World Vision
الرؤية العالمية

Study: Winterization Methods' Comparison

Final Report

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List of Acronyms

A list of acronyms used throughout the report will be listed under this section.

Acronym	Definition
CO	Carbon Monoxide
CO2	Carbon Dioxide
FMNR	Farmer Managed Natural Regeneration
HTC	Hydrothermal Carbonization
KII	Key Informant Interviews
LBP	Lebanese Pound
LCRP	Lebanon Crisis Response Plan
Mj/kg	Mega joules per kilo gram
NGOs	Non-Governmental Organizations
NOx	Nitrogen Oxides
PM	Particulate Matter
SO2	Sulphur Dioxide
TOR	Terms of Reference
UNHCR	United Nations High Commissioner for Refugees
USD	United States Dollar
VASyR	Vulnerability Assessment of Syrian Refugees in Lebanon
VOC	Volatile Organic Compounds
WVL	World Vision Lebanon

Executive Summary

The multifaceted crisis that Lebanon has been enduring has impacted the entire country, mainly vulnerable population. These populations have seen their living standards deteriorate significantly amidst the rising cost of living. As a result, the UN has estimated that almost 82% of the population were living in multidimensional poverty (UN, 2021). They have been unable to ensure their basic needs, including access to proper heating during winter. As such, commissioned by World Vision Lebanon, Qualisus Consulting undertook this study between July and August 2023, guided by the central question: "***To what extent do different heating methods vary in terms of effectiveness, cost, availability, and eco-friendliness?"*** This research project embarked on a comprehensive exploration to address the critical need for identifying reliable heating methods for vulnerable populations, particularly within the context of Lebanon. The main objective was to compare the efficacy, accessibility, cost, and the environmental friendliness of various heating modalities, ultimately aiming to inform future initiatives dedicated to enhancing the well-being of Lebanon's most vulnerable communities.

To accomplish the specified objectives outlined in the project's Terms of Reference (TOR) and effectively address the primary research question, the research team adopted a comprehensive methodological approach consisting of multiple steps. This involved conducting a systematic literature review, followed primary data collection using KIIs with olive pomace producers, academics in the environmental sciences field, livelihood technical specialists and fuel suppliers. After the collection of primary and secondary data, the research team initiated the analysis by triangulating the main findings from both the literature review and the KIIs across five main themes. These themes included the different heating types used by vulnerable populations in Lebanon, the effectiveness of each type, the availability and accessibility of each, the cost and the environmental impact.

The research findings presented a nuanced understanding of the heating methods used by vulnerable populations in Lebanon. The key findings are summarized as follows:

- Diesel fuel emerges as a primary heating choice in Lebanon due to its accessibility, practicality, and efficient heat generation. Despite its efficiency, concerns persist regarding the environmental sustainability of diesel as a heating source. Furthermore, the market presence of diesel is influenced by socio-political factors, rendering it susceptible to price fluctuations on both regional and global scales. Due to the most recent rise in the cost of diesel, majority of vulnerable household in Lebanon have switched to more cost-efficient sources such as wood. A reduction in diesel prices would likely lead to a return to its utilization due to its unmatched effectiveness, practicality, and availability.

- The unaffordability of diesel prompts the need for cost-effective and practical alternative heating options for vulnerable households. Wood utilization through illegal cutting and fires has been the prevalent recourse, negatively impacting the environment and ecosystem.

- Leveraging available biomass resources, such as olive pomace, within winterization programs is a potential solution. Effecting behavioral change toward sustainable heating practices requires multifaceted strategies involving efficient biomass collection and processing in collaboration with communities and authorities. Fostering a sense of communal ownership over natural resources, following the WV's Farmer Managed Natural Regeneration (FMNR) approach, is crucial to preserving resources. Investment

in energy-efficient technologies like rocket stoves optimized for biomass utilization is essential for household-level application.

- A significant finding underscores the viability of diversifying wood sources, notably through pruning by-products sourced from forests situated in publicly accessible areas like roadsides. Through innovative techniques like shredding and compacting, these by-products can be transformed into wood-like materials comparable to olive pomace. This discovery not only expands the range of available heating sources but also emphasizes the ample availability of potential resources for sustainable energy generation.

Direct / Space heaters (referred to as suitable in warmer climates)				
	Olive Pomace	**Diesel**	**Gas**	**Wood**
Effectiveness				
Cost				
Eco-friendliness				
Storage				

High score Medium score Low score

Key Recommendations

- Prioritize an "**Affordability-Centred Approach**" recognizing cost as the key factor for heating method selection among vulnerable communities. Implement subsidies during economic stress, offer diverse heating options, and establish market monitoring systems for pricing and availability to ensure accessible and practical heating choices.
- Allocate resources to winterization initiatives that provide viable **alternatives to diesel fuel and wood**, considering financial constraints and the negative impact of wood cutting and fire starting.
- Support projects with comprehensive winterization strategies that leverage accessible biomass resources, such as olive pomace, to address environmental concerns. Strategies involve:
    - Engaging Vulnerable Communities: Involve communities in designing and implementing winterization programs, tailoring initiatives to their preferences and needs for empowerment.
    - Building Community Capacity: Equip local communities with skills for effective biomass processing, responsible resource harvesting, proper combustion, storage, and equipment operation, enhancing their self-sufficiency and resilience.
    - Improving Processing Techniques: Collaborate with local businesses and communities to introduce innovative biomass processing methods, enhancing combustion efficiency. Provide access to equipment for optimized resource use and heat generation.
    - Establishing Market Connections: Link biomass processing businesses with markets, ensuring accessibility for vulnerable communities and wider reach of sustainable heating resources.
    - Introducing Energy-Efficient Technologies: Implement clean-burning technologies like rocket stoves to maximize biomass benefits, promoting improved heating efficiency, reduced environmental impact, and community well-being.

- Monitoring and Data Collection: Establish robust systems for data collection and monitoring to track winterization impact over time. Regularly assess heating method effectiveness, community feedback, and changing needs to inform program enhancements.
- Collaborating with Local Authorities: Work closely with local authorities to ensure legal and sustainable biomass harvesting. Facilitate permits for responsible resource use, minimizing negative environmental and social consequences.
- Environmental Awareness Campaigns: Launch campaigns educating communities about the environmental effects of various heating methods, emphasizing the advantages of biomass utilisation and promoting environmentally conscious heating practices.

Introduction

In recent years, Lebanon has confronted a profound economic and financial crisis that has affected every segment of its society. Originating in 2019, this crisis has been compounded by the dual economic shockwaves of the COVID-19 pandemic and the catastrophic explosion at the Port of Beirut in August 2020 (World Bank, 2023). Among these crises, the economic crises have yielded the direst consequences, placing Lebanon in the ranks of the world's most severe economic challenges (World Bank, 2023). Consequently, households have found themselves struggling to survive and meet their basic needs with an income that is past the poverty threshold. This situation is exemplified by the unemployment rate surging from 11.4% in 2018-2019 to 29.6% in 2022 (World Bank, 2023).

The compounding challenges extended to a profound fuel shortage, resulting in over eight instances of rolling blackouts within the national electric grid. This scarcity of fuel also had a direct impact on healthcare, food distribution, and access to clean water (World Bank, 2023). Beyond its impact on Lebanese households, this crisis left a deep imprint on the lives of vulnerable Lebanese and Syrian refugee families, already struggling to secure fundamental necessities. Recent assessments conducted by World Vision Lebanon (2023) revealed stark figures, with a significant 39.1% of the Lebanese and 83.5% of Syrian refugee households in Akkar grappling with unemployment. Those fortunate enough to have employment often occupy short-term work opportunities with unstable income streams. The onset of winter suspends numerous casual employments, including agricultural labour, contributing to diminished household income. Consequently, many vulnerable households, especially those dwelling at elevations exceeding 700 meters are confronted with the inability to afford heating expenses due to constrained resources (LCRP, 2023). The withdrawal of the diesel and gas subsidies in 2022 intensified these challenges, exacerbating the struggle for many families to procure diesel for heating purposes. The removal of subsidies led to an abrupt rise in the prices impacting diesel and gas availability and accessibility. Considering these obstacles, rural households became in need of economical alternatives for heating and resorted to utilizing wood and in some instances burning trash. These trends will be unfolded in the coming sections.

One of the main drivers of this research revolves around identifying reliable heating methods for these vulnerable populations. While diverse heating modalities exist, they diverge in efficacy, accessibility, cost, and ecological ramifications. Furthermore, the landscape of alternative heating methods in Lebanon remains inadequately researched. With this in mind, this research inquiry is framed by the question: "***To what extent do different heating methods vary in terms of effectiveness, cost, availability, and eco-friendliness?***" World Vision Lebanon has commissioned Qualisus Consulting to conduct this study between July and August 2023. The

study's objectives focus on evaluating the effectiveness of distinct winterization approaches in mitigating cold during winter, determining the differences in costs associated with each method, and conducting a comparative analysis of their environmental impact. This endeavour is aimed at informing future initiatives that seek to address the needs of Lebanon's most vulnerable populations.

In order to guide the research process, the research team discussed and agreed, jointly with World Vision Lebanon, upon a set of operational definitions for the key terms used in this research. These definitions are presented in Table 1.

Table 1 - Operational Definitions

Key Term	Definition	Source of Definition
Winterisation	This refers to the process of implementing measures and interventions to minimize the effects of cold weather and protect vulnerable populations, particularly households, during the winter season in Lebanon.	World Vision Lebanon Study ToR
Eligibility for Winterisation Assistance	Eligibility for winterisation assistance is affected by: 1. Shelter type 2. Elevation above 500m	World Vision Lebanon
Cost	This refers to financial expenses associated with implementing different winterization methods for vulnerable populations in Lebanon. The cost will be measured in USD.	World Vision Lebanon Study ToR
Environmental Impact	The parameters to be examined when assessing environmental impact encompass: 1. CO2 emissions 2. Resource depletion 3. Air, ground and water pollution	World Vision Lebanon
Effectiveness	The ability of each type of heating to minimize cold during the winter season.	World Vision Lebanon ToR.

Literature Review

The literature review process encompassed an extensive analysis of more than 40 articles, organized into five principal thematic categories aligned with the research question (see Annex 4). This body of literature was comprised of peer-reviewed articles and grey literature, which included reports, technical papers sourced from NGOs and government entities, and supplemented by news articles, primarily used to help explain the intricacies of the Lebanese context. The five principal themes were as follows:

1. **Heating Methods**: examining the spectrum of the heating methods and fuel types used by vulnerable populations in Lebanon. The heating methods examined in the report are wood, diesel, gas, and olive pomace. Additional methods will be briefly examined.
2. **Effectiveness of Heating Modalities**: looking at the efficacy of diverse heating techniques in mitigating exposure to cold conditions. An examination of the heating value of each method will be presented.
3. **Market Availability**: looking at the availability of the heating method in the Lebanese market. Examining the attainability of each source given the Lebanese geographic and economic contexts.
4. **Cost Analysis**: examining the cost of each heating method. The price of each energy source will be examined as well as the additional costs of equipment.
5. **Eco-friendliness**: assessing the ecological consequences associated with each identified heating approach. Will examine the emissions and possible negative implications of each source.

The review is structured according to individual heating methods, aligning with the prevalent practices observed among vulnerable population segments in Lebanon. This arrangement is coherent with the sequence established by the five themes introduced above.

Winterisation Approaches in Lebanon

Amidst this unprecedented economic recession amplified by multifaceted crises, survival and heating during the winter months poses an additional conundrum for Lebanon's vulnerable populations (UNHCR, 2023). The consequences of these crises have led to a widespread impoverishment, food insecurity, and a rapidly increased cost of living (Human Rights Watch, 2022). According to Al Monitor (2023) amid Lebanon's ongoing fuel crisis and economic challenges, the impending winter season has worsened conditions for its people. The steep surge in oil derivative prices is causing significant financial strain on the population. The drastic devaluation of the currency by 90% has severely limited heating options. Shortages of diesel, a crucial heating resource in mountainous areas, are evident. Individuals who relied on dual diesel-electricity heaters are now grappling with power cuts that undermine their effectiveness. Gas heaters have also become expensive due to elevated gas bottle costs. Despite the high expense, demand for firewood heaters remains strong (Al Monitor, 2023). Despite environmental worries, many Lebanese are resorting to tree cutting for firewood. Wood-burning stoves are gaining favour due to their affordability compared to diesel-operated alternatives. An illuminating statistic underscores the gravity of this situation: a striking 32% of Syrian refugees in Lebanon currently lack access to any form of heating (VASyR, 2022). Notably, this challenge is more acute within families inhabiting residential shelters, with 39% experiencing a lack of heating, compared to families in non-residential shelters (29%) and families in non-permanent shelters (8%) (VASyR, 2022). Furthermore, these dire circumstances have pushed some groups, like Syrian refugees,

to resort to burning items such as waste, plastic, and rubber to stay warm, as mentioned in the VASyR report of 2022.

As such, winterization efforts to support vulnerable populations have become crucial. The most prominent method which has been recognized by the Basic Assistance sector is the provision of cash assistance to vulnerable populations so they can afford basic heating sources. According to UNHCR (2023) more than 1,4 million vulnerable individuals from Lebanese and refugee communities received cash for winterisation assistance in the winter seasons of 2022. Furthermore, non-governmental actors in Lebanon are examining and piloting the use of alternative, more cost effective, eco-friendly heating methods such as the use of Olive Pomace (UNHCR, 2023; WVL, 2023). The post-distribution monitoring reports available indicate that a significant proportion of the cash assistance is used by vulnerable populations to purchase fuel for heating (IRC, 2014; Makhzoumi Foundation, 2016; UNHCR, 2023). The Basic Assistance Sector within the most recent Lebanon Crisis Response Plan (LCRP, 2023), considers three main heating sources, namely diesel, gas, and wood in their cost estimations. Furthermore, the VASyR (2022) report, although exclusively focused on assessing the needs of Syrian refugee families in Lebanon, also stipulates wood, diesel, and gas to be among the most used fuel sources for heating. Older winterisation assistance reports (UNHCR, 2014) indicate that the most widely distributed type of stoves and fuel vouchers were those for diesel-based heating. As such, the literature review is focused on examining the effectiveness, availability, cost and eco-friendliness of wood, diesel, and gas. Furthermore, in line with the TOR, the research team will also examine Olive Pomace as a possible alternative heating source for seasonal assistance.

Moreover, wherever information was available, the type of shelter has been taken into consideration to examine the extent to which it impacts the choice of heating method used by vulnerable populations in Lebanon. The research team was unable to find literature on the types of shelter used by vulnerable Lebanese families, however, VASyR (2022) provides a detailed account of shelter types used by Syrian refugees in Lebanon. Accordingly, the majority (61%) of female-headed households and (66%) of male-headed households reside in permanent residential shelters such as apartments, houses, or rooms. Meanwhile, a further 27% of Syrian households live in non-permanent shelters, most notably tents. Ultimately, the choice of optimal heating methods for each type of shelter is influenced by various factors, including the socioeconomic status of the household, safety considerations and efficiency concerns.

Wood

Wood is reported to be a widely used source of fuel for heating among the vulnerable communities in Lebanon (LCRP, 2023). Approximately 38% of Syrian households have reported using wood as a heating source in 2022, while the wood usage frequency among vulnerable Lebanese households has not been studied but is anecdotally evidenced to be relatively high (Raydan, 2022). The reliance on wood for heating during winter has increased among both Lebanese (Raydan, 2022) and Syrian refugee communities (VASyR,2022), predominantly due to economic crisis resulting in unaffordable fuel alternatives such as diesel and gas. It is estimated that residential units that use firewood for heating need up to 6 tons of firewood per season (Fayad, 2022). The reliance on wood for heating also varies geographically, although these patterns of use are only available for the Syrian refugee community. Akkar, Baalback-Al-Hermel, Bekaa, and Nabatiyeh are the areas most reliant upon wood for heating, whereas Beirut and Mt. Lebanon are the least (VASyR, 2022). A trend of illegal firewood harvesting has been noted among the

vulnerable communities in Lebanon in the recent years, as many are not able to afford the cost of purchasing wood (Raydan, 2022; VASyR, 2022).

Effectiveness

In terms of heating effectiveness, the energy output of 19.8 MJ/kg places wood at a relatively lower level when contrasted with the energy yields of conventional fossil fuels like diesel and gas (Wood-Energy, 2019). This discrepancy in energy production could indicate that wood might require larger quantities to generate the same level of heat as its fossil fuel counterparts. Additionally, the combustion process of wood may involve certain inefficiencies, such as heat loss through smoke and incomplete burning, which can impact its overall heating effectiveness (O'kelly, 2020). Furthermore, the heating effectiveness is also affected by the type of stove used.

A newly emerging and increasingly popular type of stove making its mark in the market is the rocket stove. A rocket stove is a compact wood-burning device that incorporates an internal elbow heater, designed to offer remarkable efficiency and practicality in situations where conventional energy sources like fossil fuels and electricity are in short supply. Operating solely on wood, an easily accessible and abundant resource, rocket stoves excel in energy efficiency, notably due to their ability to function effectively with minimal wood consumption. These stoves are particularly well-suited for survival scenarios, owing to their capability to burn commonly available materials like twigs, leaves, and wood debris (Kitchen Buds, 2023).

Furthermore, rocket stoves employ heat energy in an exceptionally efficient manner, minimizing wastage, which contrasts with open fires. By efficiently combusting only the tips of fuel wood, they eliminate both waste and smoke production. The versatility of these stoves is demonstrated by their capacity to burn various materials, encompassing leaves, twigs, and brush. The strategic arrangement of the burning wood on the grate also serves to preheat the incoming air before it enters the combustion chamber, consequently enhancing the quality of combustion (Kitchen Buds, 2023).

Availability and Cost

Wood is generally readily available in the Lebanese market from local suppliers and even some online platforms (Kinab et al., 2015), due predominantly to the presence of woodlands across Lebanon. However, there is an absence of studies and statistics on the actual availability of this resource in the market. The exact cost of wood in Lebanon has also increased due to the economic situation in the country (Raydan, 2022). Anecdotal sources estimate one ton to reach USD 120 during winter (Rose, 2022), which is considered a relatively high amount given the diminished purchasing power of vulnerable Lebanese communities. To put things into perspective, the minimum wage in Lebanon is set at 9,000,000 LBP, equivalent to USD 100 per month (Ministry of Labour, 2023), which would make purchase of wood unaffordable to those living on this income margin. Additionally, this method of heating requires wood stoves or a fireplace which are well ventilated (Walker, 2023). These stoves are purchased from the market and available in Lebanon. Their prices also vary starting at 220$ (wood and gas website, 2023). Other equipment such as pipes for ventilation are sold for additional prices (wood and gas website, 2023). These stoves can be installed in all types of shelters, including tents. Rocket stoves are also available for purchase in Lebanon, however information regarding their prices could was not available online. However, woodstoves also have potential risks as they may lead

to fires in refugee camps. For instance, in 2019, almost 150 Syrian refugees in camp in Lebanon were left homeless as a result of a fire that caught on to one of the camps because of a woodstove (Hearth, 2019).

Environmental impact

The utilization of wood can potentially lead to environmental issues such as deforestation, habitat destruction, and overall environmental degradation. Over the past two decades, wildfires have been accountable for a significant 26% of the total tree loss in Lebanon (The Guardian, 2022). It has been reported that approximately 95% of forest fires in Lebanon are attributed to human activity, whether intentional or accidental, often involving the burning of wood for cooking and heating purposes (The Guardian, 2022). Furthermore, forest fires are also cause by the disproportionate impact of climate change, with Lebanon situated in a highly susceptible climate change hotspot (Kayed, 2023). The region's temperatures are projected to rise at a rate 20% faster than the global average (Kayed, 2023). The escalating severity and recurrence of wildfires, attributed to climate change, have led to previously unaffected ecosystems such as the high-altitude juniper forests of Akkar succumbing to fire, marking a concerning shift (Kayed, 2023).

Furthermore, alongside the fire-related challenges, forests across Lebanon have encountered an escalation in tree cutting rates over the past three years (Kayed, 2023). This surge in tree cutting can be attributed to the substantial increase in diesel prices, prompting a significant shift in the market towards wood for heating purposes (Kayed, 2023). This shift has compelled local communities not only to intensify tree cutting for personal heating needs but also as a means of securing their livelihoods (Kayed, 2023). As the wood from Akkar's forests is distributed throughout the country for sale, the loss of trees is surpassing the historically established sustainable limits, raising concerns about the ecosystem's stability (Kayed, 2023).

It is also important to acknowledge that the act of burning wood itself carries further notable environmental drawbacks. As highlighted in the research conducted by Rabajczyk et al. (2020), the concept of energy poverty, which denotes limited access to affordable and modern energy services, often drives the use of wood combustion. Unfortunately, this situation exposes individuals to a range of harmful chemicals within low-effectiveness furnaces employed for home heating. This scenario results in a heightened exposure of low-income populations to particulate matter (PM), a combination of minuscule solid particles and suspended liquid droplets in the air, as well as polycyclic aromatic hydrocarbons (PAH), which are organic compounds comprising multiple fused aromatic rings made up of carbon and hydrogen atoms. Furthermore, the combustion of impregnating substances at lower temperatures yields additional compounds that are released into the environment, further impacting individual health and giving rise to various diseases. In essence, the process of burning wood releases chemicals that pose significant risks to human well-being (Rabajczyk et al, 2020).

The research conducted by Marin et al. (2022) delves into the adverse consequences of woodburning in the context of the United States. The study asserts that the resulting air pollution stemming from wood heating stands as a considerable health threat and serves as a prominent contributor to both climate change and regional haze. However, it is noteworthy to mention that when compared to hydrocarbons such as diesel and gas, wood combustion yields significantly lower levels of pollution. The forthcoming sections will delve into the detrimental environmental impacts associated with these hydrocarbons, as explored by Mahmoud et al. (2021).

Diesel

Prior to the series of crises that began in 2019, diesel fuel held the status of being the predominant heating fuel in Lebanon. However, the situation has transformed, and diesel has now been relegated to the position of the second most frequently employed heating fuel within vulnerable communities across the country (LCRP, 2023; VASyR, 2022). This trend is particularly pronounced in higher altitude regions, where winter temperatures are most severe (LCRP, 2023; VASyR, 2022). Fayad (2022) indicates that each residential unit requires more than 100 gallons of diesel during winter. While statistics on the diesel consumption among vulnerable Lebanese communities is scarce, 22% of Syrian refugee households rely on diesel to keep warm during the winter months (VASyR, 2022), especially across Baalback Al-Hermel, Beirut, and Mt. Lebanon governorates.

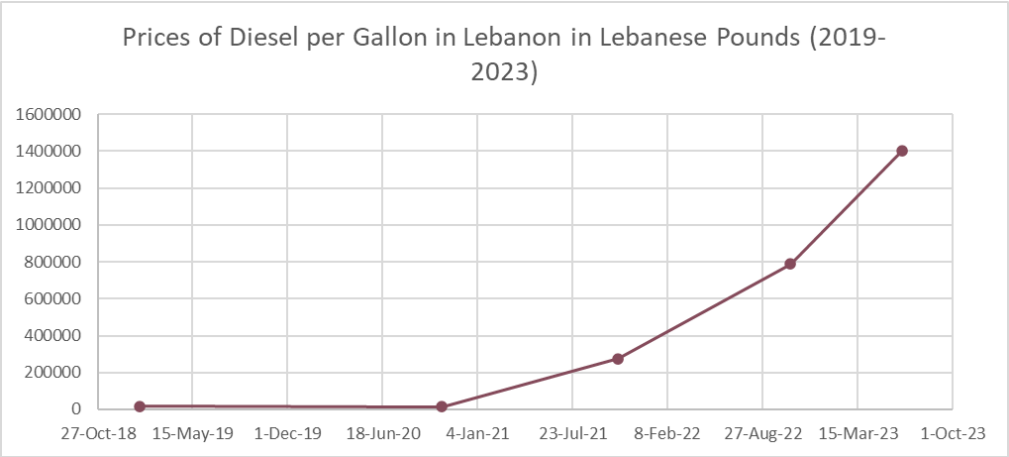
Effectiveness

The combustion effectiveness of diesel is remarkably high, generating an impressive heating value of 45.6 Mj/kg, which is the highest value in comparison to wood and gas (Wood-Energy, 2019). Utilizing diesel fuel for heating applications offers a substantial advancement in energy efficiency, supported by its higher energy density and optimized combustion efficiency in comparison to alternative fuels (Nelson, 2023). This elevated energy density results in greater heat production per unit of fuel, translating to reduced fuel consumption and enhanced heating system performance (Nelson, 2023).

Availability and Cost

Diesel oil is frequently used as the main heating fuel in some nations and regions due to its heat efficiency, however it is a relatively “luxurious” heating solution for vulnerable communities in Lebanon, especially following the multi-faceted crises which has made diesel unaffordable to many (Saghir et al, 2022). Prior to the crisis, diesel was among the most used sources of heat in Lebanon, it was available throughout the year and subsidized by the government (Ministry of Energy and Water). However, the energy crisis in Lebanon, exacerbated by other factors including the 2022 war in Ukraine, led to shortages and record high prices that have decreased the reliance on diesel (Saghir et al, 2022). The government could no longer afford to subsidize energy, which led to extreme shortages. These shortages, in addition to the increase in the price of energy due to the crisis, have made many rethink their heating methods, often looking for constant ones. Currently, diesel is available in the Lebanese market, however, at a much higher price compared to the past (see Figure 2) (The Fuel Price, 2023). As of 3 August 2023, a tank of diesel costs 1,597,000 LBP (Equivalent to USD 18 based on the exchange rate) (Ministry of Energy and Water, 2023). Considering that an average household needs more than 100 gallons of diesel during winter, this would result in a total cost of 70 million LBP (equivalent to approximately USD 2,000). This has made it difficult for vulnerable populations to afford diesel as a reliable heating source.

Figure 1 - Diesel price fluctuation across time (The Fuel Price, 2023).



1 Gallon of Diesel = 20 Liters.

Diesel heaters are readily available in the Lebanese market, although the cost of different diesel heater types is not easily identifiable and comparable in the available literature. There is a variety of diesel stoves available, many that require diesel fuel and electricity to operate, while others rely solely on diesel fuel alone (Chami modern industry, 2023). Like wood stoves, diesel heaters also require proper ventilation to manage the release of harmful gases (Chami modern industry, 2023). Ensuring the dependable functioning of a diesel heating system involves adhering to safety procedures for the storage and handling of diesel fuel (Nelson, 2023). It is advisable to employ containers that are purpose-built for diesel fuel use, as they are crafted to withstand corrosion and avert fuel contamination (Nelson, 2023). Maintaining appropriate temperature conditions is key to upholding the quality of diesel fuel, given that drastic temperature fluctuations have the potential to deteriorate fuel integrity and subsequently impact its effectiveness (Nelson, 2023). It is recommended to store diesel fuel within the designated temperature range of 10°C to 25°C to safeguard its optimal performance (Nelson, 2023). If such measures are not taken into consideration, diesel stoves can be a source of fire hazards. While it is evident that an initial financial investment would need to be made to procure and install a diesel stove, diesel fuel's propensity for comprehensive combustion minimizes waste generation, leading to decreased maintenance expenses (Nelson, 2023).

Environmental impact

When evaluating the environmental repercussions of heating systems that rely on fuel combustion, such as diesel, it becomes apparent that these systems generate a host of pollutants. These include particulate matter, nitrogen oxides (NOx), sulphur dioxide (SO2), and carbon monoxide (CO), all of which contribute to the pervasive issue of air pollution (Mahmoud et al., 2021). Moreover, it is important to consider the potential adverse environmental consequences associated with the use of high-carbon fuels produced through the hydrothermal carbonization (HTC) process. In instances where the gas resulting from HTC is released into the environment, it introduces carbon emissions, thereby contributing to climate change due to the presence of carbon dioxide (CO2) within the gas composition (Yay et al., 2021).

The act of burning conventional heating fuels, particularly those rich in carbon content like diesel, further compounds the problem by releasing air pollutants and greenhouse gases into the atmosphere. This undesirable outcome translates into pronounced adverse health effects on both individual and societal levels. Lebanon has consistently documented cases of chronic illnesses, including cancer and other respiratory diseases, attributed to pollution (Azar et al., 2016). Baayoun et al. (2019) have conducted an examination into the influence of air pollutants on health, shedding light on their detrimental consequences. Notably, the authors acknowledge the dearth of comprehensive emissions and air quality data—a challenge encountered by our research team as well when seeking to comprehend and evaluate the environmental impact of diesel.

In comparison to alternatives such as wood or olive pomace, diesel, and gas, as hydrocarbons, hold a significantly higher level of pollution potential (Mahmoud et al., 2021). This underscores the importance of exploring and promoting cleaner heating options to mitigate the negative environmental implications associated with traditional heating fuels.

Gas

Gas is significantly used as a heating method; however, it was found to be used the least among Syrian Refugees (VASyR, 2022). According to VASyR (2022), gas is used by 8% of Syrian refugee households, predominantly in Akkar, North and South of Lebanon. The research team was unable to identify any literature related to the availability or geographic distribution of gas usage for vulnerable Lebanese.

Effectiveness

When examining heating values, it is evident that gas boasts a heating value of 37.3 Mj/kg (Wood-Energy, 2019). Although this value is lower than that of diesel, it remains significantly higher than the heating value of wood. This distinction underscores gas as a considerable and efficient energy and heat source, reflecting its notable performance in heating methods. Gas heaters efficiently convert the energy present in natural or propane gas into heat, offering rapid and effective heating solutions (Wallender, 2023). Nonetheless, it is important to note that all gas heaters also generate partially combusted gas as a byproduct, which can potentially pose health risks (Wallender, 2023).

Availability and cost

Like diesel, gas has traditionally been a reliable and subsidized resource within the Lebanese markets, extensively employed for both heating and cooking purposes. However, the ongoing crisis, characterized by fuel scarcities and exorbitant price hikes, has taken its toll on the accessibility and utilization of gas. The precarious nature of the Lebanese context, influenced by the interplay of economic turmoil and fluctuating supply dynamics, has led to a notable decline in the accessibility of gas (Saghir et al., 2022). This situation is further compounded by the dual challenge of economic instability and the substantial escalation in gas prices. The outcome is a marked decrease in gas's accessibility when compared to the more favourable circumstances preceding the crisis. Although gas maintains a presence in Lebanese markets, its availability is now characterized by a significant increase in cost, in stark contrast to the cost levels prior to the onset of the crisis (Ministry of Energy, 2023). This trend serves to highlight the intricate interplay between economic factors and the energy landscape, ultimately affecting the accessibility and affordability of crucial resources like gas.

As of 3 August 2023, a gas cannister costs around 842,000 LBP (equivalent to USD 9.5 based on the exchange rate of that day). Despite, the significant difference in price with gas being cheaper than diesel, many vulnerable Lebanese and Syrian refugees are still unable to afford it. The decrease in the percentage of Syrian households replying on gas for heating from 11% in 2021 to 8% in 2022 is indicative of this (VASyR, 2022).

Gas is used to generate heat through heaters that are also widely available in the Lebanese market. These heaters can be found at varying prices, depending on the specifications, with a basic heater costing around 62$ (AghaSarkisian, 2023). These heaters are often mobile and can be moved, with a gas canister attached to the pipe pumping the gas. While it does not require specific ventilation equipment like that needed by wood and diesel, gas burning is known to negatively impact air quality (Matthews, 2023) and as these heaters produce partially combusted gas (Wallender, 2023). This makes it easier to use in tents. Additionally, there are gas tent heaters used specifically to heat tents that are similar to the special diesel heaters described in the previous section (Holley, 2022). However, both tent and normal gas heaters can lead to fires and oxygen depletion due to the emissions.

Environmental impact

Just like diesel, gas is a hydrocarbon which leads to the same environmental detrimental impacts mentioned in the section on diesel above. Gas also generates pollutants including particulate matter, nitrogen oxides (NOx), sulphur dioxide (SO2), and carbon monoxide (CO), which contribute to air pollution (Mahmoud et al., 2021). In addition, the use of high-carbon fuels made by the hydrothermal carbonization (HTC) process can also have a variety of negative environmental effects. If the gas produced during HTC is released into the environment, it contributes to carbon emissions and climate change due to it containing carbon dioxide (CO2) (Yay et al., 2021). Additionally, burning conventional heating fuels like diesel and gas, which comprise a lot of carbon, results in air pollution and greenhouse gas emissions. This leads to significant detrimental health effects on an individual and societal level. Chronic diseases including cancer and asthma are constantly recorded in Lebanon due to the pollution (Azar et al., 2016). Literature focusing on the impact of gas in Lebanon has also been scarce. Due to its hydrocarbon nature, it is more polluting than other sources such as wood and olive pomace.

Olive Pomace

Olive pomace, although not among the most frequently relied upon heating sources, is a heating alternative that is being piloted and used by several NGOs in Lebanon to assist vulnerable communities during the winter season (UNHCR, 2023; WVL, 2023). In particular, olive pomace biomass, or the residual materials generated during the cultivation, production, and processing of olives, can be used to generate heat (Kinab and Khoury, 2015). This includes various waste materials such as olive pits, olive pomace, olive tree branches, among other residual compounds used.

Kinab and Khoury (2015) extensively examine the production dynamics of olive pomace across the expanse of Lebanese territory, highlighting its primary concentration in regions where olive is produced, mainly the North and South governorates. The two aforementioned regions are responsible for 39% and 40% of national olive production. Koura, Zgharta, and Akkar in North Lebanon, as well as in Sour and Marjayon in South Lebanon are considered primary olive

producing areas in Lebanon. While these regions serve as the core production hubs, it is noteworthy that other areas also contribute to this production. The Chouf area in Mount Lebanon hosts a substantial number of olive trees, with 15% of domestic production, while the Bekaa region contributes to 6% of this production.

Effectiveness

Research indicates olive pomace can yield a heating value of 19 Mj/kg, as reported by DDS Calorimeters in 2016. This particular value positions olive pomace as the least efficient among the compared heating sources such as wood, diesel and gas. Despite this, its viability as a heating option remains noteworthy, especially when considering its other attributes such as being a renewable and locally available resource. The heat produced by biomass boilers can be used not only to heat the drying chamber but also for other areas such as offices, amenities, and storage and distribution areas, thus increasing energy efficiency (Encinas et al, 2015)

Availability and Cost

Despite the research team's endeavors to gather information on the geographical distribution of olive pomace production, the literature landscape remains somewhat devoid of discussions concerning the market availability of this resource. Nevertheless, considering Lebanon's status as an olive-producing nation, it follows that olive pomace can indeed be encountered within the Lebanese market, as corroborated by Saba et al. (2020). However, it's imperative to underscore that the accessibility of olive pomace in the market is relatively constrained in comparison to alternative heating methods (Kinab and Khoury, 2015). The selling price of olive solid waste stone, a byproduct of olive processing, was assessed in the study done by Kinab and Khoury (2015). According to Kinab and Khoury (2015), the study stressed the significance of setting a reasonable price based on the stone's energy output. To maintain competition in the energy sector, a price of less than $0.182 was suggested for 1 kg. The proposed centralized facility for the treatment of olive solid waste would be economically profitable if each ton of stone were sold for $100 (Kinab & Khoury, 2015). However, it is worth noting that these figures are from 2015 and were set as suggested prices only. The current market value of olive pomace will be assessed by the research team during the data collection phase.

The use of olive pomace to generate heat requires a biomass boiler. Biomass boilers are a type of heaters which use residual organic material, such as olive pomace and even wood, to produce heat. Biomass boiler uses thermal energy from the combustion of biomass fuel and air to produce for heating (Chantasiriwan, 2020). Biomass boilers for olive pomace are available in Lebanon, however, the research team was unable to locate any literature, academic or grey, that discuss the availability or cost of such boilers. These boilers also require ventilators to be installed in the place of residence. Just like other heating methods, switching to olive pomace for heat requires a significant upfront investment.

Environmental impact

There may be benefits to using alternative heating materials such biomass fuel briquettes or pellets, especially those produced from olive pruning waste is not a hydrocarbon and is thus more environmentally friendly than diesel or gas. Utilized as a renewable energy source, these biomass

briquettes can lessen field burning activities, reducing environmental effects including carbon emissions and resource exploitation (Saba et al., 2020). This implies that olive pomace releases significantly less carbon emissions than other forms of hydrocarbon-based heating. However, they also do contribute to emissions like those emitted by wood as both are biomasses.

The following table presents comparatively, the data that was found in the literature review regarding each type of heating.

Table 2 - Comparison table of Data Gathered from literature review.

Fuel Types	Effectiveness in reducing cold	Environmental impact	Cost	Availability & Accessibility in the Lebanese market
Diesel	45.6 Mj/kg heat effectiveness	**Emissions:** particulate matter (PM), nitrogen oxides (NOx), sulfur dioxide (SO2), and carbon monoxide (CO). **Environmental impact:** air pollution, global warming and GHG.	1 tank= 18$ (As of 3 August 2023)	Readily available Not readily accessible for vulnerable populations due to its cost and ger
Gas	37.3 Mj/kg heat effectiveness	**Emissions:** carbon monoxide (CO), nitrogen oxide (NO), particulate matter (PM) Greenhouse gas emissions. **Environmental impact:** air pollution	1 canister= 9.5$ (as of 3 august 2023)	Readily available Not readily accessible for vulnerable populations due to its cost.
Olive pomace	19 Mj/kg heat effectiveness	**Environmental benefits:** emit less carbon dioxide than diesel oil and can use resources that are readily available locally **Emissions:** VOCs and PM **Environmental impacts:** air pollution	$0.182 for 1 kg (2015, outdated numbers) no data found in literature on the price of olive pomace in Lebanon	Less available than other sources
Wood	19.8 Mj/kg heat effectiveness	**Emissions:** particulate matter (PM), polycyclic aromatic hydrocarbon (PAH), heavy metals.	1 ton= 120$ (2022)	Readily available People resorting to

		Environmental impact: Air pollution, decreased air quality, and environmental degradation.		illegal cutting down of trees

Methodology

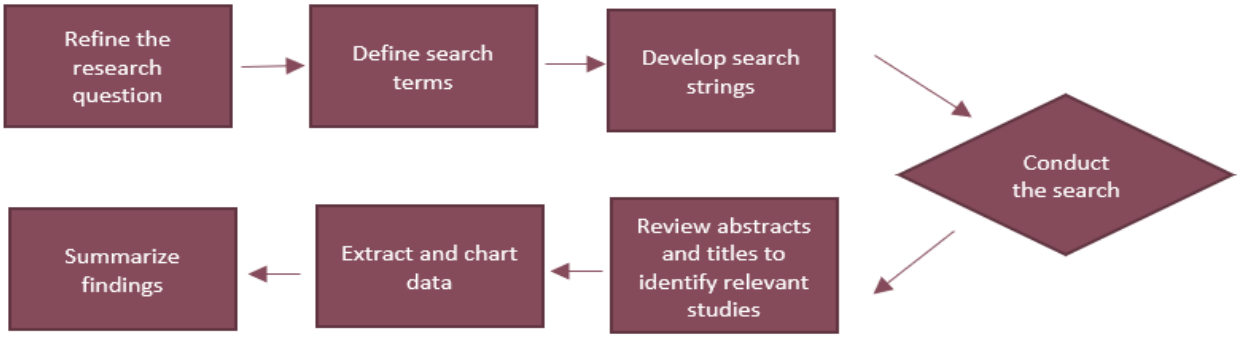
Literature Search Procedure

To accomplish the specified objectives and answer the research question, the research team adopted a comprehensive methodological approach consisting of multiple steps. This involved conducting a systematic literature review, followed by primary data collection using KIIs with olive pomace producers, academics in the environmental sciences field and fuel suppliers to obtain information about the different heating methods. After the collection of primary and secondary data, the research team kicked off the analysis by triangulating the main findings from both the literature review and the KIIs across five main themes. These themes were as follow: the different heating types used by vulnerable populations in Lebanon, the effectiveness of each type, the availability and accessibility of each, the cost and the environmental impact.

The literature review aimed at charting the existing evidence concerning different heating methods used in Lebanon by vulnerable populations, in addition to the cost, availability in the Lebanese market and environmental impact of each. It was carried out following the Arksey et al. framework (2005). The aforementioned framework provides a structured approach to analysis and reporting of literature and scoping reviews through the seven key steps (refer to Figure 1). The research variables were meticulously examined to identify specific terminologies. For instance, to further clarify the search terms “winterization methods” “environmental impact”, additional terms such as “energy consumption”, “emission levels”, and “greenhouse gas emissions” were employed. The identified terms were employed to construct a series of research strings (see Annex 1). These research strings were formulated to capture various aspects related to winterization methods, cost associated with winterization methods, environmental impact of winterization methods, aiming at investigating the relationship between them.

As such, the literature review involved a systematic approach comprising seven key steps (see Figure 1). The steps included identification of the research question, identification of relevant studies, selection of relevant studies, data charting, and collation, summarization and reporting of the results. After the completion of the literature review, the findings were presented to WVL and suggestions for improvement were considered and integrated.

Figure 2 Literature Review Process.



Data Collection

To gather primary data, Key Informant Interviews (KIIs) were carried out with relevant stakeholders in the first week of August 2023, including olive pomace producers, suppliers of fuel, experts in sustainable energy, environmental experts from academia, and staff members from World Vision Lebanon. The purpose of these interviews was to obtain firsthand insight, perspectives, and information related to the heating methods under study. As such, the research team contacted profiles provided by World Vision Lebanon and reached out to experts within their own networks including academic profiles across several universities including the University of Balamand, the Lebanese American University, and the American University of Beirut. The academics were contacted via email, phone calls, and LinkedIn. A total of nine individuals were interviewed, namely two from the academic field, four olive pomace producers, two fuel suppliers, and one livelihoods expert (see Table 3 below).

Table 3 – Primary Data Gathered

Profile	Number of Individuals Contacted	Number of Interviews Completed
Academics	14	2
Olive Pomace Producers	8	4
Fuel Suppliers	3	2
Livelihoods Expert	1	1
Total Count	26	9

Ethical Considerations

The research adhered to strict ethical guidelines to ensure the privacy and confidentiality of the participants. Informed consent was obtained prior to the carrying out of the KII. Confidentiality of the data collected was maintained throughout the research process and the collected data was anonymized and stored on Qualisus database. The KIIs followed a pre-arranged set of questions, approved by World Vision Lebanon (see Annex 2).

Quality Control

To ensure the quality of the research at hand, a quality monitoring procedure was employed. This involved systematic data collection and analysis, and triangulation of findings from different sources and careful documentation of the research process.

Data Analysis

The data analysis process involved thematic analysis of the KII transcripts and findings from the literature review. The research team identified themes and patterns related to the different heating types used by vulnerable populations in Lebanon, their effectiveness in reducing exposure to cold, the cost of each heating method, their environmental impact and availability in the Lebanese market. As such, the research team integrated the secondary and primary data sources which allowed for a more comprehensive analysis of the research question at hand. Furthermore, a research journal was maintained throughout the research process, charting the progress, success, and challenges of the work at hand (see Annex 3)

Limitations

Overall, three main limitations must be noted and taken into consideration when interpreting the findings of this research study.

Firstly, there was a very low response rate from the academic profiles, as most were not available during the month of August when the KIIs took place. The research team reached out to each profile a total of three different times across three different days using a variety of methods (phone, email, and LinkedIn messages). The absence of academic profiles limits the variety and the technical knowledge on the subject that the research team could collect.

Secondly, a significant proportion of the primary data collected came from suppliers and producers of different types of fuel, including olive pomace, whos' primary interest is to sell the product that they are representing. As such, the inherent commercial interests of these suppliers and producers might inadvertently shape the data they provide, potentially accentuating the positive attributes of their offerings while downplaying potential drawbacks. This, in turn, could impact the overall objectivity and neutrality of the research outcomes. To address this potential bias, the research team employed a rigorous data triangulation methodology during the data analysis stage.

Thirdly, there were limitations pertaining to the identification of literature that addresses the effectiveness of the heating sources in reducing exposure to cold in Lebanon as well as the cost and the availability of these heating sources in the Lebanese market. To mitigate this challenge, these insights were collected from the different KIIs carried out with the different profiles. As such, the findings from the literature review were complemented with the findings from the KIIs.

Findings

the findings section offers a triangulation of data sourced from key informants, aimed at comprehensively unpacking the heating methodologies employed in Lebanon and the factors that shape them, while considering their implication on winterization programming. Thus, the findings derived from this research are intertwined with the prevalent market dynamics, especially concerning the financial considerations surrounding wood, diesel, gas, and olive pomace. Considering the ever-changing nature of the economic landscape, , any alterations in the pricing of these resources have the potential to impact the relevance of the outcomes discussed.

The findings of this study are organized under five key themes, each contributing to a comprehensive understanding of the research question. These include the different heating methods utilized by vulnerable populations in Lebanon, the availability and accessibility of these heating methods in the Lebanese market, their effectiveness in reducing exposure to cold, the cost, and the environmental impact of each. It is worth highlighting that these factors were

frequently found to be interlinked, exerting mutual influence upon one another. This interlinkage is discussed.

. In alignment with the TOR provided by World Vision Lebanon and the objectives of the research study, the outcomes of the analysis will be harnessed to facilitate the comparison of the different heating methods in Lebanon on several levels. As such, a comparative table is inserted at the end to highlight the main findings and differences across each heating method.

Heating Methods

Based on the literature review and the interviews conducted with all key informants, the main heating methods used by vulnerable populations in Lebanon are reported to be wood, diesel and gas. Although alternative sources of heating, such as olive pomace, were investigated, this source does not appear to be among the most frequently utilized methods.

The primary heating methods reported by the interviewed key informants for vulnerable populations in Lebanon were confirmed to be wood, diesel and gas, which is in line with the findings of the literature review highlighted earlier (LRCP, 2023; VASyR, 2022). However, the utilization of heating methods varies between vulnerable Lebanese families and Syrian refugees. As highlighted by olive pomace producers and academics, Syrian refugees predominantly lean towards wood as their preferred heating choice, while Lebanese households exhibit a preference for gas and diesel as their primary source of warmth. However, it is worth noting that the dependence on diesel heating methods is diminishing even within Lebanese households, with many opting to transition to more cost-effective heat sources, such as wood. Notably, key sources of information have pointed out that the illicit harvesting of wood is on the rise especially in the regions of Mount Lebanon and the Bekaa valley, as this practice offers vulnerable families a heating solution that comes at no cost. Syrian refugees are also reported to resort to illegal wood cutting, as it is a cost free means to obtain heating for their households. Although many receive cash for winterization and fuel vouchers, it is reported that most of them end up selling these in order to generate quick cash, which is used to meet a variety of basic needs. Concerning the types of wood favored by Syrian refugees, it is pertinent to note their reliance on pine trees, favoring them over oak trees despite their comparatively lower heat effectiveness. In addition to Syrian refugees using wood for heating purposes, a subset of impoverished Syrian refugees' resort to unconventional heating methods like burning tires and nylon to stay warm, underscoring the extreme challenges they face. The VASyR (2022) reported that 5% of Syrian refugees in Lebanon resort to negative coping mechanisms to stay warm during the winter season including burning trash.

Additionally, certain key informants including the livelihood specialist and academics have emphasized that deliberate ignition of wood fires in Lebanon is a common occurrence; local municipalities often encourage people to clear the forest area post-fire, effectively granting them access to freely obtainable wood and biomass resources. The demand for wood and charcoal-burning stoves and chimneys has risen as people seek economical options. Environmental experts are striving to enhance awareness and offer sustainable alternatives to mitigate deforestation. The Chouf Biosphere Reserve has introduced eco briquettes as an ecologically friendlier heating solution.

Moreover, olive pomace producers emphasized the transition of vulnerable populations in Lebanon, from diesel to olive pomace as an alternative heating source starting 2021, where they reported a significant decrease in diesel usage and an increase in olive pomace utilization due to its easier access. While the literature also emphasized the significant shift to cheaper and more available alternatives to diesel and gas, (UNHCR, 2023), it is noteworthy to acknowledge that

olive pomace producers hold a vested interest in accentuating this transition. This prompts a prudent consideration of the potential bias inherent in their narrative. Furthermore, the constraint arising from the absence of data triangulation amplifies the imperative for caution. The scarcity of comprehensive insights into the rates of olive pomace usage within the country presents a challenge in corroborating and substantiating the accuracy of these reported shifts.

The reported observed surge in the adoption of biomass for heating purposes is exemplified by the insights shared by olive pomace producers.. Notably, industrial entities are increasingly turning to biomass-powered boilers to generate heat for their operations. These boilers are fuelled by biomass pellets, which are procurable from various sources due to the prevalence of biomass-compatible heating systems in the market. This trend is strategically marketed as an appealing alternative to diesel fuel, aligning with the need for cost-effective and environmentally conscious energy solutions. Moreover, the pricing dynamics of heating fuels, such as diesel, have further amplified the attraction of biomass. For instance, the academic key informants, the olive pomace producers and the livelihood specialist highlighted that during fluctuations in fuel prices—like the significant spike caused by the Ukraine crisis—using biomass becomes particularly advantageous when fuel prices exceed a certain threshold. As demonstrated by olive pomace producers and the livelihood specialist insight, the strategy of incorporating biomass into heating systems gains prominence as a reliable and economical approach, aligning with both environmental concerns and economic considerations, noting its availability.

Geographic disparities in the selection of heating methods among vulnerable communities in Lebanon were evident, as highlighted by insights gathered from all interviewed individuals. According to olive pomace producers and fuel suppliers, wood and olive pomace are favored in rural and elevated regions (above 700m) due to harsh weather conditions. In addition, olive logs, such as olive briquettes, are specifically used in regions like the North and Bekaa. On the contrary, households living below 700m across Beirut and Mt. Lebanon prefer the use of gas given that the winter season is not so harsh. The preference for gas as a heating method can be attributed to its efficiency and convenience. Gas heating systems provide consistent and controllable heat, hence the indoor temperature in households can be immediately raised to a comfortable level. This is beneficial in regions with less harsh winters because households do not need as much heating capacity. On the other hand, in regions with harsher winter conditions, households require the use of wood and olive pomace due to their ability to produce heat for an extended period of time. In addition, this trend is corroborated by insights shared by academic and technical experts, who underscore the correlation between altitude and heating method preference. In their accounts, a higher altitude corresponds to a heightened reliance on wood, while lower altitudes are associated with a more pronounced preference for gas and other fuel sources. These findings are somewhat supported by the available literature, particularly the VASyR study (2022) which states that wood is predominantly used in Baalback Al Hermel and Bekaa regions, while Syrian refugee families in Beirut and Mt Lebanon rely more on gas.

Availability

The availability of various heating methods is influenced by a multitude of factors, including socio-economic conditions, political dynamics, pricing fluctuations, geographical location, seasonal variations, regulatory permits, and resource distribution. These elements collectively contribute to shaping the accessibility and feasibility of different heating options within the context of Lebanon's unique challenges and opportunities. Within this context, there exists an untapped opportunity for winterization programmes to harness biomass as a readily available yet underexploited energy source for heating purposes. Table 4 summarizes the main findings pertaining to the availability and accessibility of each heating source.

Table 4 - Availability of Heating Methods.

Heating Type	Availability	Accessibility
Wood	Readily available.	Accessible for vulnerable populations, yet often harvested illegally.
Gas	Readily available.	Not readily accessible for vulnerable populations due to its geographical location.
Diesel	Readily available.	Not readily accessible for vulnerable populations due to its geographical location.
Olive pomace	available yet depending on the season.	Accessible for vulnerable populations, depending on the areas of olive production (i.e. South), season, and weather..

According to key informants, diesel and gas are widely available in the Lebanese market and can be bought from gas stations and suppliers of gas and diesel. Nevertheless, their availability is affected by socio-economic and political aspects, as witnessed during the recent economic crisis which led to the removal of the subsidies for fuel causing a rapid spike in the prices impacting diesel and gas availability and accessibility. According to an interviewed gas supplier; gas is available in canisters of three different sizes, and most families use Butane gas for heating. The 10kg and 12kg of Butane gas are mostly used by households for cooking and heating, while the 35kg canister is mostly used by restaurants.

With regards to wood, it is widely available in the Lebanese market, but its availability is dependent on the season and whether individuals or businesses have a permit to cut wood. The permit plays a crucial role in accessing wood, as not everyone has the authorization to cut trees for this purpose. Furthermore, fuel suppliers and olive pomace producers highlighted that wood is more readily available in the mountains compared to areas like Beirut. At the same time, as mentioned in the previous sections, many vulnerable families do not purchase wood, but rather gather it illegally. As per academics and the livelihood expert, a significant finding underscores the viability of diversifying wood sources, notably through pruning by-products sourced from forests situated in publicly accessible areas like roadsides. Through innovative techniques like shredding and compacting, these by-products can be transformed into wood-like materials comparable to olive pomace. This discovery not only expands the range of available heating sources but also emphasizes the ample availability of potential resources for sustainable energy generation.

With regards to olive pomace, a good season with favourable weather conditions can result in ample olive pomace production, while a bad season may lead to reduced availability. In addition, according to olive pomace producers, in areas where trees are holding olives, more olive pomace can be produced compared to areas where olive production is limited. This is relevant to the South and rural areas, where olive pomace is abundant due to the significant olive oil production. However, in regions with fewer olive trees, like Beirut, olive pomace may be scarce. These findings are somewhat supported by Kinab et al (2015), who state that olericulture holds significant importance in Lebanon, accounting for over 23% of the total cultivated land. However, the distribution of these trees is not uniform across the country's provinces. The highest concentration of olive groves is found in the vicinity of Koura, Zgharta, and Akkar in North Lebanon, as well as in Sour and Marjayon in South Lebanon. Additionally, the Chouf area in Mount Lebanon also hosts a substantial number of olive trees. The distribution of olive groves is uneven among the provinces, with 39% in the north, 40% in the south, 15% in Mount Lebanon, and only 6% in the Bekaa Valley. However, according to academics, olive pomace is still not

widely available because the production of olive pomace is sponsored by a third party, which is not a sustainable business model. In order to overcome the seasonal challenges, strong relationships with local farmers are encouraged along with a consistent and year-round supply of olive biomass, sourced from both summer and winter seasons.

Wood and olive pomace emerge as more affordable options for vulnerable populations in Lebanon, in comparison to diesel and gas. The accessibility of gas and diesel is contingent upon a multitude of factors, with the stability of the country and the dynamics of the black market exerting significant influence. The fluctuating nature of gas and diesel prices within the black market can affect the household's ability to access them. Escalations in prices can lead to a situation where suppliers withdraw the provision of diesel and gas, rendering them less attainable for consumers. Furthermore, upon re-entry into the market, the prices may surge to levels that render them unaffordable for households, which was the case in 2019-2022 (LCRP, 2023).

The findings highlight the challenges and considerations related to the availability of different heating methods. For instance, using wood for heating requires purchasing in bulk quantities, often necessitating storage space to keep it dry. Individuals relying on wood heating during the winter season must stock up on wood, demanding storage space and logistics. In contrast, diesel presents a more practical option as it allows for daily purchases based on immediate needs, with the advantage of convenience and ease of storage. Furthermore, when a diesel stove is shut off, it might release an unpleasant smell, yet it can be extinguished immediately. In contrast, turning off a wood stove requires time and results in the emission of fumes. The fire in a wood stove cannot be extinguished automatically and necessitates continuous presence and supervision. Consequently, the effectiveness and practicability of each method significantly influences people's heating choices.

In addition, it is crucial to keep in mind safety practices and precautions when introducing any heating types. Olive Pomace is generally regarded as a safe option compared to gas or wood, as it will not burn unless placed in a designated heating area including a fire-place wood burning stove or a specialized heating appliance designed to burn wood and olive pomace. Gas is highlighted as potentially dangerous, leading to explosions and fires hence why proper ventilation is essential for any heating method to avoid asphyxiation.

Effectiveness

The findings underscore a significant opportunity for winterization programs to enhance the efficacy of existing heating methods, particularly in terms of their processing procedures. This in term contributes to fostering community resilience and sustainable outcomes. Notably, while heating effectiveness plays a pivotal role in shaping the heating choices of vulnerable Lebanese and Syrian populations, the primary driving factor remains cost and pricing. This intricate interplay between effectiveness and cost is exemplified by the preference for diesel heating when prices are at their lowest. This insight highlights the need to strike a balance between maximizing heating efficiency and ensuring affordability within the broader context of winterization initiatives. Table 5 shows the different heating types and their effectiveness in reducing exposure to cold.

Table 5 - Heating Effectiveness Comparison

Heating type	Burn rate (kg/l per 1 hour to heat a room)	Heat Value (Mj/kg) (Wood-Energy, 2019)	Energy Output (Mj/hr)
Olive pomace	3 kg	19	57
Wood	2 kg	19.8	39.6
Diesel	0.1 – 0.5 litres	45.6	23.04

Gas	0.83 kg	37.3	30.99

Table 5 consists of three key points of information:

1. The burn rate, which is measured in kg/l per 1 hour in order to heat an “average” room. This information was gathered from fuel suppliers and olive pomace producers, and as such caution must be taken when interpreting these findings as the key informants were not necessarily the subject matter experts in fuel combustion. Furthermore, the parameters of an “average” room (e.g., size, height, the wall material, and the room isolation methods) were not specified when asking the key informants to provide an estimation. The research team did specify that the “average” room would refer to the type of shelter occupied by a vulnerable family in Lebanon.

2. The heat value, which is measured in mj/kg and represents the amount of heat which is released during combustion of a particular fuel type. This information was gathered from existing literature (Wood-Energy, 2019).

3. The energy output, which is measured in mj/hr and represents the amount of energy that is being released per hour and is calculated by multiplying the burn rate by the heat value. Once more these results must be interpreted with caution as this type of calculation does not account for any influencing factors which may affect energy output. This calculation is also used to estimate the amount of energy output needed (mj/h) to heat an “average” room for an hour.

When validating these findings with the livelihoods specialist and the World Vision Lebanon team, it was suggested that the burn rate for olive pomace is most likely overestimates and could be closer to 2kg per hour. Whereas the burn rate for diesel was under-estimated by the key informants and would be closer to 0.8 litres per hour needed. These suggested changes have been taken into account and reflected in Table 6. After making these adjustments, the research team was able to estimate that the average energy required to heat a “typical” room for one hour is around 36.26 MJ. Nevertheless, it's worth noting that verifying this information has proven challenging because existing literature doesn't provide a single, definitive average figure. This complexity arises from the fact that calculating average room heating requirements involves considering numerous factors[1]. As such, the estimated figure of 36.26 MJ/h should be interpreted and used with caution, since it does not take into account the vast multitude of influencing factors.

Table 6 Heating effectiveness comparison – adjusted.

Heating type	Burn rate (kg/l per 1 hour to heat a room)	Heat Value (Mj/kg) (Wood-Energy, 2019)	Energy Output (Mj/hr)
Olive pomace	2 kg	19	38
Wood	2 kg	19.8	39.6
Diesel	0.8 litres	45.6	36.48
Gas	0.83 kg	37.3	30.99

[1] Including the dimensions of the room (length, breadth, height, total window area, number of outside walls, location and level of the room, type of walls, roof structure and type, window type and floor construction type, average outside temperature, and average inside temperature during the winter seasons (Dimplex, 2023).

When looking at each heating fuel type and its effectiveness, the findings clearly demonstrate that diesel is by far the most heat efficient fuel type both in terms of the burn rate and the heat value, closely followed by gas, then wood, and finally olive pomace.

The gathered information has affirmed the varying heat effectiveness exhibited by different wood types. Inputs from the fuel suppliers and olive pomace producers further stipulate that higher heat effectiveness can be achieved from wood, especially when oakwood is being used as it provides a longer-lasting heat in comparison to pinewood, birchwood and aspen wood. Whereas olive pomace producers emphasized the added effectiveness from using granulated olive pomace form, which is reported to have a higher effectiveness.

The processing of wood and olive pomace has a direct impact on the effectiveness of various heating sources. For instance, the challenges posed by using materials like wet compressed olive pomace or easily breakable wood logs can reduce the efficiency of combustion and heat production. Such practical constraints can make these options less appealing, leading individuals to opt for more convenient and efficient alternatives like diesel. The availability and ease of use of certain heating methods are intricately tied to their effectiveness in providing consistent and reliable warmth.

The discussion with some key informants revealed that olive pomace holds promise as an effective heating source. The potential lies in its malleability for processing into wood-like logs or slabs, optimizing its combustion effectiveness. Additionally, an alternative dry pressing method was discussed, involving higher pressure to enhance the density and durability of the fuel. These insights highlight the practicality of olive pomace as a sustainable heating solution, with the prospect of further enhancing its heating efficacy through innovative processing approaches.

It is important to highlight that, while heating effectiveness is a consideration, the primary decisive factor for selecting a heating method among vulnerable Lebanese and Syrian communities remains the cost and pricing. The information gathered reveals that the demand for various heating methods is largely driven by their affordability. People are inclined to switch between heating methods in pursuit of the most economical alternative, considering heater availability. An illustrative example is the reported prevalent reliance on electricity among the majority of vulnerable populations in Lebanon and Syria, particularly during periods when electricity was accessible in Lebanon at relatively affordable rates.

Ultimately, drawing from the perspectives shared by key informants, it is evident that diesel remains the favored heating option for vulnerable individuals in Lebanon and Syria, owing to its notable effectiveness, particularly during periods of affordability. The input provided underlines the observation that while diesel consumption might decrease during phases of elevated prices, the inclination remains strong among these communities to swiftly revert to diesel utilization once costs decline. This dynamic underscores the pivotal role of diesel in meeting their heating needs, with price fluctuations significantly influencing their choice of heating method.

The preference of vulnerable communities for diesel, stemming from its efficacy, and the significant role of pricing in their decision-making process are underscored through illustrative examples shared by key informants. Notably, in border regions, a pertinent example emerges wherein vulnerable Lebanese communities previously turned to smuggled Syrian diesel. This choice was primarily driven by the comparatively lower prices of Syrian diesel in comparison to that sold on the Lebanese market, which benefited from subsidies by the Syrian government, particularly preceding the year 2010. This narrative exemplifies how the interplay between effectiveness and cost considerations influences the heating preferences of these communities.

Cost

The different heating methods accessible in Lebanon demonstrate varying cost implications. Notably, these costs emerged as pivotal determinants shaping the heating preferences of vulnerable Lebanese and Syrians. This factor was found to be subject to fluctuation depending on a number of market related factors. Consequently, enhancing the financial capacities of these vulnerable populations becomes a strategic avenue for winterization programmes to strengthen vulnerable communities' access to suitable heating solutions. It is crucial to recognize that the pursuit of cost-effectiveness occasionally intersects with environmental considerations. The quest for the most economical heating methods has, at times, led to unintended environmental repercussions. Table 7 highlights the differences in terms of cost across each heating method.

Table 7 - Cost per Heating Method reported for the period of July – August 2023

Heating type	Cost per 1 ton or per barrel in USD (Based on KIIs)	Cost based on literature
Olive pomace	Range from 200-300 USD per ton (0.2 – 0.3 USD per kg)	Not available
Wood	Range from 120-250 USD per ton which (0.12 - 0.25 USD per kg)	120 (Rose, 2022) 0.12 USD per kg
Diesel	160 USD per barrel (0.8 USD per liter[2])	143 per barrel which is equivalent to 0.7 USD per liter. (Ministry of Energy and Water, 2023)
Gas	9.5 USD for 10 kg (0.95 USD per Kg)	9.5$ for 10kg (Ministry of Energy and Water, 2023) 0.95 USD per KG

Drawing from the gathered findings, wood emerges as the most cost-effective heating option at a cost of only 0.25 USD per kg, followed by olive pomace, diesel and eventually gas. The literature echoes these findings, as exemplified by Rose (2022), who asserts that 1 ton of wood can be obtained for $120. It is pertinent to highlight that the Ministry of Energy and Water (2023) has established a slightly different pricing for diesel, pegging it at $143 per barrel, marking a $17 variance from fuel suppliers' pricing. As for gas, the Ministry of Energy and Water (2023) designates a cost of $9.5 per tank, which is also the set pricing use by gas suppliers. While the literature doesn't explicitly delve into the cost of olive pomace, it is essential to acknowledge the potential for price fluctuations contingent on individual suppliers.

Nonetheless, it is crucial to go beyond the mere cost comparison of each heating method and consider their effectiveness. Solely assessing cost doesn't account for the quantity of each heating source necessary to effectively warm a living space for a one-hour duration. To achieve this objective, the research team has conducted a comparison between the Energy Output (MJ/h) required to heat an "average" room for one hour and the corresponding cost in USD needed to attain the desired energy output (see Table 8).

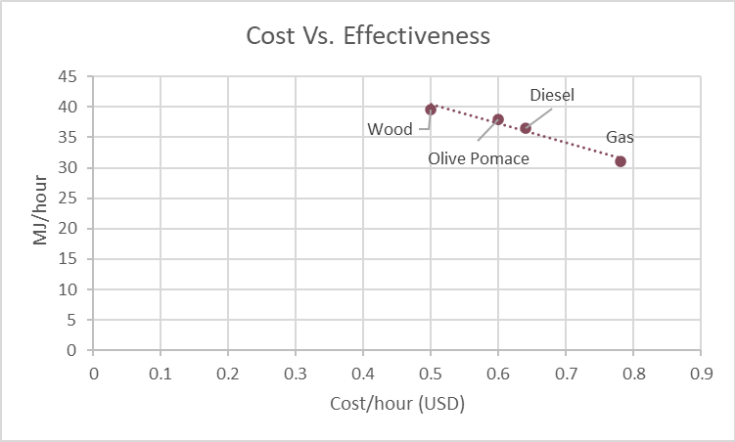
[2] 1 barrel = 200 liters of diesel

Table 8 - Cost and Energy Output Comparison

Heating type	Burn rate (kg/l per 1 hour to heat a room)	Energy Output (MJ/h)	Cost in USD per kg/l	Cost in USD to achieve needed MJ/h
Olive pomace	2 kg	38	0.3	0.6
Wood	2 kg	39.6	0.25	0.5
Diesel	0.8 litres	36.48	0.8	0.64
Gas	0.83 kg	30.99	0.95	0.78

A more comprehensive evaluation, factoring in both cost and energy output (see Figure 3), reveals that wood requires the least amount of financial input, whilst requiring the highest energy output in MJ/h to heat an “average” room. Olive pomace and diesel require a relatively similar financial investment, while diesel requires significantly less energy output in (MJ/h) in comparison with olive pomace. This can partly be explained by the higher heat value in MJ/l of diesel in comparison with olive pomace as demonstrated in Table 6 earlier. As for gas, it emerges as the costliest option while requiring the least energy output.

Figure 3 Cost Vs Effectiveness



Moreover, as previously emphasized, practicality and accessibility of each heating type play a crucial role determining which method will be chosen. For example, diesel boasts convenience in terms of accessibility, without the need for bulk purchasing or extensive storage. Diesel stoves can be filled with fuel and left to operate for a defined period, without constant monitoring or refilling. Conversely, achieving one hour of heating through wood demands 2 kg, translating to a staggering 48 kg of wood for a full 24-hour period. This requirement necessitates purchasing in large quantities, ensuring safe and dry storage, and the manual input of wood into the stove each hour—an impractical endeavour.

Considering both the practicality and energy efficiency of diesel fuel, it's logical to assume that if the cost of diesel were to decrease, keeping all other factors constant, diesel would once again become a more favourable choice. The research team has conducted a cost-effectiveness comparison for a scenario in which diesel prices return to their pre-crisis levels of approximately 0.64 USD per litre, as seen in 2019 (The Fuel Price, 2023). In such a scenario, the cost required to heat an "average room" using diesel fuel would significantly decrease (refer to Table 9), making it nearly as cost-effective as using wood. Therefore, it remains crucial to continually monitor diesel fuel prices in the market, as these fluctuations directly influence the heating method choices made by vulnerable communities in Lebanon.

Table 9 - Cost and Energy Output calculation if Diesel price changes

Heating type	Burn rate (kg/l per 1 hour to heat a room)	Energy Output (MJ/h)	Cost in USD per kg/l	Cost in USD to achieve needed MJ/h
Olive pomace	2 kg	38	0.3	0.6
Wood	2 kg	39.6	0.25	0.5
Diesel	0.8 litres	36.48	0.64	0.51
Gas	0.83 kg	30.99	0.95	0.78

Eco-friendliness

The diverse range of heating methods is accompanied by varying degrees of environmental impact. Diesel and gas are associated with higher environmental consequences, whereas olive pomace and wood are linked to comparatively lower ecological impacts. These findings underscore the importance for winterization programs to adopt a comprehensive approach in their pursuit of environmentally friendly heating solutions for vulnerable communities. A crucial aspect involves fostering a sense of ownership among these communities towards the resources available within their environment. Table 10 summarizes the main findings pertaining to CO2 emissions by heating source and resource depletion by heating source.

Table 10 Environmental Impact

Heating type	Carbon emissions	Resource depletion
Olive pomace	Relatively neutral due to it not being a hydrocarbon and is derived from renewable energy. Very low CO2 emissions	Soil degradation
Wood	Low CO2 emissions	Deforestation and soil degradation
Diesel	High CO2 emissions	Water pollution
Gas	High CO2 emissions	Water pollution

Based on the inputs from the key informants, the two most pollutant fuel types are gas and diesel, followed by olive pomace and wood. Diesel and gas have the highest emissions of CO2 since they are fossil fuels. The combustion of diesel and gas release CO2 into the atmosphere, hence polluting the environment. Olive pomace producers and fuel suppliers reported gas and diesel as being the most pollutant heating sources, producing black smoke when burned. The literature supports such claims in which the environmental impact of hydrocarbons (including gas and diesel) generates pollutants including particulate matter, nitrogen oxides (NOx), sulfur dioxide (SO2), and carbon monoxide (CO), which contribute to air pollution (Mahmoud et al., 2021). Furthermore, the extraction of diesel and gas leads to water contamination and habitat disruption.

Olive pomace and wood are both biomass fuels derived from renewable sources since they come from trees and agricultural waste, respectively. As such, the use of olive pomace and wood as a heating source are considered relatively carbon-neutral in the long-term, when compared to other types of fuel. However, if not harvested properly, excessive logging and agricultural practices can lead to soil degradation and deforestation. According to olive pomace producers, when properly processed and dried, olive pomace becomes an eco-friendly and effective heating source, free from smoke and unpleasant smells. Its production is considered to have minimal negative impact on the environment, emitting only small levels of CO2 during combustion. However, academics in the environmental health fields disagree with the statements of olive pomace producers. According to them, every flammable substance generates CO2 emissions which leads to air pollution and environmental degradation. The latter statement is also supported by the literature in which Musalam et al (2017) argues that the amount of combustion residuals (PM, ash and unburned carbon) for olive pomace increases as the percentage of pomace in the fuel increases. However, it decreases with higher temperatures and longer combustion times. This suggests that olive pomace is polluting but at a much-reduced rate compared to the other sources of heating.

As such, it is necessary to conduct further research, especially in terms of measurements of emissions including PM, CO2, and VOC to be able to compare the different levels of emissions.

Overall, burning wood, gas, diesel, and olive pomace emits pollutants in the environment including particulate matter, nitrogen oxides (NOx), sulfur dioxide (SO2), and volatile organic compounds (VOCs). These emissions contribute to decreased air quality, hence air pollution. This is supported by Munawer et al (2018) who agrees that the combustion of such heating sources lead to the emissions of toxic substances into the air hence air pollution. Academics in the environmental sciences field and olive pomace producers highlighted the need to emphasize the health effects of these toxicants. Air pollution is associated with negative health effects on populations and can range from asthma to chronic respiratory conditions.

Moreover, as previously emphasized and elaborated upon in various sections of this report, the twin issues of deforestation and intentional ignition of fires for the sake of exploiting wood as a cost-free fuel source bear profound consequences for Lebanon's ecosystem and biodiversity. It is imperative to channel efforts towards dissuading such practices and offering viable alternatives to the affected communities. To counteract the environmental repercussions stemming from deliberate forest fires aimed at wood collection, a range of measures can be implemented. Strengthening regulations pertaining to forest management, fostering community awareness campaigns, and advocating for alternative heating solutions are of paramount importance. The deployment of reforestation initiatives, enhancement of early detection systems, and active engagement of local communities can play a pivotal role in rehabilitating affected areas and averting future incidents. Collaboration with relevant authorities and the introduction of incentive programs can serve as powerful tools to discourage detrimental practices. This approach ensures a well-balanced strategy that places equal emphasis on safeguarding the environment and promoting sustainable resource utilization.

The research findings illuminated a prevalent lack of ownership among individuals, especially in the context of publicly held assets like natural reserves. This perception stems from the belief that these resources are susceptible to eventual depletion by external parties. Consequently, individuals often justify unsustainable resource use, driven by the rationale that it is better to extract benefits from these resources before others do. The importance of cultivating ownership becomes particularly evident based on insights from key informants. The adoption of World Vision's Farmer Managed Natural Regeneration (FMNR) approach presents a highly relevant solution to address the issue of deliberate forest fires for wood collection. This method offers a sustainable and pragmatic alternative that not only discourages destructive practices but also fosters a sense of community ownership over valuable natural resources. This underscores the significance of establishing a meaningful connection between communities and these resources through strategies such as FMNR. These approaches empower communities to responsibly steward these resources, while also challenging the notion of inevitable resource depletion. By doing so, they promote the adoption of sustainable practices that prioritize long-term benefits over short-term gains.

Discussion

Table 11 Overall Comparison Table for the KIIs

Fuel Types	Effectiveness in reducing cold	Environmental impact	Cost	Availability & Accessibility in the Lebanese market
Diesel	0.8 litres needed to provide one hour of heating	High carbon emissions	Between 0.7 – 0.8 USD per letre.	Readily available Not readily accessible for vulnerable populations due to its cost. Very practical heating source does not require purchase in bulk or mass storage.
Gas	0.83 kg needed to provide 1 hour of heating	High carbon emissions	0.95 USD per kg	Readily available Not readily accessible for vulnerable populations due to its cost. May pose a safety hazard. Relatively practical heating source.
Olive pomace	2 kg needed to provide 1 hour of heating	Relatively neutral carbon emissions Soil degradation	Between 0.2 and 0.3 USD per kg	Readily available depending on the season and geographic location. Not very practical. Requires purchase and storage in bulk and specific storage conditions.
Wood	2 kg needed to provide 1 hour of heating	Low carbon emissions Soil degradation and deforestation	Between 0.12 and 0.25 USD per kg	Readily available depending on the season and geographic location. Not very practical. Requires purchase and storage in bulk and specific storage conditions.

Providing a comprehensive perspective, Table 11 encapsulates the primary heating options in Lebanon. Among the four examined fuel types, diesel fuel emerges as an exceptional choice due to its ease of access, practicality, and efficient heat generation. Nevertheless, it is essential to recognize that while diesel excels in efficiency, concerns regarding its environmental sustainability persist. Moreover, its market presence remains susceptible to volatility due to socio-political influences spanning both regional and global domains.

Integral to the decision-making process is the pivotal role of cost in selecting heating methods for the vulnerable communities of Lebanon and Syria. While the effectiveness of a method remains relevant, economic feasibility frequently takes precedence. In the period preceding the 2019 fluctuations in diesel prices, diesel was the primary heating source for both Lebanese households and Syrian refugee families. However, the sharp escalation in costs prompted these vulnerable households to seek alternative solutions. Insights from key informants indicate a strong likelihood

that a reduction in diesel prices would lead people to revert to its use. This inclination is rooted in diesel's unmatched effectiveness, practicality, and wide availability as a heating source.

In light of the unaffordability of diesel for a significant portion of vulnerable households in Lebanon, it becomes essential to present them with alternative options that are not only cost-effective but also practical and accessible. As highlighted throughout the findings, the predominant recourse for both Lebanese and refugee communities have been to resort to wood utilization, often through illicit wood cutting and the initiation of fires. However, these practices have severely detrimental consequences on Lebanon's environment and ecosystem, demanding swift intervention and mitigation.

Within the framework of winterization programs, tapping into available biomass resources, including olive pomace, presents an avenue for action. Nonetheless, effecting behavioural change will be intricate and challenging. Addressing this necessitates multifaceted strategies encompassing efficient collection and processing of biomass in collaboration with communities and authorities. Drawing from World Vision's Farmer Managed Natural Regeneration (FMNR) approach, fostering a sense of communal ownership over natural resources becomes paramount. This investment aims to cultivate a collective commitment to resource preservation.

Simultaneously, a concerted effort is crucial to curb deforestation and fire-starting, involving collaboration with local municipalities and law enforcement agencies. Raising awareness within vulnerable communities about the varying efficiency of heating methods can play a pivotal role. Introducing programs that encourage the collection and processing of available biomass within their localities for winter heating can be instrumental. However, this necessitates substantial investment at the community level and within natural resource management. The goal is to ensure the preservation of natural reserves, guarding against further deforestation and soil erosion through carefully crafted initiatives.

Concurrently, there is a compelling need to invest in the establishment of small, locally driven businesses that offer biomass processing services. Such an investment is pivotal in ensuring the widespread availability of processed biomass and a consistent supply across the nation. These localized enterprises must be intricately connected to the market, fostering accessibility for the vulnerable communities they serve. Creating this link is essential to facilitate seamless access to processed biomass resources.

Moreover, as a parallel effort, substantial investment should be directed towards the development of energy-efficient technologies, specifically the creation of rocket stoves optimized for biomass utilization. These innovations would be tailored for household-level use within vulnerable communities. The design and implementation of such stoves will play a crucial role in enabling the straightforward application of the harnessed and processed biomass at the individual household level.

Conclusion

The insights gathered from this research shed light on the intricate web of factors that influence the availability, accessibility , and effectiveness of heating methods among vulnerable Lebanese and Syrian communities. The findings highlight the pivotal role of cost and pricing as the primary drivers for the selection of heating methods, with effectiveness and environmental considerations often taking a back seat. This dynamic underscores the necessity of developing winterization programmes that go beyond merely providing heating solutions; they must be centred on building the resilience of these communities amidst the multifaceted challenges facing Lebanon. Additionally, the findings underscore the significance of piloting alternative heating solutions that

move away from diesel-based methods. Concurrently, it's imperative to closely monitor diesel fuel price fluctuations, as a reduction in diesel costs is likely to lead to a resurgence in its use for heating purposes.

Recommendations

Invest in "Affordability-Centred Approach". Acknowledge that the primary driver for heating method selection among vulnerable communities is cost and pricing. Implement subsidies or financial support mechanisms during periods of economic stress to make heating sources more accessible. Offer a diverse range of heating solutions that accommodate dynamic preferences, ensuring that affordability remains a central consideration. As an integral component of the process, it is imperative to establish consistent market monitoring systems that meticulously track the prices and availability of various heating methods, accompanied by a comprehensive assessment of key factors that influence these dynamics. Special attention should be paid to monitoring the fluctuation of the cost of diesel fuel, as a reduction in diesel costs is likely to lead to a resurgence in its use for heating purposes. It's crucial to take these factors into account when making decisions regarding investments in the development of alternative heating methods. This consideration ensures that investments are cost-effective and result in practical solutions that will genuinely benefit the target populations.

Allocate resources to winterization initiatives that offer alternative options to dependence on diesel fuel and wood. Given the financial constraints faced by a considerable segment of vulnerable households in Lebanon, coupled with the recourse to illegal wood cutting and fire starting as substitutes, there is a critical need to support initiatives that present viable alternatives to diesel and wood. Funding projects that have formulated comprehensive winterization strategies, leveraging the abundant biomass resources accessible in Lebanon, including olive pomace, is paramount, acknowledging their accessibility and comparatively reduced environmental implications. Components of such strategy should include:

- Inclusive Community Engagement**:** Engage vulnerable communities in the design and implementation of winterization programmes. Seek their input, preferences, and feedback to tailor initiatives to their specific needs and preferences, fostering a sense of ownership and empowerment.
- Community Capacity Building**:** Empower local communities with practical knowledge and skills to process and utilize biomass resources effectively. Conduct training sessions on responsible resource harvesting, proper combustion practices, storage techniques, and equipment operation. This approach enhances community self-sufficiency and resilience in meeting their heating needs.
- Enhance Processing Techniques**:** Collaborate with local lead businesses and communities to introduce innovative processing techniques for biomass, including olive pomace, improving their combustion efficiency. Facilitate access to equipment like shredders and compactors to optimize resource utilization, reduce waste, and ensure consistent heat generation.
- Market Linkages: Facilitate the connection of biomass processing businesses with the market, ensuring accessibility for vulnerable communities and enhancing the reach of sustainable heating resources.
- Energy-Efficient Technologies**:** Introduce energy-efficient and clean-burning technologies, such as rocket stoves, that can maximize the benefits of biomass resources. Promote

these technologies as part of winterization initiatives to improve heating efficiency, reduce environmental impact, and enhance community well-being.

- Data Collection and Monitoring**:** Establish a robust data collection and monitoring system to track the distribution and impact of winterization assistance over time. Regularly assess the effectiveness of different heating methods, community feedback, and changing needs to inform programme adaptations and improvements.
- Collaboration with Local Authorities**:** Collaborate closely with local authorities to ensure the legality of biomass harvesting. Facilitate the issuance of permits for sustainable resource utilization, promoting responsible practices that minimize negative environmental and social consequences.
- Environmental Awareness Campaigns**:** Launch awareness campaigns to educate communities about the environmental consequences of different heating methods, emphasizing the advantages of utilizing biomass resources. Promote responsible heating practices that contribute to environmental sustainability.

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Annexes

Annex 1 – Research Strings

Annex 2 – Data Collection Tools

Annex 3 – Learning Journal

Annex 4 – Literature Review Detailed Findings