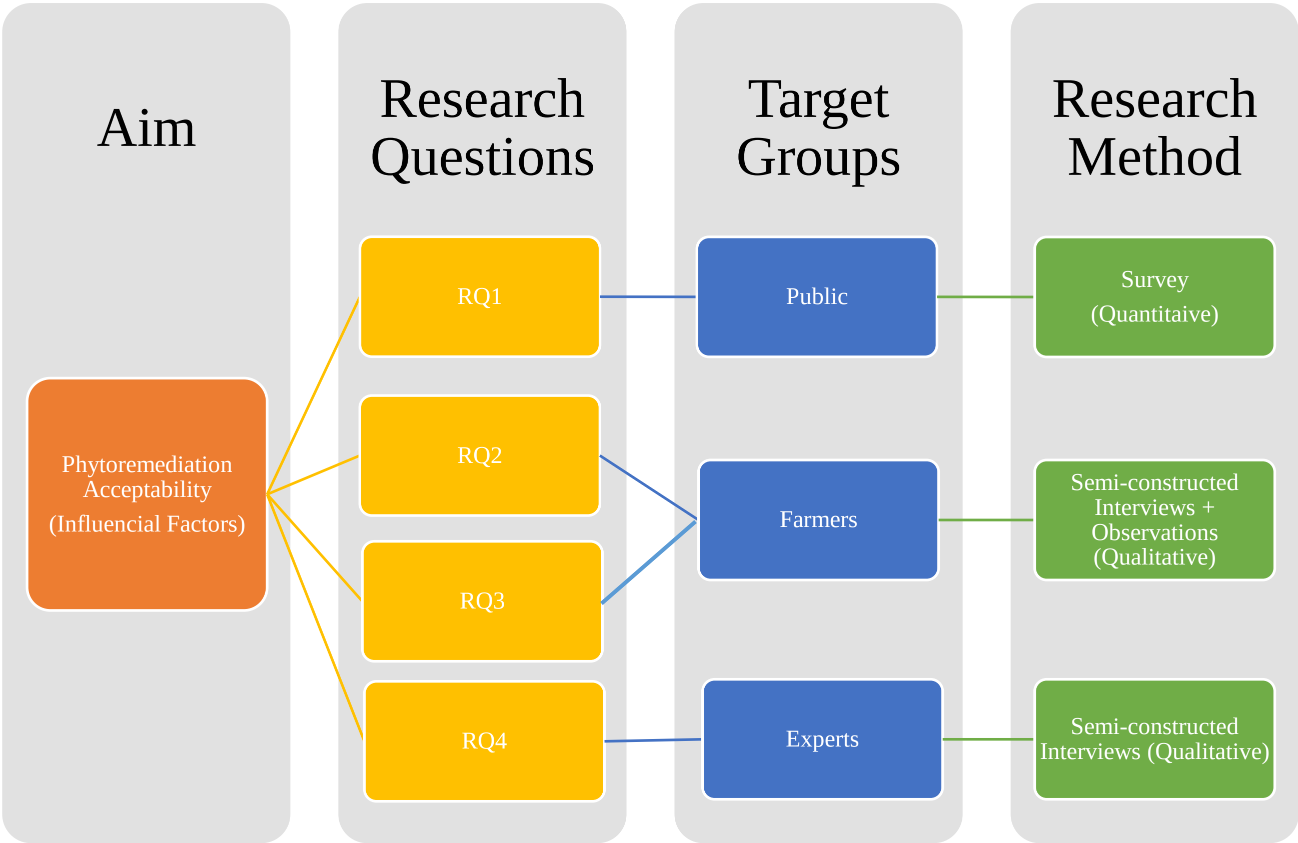


Figure 1. Methodological Framework

3.3.1 Target Groups

3.3.1.1 Residents

Residents of "Deir Qanoun Ras el Ein" municipality represent the general public as one of the target groups involved in this study. The residents of the town are the closest geographically to the dumpsite, and certainly, as they have been the most affected by the dumpsite, their protests played a decisive role in its final closure. Although crops cultivated near the dumpsite are sold to central markets, mostly Tyre's, and not only to them, the residents of "Deir Qanoun Ras el Ein" municipality are among the potential consumers of these crops. In general, people buy their vegetables from the central market, whether directly or indirectly. Some residents do grow some vegetables in their own gardens; however, it is often insufficient, and they still rely on the market's produce. It is worth mentioning that, farmers of the agricultural lands surrounding the dumpsite are mostly residents of "Deir Qanoun Ras el Ein" municipality and their families do consume their own produce.

Nonetheless, they were excluded from the target group as resident's population and thus they were not included in the survey. Worth mentioning, it is very common for farmers and their families to share with their neighbours and relatives some of their own-grown produce. This accounts as well for choosing the residents of "Ras el Ein Dumpsite" to represent the public in this research study.

3.3.1.2 Farmers

The agricultural plain that strictly surrounds the dumpsite is estimated at around 50 hectares with around 50 farmers working on these lands. However, none of the working farmers own the land. While just few hectares are owned by private landlords who rent it out for farmers, the majority of the lands are public areas owned by Tyre Municipality. After working on the lands for decades, farmers, by custom, have assumed command over the lands they cultivate, and it became their source of living. For around a century, farmers pass on these lands to the next generation.

3.3.1.3 Experts

This target group comprises experts who understand the Lebanese environmental context and play a role at the national and institutional level. These include academics, researchers, officials, consultants and other professionals who know about past and ongoing remediation projects around the country. Experience or knowledge about green remediation methods was also among the criteria for the selection of these experts.

3.3.2 Research Methods

3.3.2.1 Quantitative Research Method

To answer the research question (RQ1) pertaining to residents of the "Deir Qanoun Ras el Ein" municipality, a quantitative research method was adopted, and a survey was designed for that purpose. Based on literature review, three factors seem to have influence on phytoremediation acceptability. These are i) public *risk perception* of the environmental and health impacts of cultivating the lands surrounding "Ras el Ein" dumpsite with edible crops and consuming them ii) environmental *values* hold by the residents; and iii) public *trust* in the government and experts implementing the remediation plan.

3.3.2.1.1 Model and Hypothesis

The below figure 2 depicts the model which sets the assumptions related to the factors influencing public acceptability of phytoremediation.

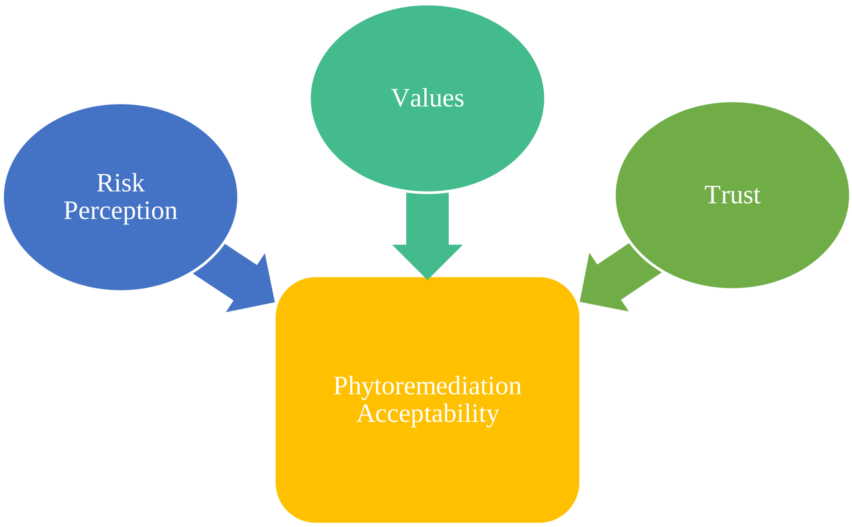


Figure 2. Public Acceptability of Phytoremediation Model

Accordingly, the below hypotheses were formulated:

H1: *Public perception of the risk of contamination that "Ras el Ein" dumpsite poses to the surrounding soil and cultivated edible crops as well as their health has direct impact on phytoremediation acceptability.*

H2: *The values which the public hold with respect to the environment have direct impact on phytoremediation acceptability.*

H3: *Public trust in the government's and experts' execution of the remediation procedure has direct impact on phytoremediation acceptability.*

3.3.2.2 Survey Design

To test the above-mentioned hypotheses, a survey (Appendix I) was designed for the residents. Following the consent form, the survey includes five sections: A) Demographics and Background Information; B) Risk Perception; C) Values; D) Phytoremediation

Acceptability; and E) Trust. The survey was mostly based on 5-point agreement Likert scale, proven to yield high quality answers (Revilla, Saris, and Krosnick 2014) and to a less extent some Yes or No questions.

Section A includes general demographic questions including age, sex, education, income and number of household members and income. Additionally, it includes background questions relating to proximity of residence to dumpsite, household's source of vegetables as well as residents' knowledge of the agricultural practices near the dumpsite and places where these crops are sold.

Section B comprises the risk perception section. It includes questions relating to environmental health risk perception including contamination of the surrounding environment including soil, air, groundwater, seawater, fauna and flora as well as crops (Qs 16 and 17). In addition, a few more questions address the perceived health impacts from environmental contamination (Q 18) and exposure pathways (Q19). Q20 relates to previous experiences which residents have had with the potentially contaminated soil and crops at the site. The two last questions in this section reflects a psychological and cognitive factor related to controllability of residents' exposure to contamination (Qs 21 and 22).

Section C comprises the environmental values section. It includes questions based on Thompson and Barton (1994) scales of ecocentrism and anthropocentrism adopted by various authors, for example by Weir (2015). While this original scale encompasses a long list of variables for both orientations, only some were chosen for this study. The reason for this choice lays in resource constraints and in the adaptability to the study area. Additionally, the selection was necessary to address multiple factors, control length of the survey and get high response rate. Five items (Q23, 24, 25, 26 and 28) addressed anthropocentrism and 4 items (Q27) addressed ecocentrism.

Section D encloses questions relating to phytoremediation acceptability among other common soil remediation methods, to increase the validity of the measurement. Participants were given a small introduction about contamination methods and three approaches were presented to them along with their advantages and disadvantages (see diagram in appendix). These are phytoremediation, engineered-based methods (with soil washing as an example) and the "Dig and Dump" method. They were asked to rank these methods (Q31) as well as the factors (Q32) influencing the latter ranking (cost, effectiveness, environmentally-friendliness, speed of clean-up and familiarity with the method). To ensure getting a 5-point Likert agreement response on rating phytoremediation acceptability, in specific, the section included three more questions related only to this method (Qs 33, 34 and 35).

The final section (E) addressed questions relating to public trust in the government (Q39) and experts (Q40) to implement and oversee the application of phytoremediation on the site.

After formulation, the survey was translated to Arabic by the researcher who is native to the country. Due to limited time, the translated version was not validated by an official translator. However, the survey was pilot tested with five residents prior to its adoption. Nonetheless, no changes were deemed necessary.

3.3.2.3 Qualitative Research Method

To answer RQ 2, 3 and 4, qualitative research methods were followed. Semi-constructed interviews were planned to address the farmers' and experts' perspectives. Examples of the interviews' questions are provided in the section below.

3.3.2.3.1 Farmers Interview Questions

- What can you inform me about "Ras el Ein" Dumpsite?
- What can you share with me about the soil around the dumpsite?
- What can you share with me about the crops grown around the dumpsite?
- How do you think your health is affected by the presence of Ras el Ein Dumpsite?
- Have you ever heard of green technologies, using plants and soil microbes, to clean up contamination?

- Couple of clean-up methods were presented and explained with their diagrams, advantages and disadvantages. What do you prefer and why?
- Will you allow remediation to take place at your land? (what encourages/discourages)

3.3.2.3.2 Experts Interview Questions

- To your knowledge, what are the typical soil remediation methods recommended in Lebanon?
- What factors play a role in the decision-making process of remediation techniques?
- What is the current status of phytoremediation application in Lebanon?
- What about the technology's stakeholder acceptance where it has been implemented so far?
- What do you think is the prospect of phytoremediation in Lebanon?

3.3.3 Data Collection

3.3.3.1 Survey with Residents

In total, 70 residents participated in the study. A simple random sampling technique was followed for conducting interviews with the residents of "Deir Qanoun Ras el Ein" municipality. This method ensures an equal chance of representation of every member of the population. People in households and shops were randomly approached to fill out the survey. Upon pilot testing, respondents were reluctant to fill out the survey by themselves and the researcher had to read the questions out loud and answer them. Therefore, to ensure consistency, all surveys were self-administered by the researcher.

3.3.3.2 Semi-constructed Interviews with Farmers

A total of 13 individual in-depth interviews, based on pre-defined and open-ended questions, were conducted with farmers working on the lands surrounding the dumpsite. Depending on the respondent preference and consent, seven interviews were audio-taped using the researcher's phone and six were based on written notes only. Visits and interviews were conducted in the early mornings to ensure the presence of as many farmers as possible. Some farmers did not accept to be interviewed while most of them approved it. Since farmers work on more than just one piece of land, most of the farmers working on the lands very close to the dumpsite area were interviewed. However, members of the same family were excluded.

3.3.3.3 Semi-constructed Interviews with Experts

A total of seven experts were interviewed as part of this research study. Snowballing sampling technique (can you add a reference here for the method) was used for selection of experts. Semi-structured individual in-depth interviews, based on pre-defined and open-ended questions, were conducted with the experts, except for one email interview. As the topic of soil remediation and phytoremediation is still very new to the Lebanese context, very limited number of experts are capable to discuss the topic in depth. Outreached experts helped in finding other colleagues whom they think their expertise, understanding, and knowledge of the Lebanese context would be an added value. In total, four interviews were recorder and three were based on written notes only.

3.3.3.4 Sample Size Considerations

3.3.3.4.1 Quantitative Research Method (Survey)

A bigger sample size (between 200-300) was needed to attain 90% / 95% confidence levels, with 5% margin of error, for a population of around 2000 people (Creative Research Systems 2012). However, due to limited resources and considering this study to be an exploratory one, only 70 residents were surveyed.

3.3.3.4.2 Qualitative Research Method (Interviews)

As there is no standard to set a sample size for qualitative research, the mostly used guiding principle is saturation (Morse 2015). After the first five interviews with farmers, the researcher noticed that information started to get repetitive and answers are expected and familiar. However, to ensure that all those who work on the lands most adjacent to the dumpsite are included in the study, more interviews were done until saturation was attained and no remaining farmers were available to be interviewed.

Concerning the experts' interviews, the researcher attempted to interview as many experts as could be reached. However, environmental topics are still new to the Lebanese context.

Assuming soil remediation is already rare on international basis, one can expect that it wouldn't be better in this region of the world, especially if discussing a new remediation technology as well. Also, around four to five experts have declined the invitation for an interview.

Guest, Bunce and Johnson (2006) recommended that 12 interviews are enough when trying to understand shared perceptions and experiences of a relatively homogenous group of respondents. While many themes would have come up by the 6th interview, they concluded that by the 12th, almost all themes would have emerged, and researchers would have reached data saturation (Guest, Bunce and Johnson 2006). Coenen *et al.* (2012) found that data saturation is attained by 13th interview. Morgan *et al.* (2002) found out that most concepts would arise between five and six interviews (Guest, Namey, and McKenna 2017). However, by the 10th interview, between 80-92% of themes would be identified (Guest, Namey, and McKenna 2017).

3.3.4 Data Analysis

3.3.4.1 Quantitative Data

Collected data from surveys was coded and analysed using Statistical Package for Social Sciences (SPSS) software version 25 and Warp Partial Linear Squares software (Warp PLS) trial version 6. The use of SPSS was limited to descriptive data analysis while structural equation modelling (SEM) was done using Warp PLS. PLS-SEM fits this exploratory study as it was proven to be a robust software against non-normally distributed data based on small sample sizes (Lowary and Gaskin 2014). This software is also advised for studies where indicators are formative in nature (Khan 2013). Questions or observables used in the survey are considered to be formative indicators. This means that each question reflects a different indicator than the other questions. In other terms, every question comprises and defines a unique aspect of the construct that the other questions don't (Jarvis et al., 2003). PLS-SEM allows the analysis of the hypothesized relationships between the model constructs at the first and second (higher) order of conceptualization (Landis, Beal and Tesluk 2000; Hair *et al.*2014). Whereas the first-order level is used to verify the factor structure, the second-order level allows to improve the statistical power of the model by decreasing the number of indicators and thus minimizing the need for a bigger sample size.

3.3.4.2 Qualitative Data

All interviews were transcribed by the researcher. Due to time limitation, only the first interview was verbatim transcribed, as an exercise to enhance the researcher's interviewing skills and the quality of the following ones. NVivo 12 Pro software was used to analyse the qualitative data collected from the transcribed interviews with farmers and experts. Written texts were imported the software which enable coding of the data into different nodes. Afterwards, nodes of related context were grouped under a parent node or theme.

3.3.5 Ethical Considerations

Data Collection was conducted with compliance to CEU Ethical Research Policy and Guidelines of 2010. Regarding the survey, a consent form was presented in its front page, addressing relevant information about the researcher and the study in addition to other ethical considerations. Prior to participation, residents were informed that all data will be handled with confidentiality and that no names or any means of identification will be disclosed. Similar procedure was followed for interviews with farmers and experts. In addition, interviewees were asked in-advance for their consent regarding i) conducting the interview; ii) recording the interview; and/or iii) taking notes during the interview. Recorded interviews were done on the researcher's phone and later data were processed as described above.

4 Results

This section presents the findings of this study. First, it displays the quantitative data analysed from the surveys to answer RQ1. Then it summarises the main results generated from analysis of the qualitative data, collected by interviews, to respond to RQ2 and RQ3 pertaining to farmers as well as RQ4 pertaining to experts.

4.1 Survey Results

4.1.1 Descriptive Statistics

4.1.1.1 Demographic, Socio-economic and General Factors

Table 1 displays the demographic and socio-economic data of the survey respondents including age, gender, household income and number of members in addition to participant's highest education qualification. Noticeably, majority of the families belong to the lower economic status (<1000$/month) with less than five members per household.

Demographic	**Category**	**Frequency**	**Percent**
Age (Years)	≤20	5	7.1
	21-29	16	22.9
	30-39	15	21.4
	40-49	23	32.9
	50-59	10	14.3
	60	1	1.4
Sex	Male	27	38.6
	Female	43	61.4
Respondent's Highest Education Qualification	Primary	4	5.7
	Secondary	23	32.9
	High School	22	31.4
	Undergraduate	16	22.9
	Graduate	5	7.1
Number of Household Members	1-5	48	68.6
	6-10	21	30.0
	>10	1	1.4
Household Monthly Income ($)	<500	6	8.6
	501-1000	41	58.6
	1001-1500	18	25.7
	1501-2000	2	2.9
	>2000	2	2.9

Table 1. Demographics and Socio-economic Factors

In terms of knowledge about the agricultural practices surrounding “Ras el Ein” Dumpsite, the vast majority are aware of the cultivation of edible crops on the site (Figure 3)

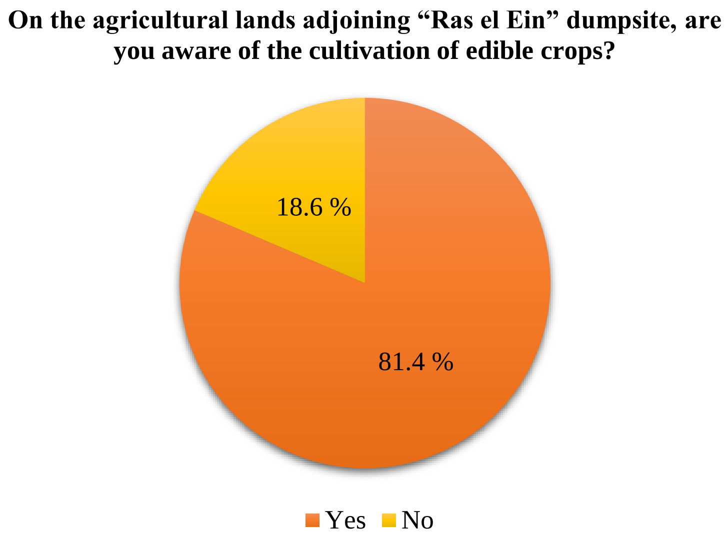


Figure 3. Knowledge about agricultural practices surrounding Ras el Ein Dumpsite

The next figure 4 displays the distribution of the survey respondents in terms of their proximity to “Ras el Ein” Dumpsite. Samples were selected within the municipality of “Deir Qanoun Ras el Ein” Municipality. The highest percentage of residents surveyed is located within the largest area belonging to the municipality’s jurisdiction, which is between 2-3 Km away from the dumpsite. The rest of the respondents reside on the peripherals of the municipality’s largest jurisdiction area including “Ras el Ein” Area and “Samaaeyye” town, respectively closest to the dumpsite.

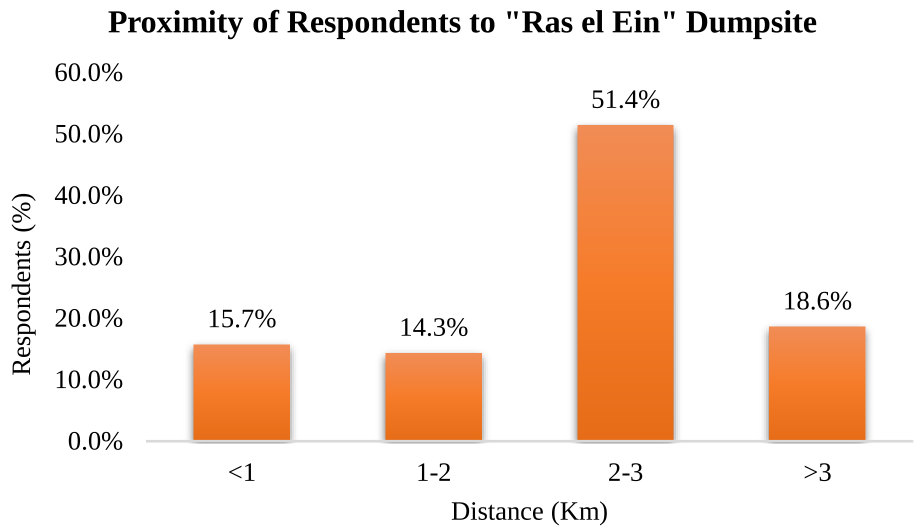


Figure 4. Proximity of Respondents to "Ras el Ein" Dumpsite

The below figure 5 shows that the most sources which respondents buy their vegetables from are local shops and street hawkers. In parallel, they use vegetables which they grow in their own garden.

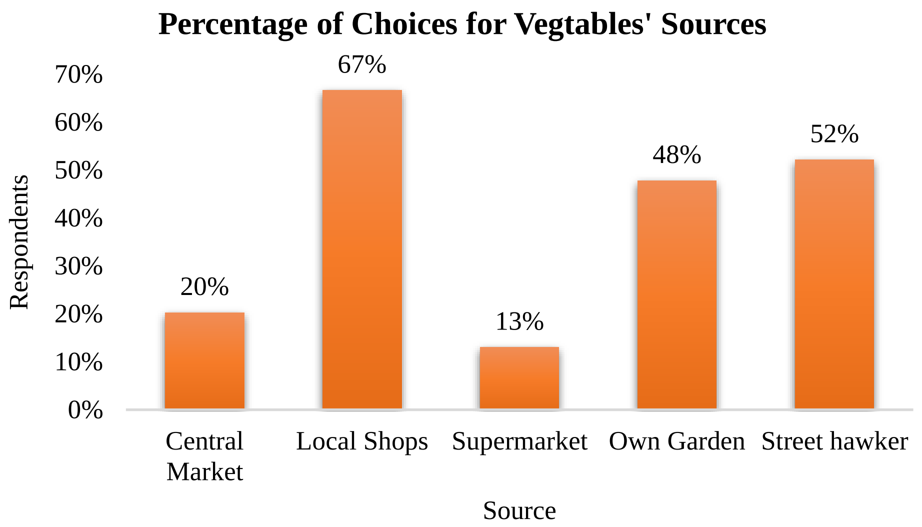


Figure 5. Respondents' Sources of Vegetables

As for the below figure 6, respondents have mostly chosen central markets as the anticipated destination where farmers sell the produce they grow surrounding "Ras el Ein" dumpsite.

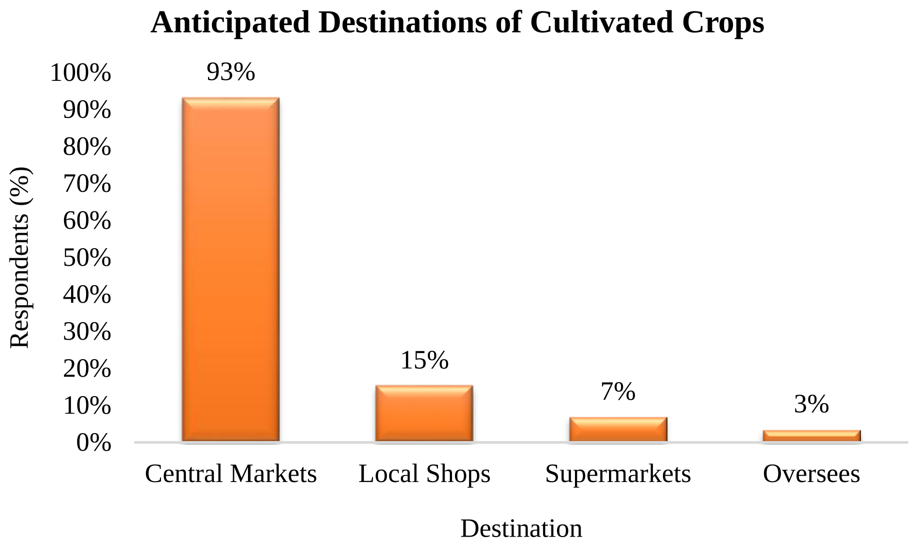


Figure 6. Respondents' Anticipated Destination of Cultivated Crops near Dumpsite

4.1.1.2 Ranking of Soil Remediation Approaches

Three soil remediation techniques were presented to respondents. These are phytoremediation, dig and dump, and engineered-based methods. First, respondents were asked if they have heard of any of the three approaches. Answers to the latter questions are displayed in the below figure 7. It is depicted that the majority of respondents haven't heard of any of the presented approaches.

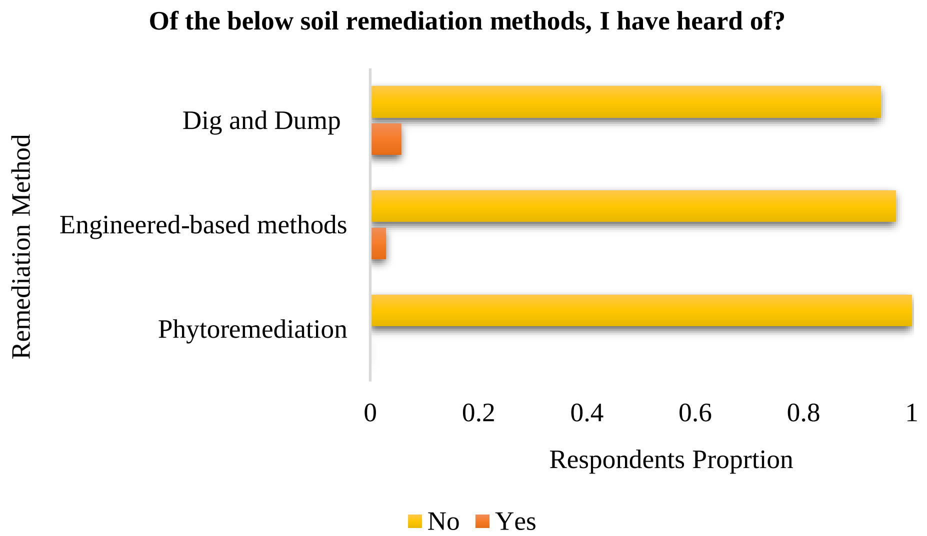


Figure 7. Respondents' Ranking of Remediation Approaches

Second, respondents were asked to rank the three remediation approaches in terms of their preference to be applied on “Ras el Ein” investigated site (Figure 8). 51.4% of respondents ranked phytoremediation as their most desirable option. Engineered-based methods ranked as the second preferred method by 41.4% of the respondents. As for the least desirable option, 57.1% of respondents gave it for dig and dump method.

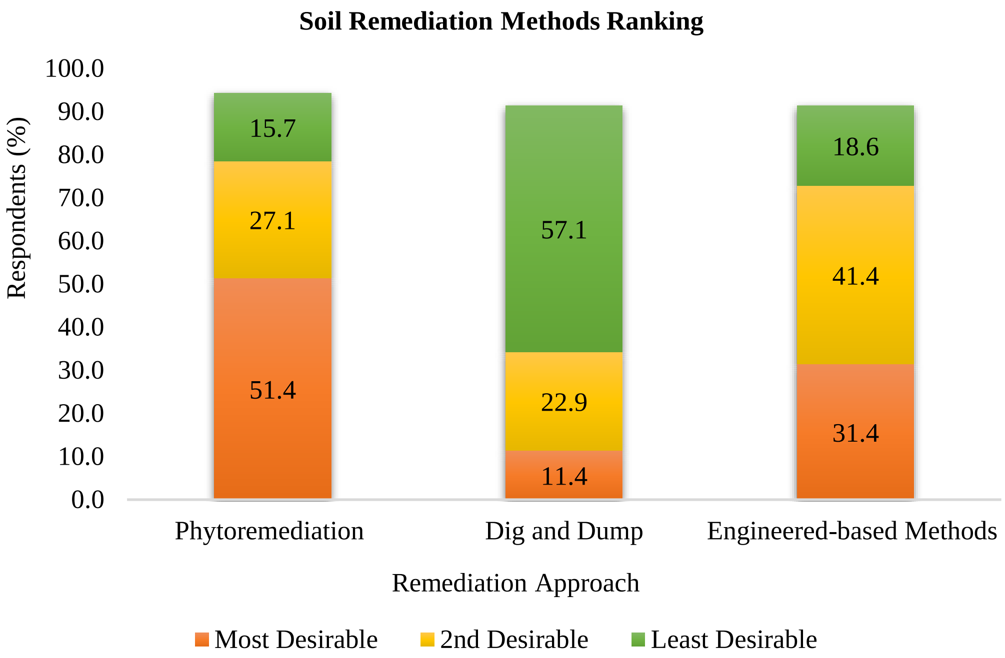


Figure 8. Soil Remediation Approaches' Ranking according to Respondents' Preference

4.1.1.3 Ranking of the Factors Influencing Soil Remediation Methods' Ranking

Respondents were also asked to rank the factors, which have influenced their preferences toward the soil remediation methods ’ranking (figure 9). Factors included cost, effectiveness, environmental-friendliness, familiarity with the method and speed of clean-up. “Speed of clean-up” has mostly been ranked mainly as either the 1st (41.4%) or 4th (30%) influential factor. “Environmental friendliness” was ranked mostly as the 1st (34.3%), 3rd (28.6%) or 4th (27.1%) ranks. “Effectiveness” assigned ranking was mainly the 2nd (78.6%). As for the factor which was vastly selected as the least influential one by 95.7% of respondents it is “familiarity with the method”.

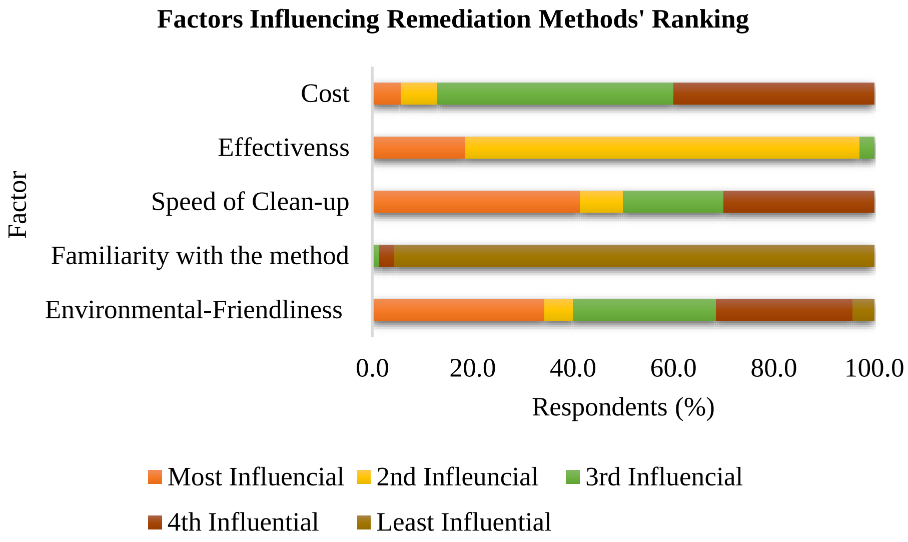


Figure 9. Respondents' Ranking of the Factors Affecting their Remediation Approaches' Ranking

4.1.1.4 Ranking of the factors against Phytoremediation Ranking

To examine the respondents' factors ranking against their phytoremediation ranking, in particular, the below stacked bar chart was designed (Figure 10). In other terms, it displays the ranking of the factors among the respondents who chose phytoremediation as their most desirable approach. It shows that "environmental friendliness" was ranked mostly as the primary influential factor by 63.9% respondents. "Effectiveness" was majorly set as the 2nd most influential factor by 72.2% respondents. "Cost" ranged almost closely between being ranked as the third (41.7%) or fourth (36.1%) influential factor. Most attributed rank to the "Speed of clean-up" factor was the fourth. "Familiarity with the method" rank was vastly set as the least influential (97.2%) on respondants' ranking of phytoremediation.

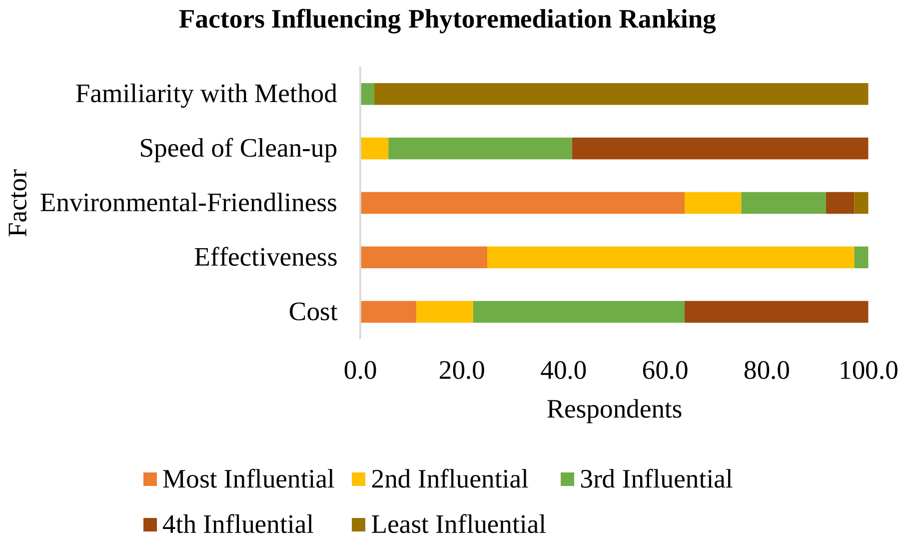


Figure 10. Ranking of the Factors Influencing Respondents' Phytoremediation Ranking

To test the relationship between the respondents' ranking of phytoremediation and their ranking of the factors considered to influence the latter, a series of chi-square tests were carried out. Table 2 summarizes the results of the analysed associations. The three factors affecting respondents' ranking of phytoremediation are: "environmental friendliness", "effectiveness" and "speed of clean-up". However, the p-values pertaining to the factors "cost" and "familiarity with the method" of the chi-square tests were not shown to be significant.

Factor	**Significance**	**Ordinal Chi-Square Relationship**		
	Pearson Chi-Square	**Kendall's tau-b**	**Gamma**	**Approximate Significance**
Cost	.448	.133	.218	.211
Effectiveness	.047	.144	.317	.246
Environmental Friendliness	.000	.599	.781	.000
Speed of Clean-up	.000	-.729	-.907	.000
Familiarity with the method	.068	-.127	-.469	.373

Table 2 Chi-Square Analysis for the Factors Affecting Phytoremediation Respondents' Ranking

A strong significant relationship between the ranking of "environmental friendliness" and that of "phytoremediation" is well supported. The p-vale indicated a significant relationship both in the chi-square test as well as test of ordinal relationship. The latter explains whether there is an association between an ordinal variable (factor) and another (Kendall's tau-b, Gamma). The strength of the relation between the ranking of "environmental friendliness" and that of "phytoremediation" ranges between 0.599 (Kendall's tau-b) and 0.781 (Gamma). Similarly, there was a significant relationship between the ranking of phytoremediation and that of "speed of clean-up" factor, with a p-value of $<.005$. The strength of this relationship falls between -.729 (Kendall's tau-b) and -.907 (Gamma).

"Effectiveness" seems to be an influential factor in the respondents' ranking of phytoremediation method, with a p-value of .047 for the chi-square test. However, the pertaining ordinal chi-square relationship did not show a significant value, indicating an unreliable direction and strength of the relationship between the rankings of these two variables.

"Environmental friendliness" ranking has been shown to be significantly influential upon the ranking of phytoremediation by respondents. Indeed, 63.9% of respondents who chose phytoremediation as their primary remediation option to be applied on site, chose environmental friendliness as the most influential factor. This is well reflected by having the main advantage of phytoremediation over the other two presented approaches is that it is a green technology On the contrary, all respondents (100%) who ranked "speed of clean-up" as the most influential factor has chosen phytoremediation as their least desirable remediation approach to be applied on "Ras el Ein" site. This is well supported from the significant, strong but negative relationship between the ranking of "speed of clean-up" and that of phytoremediation. This is attribute to the fact that phytoremediation is a slow soil remediation technique. Thus, obviously, people who would prioritize speed of contamination clean-up factor, would have less preference for this approach.

Certainly, ranking of the “familiarity with the method” has no association with phytoremediation ranking, as all the respondents have not heard of the method before. So, they considered this factor as irrelevant to their ranking. “Cost”, which mostly has been ranked as the third or fourth influential factor, was proven not to affect respondents’ phytoremediation ranking. Interestingly, participants were often commenting, upon answering this question, that cost is not important upon deciding on the remediation method. This is because they are not the ones to pay directly for the remediation plan to be implemented. This also reflects that the public considers cost to be unimportant when they perceive high risk and expect the government, or whoever will fund the plan, to act accordingly regardless of the actual financial capacity.

4.1.2 SEM Analysis

To understand how the factors of “risk perception”, “values” and “trust” affect public acceptability of the application of phytoremediation on the investigated site, the model was run in WARP PLS software. Questions or observables used in the survey are considered to be formative indicators. This means that each question reflects a different indicator than the other questions. In other terms, every question comprises and defines a unique aspect of the construct that the other questions don’t. As such, WARP PLS was used for it is well suited to be used for SEM analysis on formative indicators.

4.1.2.1 Factor Description and related observables

Factor	**Sub-Categories**	**Description**	**Observables**
PA (Dependent Variable)	Phytoremediation Acceptability (PA)	Accepting and pushing for the application of phytoremediation	PA5, PA6, PA7
Risk Perception (Independent Variable)	Environmental Health Risk Characteristics (EH_RP) Psychological and Cognitive Factors (PC_RP)	Contamination risk to environment Health risk from contamination Experience Controllability	RP1b; RP1d; RP2 RP3d; RP4c RP5a; RP5b RP6c, RP7a
Values (Independent Variable)	Anthropocentric Values (V_Ant) Ecocentric Values (V_Eco)	Pro-environment for the ultimate sake of human Pro-environment for the ultimate sake of environment	V1; V2 V4; V6 V5a; V5b; V5c; V5d

Trust (Independent Variable)	Trust of parties' responsible for remediation (T)	Trust of government/ experts executing remediation plans	T4; T5

Table 3. Chi-Square Analysis for the Factors Affecting Phytoremediation Respondents' Ranking

4.1.2.2 First-order Level of Conceptualization

Figure 11 shows the operationalization of the factors at the first-level order of abstraction. At this level, each question/indicator represents one dimension of the factor/construct. The factors were analysed at the first order level to verify the suitability of factor structure (Appendix II) (Hair *et al.* 2010). Uni-dimentionality, composite reliability and discriminate validity do verify the factor structure. However, low Cronbach alpha is explained by the formative nature of the constructs and the low inter-item correlation of the question observables. Besides, Cronbach alpha is influenced by the number of measured questions; it decreases with low number of indicators. Appendix III depicts the loading and cross-loading values of each of the observables and the constructs of the first-level order model, which provide evidence for uni-dimensionality with loading values all were >.3 and highly significant p values (Appendix III). The square roots of average variances extracted (AVEs) along the diagonals of (Appendix V) supported the discriminate validity of each factor. It shows that the indicators have explained more than 50% of the variance with exception of the first two (EH_RP; V_Ant). Low AVEs suggests that the used question observables do not capture the dimensions of the construct fully and there might be a need to include additional questions in future studies to verify the factor structure in the studied population.

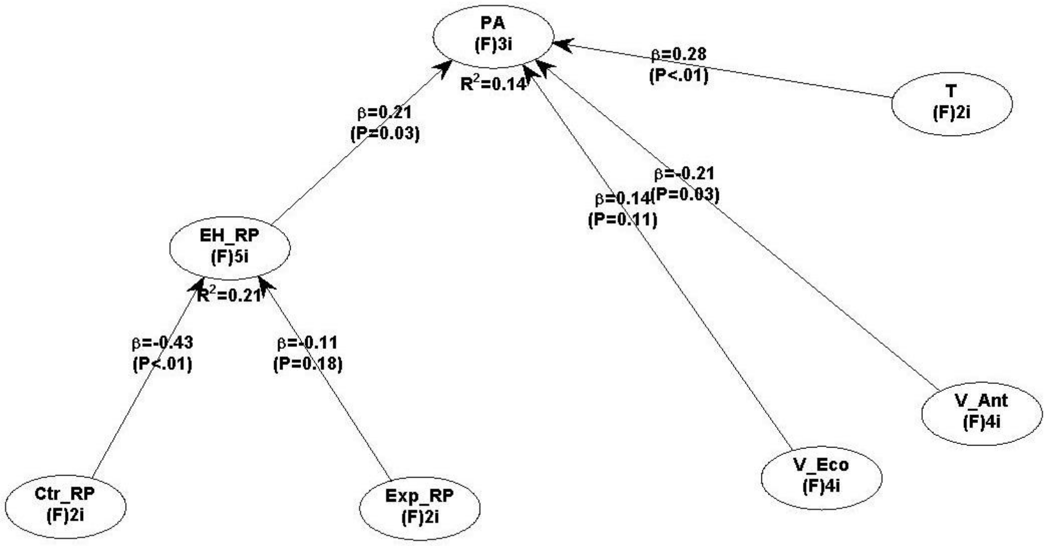


Figure 11. First-Order Operationalization of the Model by WARP PLS-SEM

4.1.2.3 Second-order Level of Conceptualization

Figure 12 shows the operationalization of the factors on the second-order level of abstraction. Second order dimensions are operationalized by latent variable scores using the second indicator approach. At the second-order level, the number of indicators are reduced to decrease the need for a high sample size and to improve the statistical power of the model. The model fit and quality indices of the second-order level are shown in Appendix VI.

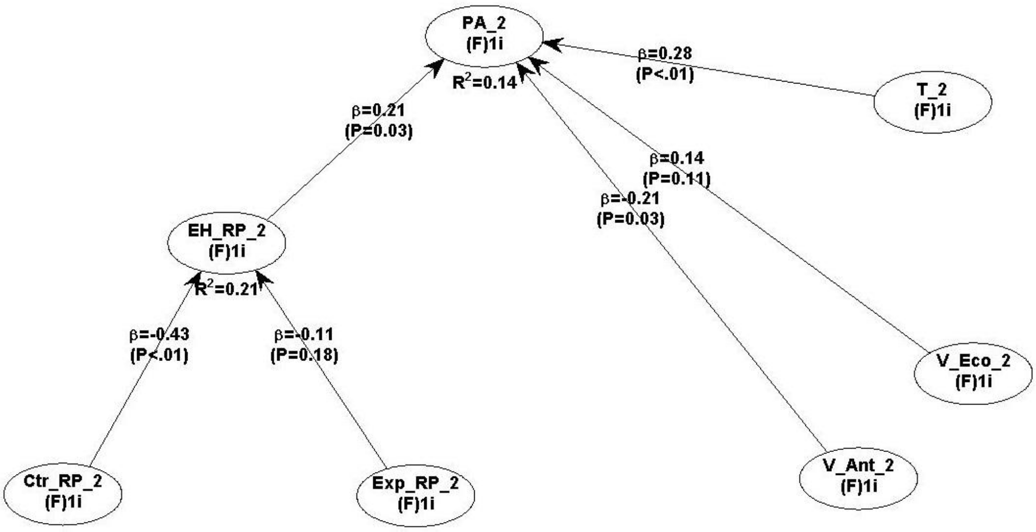


Figure 12. Second-order Operationalization of the Model by WARP PLS-SEM

Figure 12 suggests that risk perception (EH_RP), anthropocentric values (V_Ant) along with trust (T) have retained statistically significant path relations with the dependent factor phytoremediation acceptability (PA). Regarding the psychological and cognitive factors, only controllability showed to have significant path relation with the factor risk perception.

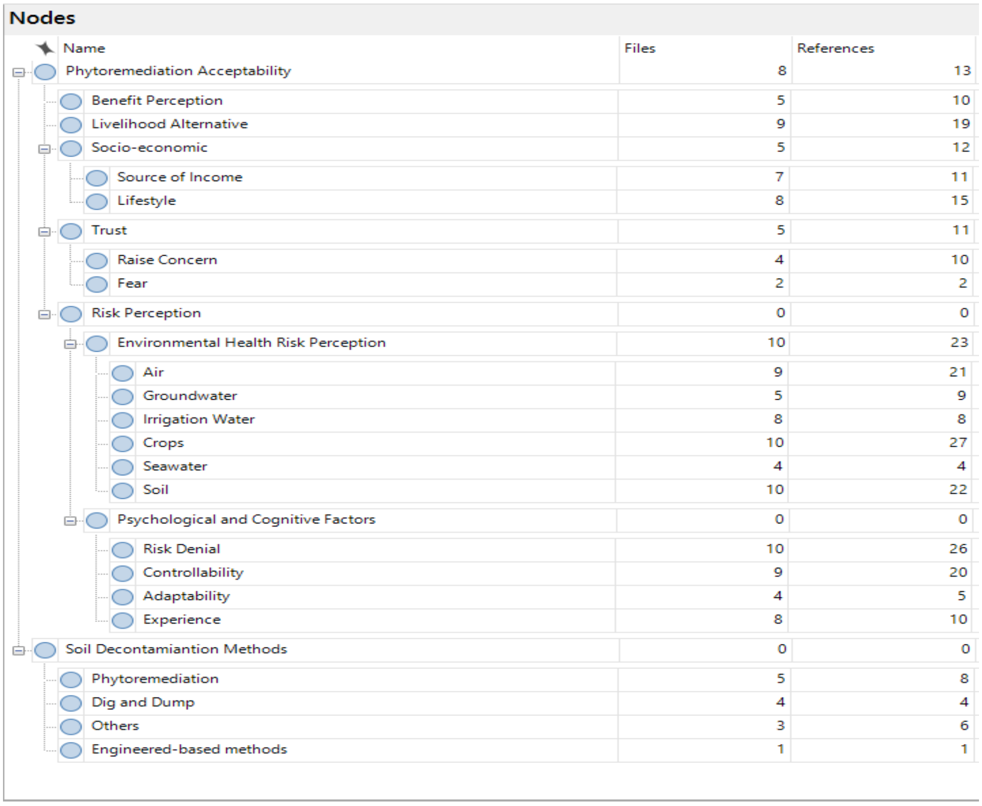
4.1.2.4 Hypothesis Testing Results

Hypothesis Statement	**Testing Result**
H1: Public perception of the contamination risk that “Ras el Ein” dumpsite poses to the surrounding soil and cultivated edible crops as well as their health has direct impact on phytoremediation acceptability.	Supported
H2: The values which the public possesses with respect to the environment have direct impact on phytoremediation acceptability.	Supported for Anthropocentric Values only
H3: Public trust in the government’s and experts’ execution of the remediation procedure has direct impact on phytoremediation Acceptability.	Supported

Table 4. Hypothesis Testing Results

4.2 Farmers' Interviews Results

The series of interviews conducted with the farmers were analysed using NVivo 12 Pro software. The nodes revealed from interviews' data coding are presented in the below screen capture (Figure 13).



Nodes

Name	Files	References
Phytoremediation Acceptability	8	13
Benefit Perception	5	10
Livelihood Alternative	9	19
Socio-economic	5	12
Source of Income	7	11
Lifestyle	8	15
Trust	5	11
Raise Concern	4	10
Fear	2	2
Risk Perception	0	0
Environmental Health Risk Perception	10	23
Air	9	21
Groundwater	5	9
Irrigation Water	8	8
Crops	10	27
Seawater	4	4
Soil	10	22
Psychological and Cognitive Factors	0	0
Risk Denial	10	26
Controllability	9	20
Adaptability	4	5
Experience	8	10
Soil Decontamiantion Methods	0	0
Phytoremediation	5	8
Dig and Dump	4	4
Others	3	6
Engineered-based methods	1	1

Figure 13. Nodes Created from Coding the Data of Farmers Interviews

4.2.1 Farmers' Risk Perception

To understand farmer's risk perception of the environmental health risk associated with the dumpsite, the below map was visualized (Figure 14). It shows the attributes of risk perception in addition to the factors influencing it.

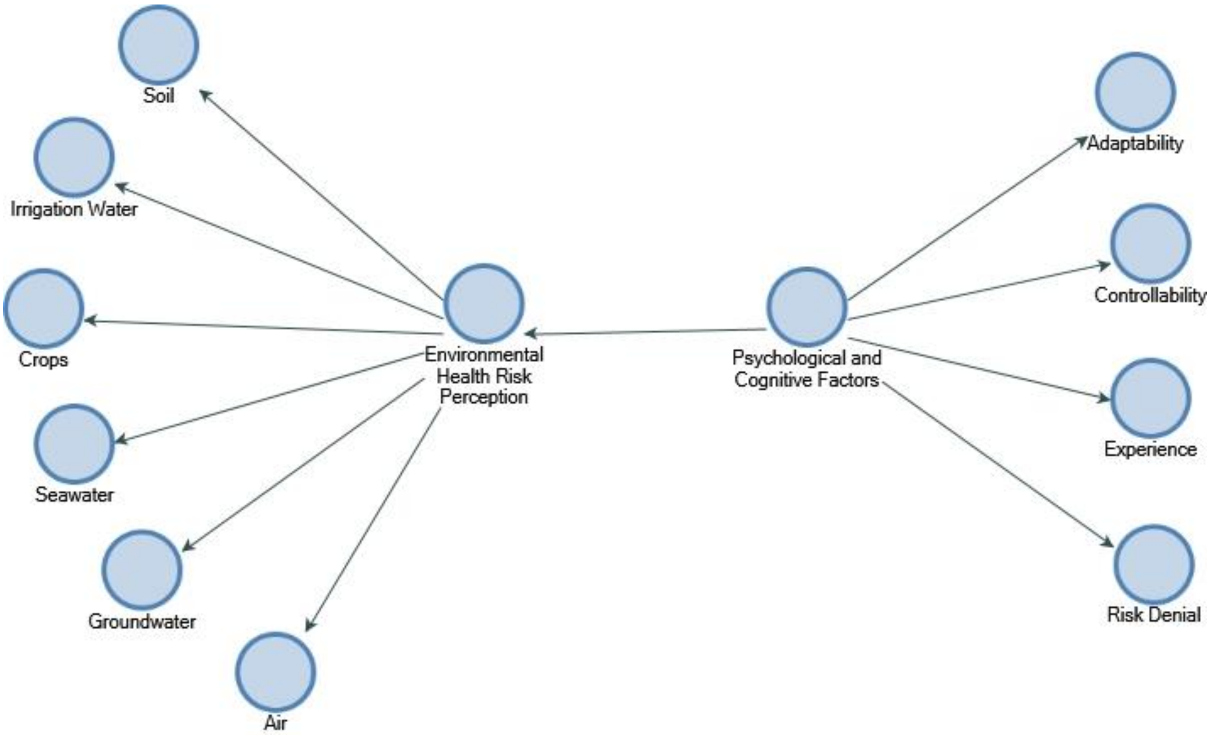


Figure 14. A Map showing the attributes of risk perception and influential factors

Environmental Health risk perception was reflected through farmer's perception to soil, crops, irrigation water, seawater, groundwater and air. It shows that several psychological and cognitive factors affect farmer's risk perception, including adaptability, controllability, experience and risk denial.

4.2.2 Farmers' Phytoremediation Acceptability

Another diagram was visualized to comprehend the factors which affect farmers' acceptance of phytoremediation, among the emergent factors (Figure 15). Farmer's acceptance of phytoremediation is governed by five factors. These are risk perception, benefit perception, livelihood alternative, trust and socio-economic factors.

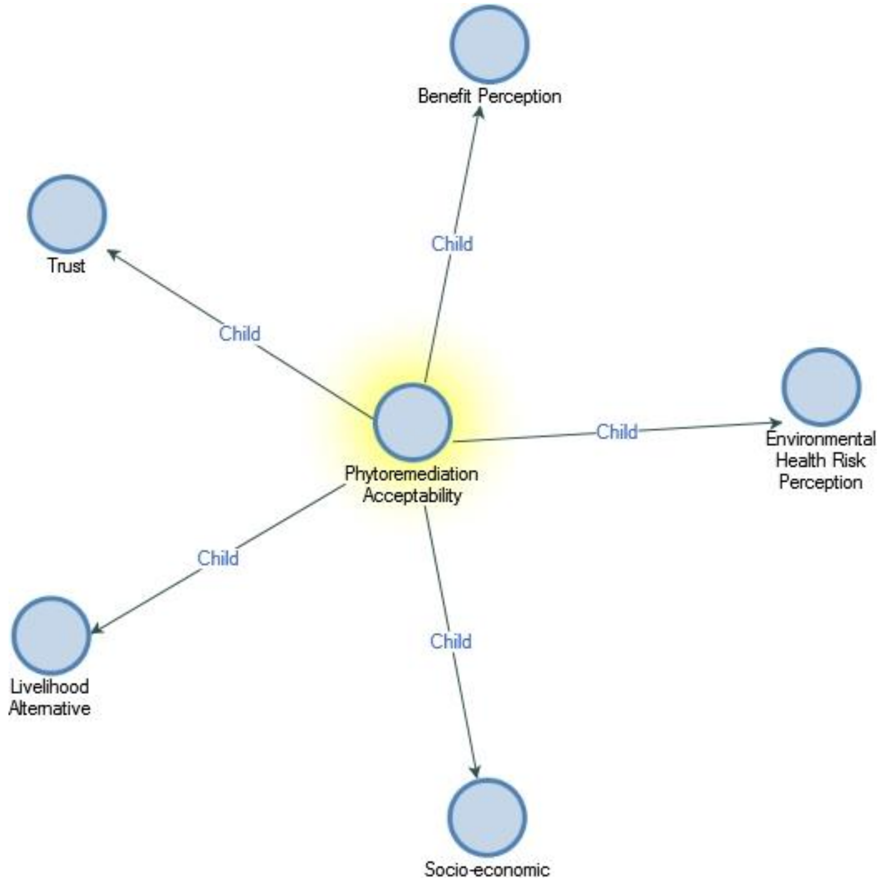


Figure 15. Factors affecting farmer's phytoremdiation acceptability

4.3 Experts' Interview Results

After coding the experts' interviews with NVivo, the below nodes and themes have emerged (Figure 16).

Nodes

Name	Files	References
Phytoremediation Acceptability	2	4
Cost-Efficiency	6	12
Cost	4	5
Effectivenss	1	2
Speed	4	7
Familiarity	1	2
Knowledge and Experience	4	9
Initiatives for Green Remediation Technology	3	11
Public Acceptability	4	6
Incentives	4	12

Figure 16. Factors affecting farmer's phytoremdiation acceptability

To visualize the different factors affecting phytoremediation acceptability, from the experts' perspective, the below diagram was created (Figure 17). At the level of decision-making, three major factors affect phytoremediation acceptability. Those are cost-efficiency, familiarity and public acceptability. First, cost-efficiency is a balance between cost, speed and effectiveness of phytoremediation on a specific site and related technical attributes. As for familiarity, it is influenced by the knowledge and experience of the parties involved in the decision-making process. Third comes public acceptability, which was shown to be an important component in the decision-making process of phytoremediation adoption as a remediation technology.

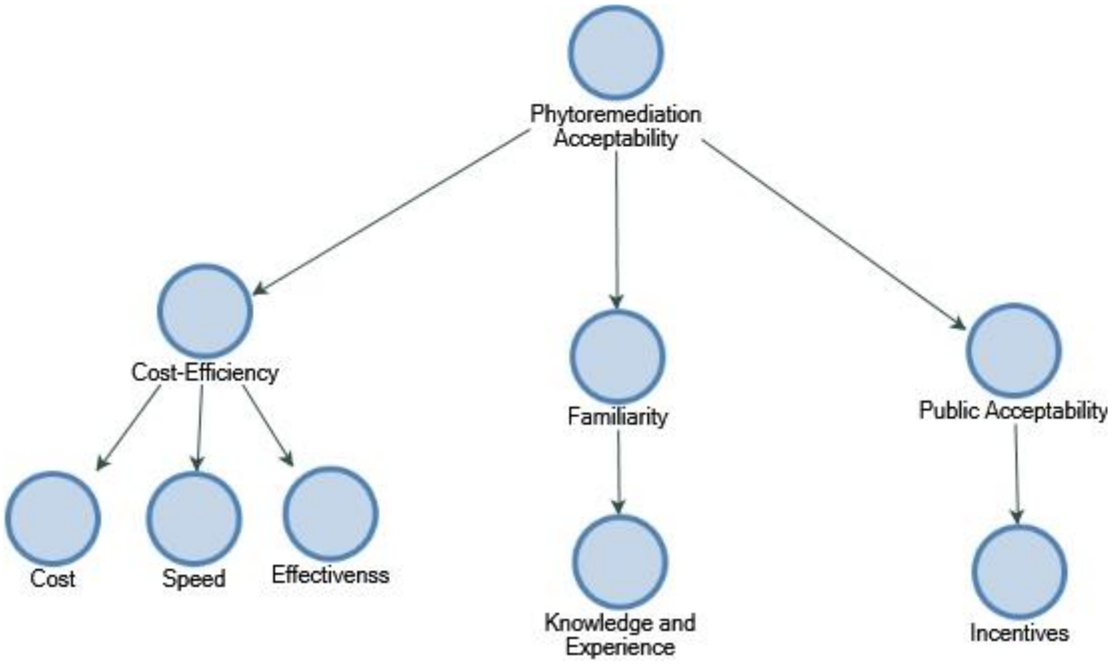


Figure 17. Factors Influencing Phytoremediation Acceptability at the level of Decision-making

5 Discussion

The below section presents the discussion of the results generated in this research study. Sections are presented in the order of the four research questions intended to be answered in this study.

5.1 Research Question 1

RQ1: *What is the impact of risk perception, values and trust on the public acceptance of phytoremediation application on the agricultural lands surrounding "Ras el Ein" dumpsite?*

The model depicted in Figure 12, shows the risk perception (precedent by controllability), values (anthropocentric) and trust have direct impact on the public acceptance of phytoremediation technology. The below sub-sections explore further the relationships between each of the independent variables and the dependent variable.

5.1.1 Risk Perception and Public Phytoremediation Acceptability

Risk perception has been evaluated on the level of the environmental health risk posed by the dumpsite to the surrounding soil and crops and thus public health. In fact, risk perception has been shown to have a strong and significant impact on the public acceptance of phytoremediation. In other words, as people perceive more associated risk with the investigated site, they are more inclined to accept phytoremediation. Generally, respondents' perception of the environmental health risk paused by the dumpsite was high. Interestingly, phytoremediation has ranked first among the presented approaches for soil remediation. This contributes to the explanation of the relationship supported in the model.

Among the most influencing precedent factors on risk perception is the psychological and cognitive factors. The latter are expressed in this study by public controllability and previous experience with the risks posed by the investigated site.

5.1.1.1 Controllability as a Precedent Factor for Risk Perception

Controllability showed a significant and strong negative influence on public risk perception of the environmental health risk. This is explained by the fact that residents of the surrounding villages mostly have no direct control on the sources they get their vegetables from. Most of the surveyed people are aware that the produce of “Ras el Ein” site is sold at the central markets. However, respondents mostly either buy them from central markets directly or indirectly from street hawkers and local town shops. While they have low controllability on their exposure to the crops grown at the investigated site, their risk perception of the associated environmental health risk increases.

5.1.1.2 Experience as a Precedent Factor for Risk Perception

Experience has no influence on the perception of the risk by the residents of the area. The majority of respondents reported not to have experienced any previous heath incidents, which they have directly related to the soil or crops surrounding “Ras el Ein” dumpsite. On the contrary, almost all respondents commented on various health and respiratory problems related to air pollution, which lay people refer to as “smoke”. Effects from “smoke” and “smell” are more tangible to lay people compared to those from consuming contaminated crops. Especially if these crops are contaminated with heavy metals, consumers are likely not to experience any direct impacts on the short-term period. Such contaminants accumulate in the organs and tissues of consumers, causing serious long-term health effects. After years, people could not relate back to such environmental health risks. In this sense, experience in the context of previous associated health impacts with soil or crops near the dumpsite have shown no impact on the risk perception of the associated environmental health risk.

5.1.2 Values and Public Phytoremediation Acceptability

As discussed previously, there could be two orientations for environmental values, anthropocentrism and ecocentrism. While both aspire for the conservation of the environment, motives for doing so differ. In this sense both orientations where assessed to reveal this difference and how it affects phytoremediation acceptability. While anthropocentric values showed significant relationship with the acceptance of phytoremediation, there was no relationship between the latter and ecocentrism.

Anthropocentric values showed a negative significant relationship with phytoremediation acceptability. Respondents who possess anthropocentric values are less likely to accept phytoremediation application on the investigated site. Though those people do have tendency toward such a green remediation technology, it seems that it doesn't offset the compromise they shall do. Phytoremediation, despite being an environmentally friendly, is a slow approach for soil remediation. Since respondents had shown high perception of the risk associated with the site, they are not willing to compromise their own health and wellbeing for the sake of the environment.

5.1.3 Trust and Public Phytoremediation Acceptability

The model supported a strong significant relationship between the trust of the parties responsible to oversee and implement the application of the technology on the designated site. Specifically, they have shown greater trust in experts executing the remediation plan than the government. On another level, residents of this area are mostly farmers, not necessarily on the investigated site, who have adequate understating of the phytoremediation approach. In other words, they understand that it is an easy and low-tech method, which doesn't need high expertise. Indeed, this contributes to the strong relationship evident between trust and phytoremediation acceptability.

5.2 Research Question 2

> RQ2: *How do the farmers, working on these agricultural lands, perceive the risk that the dumpsite poses to the surrounding environment, including soil quality and cultivated edible crops, as well as public health?*

Farmers perception of the environmental health risk associated with the dumpsite is dependent on psychological factors related to controllability, adaptation, risk denial and experience. The below sub-sections explain how the latter factors affect farmers' risk perception.

5.2.1 Farmers' Perception of the potential risks to soil, crops and public health

Generally, farmers expressed very low perception of the risk that the dumpsite potentially causes to the soil and crops they cultivate. When asked about it, they were surprised and insisted that after its closure, the dumpsite has not been posing any threat to the environment or public health. Almost all answers were similar to the below quotes of different farmers:

"Now that it is closed, I don't think the dumpsite pollutes the nearby environment"
"After the dumpsite closure, it has had no impact on the surrounding environment or nearby villages"
"The dump has no impact and doesn't pollute, not on soil nor on crops".

As for the period before its closure, most of the farmers associated the dumpsite's risk with air pollution rather than with soil and crops' contamination. Since the dumpsite used to undergo open burning, the mostly cited impact throughout the interviews was "smoke". According to two of the farmers,

"Before only smoke of the burning dumpsite used to be problematic for the people's health and the surrounding crops"

"It is only the smoke. We used not to pick it up as we couldn't even go to the land…but the impact of the dump as a dump on the vegetables and on Ras el Ein area from agricultural aspect, is not at all, not at all, not at all."

Reported by all of the farmers, smoke is considered as the major, if not the only, impact the dumpsite existence has on crops. After the burning event, crops are often thrown away as they are not anymore suitable for selling. However, the wind carrying the smoke is often western and thus it would carry the smoke to the side of the villages. In this case, farmers reported that they would still harvest and sell their produce. Apparently, as long as the damage is invisible, very low risk is perceived by the farmers. Unfortunately, whether from open burning or from leachate, contaminants accumulating in the vegetables could cause no physical damage. Indeed, to prove their claims, farmers were often asking the researcher to observe the crops, how big, healthy and "nice" they look.

"Look at these lettuce and beans that I have cultivated next to the dump; they are pretty nice."

By the same token, farmers reported by majority that they have not witnessed any deterioration with regard to their soil quality. On the contrary, they declared that the pieces of lands mostly adjacent to the dumpsite had even better produce. This is probably due to high soil fertility near the dumpsite.

"It is even better there. Vegetables growing out there are better than here in terms of quantity and quality."

"Look at thesis big lettuce, this produce reflects that the land has no problem. It is impossible to have such a produce on a contaminated land. Decent Lettuce."

On another level, farmers often associate contamination of soil and crops with pesticides they use. They think that if anything could cause contamination, it would be those chemicals. The massive awareness done on pesticide use and its harmful effects play a big role with that. In addition, farmers have direct contact with buying and applying pesticides, in a non-regulated industry. On the contrary, it is not similarly acknowledgeable and tangible the contamination posed by dumpsite on the crops. As per one of the farmers,

"the contamination problem is not from the soil or site but from the chemicals we are using, which undergoes no censorship"

5.2.2 Psychological and Cognitive Factors

Obviously, the low risk perception reported by farmers, working within a distance of 0-500Km away from the dumpsite, is highly influenced by several psychological and cognitive factors.

5.2.2.1 Controllability

Farmers assume controllability of the factor, which might contribute to their soil and crops' contamination. Concerning leachate, farmers are quite aware of the fact that the dumpsite generates leachate. However, they tend to think that they have controlled that through digging a canal between the dumpsite and the adjoining agricultural lands to divert it. However, this canal moves around the agricultural lands and meets with irrigation water canal before it pours in the sea. As for irrigation water, farmers sense controllability over the water they use by trusting it to be of acceptable quality. However, the main irrigation canal passing adjacently to the dumpsite is full of garbage and was proven to be unsuitable for irrigation. There are other smaller canals diverted directly from the springs to irrigate some lands. However, upon observation, at some points, this irrigation water gets mixed with the leachate directed from the dumpsite toward the sea and thus becomes contaminated. Farmers also believe that natural factors like rain could wash off the dirty leachate and prevent soil from contamination. Connecting to the aforementioned comment about pesticide use, farmers have religiously reported the precautions they take with harvesting their crops after applying some pesticides. According to them, they don't violate this ethical rule for its negative impact on the consumer's health.

5.2.2.2 Adaptability

Farmers, their families and neighbours have got used to the dumpsite presence around their agricultural areas for the past 25 years. They have recurrently stated that they might have got used to it and that is why they don't see it as a serious threat to the environment and public health. Even when some scavengers used to come and live at the top of the dumpsite to collect whatever they can sell, farmers would get invited over the mountain of waste for coffee and tea. The dumpsite became just like any other spot in the area and farmers working there have developed a sense of adaptability to the existence of their lands around this dumpsite. Like a farmer said, "We have been cultivating for 36 years…let them test the people before the soil…or maybe we have become addicted to it."

5.2.2.3 Risk Denial

Although farmers possess low perception toward the environmental health risk that the dumpsite poses, they have exaggerated their expression about the safety of the soil and crops cultivated on site. Concerning leachate, they admitted that it might contaminate groundwater; however, they could not declare the association with it causing soil contamination as well. Most of the famers reported that they haven't, at any point, suspected the contamination of their crops. Below are some quotes from different farmers reflecting this factor.

"We know there is no pollution. No harm. Not to sea not to the fish. It is all pure. All is clean…look at the plants and see they are ok".

"Look at the dump it is dry; you have grass growing on top; no problem at all"

"We know Ras el Ein area is the cleanest in Lebanon"

"The water in Ras el Ein is the purest in the Middle East."

5.2.2.4 Experience

In terms of previous experience with any negative impacts related to their exposure to soil and crops, none of the interviewees reported to have experienced any incidents. Noticeably, farmers, their families and neighbours do consume the produce they grow. This has been documented throughout all the interviews as well as observations of people sharing their produce. However, they have experienced health problems related to air pollution, which contributes to their high-risk perception of air pollution. On the contrary, no experience with previous contact with soil or crops' consumption from the site has contributed to their low risk perception of the hazard. Some of the quotes, which depict this factor, have been presented below.

"And my proof, is that we have a relative, Abou Afif, who is 90 years old and completely healthy."

"We haven't observed any effects so far and the proof is that we have old healthy men"

"Not any health conditions. We just leave the land. No masks. The soil or the crops never harmed anyone."

Indeed, farmers have very low risk perception for the risk of contamination that the dumpsite has on the surrounding environment, including soil and crops, and its subsequent risk on public health. Evidently, the psychological and cognitive factors, including controllability, adaptability, risk denial and experience heavily influence farmer's risk perception. Their high sense of controllability, low previous experience, risk denial and adaptability to the site have contributed significantly to farmers' low perception of the environmental health risk posed by "Ras el Ein" dumpsite.

5.3 Research Question 3

RQ3: *What factors do influence farmers' acceptability of the application of a green technology, namely phytoremediation, to clean-up the potentially contaminated soil?*

Farmers' acceptance of phytoremediation is governed by their risk perception, benefit perception, trust, socio-economic status and provision of a livelihood alternative. The below sub-sections explore the relations between each of these factors and farmers' phytoremediation acceptability.

5.3.1 Risk Perception and Farmers' Phytoremediation Acceptability

Farmer's risk perception, explored explicitly in section 1.2, has impact on phytoremediation acceptability. In fact, the farmers' low perception of the associated environmental health risk influenced negatively the acceptance of the application of phytoremediation on the designated site. Upon introducing the method to the farmers, among other approaches for them, they have shown tendency toward phytoremediation. This is because it is very similar to what they do every day, and they were able to comprehend it. However, since they don't see that contamination is really a problem, they were reluctant to approve any of the suggested methods, including phytoremediation. They have suggested another method, which they already employ, and think is enough to "clean-up" the soil. This includes tilling the surface layer of the soil and leaving it under the sun to sterilize it for two to three months of the summer. According to one of the interviewees, "*the only way to decontaminate the land is to till the soil and leave it under sun for summer months*."

5.3.2 Benefit Perception and Farmers' Phytoremediation Acceptability

One of the farmers stated, "*it is hard…these people are renting out the land to benefit from it, so they won't be responsive to such proposals*". With some exceptions, the majority of farmers don't pay any rental fee since they have assumed ownership over the land over time, which in fact the government owns. Additionally, the minimal annual fee for irrigation water, being around 50$, is not paid by all farmers. These people assuming ownership might even rent it out sometimes to other farmers. For them, the land is fertile, gives "nice" produce and is for free. It is next to their homes and families. They tend to perceive high benefit from continuing to cultivate the land, despite being potentially contaminated. Accepting to apply phytoremdiation on the site means taking the land from them for quite a long time. Thus, benefit perception influence negatively farmer's acceptance of phytoremediation on "Ras el Ein" dumpsite.

5.3.3 Trust and Farmers' Phytoremediation Acceptability

Trust has a strong impact on farmers' acceptance of phytoremediation on "Ras el Ein" site. Lack of trust in the government goes at all levels in Lebanon. Political coverage for the dumpsite for over 20 years, despite the many attempts of the farmers to raise concerns about it, have contributed to magnify this distrust. Responses similar to "this day will never come…it will never happen in Lebanon" have emerged significantly during the interviews. As agriculture is neglected in Lebanon and so farmers, it is hard to expect that farmers would trust the government to carry out such a remediation plan. As one of the farmer's stated "Who, the government? our government? If you have a penny, it would take it from you". Farmers have also shown no trust in experts to execute the remediation plan, reflecting on previous bad experiences with agricultural engineers and claiming to know more than them.

There is also other dimension of trust with respect to farmers, which is fear. Farmers live in continuous fear that someday the government would take back the land, kick them out and not give them anything in return. As there is no built trust between the farmers and the governments, they feel there is no guarantee that the government would return back the land for them after taking that long to remediate it. Thus, they tend to be reluctant to accept phytoremediation.

5.3.4 Socio-economic Status and Farmers' Phytoremediation Acceptability

Socio-economic factors of farmers influence strongly their acceptance of phytoremediation. As depicted by one of the farmers, "nobody will accept this…you know our socio-economic status in this country these times.". Farming on this site represents a source of living for these families. Even when given the possibility that the land might be contaminated, farmers responded that they would not stop their activity, because they need to keep their families alive. While some of the farmers said that this is their only livelihood source, others have mentioned that they have other sources of income. The wife of a farmer emphasized that "you don't believe anyone who tells you they have no other source of income, maybe only very very few but these would be starving". This is a topic worth further investigating. However, most of these families are indeed poor and perhaps farming is a lifestyle for them.

These farmers have been cultivating these lands for so many decades now. They have been precedent by their fathers and grandfathers. This is what they know how to do and enjoy doing it. Quotes like "only death stops me from working with agriculture" and "some people would die and not leave their lands", capture the fact that farming is more of a lifestyle for these farmers, besides being their source of income.

5.3.5 Livelihood Alternative and Farmers' Phytoremediation Acceptability

One farmer said, "if the government is to execute the remediation plan, we cannot do anything and cannot stop in front of it…but we need an alternative". The availability of a viable option as a livelihood alternative impacts the acceptability of phytoremediation on "Ras el Ein" site. Upon the adoption of a remediation plan, it is important that an alternative is presented for the farmers working on site. One could be money compensation so that they would be able to survive with their families during the remediation period. Another more secure alternative is providing farmers other lands to farm. Although famers do not own the lands and the government could easily kick them out with no alternative, pursuing such an approach with them would further enhance the whole phytoremediation acceptability model and experience across the country.

5.4 Research Question 4

> RQ4: *What factors do influence the decision-making process of the selection of soil remediation methods and, in particular, phytoremediation in Lebanon?*

According to experts, six main factors influence the acceptance of the application of phytoremediation on a given site. These are cost-efficiency, familiarity (influenced by knowledge and experience), public acceptability as well as the policy-making process. The below sub-sections explore the relations between each of these factors and phytoremediation acceptance on the decision-making level.

5.4.1 Cost-efficiency and Phytoremediation Acceptability

Cost, effectiveness and time certainly play a role in the acceptance of the phytoremediation technology as a remediation approach on a given site by the decision makers. Assessing the site characteristics and contamination technical attributes come as a primary step. Among the experts, a highlighted advantage of phytoremediation was cost. This is an important factor as there are lots of sites in need for soil remediation across Lebanon, with no allocated budget.

However, effectiveness also plays a role in this perspective. So, according to some experts, if phytoremediation is proven efficient on a given site, cost is indeed an advantage. However, according to an environmental expert, on sites where effectiveness of the clean-up is ensured by another approach, a conventional one, cost should not be a limiting factor. Speed of clean-up also matters in the decision-making process. However, these three factors, cost, effectiveness and speed, are evaluated simultaneously depending on a set of criteria envisioned for the project execution. While some experts have stressed the importance of adopting long-term plans that favour more green and cost-effective choices, others have noted that this lacks in Lebanon and might compromise the acceptability of the method.

5.4.2 Familiarity and Phytoremediation Acceptability

Familiarity with method being employed on site is of great importance. Consultancy firms interviewed assured that when ministries commissioned them to such projects, typical concerns raised were “Have you tried it before? Is it successful?”. It has been reported by the different experts and officials that MoE have no knowledge or experience regarding remediation technologies. Just like when they lack expertise for other projects, MoE would outsource these remediation project proposals to consultancy firms for assessment. However, these consultancies are usually given limits, like time, which they set their study accordingly. Consultancies would typically prepare environmental assessments and submit back to MoE. In general, consultancy firms in Lebanon are still not very well acquainted with green remediation technologies and phytoremediation. In fact, the whole remediation topic is new to the Lebanese context. According to a senior environmental officer at the MoE no projects were presented or executed on soil remediation yet in Lebanon. Only very little small-scale trials were done on wastewater and constructed wetlands. This is confirmed by all the experts interviewed for this study. However, the only relevant case, which is worth mentioning, is the oil spill of the 2006 along the Lebanese coast. The MoE and some environmental consultants employed engineered-based techniques along like soil washing and stabilization to remediate the beach sands. One of the experts mentioned that "*MOE is aware of these techniques and what happened, they might think of these because they have made something similar in the past"*.

Constructed wetlands to remediate surface water and wastewater are the only form of green remediation technologies applied in Lebanon. However, the initiative came from international organizations like USAID and EU along with NGOs like AFD from France. They are counselling municipalities interested in applying such green techniques under their jurisdiction, featuring high public acceptability as well.

5.4.3 Public Acceptability and Phytoremediation Acceptability

Interviewed experts emphasized the importance of public acceptability for the successful phytoremediation application on a contaminated site. This was emphasized by consultants, researchers, academics and officials. Because of previous experience with projects, which were aborted because of public opposition, more weight is being attributed to public acceptability schemes by ministries and consultancy firms.

As part of public acceptance, some experts stressed the importance of incentives given to stakeholders benefiting originally from the site. According to one of the experts in consultancy groups, it is better to "engage them, find solutions and figure out how this possibly impacts their livelihood and how to compensate to reach a win-win situation."

6 Conclusion and Recommendations

The problem of unsafe MSW disposal in open dumpsites is one of the oldest environmental problems worldwide. Lebanon incapacity to deal with the massive spread of uncontrolled dumpsites all over its territory has led to environmental degradation and severe impacts on public health. “Ras el Ein” dumpsite serves a perfect case study for this problem. The sites’ cultural and historic value has been jeopardized by the presence of a mountainous dumpsite, which sits in the middle of its agricultural plain. Open dumpsites are proven to contaminate the surrounding environment with various microbiological and chemical pollutants, including heavy metals. Indeed, crops grown on contaminated soils near uncontrolled dumps have been associated with environmental health risks. As such, Ras el Ein dumpsite is believed to be the cause of an environmental and public health risk to the surrounding area. As many rehabilitation options have been considered for the dumpsite, this research focuses on the adjacent agricultural lands where farming practices take place. Contrary to conventional soil remediation techniques, phytoremediation has the potential to clean up contaminated soils through an inexpensive and environmentally-friendly approach that is easy to employ and restores soil’s quality as well. While research have focused a lot on the technical attributes of phytoremediation and its application, very little research has focused on its social attribution. Assessing social acceptability of phytoremediation is as important as evaluating its technical attributes. This study aspires to contribute to this limited area of research by exploring the factors, which affect phytoremediation acceptability at the level of multiple stakeholders. In the context of “Ras el Ein” dumpsite, phytoremediation acceptability was assessed on the level of the nearby residents, farmers as well as experts involved in decision-making. The study found out that public phytoremediation acceptability is influenced by lay people’s risk perception of the associated environmental health risk, their trust of the parties responsible to carry on the remediation plan and well as the anthropocentric environmental values that they possess. In terms of farmer's acceptability, it turned out that risk perception and trust do as well affect their acceptance of phytoremediation on their lands. However, additional factors included benefit perception, provision of livelihood alternative and socio-economic status. On the decision-making level, phytoremediation acceptability is governed by its cost-efficiency related factors, familiarity influenced by knowledge and experience as well as public acceptance.

This study serves to provide a holistic and unique understanding of what governs phytoremediation acceptability at multiple levels of involved stakeholders. Many factors have been explored by this study. Future research could choose to get more specific about some of these factors and explore their detailed relationship with phytoremediation acceptability using bigger sample sizes.

While soil remediation is still an underdeveloped field in Lebanon, phytoremediation could have potential among other remediation approaches. It is important that researchers, academic and environmental professionals set a platform for developing and marketing this approach across the public and private sectors. Indeed, Phytoremediation presents a very good opportunity for Lebanon to kick off remediation plans with an inexpensive and environmentally-friendly approach that have the potential to be widely acceptable.

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8 Appendices

8.1 Appendix I: Residents' Survey

Consent Form

You are kindly invited to participate in a research study that aims to investigate the public and farmers' acceptance of the application of phytoremediation technology to clean-up the potentially-contaminated agricultural soil adjoining "Ras el Ein" Dumpsite.

Title: Stakeholder Acceptance of Phytoremediation Technology to Clean-up Agricultural Lands Adjoining Open Municipal Solid Waste Dumpsites: The Case of "Ras el Ein" Dumpsite, Southern Lebanon.

Principal Investigator: Alice Al Baghdadi, M.Sc. Student.

The research is funded by Central European University and MESPOM programme, as part of the completion of the student's master thesis.

By participating in this study, participants will ultimately contribute to providing solutions to the problems associated with solid waste management sector in Lebanon and mitigating its impacts on the environment and public health.

If you agree to participate in this study, you will be asked to fill out a questionnaire of 41 questions. It will take around 30 minutes to complete it. All collected data will be handled with confidentiality and all names and means of individual identification will remain anonymous. There are no right or wrong answers to any of the questions. You are kindly asked to read each question carefully and choose the answer(s) that best matches your opinion.

Section A includes general demographics and background questions. Section B asks participants' perception of the environmental and health risks associated with the dumpsite and its surrounding area. Section C comprises questions about values related to the environment. Section D explores aspects related to some clean-up technologies and their potential application. The last section includes couple of questions relating to public trust in the government and experts responsible to carry on the clean-up procedures.

If you have any inquiries, please contact Ms. Alice Al Baghdadi by phone on 70-011965 or by email on al-baghdadi_alice@student.ceu.edu.

Completion and return of this questionnaire indicate that you have read and approved the information provided in this form.

Date:

Please cross the box(es) which best matches your opinion.

A. Demographics and Background Information

1. Age (Years): □ ≤20 □ 21-29 □ 30-39 □ 40-49 □ 50-59 □ ≥60
2. Gender: □ Male □ Female □ Other
3. Marital Status: □ Single □ Married □ Divorced □ Widowed
4. Household Members: □ 1-5 □ 6-10 □ >10
5. Household Income ($):

   □ <500 □ 501-1000 □ 1001-1500 □ 1501-2000 □ >2000
6. Highest Educational Level:

   □ Primary School □ Secondary School □ High School □ Bachelor □ Post- Graduate

   □ None
7. Profession(s): ____
8. Proximity of residence to "Ras el Ein" dumpsite (Km)?
9. Length of stay at current residence (years): □ <1 □ 1-5 □ 6-10 □ >10
10. Is this your permanent place of residence? □ Yes □ No
11. If not, I permanently live in ____________________________________
12. Where do you buy the vegetables and fruits you consume at your household from? (You can choose more than one option)

    □ Central Market □ Supermarkets □ Local shops □ Own garden/ agricultural land

    □ Street hawker
13. On the agricultural lands adjoining "Ras el Ein" dumpsite, are you aware of the cultivation of edible crops? □ Yes □ No

    If "No", please proceed to Q16.
14. For how long have you been aware that the agricultural lands adjoining "Ras el Ein" Dumpsite are cultivated with edible crops like vegetables and fruits? ___________________________
15. Where do you think the produce, grown around the dumpsite, is sold?

    (You can choose more than one option)

    □ Central Market □ Supermarkets □ Local shops □ Shipped overseas □ I don't know

B. Risk Perception (RP):

16. “Ras el Ein” Dumpsite poses a risk of contamination to the surrounding environment.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Air (RP1a)					
Soil (RP 1b)					
Seawater (RP1c)					
Fauna and Flora (RP1d)					
Groundwater (Springs, Wells and Aquifers) (RP1e)					

17. I think crops, grown around “Ras el Ein” dumpsite, are contaminated. (RP2)

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

18. The potentially-contaminated environment (air, soil, seawater, groundwater, flora and fauna) surrounding “Ras el Ein” dumpsite poses a risk to me and my family’s health.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Air (RP3a)					
Soil (RP3b)					
Seawater (RP3c)					
Fauna and Flora (RP3d)					
Groundwater (Springs, Wells and Aquifers) (RP3e)					

19. I can get affected by the potentially-contaminated soil by

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Soil Ingestion (RP4a)					
Dermal Contact (RP4b)					
Crops’ consumption (RP4c)					
Air/Dust Inhalation (RP4d)					

20. I have suffered from health impacts, which I have related directly to the soil/crops surrounding “Ras el Ein” Dumpsite?

	No	Yes, please specify when was that, what were the health impacts and how did you relate them
Soil (RP5a)		
Crops (RP5b)		

21. I think I can protect myself and my family from the potentially-contaminated soil, surrounding “Ras el Ein” dumpsite, by

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Avoiding the site completely (RP6a)					
Avoiding dermal contact (RP6b)					
Avoiding crops’ consumption (RP6c)					

22. I think I can protect myself and my family from the potentially-contaminated crops, grown on the agricultural lands surrounding “Ras el Dumpsite”, by

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Not consuming them at all (RP7a)					
Washing them thoroughly (RP7b)					
Removing some parts away (RP7c)					
Consuming crops which can be cooked only (RP7d)					

C. Values

23. Technology can overcome any environmental problem. (V1)

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

24. Nature is a storehouse of resources for humans to use. (V2)

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

25. Conserving natural resources is unnecessary because alternatives will always be found. (V3)

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

26. Humans have the right to control the rest of nature. (V4)

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

27. Humans have moral obligation to

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Other Humans, including future humans (V5a)					
Animals (V5b)					
Plants and Trees (V5c)					
Non-living components of nature (rocks, soil…) (V5d)					

28. Contaminated soil must be cleaned up only if it poses a risk to people's health. (V6)

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

Soil, surrounding MSW dumpsites, can be contaminated with various types of contaminants. There are numerous methods which can be used to clean-up contaminated soil. Attached to the back of the questionnaire is an appendix with a list of some common applied methods, which be used to the clean-up soil and are effective on various types of contaminants. Please examine them carefully and answer the below questions.

D. Phytoremediation Acceptability

29. The soil surrounding "Ras el Ein" dumpsite should be cleaned up if proven contaminated. (PA1)

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

30. Of the remediation methods specified below, I have heard of

□ Engineered-based Methods (PA2a) □ Phytoremediation (PA2b) □ Dig and Dump (PA2c) □ None

□ Other, please specify: ____

31. Rank the below proposed methods for cleaning-up the potentially contaminated soil surrounding "Ras el Ein" Dumpsite. (1: most desirable and 3: least desirable)

Method	Rank
Dig and Dump (PA3a)	
Phytoremediation (PA3b)	
Engineered-based methods (PA3c)	
None of the above (PA3d)	

32. Rank the below factors according to their influence on your ranking of Q31. (1: most influential and 3: least influential)

	Rank
Cost (PA4a)	
Effectiveness (PA4b)	
Environmentally-friendly (PA4c)	
Speed of clean-up (PA4d)	
Familiarity with method (PA4e)	
Other, please specify	

33. Phytoremediation is an acceptable method for cleaning up the potentially-contaminated soil surrounding "Ras el Ein" dumpsite. (PA5)

    □ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

34. I am willing to push for the implementation of phytoremediation method to clean up the potentially contaminated soil surrounding Ras el Ein dumpsite (PA6)

    □ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

35. If phytoremediation was applied on the surrounding soil, I would feel safe to consume the crops grown on the site (PA7)

    □ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

E. Trust

36. Based on your knowledge, have you or anyone else raised concerns about growing edible crops in the land surrounding "Ras el Ein" Dumpsite before? (T1)

    □ No □ Yes, please specify these concerns________________________________

37. Has anyone responded to these concerns? (T2)

    □ No □ Yes, please specify these concerns________________________________

38. I am willing to address this issue (again). (T3)

    □ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

39. I trust the government to choose, implement and oversee phytoremediation of soil in a manner that would be acceptable to me? (T4)

    □ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

40. I trust the experts to choose, implement and oversee phytoremediation of soil in a manner that would be acceptable to me? (T5)

    □ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

41. I would like to be involved in the process of choosing and overviewing the remediation method to be applied on the potentially contaminated site. (T6)

□ Strongly Agree □ Agree □ Neutral □ Disagree □ Strongly Disagree

Participant's Comments:

____

____

____

____

Appendix

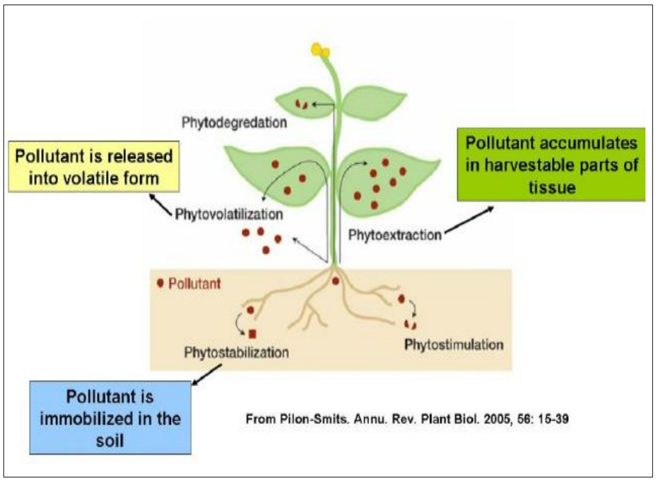
Conventional Engineered-based Methods

Engineered-based methods: using physio-chemical/thermal methods and heavy machinery to clean up the soil.
Advantages: Quick and very effective
Disadvantages: expensive; destructive impact on soil quality; not environmentally friendly; residual waste for disposal

Dig and Dump

Dig and Dump: (Physical method): removal of soil from site, dumping it somewhere else and replacing with new soil.
Advantages: Quick; site is ready for redevelopment.
Disadvantages: expensive; untreated soil is a problem for another area.

Phytoremediation (Biological Method)



Phytoremediation (Biological method): Plants destroy/transfer/remove/stabilize contaminants present in the soil.
Advantages: inexpensive, low-tech method; aesthetically pleasing; environmentally-friendly
Disadvantages: takes time to clean-up, residual plant biomass for disposal

8.2 Appendix II: Latent Variable Coefficients

	EH_RP	V_Ant	T	PA	Ctr_RP	Exp_RP	V_Eco
R-squared Coefficients	0.21			0.143			
Adjusted R-squared coefficients	0.186			0.09			
Composite reliability coefficients	0.769	0.49	0.737	0.872	0.728	0.868	0.93
Cronbach's alpha coefficients	0.625	0.176	0.287	0.767	0.254	0.696	0.895
Average variances extracted	0.411	0.348	0.584	0.707	0.573	0.767	0.77
Full collinearity VIFs	1.153	1.034	1.097	1.029	1.172	1.083	1.116
Q-squared coefficients	0.217			0.156			

8.3 Appendix III: Combined loadings and cross-loadings of Indicators at the first-order level of Conceptualization

	EH_RP	V_Ant	T	PA	Ctr_RP	Exp_RP	V_Eco	Type (a	SE	P value
RP1b	0.678	0.178	-0.105	-0.121	0.136	0.275	-0.056	Formati	0.096	<0.001
RP1d	0.644	-0.227	0.228	0.023	0.377	-0.098	0.217	Formati	0.097	<0.001
RP2	0.76	-0.221	-0.112	0.08	-0.082	0.153	-0.101	Formati	0.093	<0.001
RP3b	0.678	0.304	-0.052	-0.082	-0.109	-0.146	-0.012	Formati	0.096	<0.001
RP4c	0.377	-0.034	0.121	0.164	-0.528	-0.372	-0.044	Formati	0.106	<0.001
V1	0.239	-0.291	0.113	-0.176	0.119	-0.021	0.062	Formati	0.109	0.005
V2	0.28	0.694	0.061	-0.168	0.033	0.087	0.11	Formati	0.095	<0.001
V4	-0.198	0.845	0.033	0.031	0.027	-0.034	-0.03	Formati	0.091	<0.001
V6	0.126	0.334	-0.112	0.12	-0.034	-0.115	-0.098	Formati	0.107	0.001
T4	0.001	0.187	0.764	-0.088	-0.104	0.151	-0.162	Formati	0.093	<0.001
T5	-0.001	-0.187	0.764	0.088	0.104	-0.151	0.162	Formati	0.093	<0.001
PA5	-0.04	0.066	-0.058	0.958	-0.006	-0.003	-0.004	Formati	0.088	<0.001
PA6	-0.003	0.012	-0.084	0.958	-0.088	-0.009	-0.058	Formati	0.088	<0.001
PA7	0.076	-0.14	0.254	0.534	0.168	0.021	0.113	Formati	0.1	<0.001
RP6c	0.23	-0.011	0.065	0.029	0.757	0.16	-0.038	Formati	0.093	<0.001
RP7a	-0.23	0.011	-0.065	-0.029	0.757	-0.16	0.038	Formati	0.093	<0.001
RP5a	0.037	0.04	0.082	0.067	0.085	0.876	0.122	Formati	0.09	<0.001
RP5b	-0.037	-0.04	-0.082	-0.067	-0.085	0.876	-0.122	Formati	0.09	<0.001
V5a	-0.046	-0.045	-0.327	-0.069	-0.255	-0.051	0.678	Formati	0.096	<0.001
V5b	0.04	0.104	0.041	0.048	-0.009	0.069	0.934	Formati	0.088	<0.001
V5c	-0.004	-0.029	0.167	0.02	0.099	-0.045	0.917	Formati	0.089	<0.001
V5d	-0.002	-0.042	0.033	-0.017	0.095	0.012	0.954	Formati	0.088	<0.001

8.4 Appendix IV: Indicator Weights (First-order level)

	EH_RP	V_Ant	T	PA	Ctr_RP	Exp_RP	V_Eco	Type (a	SE	P value	VIF	WLS	ES
RP1b	0.33	0	0	0	0	0	0	Formati	0.107	0.002**	1.497	1	0.224
RP1d	0.314	0	0	0	0	0	0	Formati	0.108	0.002**	1.279	1	0.202
RP2	0.37	0	0	0	0	0	0	Formati	0.106	<0.001***	1.505	1	0.281
RP3b	0.33	0	0	0	0	0	0	Formati	0.107	0.002**	1.4	1	0.224
RP4c	0.184	0	0	0	0	0	0	Formati	0.113	0.054	1.249	1	0.069
V1	0	-0.208	0	0	0	0	0	Formati	0.112	0.034*	1.054	1	0.06
V2	0	0.5	0	0	0	0	0	Formati	0.102	<0.001***	1.162	1	0.347
V4	0	0.607	0	0	0	0	0	Formati	0.098	<0.001***	1.204	1	0.513
V6	0	0.239	0	0	0	0	0	Formati	0.111	0.017*	1.021	1	0.08
T4	0	0	0.654	0	0	0	0	Formati	0.097	<0.001***	1.029	1	0.5
T5	0	0	0.654	0	0	0	0	Formati	0.097	<0.001***	1.029	1	0.5
PA5	0	0	0	0.452	0	0	0	Formati	0.103	<0.001***	9.608	1	0.432
PA6	0	0	0	0.452	0	0	0	Formati	0.103	<0.001***	9.624	1	0.433
PA7	0	0	0	0.252	0	0	0	Formati	0.11	0.013*	1.112	1	0.135
RP6c	0	0	0	0	0.661	0	0	Formati	0.096	<0.001***	1.022	1	0.5
RP7a	0	0	0	0	0.661	0	0	Formati	0.096	<0.001***	1.022	1	0.5
RP5a	0	0	0	0	0	0.571	0	Formati	0.099	<0.001***	1.398	1	0.5
RP5b	0	0	0	0	0	0.571	0	Formati	0.099	<0.001***	1.398	1	0.5
V5a	0	0	0	0	0	0	0.22	Formati	0.111	0.026*	1.581	1	0.149
V5b	0	0	0	0	0	0	0.303	Formati	0.108	0.003**	4.273	1	0.283
V5c	0	0	0	0	0	0	0.298	Formati	0.109	0.004**	7.397	1	0.273
V5d	0	0	0	0	0	0	0.31	Formati	0.108	0.003**	9.922	1	0.295

Asterisk $*p < .05$; $**p < .01$; $***p < .001$

VIF = indicator variance inflation factor; WLS = indicator weight-loading sign; ES = indicator effect size

8.5 Appendix V: Correlations among l.vs. with sq. rts. Of AVEs

	EH_RP	V_Ant	T	PA	Ctr_RP	Exp_RP	V_Eco
EH_RP	0.641	0.07	0.118	0.037	-0.321**	-0.126	-0.07
V_Ant	0.07	0.59	-0.037	-0.061	0.087	-0.002	-0.108
T	0.118	-0.037	0.764	0.044	-0.16	0.078	-0.217
PA	0.037	-0.061	0.044	0.841	-0.013	0.092	0.086
Ctr_RP	-0.321**	0.087	-0.16	-0.013	0.757	0.148	-0.04
Exp_RP	-0.126	-0.002	0.078	0.092	0.148	0.876	-0.173
V_Eco	-0.07	-0.108	-0.217	0.086	-0.04	-0.173	0.878

Asterisk ***p* < .01

8.6 Appendix VI: Second-order Model fit and Quality Indices

Classic indices	**Additional indices (indicator corr. matrix fit)**
Average path coefficient (APC)=0.230, P=0.011	Standardized root mean squared residual (SRMR)=0.000, acceptable if <= 0.1
Average R-squared (ARS)=0.176, P=0.031	Standardized mean absolute residual (SMAR)=0.000, acceptable if <= 0.1
Average adjusted R-squared (AARS)=0.138, P=0.058	Standardized chi-squared with 20 degrees of freedom (SChS)=0.000, P<0.001
Average block VIF (AVIF)=1.035, acceptable if <= 5, ideally <= 3.3	Standardized threshold difference count ratio (STDCR)=1.000, acceptable if >= 0.7, ideally = 1
Average full collinearity VIF (AFVIF)=1.098, acceptable if <= 5, ideally <= 3.3	Standardized threshold difference sum ratio (STDSR)=1.000, acceptable if >= 0.7, ideally = 1

Tenenhaus GoF (GoF)=0.420, small >= 0.1, medium >= 0.25, large >= 0.36

Sympson's paradox ratio (SPR)=1.000, acceptable if >= 0.7, ideally = 1

R-squared contribution ratio (RSCR)=1.000, acceptable if >= 0.9, ideally = 1

Statistical suppression ratio (SSR)=0.500, acceptable if >= 0.7

Nonlinear bivariate causality direction ratio (NLBCDR)=0.750, acceptable if >= 0.7