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FACULTEIT BEDRIJFSECONOMISCHE WETENSCHAPPEN

master in de toegepaste economische wetenschappen: handelsingenieur: technologie-, innovatie- en milieumanagement

Masterproef

Solar cooking in Senegal: an application of best-worst scaling

Promotor :
Prof.dr.ir Steven VAN PASSEL

Copromotor :
Prof. dr. Gilbert SWINNEN

Janka Vanschoenwinkel

Masterproef voorgedragen tot het bekomen van de graad van master in de toegepaste economische wetenschappen: handelsingenieur , afstudeerrichting technologie-, innovatie- en milieumanagement

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To all volunteers in developing countries, as I now understand how much patience, perseverance and dedication their work demands.

Acknowledgments

Finally, here it is: my thesis! It took me a long time before I finally knew what to write about. I wanted a topic that was unusual, challenging, and of added value for developing countries. I wanted a topic that was related to the environment and to innovation. And, I wanted a topic that would allow me to combine all the knowledge I gained during my business engineering studies. However, it turned out much better than my expectations. Thanks to an article my mum read in the newspaper, I came into contact with solar cooking. Before I realized it, I left on a field trip to Senegal and I had never expected to learn this much in only a short period of time. During the preparations, the fieldtrip and the processing of the data, I got the help of numerous people, some of them I even don't know as it was through e-mails and online forums. I don't have enough place to mention all of those people by name, but I want to thank all of you!

In the first place my gratitude goes to all Senegalese respondents who welcomed me in their houses, who answered all my questions and who prayed for a good ending of my research. There were also numerous Senegalese people who made my stay and research as pleasant and organized as possible. In this respect Fatou, Cheikh and Sally were vital. They devoted a lot of time to me and listened to what I was looking for when selecting a representative respondent sample. I especially want to thank Fatou for hosting me three weeks in her house, for allowing me to become godmother of Abib, her son who was born when I was there, and for inviting me to celebrate together with her and her family the end of the Ramadan and the baptism. I also want to thank Ibrahima and Aby for all the cultural exchanges, and for the many times I was welcome to drink tea. Finally, I want to devote a special word of thank to Mamadou Ndiaye. You were supposed to be my translator, but became much more than that: you were a guide, a true friend and a real support during my entire stay and I simply can't imagine what I would have done without you.

Yet, while the fieldtrip was undoubtedly the most exciting and challeging part of my thesis, I also want to thank the people that helped me preparing it and bringing it to a good end when analyzing the data. In this respect I sincerely want to thank Kristina Naeyaert and Herman Nachtergaele, two committed organizers of the Sol Suffit project who were very open to me and who allowed me to make use of their resources in Senegal. I wish them a lot of success with the continuation of their project. Within the university I want to thank everybody who educated me during the last five years. In particularly, I want to thank two persons who were there at the end of my studies. To Sebastien Lizin: thank you for the great advice you gave me and thank you for your patience when I came once again with a very long text with everything I wanted to say. To my promoter, prof.dr.ir. Steven Van Passel: thank you very much for your help, but especially for all the support and opportunities you gave and are giving me. I owe you a lot! In addition, I also want to thank my co-promoter, prof.dr. Gilbert Swinnen, for his contributions to the analyses of the results.

Last but not least, I want to thank VLIR-UOS and my parents for their financial support. I want to thank my friends for being there when I was panicking, and I want to thank Marlène and Elodie for correcting all my French translations. Finally, a last word to my parents: thank you for being there for me whenever I need you and thank you for the education you gave me.

Janka Vanschoenwinkel, May 2013

Abstract

Worldwide, and mostly in developing countries, over three billion people depend on solid fuels such as wood, agricultural waste, animal dung and charcoal, to cook their daily meals. The unsustainable use of these fuels leads to local deforestation, erosion, soil degradation and health problems. This has serious consequences for local populations. Women and kids for instance are forced to spend more time collecting these fuels which comes at the expense of economic, educational and social activities. Moreover, if nothing is done, by 2030, more than 4000 people a day will die because of indoor air pollution caused by these solid fuels.

A possible solution for these problems is that these people stop using their traditional cookstoves and switch to nontraditional cookstoves such as LPG, electric, or advanced biomass cookstoves or solar cookers. Unfortunately, numerous projects disseminating these nontraditional cookstoves failed or were unsuccessful because users didn't accept the new technologies.

Therefore, during the last three decades, researchers attempted to understand variables that influence household energy use and cookstove decisions. Yet, they overemphasized for a long time the importance of economic factors, making them overlook numerous social, technical, religious, cultural and other contextual variables and the causal relationships between them. Consequently, in order to fill in the multiple knowledge gaps in the household energy transition process, a conceptual framework is necessary.

For this reason, this work presents a conceptual framework where multiple variables can be studied simultaneously. In addition, the framework highlights the importance of two largely underexamined variables: product-specific preferences and organizational variables. Given the importance of product-specific preferences, they are centralized in the first level of the framework: households namely examine characteristics of fuels and cookstoves before they make their choice. Knowing what households prefer will help for instance in adapting the cookstove design better to households' needs. However, households do not only make decisions on an attribute-by-attribute comparison. Their preferences are also influenced by their perceptions, attitudes, culture, context and social environment. Therefore, to capture these influences and to better explain the existence of certain preferences, the framework also contains a second level. On top of that, the framework has a third level, emphasizing the influence of variables within the control of the cookstove disseminating organization itself, on households' decisions.

After having presented the framework, the framework is applied to a real-life solar cooking case study in rural Senegal. There the SolarCooker Eco3 has recently been introduced as an alternative for the previous CooKit solar cooker. Yet, even though the SolarCooker Eco3 is a huge improvement, locals still seem to have difficulties with the adaptations they have to make. This study therefore examines how people tradeoff benefits of the solar cooker (time savings, cost savings and health benefits) with features of their traditional cookstoves that the solar cooker doesn't necessarily has (the possibility to cook inside, a high capacity and the possibility to prepare their traditional dish). In addition, a price-attribute is included. In total, a sample of 126 respondents from eight different villages was interviewed. The tradeoff behavior or the preferences of the respondents (the first level of the framework) are elicited by means of best-worst scaling. In

addition, about twenty additional people such as local school teachers, leaders of villages… were interviewed to elicit additional information.

Firstly, by segmenting these respondents based on their preferences, this work proofed distinct market segments with significantly different preferences are present in the sample. On top of that, these segments seemed to be characterized by clear socio-demographic characteristics. 8 out of 11 of the socio-demographic variables elicited namely appeared to be significant in explaining differences in preferences between the different market segments. In this way, the sample could be divided in three segments. One segment clearly gave more value to money savings. This could be explained by the fact that respondents cooked for numerous persons and had a lot of fuel costs, indicating that they came from a fuel scarce context. Another segment valued time savings of the solar cooker and traditional characteristics such as the possibility to prepare the traditional dish, significantly higher than the other segments. This is explained by the fact that users here came from more traditional and remote villages that still heavily relied on wood collection for their cooking energy needs. Finally, a third segment existed of people from Moor and more "high standard" villages that wanted discretion, privacy, status and comfort.

These results suggest the fact that solar cooking organizations should differentiate more between end-users that have different needs and preferences. This can be done by customizing marketing and promotion strategies to the different market segments or by adapting the solar cooker design to the different end-users. Concerning this solar cooking design, this study namely shows that the solar cooker is not well enough adapted to the targeted end-user. Capacity seems to be a huge bottleneck for households that cook for more than 10 persons and some users seem to have difficulties adapting themselves to the fact that they can't cook inside. In addition, from open interviews, it appeared that the solar cooker was difficult to use. However, these inconveniences did not necessarily imply that when the solar cooker is not perfect, it won't be used or accepted.

Whether users will use the solar cooker or not if it is not perfect, depends on numerous factors. Probably the most important factor in this project is the fact whether users are well-informed about the solar cooker. The respondents in this sample were clearly not aware of health benefits of the solar cooker – even though they valued these items the highest from all items – and they didn't know sufficiently how to use the solar cooker. In addition, we noticed it is possible that benefits of the solar cooker of which users were aware before they used the solar cooker, become less clear to the user once they are using the solar cooker. Furthermore, the amount of information that respondents had had apparently also influenced their willingness to adapt themselves to the solar cooker as respondents from more traditional villages, who hadn't yet heard about solar cooking, valued traditional cookstove characteristics higher than people who had already heard about solar cooking. Finally, the type of information that has been given to users before they received or bought the solar cooker also had an impact on users behavior. When users had an unrealistic image of the solar cooker, they had the tendency to become disappointed and not to use the solar cooker once they found out that the image they had was wrong. Other reasons that influenced whether people would use the solar cooker or not, could be found in cultural, religious, contextual and social influences that have to be taken into account in the project. In this respect it turned out that involving the correct local people in the village, and understanding the structure or hierarchy of the village, was very important, and had an important influence on the project and on the (potential) end-users.

As a conclusion, it can be said that the developed framework was very well capable of explaining preferences and reasons to use or not to use the solar cooker. Yet, probably the most striking insight came from the fact that the influence of organizations on the success of a solar cooking project was very large. Depending on numerous actions of cookstove organizations, end-users can change their attitude, perceptions and motivation, that influence their preferences for certain cookstove characteristics and cookstoves. In this respect, solar cooking still has a lot of possibilities to grow if solar cooking organizations behave as dynamic and adaptive as possible.

Samenvatting

Meer dan drie miljard mensen zijn, wereldwijd, en grotendeels in ontwikkelingslanden, nog steeds dagelijks afhankelijk van vaste brandstoffen zoals hout, houtskool en landbouwafval, om hun maaltijden te bereiden. Het overgebruik van deze brandstoffen leidt tot lokale ontbossing, erosie, bodemdegradatie en gezondheidsproblemen. Dit heeft serieuze gevolgen voor de lokale bevolking. Vrouwen en kinderen moeten bijvoorbeeld meer tijd besteden aan het zoeken en verzamelen van brandhout, wat ten nadele van economische, educatieve en sociale activiteiten komt. Bovendien zullen er, indien niets gedaan wordt, tegen 2030 meer dan 4000 mensen per dag sterven aan luchtvervuiling in keukens, veroorzaakt door vaste brandstoffen.

Een mogelijke oplossing voor deze problemen is een overschakeling van traditionele kookstoven naar niet-traditionele kookstoven zoals LPG-, elektrische- of gevorderde biomassa-kookstoven of solar cookers. Jammer genoeg faalden vele van de projecten die opgezet werden om deze niet-traditionele kookstoven te verspreiden. Reden hiervoor waren de eindgebruikers die de nieuwe technologie niet leken te accepteren.

Onderzoekers probeerden daarom in de laatste drie decennia te begrijpen welke variabelen een invloed hebben op het energiegebruik van huishouden en de keuze van hun kookstoof. Hierbij beklemtoonden ze echter het belang van economische factoren te sterk waardoor verscheidene andere variabelen (sociale, technische, religieuze, culturele, contextuele… variabelen) en hun onderlinge causale relaties compleet over het hoofd gezien werden. Om meer te weten te komen over het energie-transitieproces van huishoudens in ontwikkelingslanden is het daarom nodig een conceptueel kader te ontwerpen dat toelaat verscheidene variabelen gelijktijdig te bestuderen.

Deze studie ontwikkelt zo’n conceptueel kader en beklemtoont daarbij ook de belangrijkheid van twee variabelen die nog niet voldoende aandacht kregen in de literatuur: product-specifieke voorkeuren en organisatorische variabelen. Gezien de belangrijkheid van product-specifieke voorkeuren, worden deze gecentraliseerd in het eerste niveau van het conceptuele kader: huishoudens bestuderen namelijk product-specifieke eigenschappen van brandstoffen en kookstoven alvorens hun keuze te maken. Het achterhalen van de voorkeuren die huishoudens hebben voor bepaalde eigenschappen kan daarom helpen om de kookstoof beter af te stemmen op de noden en wensen van de eindgebruiker. Huishoudens maken echter niet enkel beslissingen op basis van product-specifieke eigenschappen. Hun voorkeuren worden ook beïnvloed door hun percepties, attitudes, cultuur, context en sociale omgeving. Om deze invloeden te kunnen meten en om verschillen in voorkeuren van verschillende huishouden te kunnen verklaren, werd er daarom een tweede niveau aan het kader toegevoegd. Tot slot bevat het conceptuele kader nog een derde niveau met organisatorische variabelen, onder controle van de organisatie zelf.

Na het voorstellen van het conceptueel kader, wordt dit toegepast op een solar cooking gevalstudie in ruraal Senegal. Recent werd er hier de nieuwe SolarCooker Eco3 geïntroduceerd om het vorige model, de CooKit, te vervangen. De SolarCooker Eco3 was een grote verbetering ten opzichte van zijn voorganger maar bleek desondanks nog steeds niet frequent gebruikt te worden door zijn eindgebruikers. Deze studie onderzoekt daarom hoe de eindgebruikers de voordelen van de solar cooker (tijd- en kostenbesparingen en gezondheidsvoordelen) afwegen ten opzichte van de

aanpassingen die ze moeten maken (prijs, mogelijkheid tot binnen koken, capaciteit en mogelijkheid om het nationale gerecht te bereiden). Hiervoor werd een steekproef van 126 respondenten uit acht verschillende dorpen ondervraagd. Hun voorkeuren werden achterhaald door middel van best-worst scaling. Daarbovenop werden ook nog een twintigtal extra mensen zoals lokale onderwijzers, dorpsleiders… geïnterviewd om bijkomende informatie te verkrijgen.

Uit het onderzoek blijkt op de eerste plaats dat, wanneer er gesegmenteerd werd op voorkeuren van respondenten, duidelijk verschillende marktsegmenten teruggevonden konden worden in de steekproef. De segmenten verschilden significant in hun voorkeuren en konden bovendien ook beschreven worden aan de hand van duidelijke socio-demografische eigenschappen. Maar liefst 8 van de 11 socio-demografische variabelen in deze studie bleken significant om verschillen in voorkeuren van marktsegmenten uit te leggen. Op deze manier kon de steekproef ingedeeld worden in drie segmenten. Een eerste segment gaf significant meer nut aan economische voordelen van de solar cooker. Dit kon verklaard worden door het feit dat respondenten in dit segment voor veel mensen moesten koken en hoge brandstofkosten hadden door het feit dat hout sprokkelen in hun directe omgeving niet meer mogelijk is. Een tweede segment daarentegen gaf significant meer waarde aan tijdsbesparingen en aan traditionele kookstoofeigenschappen zoals de mogelijkheid om het traditionele gerecht te kunnen bereiden. Dit kan verklaard worden door het feit dat deze personen afstammen uit erg traditionele en verafgelegen dorpen die sterk afhankelijk zijn van het verzamelen van hout voor hun kookenergiebehoeften. Tot slot is er nog een derde segment dat bestaat uit Moren of personen uit dorpen die een iets hogere levensstandaard gewoon zijn. Deze zochten een kookstoof die hun discretie, privacy, status en comfort kon bezorgen.

Hieruit kan vervolgens afgeleid worden dat solar cooking organisaties idealiter een onderscheid zouden moeten maken tussen eindgebruikers die verschillende noden en voorkeuren hebben. Dit kan door middel van aangepaste marketing en promotiestrategieën of door het design van de solar cooker aan te passen aan de verschillende eindgebruikers. Wat betreft dit design stelde deze studie namelijk vast dat de solar cooker nog niet goed afgestemd is op de eindgebruiker. Capaciteit blijkt bijvoorbeeld een zeer grote hindernis te zijn voor huishoudens die voor meer dan 10 mensen moeten koken. Bovendien waarderen respondenten de mogelijkheid tot binnen koken enorm wat erop kan wijzen dat ze moeilijkheden hebben om zich aan te passen aan een solar cooker waarmee men enkel buiten kan koken. Daarbij komt dan ook nog het probleem dat de respondenten aangaven dat de solar cooker niet gebruiksvriendelijk en moeilijk te gebruiken was. Echter, deze nadelen impliceren niet dat wanneer een solar cooker niet perfect is, deze niet gebruikt of geaccepteerd zal worden.

Of huishoudens al dan niet de solar cooker zullen gebruiken wanneer deze niet perfect is, hangt namelijk van verscheidene factoren af. Waarschijnlijk is de belangrijkste factor in dit project het gegeven of de solar cooking organisatie al dan niet slaagde huishoudens goed te informeren over de solar cooker. Respondenten in deze steekproef waren zich duidelijk niet bewust van de gezondheidsvoordelen die de solar cooker biedt – ondanks het feit dat ze deze items het meeste nut van allemaal toewezen – en ze wisten ook niet voldoende hoe ze de solar cooker moesten gebruiken. Daarenboven merkte deze studie op dat het mogelijk is dat de voordelen van de solar cooker, waarvan gebruikers zich bewust waren voordat ze zich de solar cooker aanschaften, minder duidelijk worden eens ze de solar cooker gebruiken. Ook de hoeveelheid informatie dat respondenten gehad hadden, beïnvloedde hun bereidheid tot het zich aanpassen aan de solar cooker omdat respondenten van meer traditionele dorpen, die nog nooit van solar cooking gehoord hadden, traditionele kookstoof eigenschappen hoger waardeerden dan mensen die al van solar cooking gehoord hadden. Tot slot beïnvloedde ook het soort informatie dat respondenten kregen voordat ze zich een solar cooker aanschaften, hun gedrag. Wanneer huishoudens een onrealistisch beeld van de solar cooker hadden, dan hadden ze de neiging teleurgesteld te worden en de solar cooker niet te gebruiken eens ze begrepen dat het initiële beeld dat ze hadden, fout was. Andere redenen om de solar cooker niet te gebruiken waren culturele, religieuze, contextuele en sociale invloeden die ook in rekening genomen moeten worden in het project. In dit opzicht bleek het belangrijk te zijn de juiste lokale mensen uit het dorp te betrekken in het project, en de structuur en hiërarchie van het dorp goed te begrijpen.

Het ontwikkelde conceptuele kader blijkt dus goed toepasbaar te zijn op een waar solar cooking project. Het kon vele voorkeuren en de daaruit volgende beslissingen van de eindgebruikers verklaren. Toch is het belangrijkste inzicht waarschijnlijk dat de invloed van organisaties op het succes van de solar cooking project erg groot is. Afhankelijk van verschillende acties van de organisatie, kan de eindgebruiker zijn attitude, perceptie en motivatie, die een invloed hebben op hun voorkeuren voor verschillende kookstoof karakteristieken en kookstoven, veranderen. In dit opzicht heeft solar cooking dus nog vele groei mogelijkheden indien solar cooking organisaties zich zo dynamisch en adaptief mogelijk opstellen.

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AFREA	African Renewable Energy Access Program
DME	Department of Minerals and Energy
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IAEE	International Association for Energy Economics
IEA	International Energy Agency
KoZon	Koken met de Zon als warmtebron
OECD	Organisation for Economic Co-operation and Development
SCI	Solar Cookers International
UNDP	United Nations Development Programme
WHO	World Health Organization




"This is one of the solvable problems that we face in the world today, and I have been pushing the global alliance for clean cookstoves, because it is a triple winner."

Secretary of State Hillary Clinton, April 13, 2012

1. State of the art

1.1. Fuel scarcity and issues

Food is an important concept in the life of human beings. Today, more and more energy possibilities exist for its preparation, but still a lot of people continue relying on biomass fuels. This is among others because in many developing countries, socioeconomic factors (e.g. poverty) often force people to use these "free" sources [1, 2]. Wood is in many cases the (in a short-term view) least expensive fuel. Also, in some regions people simply don't have a choice because alternative fuels are not available [3, 4]. As a result, worldwide over 3 billion people depend on solid fuels – such as wood, agricultural waste, animal dung and charcoal – for cooking purposes [5, 6]. Most of these people live in Sub-Saharan Africa and in Asia [7]. In Sub-Saharan Africa, that has the largest percentage of people using biomass, over 80% of households burn solid fuels and about 70% of them use wood-based biomass as their primary cooking fuel [7, 8]. The situation in Sub-Saharan Africa will even get worse since wood as an energy source is predicted to stay at least at current levels [8, 9]. This is different from other countries where wood usage is expected to decrease [8].

Furthermore, overreliance on and an unsustainable usage of these biomass fuels leads to numerous consequences for health, environment and social and economic development [7, 10]. At a global level, household biomass burning is responsible for about 18% of global black carbon emissions which has an impact on climate change [7, 11]. In addition, in some (often rural) areas, energy needs also cause local deforestation, soil degradation and erosion [7, 12]. Local deforestation causes many fuel scarcity and fuel security problems [13]. This forces families (especially women and kids) to walk longer and further to collect the necessary wood to prepare their meals. The extra time needed for this comes at the expense of economic, educational and social activities [3, 14-17]. The collecting is also a heavy physical burden for women and children and gender inequality is also closely linked to the energy gap [7, 18]. Yet, unlike black carbon emissions, it should be pointed out that deforestation caused by cooking needs is, mostly a local problem, not a global one. There are many other causes of global deforestation and cooking needs are not the main cause [12, 19].

On top of all these issues, combustion of biomass-fuels also leads to serious health problems. Gupta and Köhlin [20] point out the seriousness of indoor air pollution in developing cities, comparing it with the smog in London due to which people died. The burning of biomass causes fumes that have a negative impact on health, ranging from respiratory diseases to cancers, tuberculosis, cataracts and cardiovascular impacts [7, 15, 21-23]. By 2030, there will be dying 1,5 million people yearly (or more than 4000 people per day) due to exposure to indoor air pollution [24]. Other health issues might be caused by the fact that people who can't find fuels, will eat less or more uncooked food. They might stick to less nutritious ingredients [25] (cited in [26]) that need less cooking time and this might be negative for their health as well [17, 27].

1.2. Solution

In spite of the problems related to cooking with fossil fuels, cooking energy only recently came on the international agenda [17, 28]. In addition, articles on the related energy poverty problems are under-presented in major energy journals [29]. Fortunately, a switch from traditional biomass fuels to more modern fuels – such as LPG, electricity or biogas – can help combat the previously mentioned issues in section 1.1 [30, 31]. Alternatively, a second option is to increase sustainability of current traditional biomass fuels with improved stoves that reduce emissions (if necessary in combination with chimneys), and/or increase fuel efficiency to save fuels [30]. Numerous different improved cookstoves were designed and they can be divided in eight different categories: advanced biomass cookstoves, alcohol cookstoves, biogass cookstoves, electric cookstoves, LPG cookstoves, plancha cookstoves, rocket cookstoves and solar cookstoves [32]. In this work, we follow the example of Mobarak et al (2012) [33] who used the term "nontraditional cookstoves" to describe all the different types of "improved" cookstoves that replace the traditional household cookstoves. This because in this literature study, we don't want to refer to one specific cookstove. In addition, the label "improved" is subjective as some improvements may come at the expense of performance in other areas [33].

Since the household energy gap is a huge bottleneck in achieving the Millennium Development Goals, the United Nations Millennium Project targets since 2009 energy directly by aiming for a reduction of 50% in the number of people without effective access to modern cooking fuels by 2015 [34]. This implies that each day 800.000 extra households need to get access to improved energy to cook [7]. Yet, Foell et al (2008) [35] noted in 2008 that only household numbers in the order of 100.000 per year were provided with nontraditional cookstoves. Much still has to be done.

In this respect, it should be noted that projects disseminating nontraditional cookstoves, already date back to the 1970s [36] and can be found back all over the world [4, 12, 14, 20, 37-49]. Nevertheless, these projects were not always successful, often caused by resistance of users [37, 43, 45, 50]. There was a lack of widespread adoption, and many projects failed [1, 10, 17, 31]. Projects that implemented more than 10000 cookstoves are exceptional [51] and GTZ [13] noted that "as a rule" once solar cookers were implemented in a village and the project ended, most users stopped frequently using their solar cooker. Yet, no cookstove program can succeed if people don't accept the new technology [36]. Benefits can only be obtained if users use the cookstoves.

1.3. Household energy adoption analyses and theories

Consequently, given the high upfront and program costs of nontraditional cookstove implementation projects, researchers are trying to explain what exactly influences people in choosing their cooking method. Eliciting and understanding the factors that determine fuel choice is important as this will help devising the correct instruments to ensure people switch to nontraditional cookstoves and to increase acceptance [20]. During more than three decades, researchers (whether they were engineers, economists, sociologists, or anthropologists [52]) have temped to understand variables associated with household energy use [53]. In what follows, we briefly review current knowledge on factors influencing adoption. Figure 1 gives an overview.

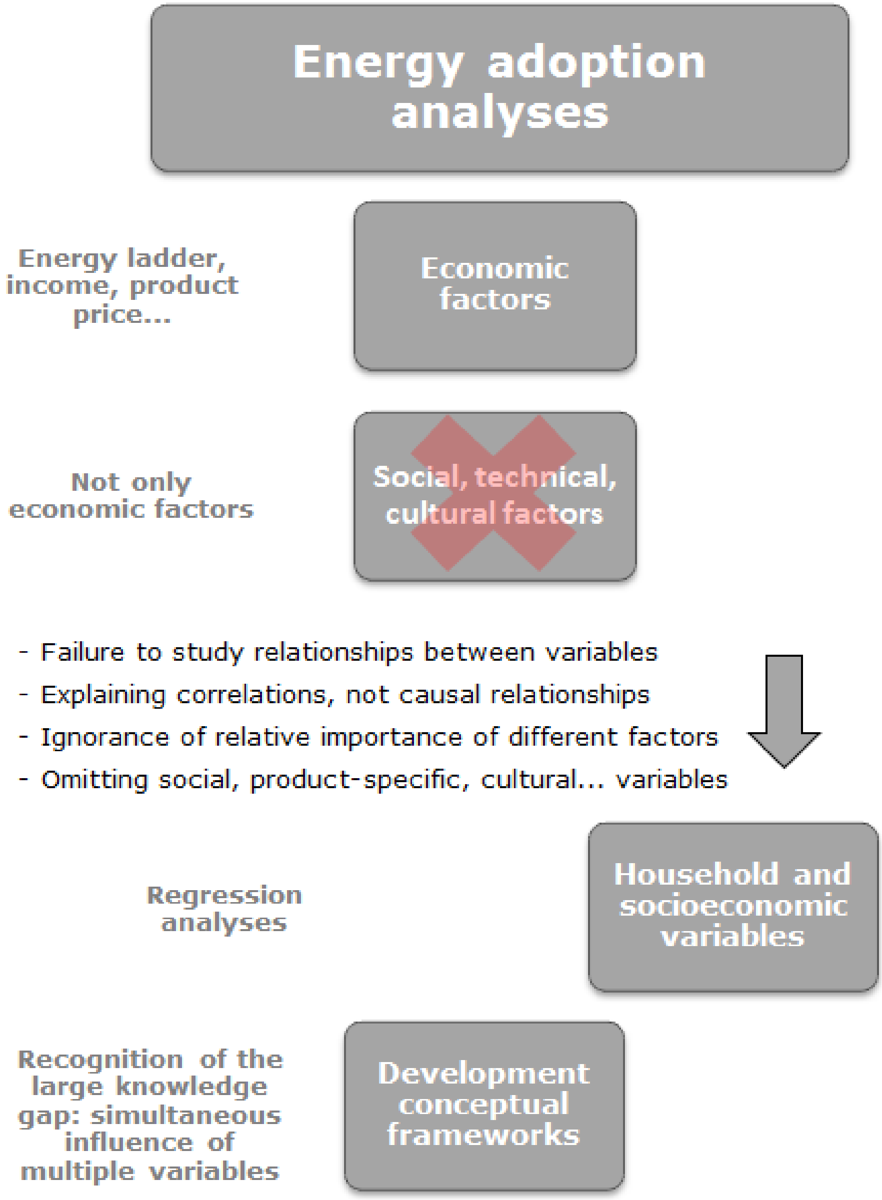


Figure 1. Summary of literature

Initially, many studies indicated that economic factors (e.g. product price and household income) are determining adoption rates [1, 54]. Income in general (whether measured as income, expenditure, area of land under household management, assets, or profit [55]) is even the most studied adoption factor and most studies state that wealthier households are more likely to adopt a nontraditional cookstove [55]. Income is also one of the key variables in the energy ladder model, a prominent model in energy choice modeling, that recognizes the income dependency of energy choices [53]. The energy ladder illustrates how households move linearly up a ladder from traditional fuels to modern fuels as their income rises. Dung, wood and charcoal are consequently abandoned for more efficient, more costly, more advanced and less polluting fuels like kerosene, LPG and electricity [53, 56, 57].

Given the high budget restrictions people in developing countries face and the importance of income, studying the influence of income, prices, subsidies and taxes is certainly relevant and frequently done [53, 55]. However, economic studies bounced against other non-economic factors that appeared to be important. Arthur et al (2012) [58] for instance found that fuels low on the energy ladder (such as firewood and charcoal) are less sensitive for changes in price. Yet, it was unclear whether this high elasticity is caused because those traditional fuels are ranked high on user's preference list (and consequently people are willing to pay more for it), or because people are just dependent on them. Apparently, income alone is not capable of explaining adaptation and a better understanding of other factors influencing adoption is needed [58].

Indeed, households are not only influenced by economic factors and it appears that the energy ladder should be augmented with many more social, technical and cultural factors (e.g. affordability, availability, cultural preferences) [56]. A simple one-way linear process cannot adequately describe the reality [59]. In addition, the ladder wrongly assumes that once a household moves up the ladder, it substitutes the "lower" traditional fuels with the "higher" fuels. In reality, when households move up the ladder, traditional fuels are also kept and not suddenly abandoned: households use a mixture of different fuels and techniques so that advantages of multiple fuels are obtained [53, 59]. Multiple fuel usage is the "norm" in developing countries and researchers need to consider this partial substitution in their analyses [36]. Masera et al (2000) [56] call this "fuel stacking" and they made a model that recognizes the fact that each fuel has its pros and cons. Households examine multiple characteristics of fuels and cookstoves (such as ease of use and handling, indoor air pollution, style of food preparation, duration of the preparation…) before they decide on which cookstove to use [20]. Cooking and food traditions, cooking frequency and ethnicity, increasing fuel security and preferences, all explain why there is no such thing as a "linear switching between fuels", but rather an "accumulation of energy options" [31, 53, 60]. Even though the presence of the energy ladder is confirmed by some field studies [20], it should be clear that the impact of income should not be overemphasized [53].

As a result, researchers realized that in the past they overlooked numerous factors of influence on cookstove and fuel choice. Variables range from socioeconomic variables, to product-specific variables [31, 47], from households' knowledge and awareness about new technologies, to local needs [61] and user preferences [44], from behavior-specific beliefs [53], culture, and religion [20] to other contextual variables [53], and from variables related to the implementation project itself to communication, marketing [55] and involvement of local villagers.

Unfortunately, even though numerous factors of influence on the household switching process are already known [53], most adoption studies only look at household characteristics and socioeconomic variables [31] such as the gender of the household head, occupation, age, education, household size, decomposition of the household, income and biomass collection [1, 20, 38, 62]. The regression analyses that were used to explain the adoption or non-adoption of a nontraditional cookstove, omitted social, product-specific, cultural and many other variables, ignored relationships between variables and only explained correlations, not causal relationships [53, 63]. The combined effect of different categories of variables hasn't been studied frequently and it is consequently also unclear what the relative importance of all the different factors is on fuel choice [55]. Researchers admit that the fuel switching process has been greatly simplified [36] and Lewis and Pattanayak [55] even criticize that much quantitative studies made estimates that were “easily captured” (income, education, family size….) compared to the complexity of the adoption process.

1.4. Conceptual framework

As a result, there are still multiple knowledge gaps in the household energy transition process. In order to guide future analyses, Kowsari and Zerriffi [53] developed a conceptual framework (Figure 2. a conceptual framework (Kowsari and Zerriffi [53])) that explains how different groups of variables simultaneously influence the final fuel or cookstove choice. At the center of their model, they put a three dimensional energy profile. This energy profile is actually the energy mix that the household ends up choosing. Yet, the energy mix is not described as the different energy options, but as a relationship between energy services, devices and carriers. In its turn, the three dimensional energy profile is influenced by four broad categories of variables: attitudes, habits and experiences, capabilities, and external conditions.

We consider this framework as a good basis to continue further analyses of the cookstove choice process. However, for our case study, we use a slightly modified version of their framework. Our framework can be found back in Figure 3. In the center of the framework we put product-specific preferences. This is because households examine characteristics of fuels and cookstoves before they decide on which fuels or cookstove to use. Given the fact that households have multiple needs, they often have to make a trade-off between them. They will choose the fuel or cookstove of which the perceived benefits outweigh the perceived costs. It is consequently important to

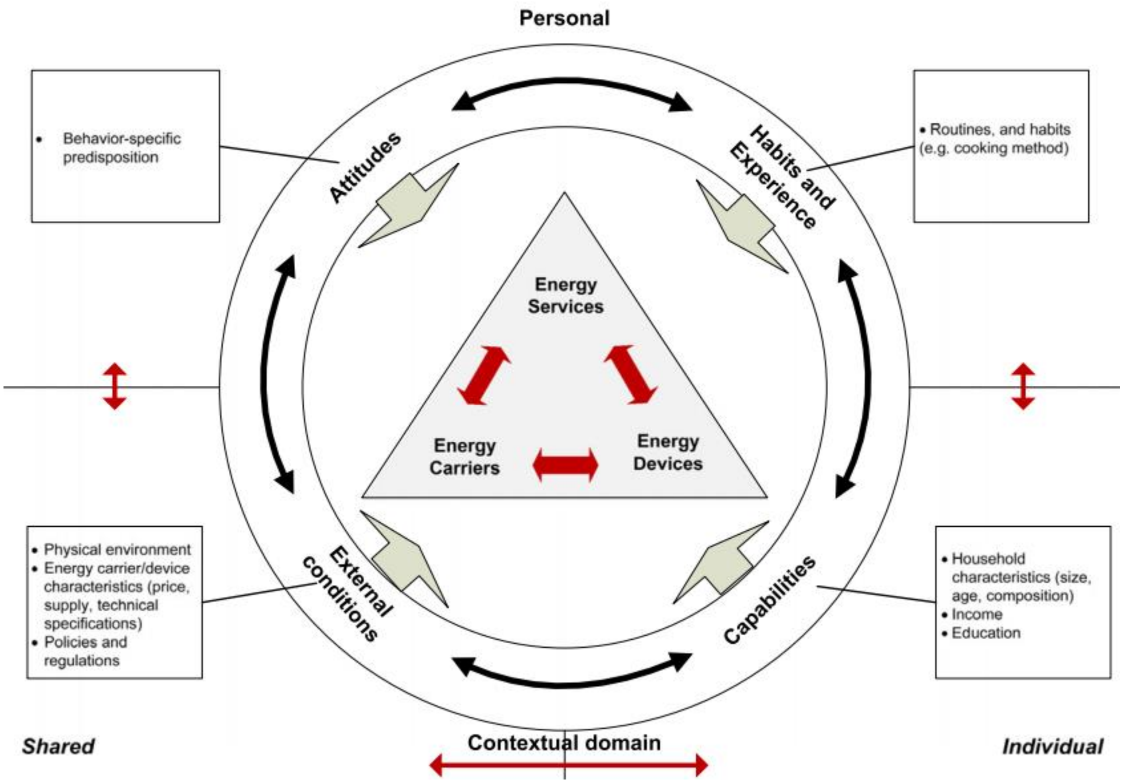


Figure 2. a conceptual framework (Kowsari and Zerriffi [53])

understand how users make these trade-offs and which weights they give to several factors. However, these product-specific preferences in the first level are influenced by factors such as user's perceptions, attitudes, culture, social, religion and physical environment. Therefore, once preferences are known, it is also important to further fathom these preferences in order to understand the reason of their existence. This is the second level of our framework. Finally, different from the framework of Kowsari and Zerriffi, we also add a third level, containing specific external factors that are within the control of the cookstove organization itself. In line with Troncoso et al (2011) [37], who argue that the adoption process faces three under-examined factors (the technology and its product characteristic preferences, the user and his personal context, and organizational factors), we redesign the framework of Kowsari and Zerriffi [53] with a third level. In addition, we argue that the framework of Kowsari and Zerriffi, and our adapted framework, do not form a framework on their own, but are instead part of a bigger framework.

In what follows, we motivate our adapted framework, followed by a positioning of our framework within the bigger decision framework. We end the first chapter by presenting our solar cooking case study. In chapter 2, we present the methodology used to examine product-specific preferences and develop the questionnaire. The results are presented in chapter 3 and further discussed in chapter 4.

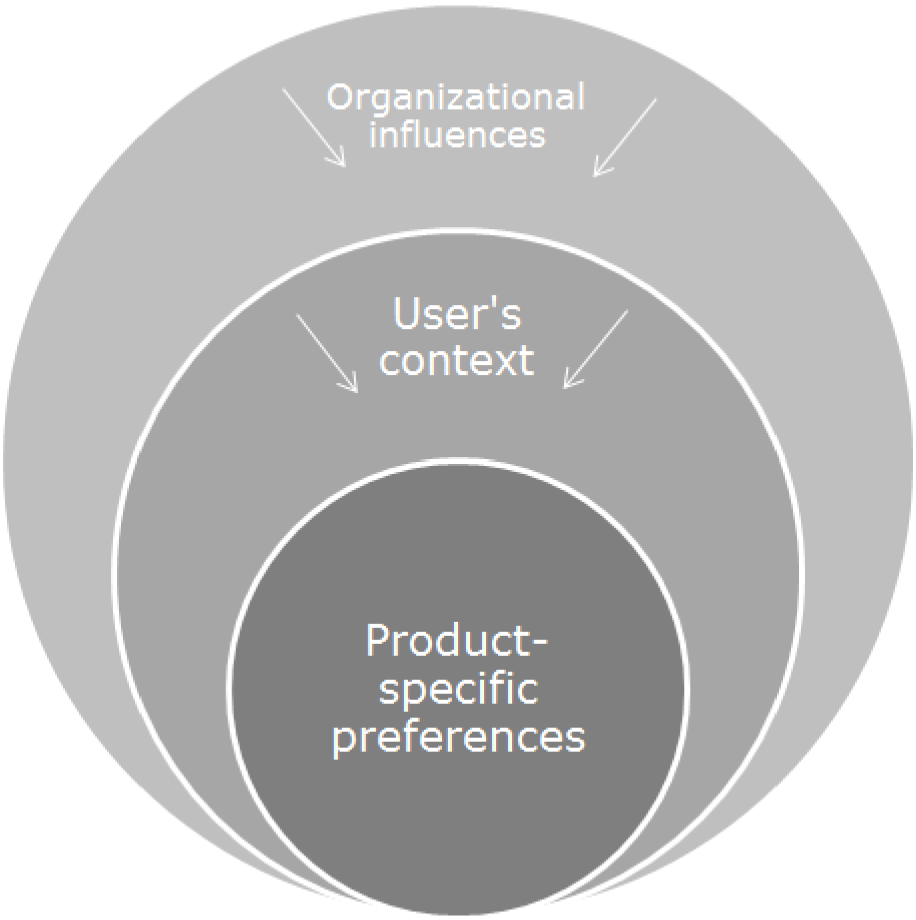


Figure 3. Adapted framework

1.5. Motivation adapted framework

As illustrated, we centralize in our framework product-specific preferences. This is similar to the framework of Kowsari and Zerriffi [53], that highlights that households choose a cookstove or fuel based on the services it can provide them with, not based on the good itself. Product-specific factors influence the cookstove choice of the users. Nevertheless, product-specific preferences are highly under-examined and we therefore present four main arguments why they are so important.

First of all, future cookstove analyses should make a distinction between initial adoption, and sustained usage of the cookstove. Currently, most studies stop after having investigated cookstove adoption [55]. They overlook whether these cookstoves are indeed used after adoption and as a result we can't always explain why users stop solar cooking once the project has ended [13, 37]. Since sustained use is indispensable to obtain benefits of the cookstoves, it is short-sighted that projects are only evaluated based on the number of disseminated cookstoves [39]. Even though it is still unclear which factors are important for sustained usage, it is suggested that product-specific factors like compatibility of the cookstove with local cooking practices are potentially more influencing for sustained usage [36].

A second reason why product-specific factors need more attention is that even if one knows more about socioeconomic factors, they change only slowly over time, or are difficult to be changed [31]. Product-specific factors on the other hand can easily be changed by adapting for instance the cookstove design or by changing household's understanding about different technologies and alternatives [31].

Thirdly, users buy or use goods to satisfy the needs that create their utility [64]: they look at characteristics of the good [65]. Consequently, the development of nontraditional cookstoves and the implementation of projects have to be more needs-oriented and have to respond to consumer preferences [44, 61]. Unfortunately, perceptions of the end-user were not often taken into account in the design of cookstoves and projects because there is a lack of understanding of user tastes, preferences and needs [1, 38, 66]. This lack of understanding caused already numerous program failures [1]. Cookstove promoters for instance highlighted cookstove features like fuel economies, combating deforestation and health benefits, while these cookstove features are not necessarily of highest priority for the end-users. Mobarak et al (2012) [33] therefore wonder whether current technologies are all "improved" in terms of attributes that inhabitants value the most. In order to find out whether this is true, it is important to identify all the needs of potential users. Features like speedy cooking, convenience, status and other characteristics typical of the device are often of higher concern than cookstove features such as fuel economies and health benefits [33, 66]. In addition, next to cooking services, a traditional cookstove can also fulfill socio-cultural (e.g. a three stone fireplace in Ghana is a symbol of a united family) and other needs like light, heat and smoke production (for instance to deter insects) [12, 19]. A certain cookstove is thus more appropriate compared to another cookstove when it is capable of providing the services it is designed for (e.g. cooking) while satisfying multiple other economic, commercial, technical, social and behavioral needs [67]. When a traditional fuelwood fire is capable of giving the food a certain smoky flavor, and villagers prefer this taste above the taste of a cookstove without fire (e.g. LPG, solar cooker…), they might prefer the traditional fuelwood fire [10].

Finally, next to identifying all the different needs, one should also know the relative importance or preferences for these needs. One product can't fulfill all individual needs and sometimes users have to make tradeoffs between their different needs. They will only invest their resources in a product if the perceived benefits (e.g. fuel savings) outweigh their perceived costs (e.g. change in food taste) [68]. In case of cooking, such input costs are not only monetary costs (e.g. the investment cost of the cookstove), but include as well the costs of a possible change in the taste of traditional food or longer cooking times typical of the new cookstove or alternative fuel. All necessary adaptations might have direct utility costs and those costs of adaptation have to be taken into account [68]. In order to explain the choices users make, and the way they tradeoff cookstove characteristics, it is important to understand users preferences as these influence the tradeoffs users make [31].

We now illustrated that users have clear preferences that influence their fuel or cookstove choice and motivated why we put product-specific preferences in the first level of our model. However, decisions are not only made based on attribute-by-attribute comparisons [69]. Preferences are also influenced by user's perceptions, attitudes, culture, and social and physical environment [53]. A second level, capturing variables explaining differences in preferences is consequently added to the framework. Cooking is in many societies a very traditional activity [17, 70] and examining cooking habits, cultural and social influenced might reveal important information on preferences.

Finally, we add a third level to our framework. This is because only few adoption studies [1, 39] considered the timing of adoption of the cookstove and only looked at the issue from a static point of view, while adoption is naturally dynamic in nature [1]. Adoption is fostered by a sort of learning stage where potential users learn about a new technology, talk about it with their friends, become aware of the advantages of it, start perceiving it as something useful and where their intention and behavior progress in a certain direction [36, 37, 53]. The adoption process is consequently influenced by the amount of information users get because this influences their degree of awareness and their perceptions (e.g. variables in the second level of the framework). When users don't have enough or wrong information, they will form perceptions based on their own (possibly wrong) beliefs about the characteristics of the cookstove [20] and this will influence their preferences. Consequently recent nontraditional cookstove studies start to take into account this awareness, lack of information and perception issue [12, 20, 54, 55]. Information, communication and marketing in nontraditional cookstove projects are consequently very important [55] and fall under the responsibility and control of the cookstove organizations. Some projects who didn't take this into account or who adopted inappropriate promotion strategies, failed [1]. Pattanayak and Pfaff (2009) [68] even state that adoption of cookstoves is slow because projects have not yet succeeded in sufficiently convincing households to change their behavior. Yet, the influence of the organization is not only informative. Other third level organizational variables – such as involving locals in the project [61] or selecting certain villagers as "early adapters" or opinion leaders [39] – are also important. It is thus clear that some variables are within the control of the organization. We call them organizational variables and place them in the third level of our framework. These variables can influence variables in the second level, that in their turn influence preferences of users. Consequently, organizations have multiple ways of indirectly influencing preferences. Unfortunately, the influence of organizational factors hasn't been examined or taken into account frequently in cookstove adoption research [37].

1.6. Positioning of the framework

Having presented our adapted framework, we continue our discussion by emphasizing the fact that our framework does not explain cookstove choice behavior. Instead, our model attempts to get insights into preferences and related tradeoffs that are only one piece of the puzzle in explaining choice behavior. In order to explain real choice behavior, a time component should be included in the framework as attitudes, awareness and preferences… are formed over time. When reading this work, it is consequently important to keep in mind the broader framework.

In order to visualize the position of this study in the broader framework, we constructed in figure Figure 4 an illustration of the broader decision process. It is based on the work of Louviere et al (2000) [71], and additional insights we got from the framework of Kowsari and Zerriffi [53], diffusion theories and literature. The entire choice process starts with a user who becomes aware of a problem and who is motivated to find a solution for it. Then he will learn about possible solutions and related attributes and characteristics of these solutions. He will form believes and perceived values of these characteristics and form a utility function. This allows the user to tradeoff attributes and form a preference ordering for these attributes. Note that this is where this work comes in. To emphasize this, we re-used the circles from Figure 3, in Figure 4. Afterwards, these preferences will allow them to evaluate different solutions and make a ranking of the different solutions. During the entire process, users' intentions and behavior to adopt a solution for his problem will progress in a certain direction and finally the user will, or will not make a final decision. Louviere et al (2010) [72] remark that parts of this decision process can be repeated and reviewed. For simplicity, this is not indicated in Figure 4. Note that we illustrated the decision process to position our study, not to end up with a perfect framework of the decision process. This is not the goal of this study and other approaches or extensions to our model are possible.

As a result our framework in figure 3 that we use for our case study, is still a simplification of the real world. A time component in the framework for instance, might improve the model significantly because preferences are formed over time. Yet, we only examine preferences at one point in time and hasty decisions concerning the link between preferences and the final decision consequently should be avoided as many other factors still should be included. Therefore, when reading this work, it is important to keep in mind the broader framework and the deficits of this study. Given the fact there haven't been yet many efforts to build and use a structured framework to study cookstove uptake [53], and given the fact that we have a short-term study, our framework is sufficient for our case study. We now continue with a description of our case study.

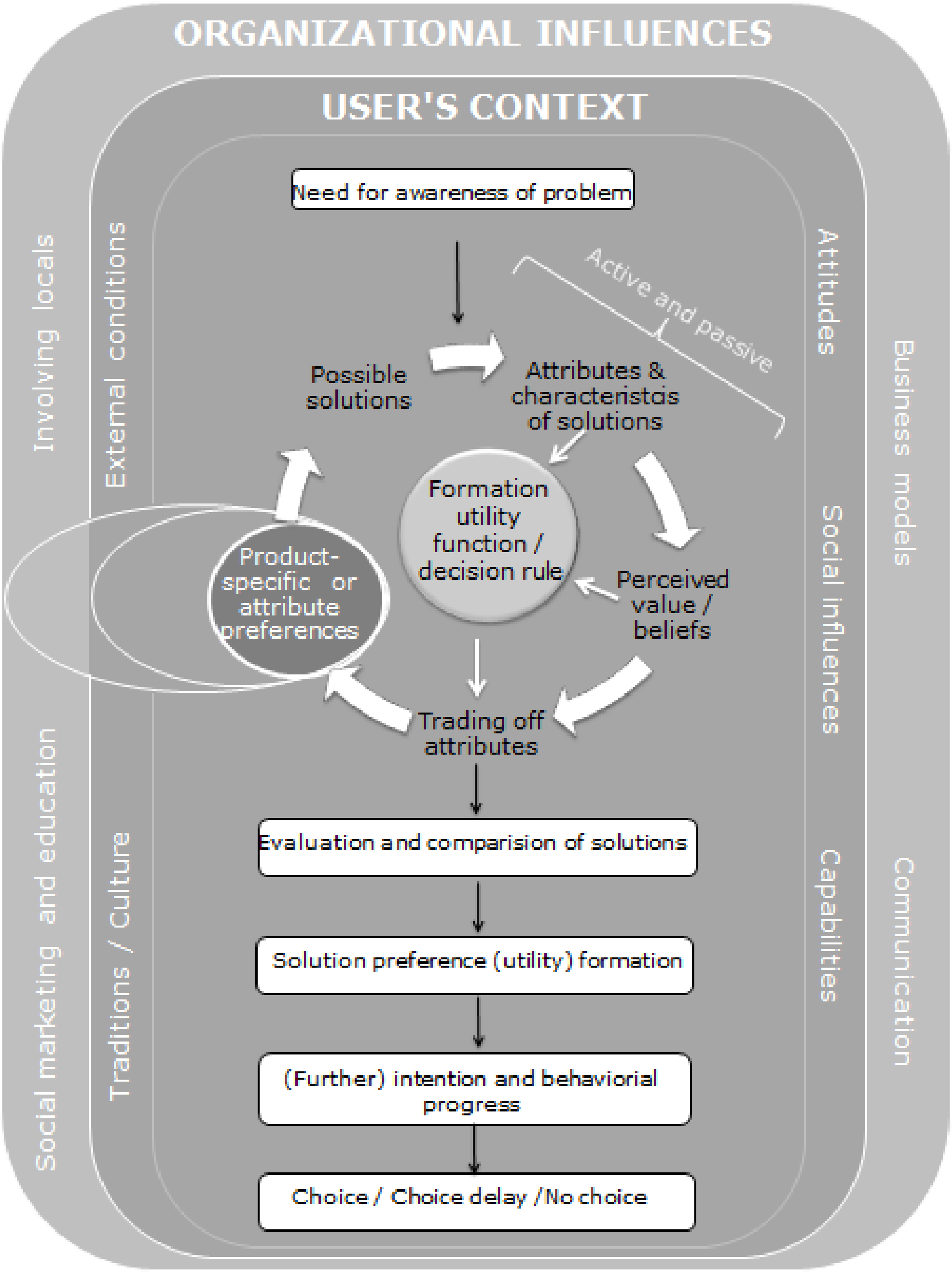


Figure 4. This study within the broader decision process

1.7. Case Study

1.7.1. Case study solar cooking

Even though there are multiple nontraditional cookstoves, this work focusses on solar energy for cooking purposes. Solar cooking is not new and the first box-type solar cookstoves date back to 1774 [73]. Currently, there are 352 different types of solar cookers which are categorized in five categories by Solar Cookers World Network [74]: the solar cooker boxes, the panel solar cookers, the parabolic solar cookers, the Fresnel solar cookers and the trough solar cookers. As the energy of the sun is free, there are almost no variable costs on a solar cooker and consequently solar cookers can be very useful clean energy alternatives for a lot of developing countries where sun is highly available. Especially in sunny regions where alternative fuels like electricity, gas or kerosene are not always accessible. Solar cookers can help combat health and deforestation issues [26] and it provides women with a cleaner kitchen [38] since there is no smoke anymore. Women also smell better, don't have red eyes from the smoke and can't burn themselves [75].

Yet, solar cookers, just like other nontraditional cookstoves, face a lot of difficulties in getting local acceptance [26]. The benefits of the solar cooker are for instance not always clear to the users [26, 70, 76]. Furthermore, the solar cooker has some inconveniences, one of which the fact that it is weather dependent. Cooking early in the morning, in the evening, by night or on cloudy days is consequently impossible and the solar cooker is a non-stand-alone technology. As a result, in case households want to prepare a solar cooked dinner, they have to prepare it during the day and re-heat it shortly during the evening. The solar cooker is sometimes also slower than traditional fuels and there are capacity limitations which makes the solar cooker too small for the big households in developing countries, where grand-parents, parents, kids… often live together [26]. This requires big dishes to be prepared over different solar cookers or with a mix of solar and traditional cookers.

Consequently, solar cooker users certainly have to adapt their way of cooking to the solar cooker, but there are also other adaptations they have to make. A solar cooker can't provide some services that traditional fires provide (e.g. keeping away insects, heating…) [26]. The solar cooker also gives food a different taste since the solar cooker retains more nutrients and makes meat tender [77]. This makes food healthier though it is not always appreciated by people who prefer the usual (smoke) flavor [78]. On top of all that, there are other problems such as the financial issues [70] or special design and aesthetics requirements users desire [79]. Coyle [75] for instance tells anecdotes of people who don't want to use squared solar box cookers because only circular shapes represent perfection. Furthermore, people often have incorrect believes about solar cookers. In Haiti people for instance ran away when they saw a promoter cooking with a solar cooker because they thought black magic was involved [75]. The solar cooker also requires people to cook outside. Some users don't like cooking outside because they are afraid that when the solar cooker (and the food inside it) is standing unattended outside, it can be stolen [14]. The safety of the solar cooker is also important [79]. Some people are scared of reflection and irritation for their eyes.

As a conclusion, as we also illustrated when building our framework, there are multiple different categories of variables that influence the solar cooking adoption process. In this work however, we don't aim to give a detailed overview of all possible variables (we for instance didn't mention social variables). With the examples above, we only wanted to make the difficulties solar cooking projects face more concrete. Table 1 categorizes the examples given to give an overview of the solar cooking variables we illustrated. The table does not have the intention to be complete.

Table 1. Summary of factors influencing solar cooking acceptance

Undervaluation or/and unawareness of	**Technical barriers**	**Cultural barriers**
- Money savings	- Weather dependency	- Taste
- Health benefits	- Does not provide additional services	- Shape
- Time savings	- Capacity	- Unknown technology
	- Speed	- Privacy
Financial barriers	- Maneuverability	
- Price	- Safety	

The implication of the fact that there are different groups of variables influencing adoption and sustained use is that, in order to get a full understanding of the diffusion process, all those factors have to be examined together and taken into account simultaneously [55]. Yet, except for some studies that discuss multiple factors [4, 46, 73, 78-83], there haven't been initiatives in the solar cooking field to study the influence of different categories of variables simultaneously, let along the combined effect of different variables. In addition, it seems that information on solar cookers, the performance of those cookers, reasons for failure and key factors to success are highly scattered and hard to get [84]. In this respect, the Solar Cookers World Network, a wiki-based site, has been created to share solar cooking information and experiences [85]. Yet, even there solar cooking organizations won't easily share their experiences and most organizations learn through the years by trial-and-error. However, there are several reasons why projects don't easily share experiences. One of them can be derived from Troncoso et al (2011) [37] who reported that project schedules have to fit commitments with donors. In order to get finance, the project must have a good image.

We therefore continue using the framework presented before, even though it is developed for all types of cookstoves and not for solar cooking in particular. Solar cooking can learn a lot from research in other nontraditional cookstove domains as analyses in those fields sometimes stand further than analyses in their own field.

1.7.2. Case Study Sol Suffit – Solar Cooking Project in Senegal

Our case study deals about a solar cooking project in northern Senegal: Sol Suffit. Sol Suffit is a project of Natuur.koepel, a Belgian association. They started in 2008 a solar cooking project in Djoudj, rural Northern Senegal. Afterwards, they elaborated the project to other regions, one of which la Langue Barbarie which is also situated in northern rural Senegal. Both regions suffer from deforestation problems although deforestation problems are significantly higher in Djoudj.

In Djoudj, Sol Suffit initially provided locals with the CooKit, a foldable cardboard solar cooker also studied by Toonen [4]. The CooKit however, required users to put their cookpot in a plastic bag to create a greenhouse effect. As a result, users could not stir in their meals. Capacity was also very low (maximum 4-5 persons) and baking and frying was not possible. This made it impossible to prepare the national dish, the Thieboudienne and users complained about the disadvantages of the CooKit. Sol Suffit replied to their demands by coming up with a new solar cooker, better adapted to the needs of the locals. They implemented in December 2011 the SolarCooker Eco3 in Djoudj. This solar cooker had a cooking capacity of 8-10 persons, was capable of reaching higher temperatures which made it possible to fry and thus to make the national dish, and finally also allowed stirring because no plastic bag was necessary anymore.

In la Langue Barbarie on the other hand, users did not yet have a solar cooker at the moment the research was done. At that point of time, the solar cooking project there was on the verge of starting and one was still introducing the solar cooking concept to the local villagers by means of oral presentations and demonstrations about solar cooking. Consequently, some people in la Langue Barbarie did already know what solar cooking was, while others hadn't yet heard about it. In Figure 5, the two solar cooking models used in the project can be found. We refer to www.kozon.org and www.solarcooking.be for more information about the two models[1].

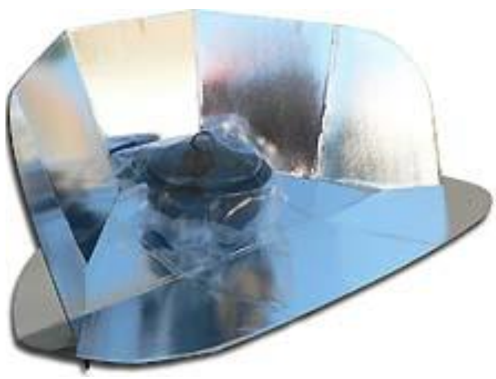
The CooKit	**The SolarCooker Eco3**
	

Figure 5. The solar cookers in the project (Solar Cookers World Network [86] and Sol Suffit [87])

Unfortunately, Sol Suffit noticed that, even though the new SolarCooker Eco3 was a big improvement compared to the CooKit, the owners of the SolarCooker Eco3, still didn't use the solar cooker very frequently. Interviews with Sol Suffit volunteers taught us that even though the capacity of the new solar cooker was higher (up to 8-10 persons), it still wasn't sufficient for some big families. This caused the inconvenience that solar cooking owners could not prepare big dishes unless they spread them over different cookstoves or unless they prepared them in small amounts by using the solar cooker multiple times over a longer time period. Alternatively, the could as well

[1] For a clearer image of the project, we refer to a short video in Djoudj, illustrating the fuel problems, the new solar cooker and some demonstrations (http://vimeo.com/37363138).

only prepare smaller dishes such as sauce, la bouillie, tea, rice… Yet, Sol Suffit couldn't do a lot about the capacity issue since at the time of this research, they didn't have the means to make a bigger solar cooker without lowering the safety of the solar cooker dramatically. Furthermore, the solar cooker was bigger and more difficult to store. In addition, Sol Suffit noted that the users prefered cooking inside because of the heat outside. Some users even suggested Sol Suffit to make some kind of pipe to transfer the heat of the solar cooker outside to the inside of their houses. In that way they would be able to solar cook inside. Users also don't like the dependency on weather conditions. Finally, they also complained about the fact that the SolarCooker Eco3 is less convenient to use than the initial CooKit.

One can consequently conclude that users have to adapt to the solar cooking technology and that this has some perceived costs in their eyes. Yet, on the other hand, the solar cooker has benefits such as cost and time savings, and health benefits. The users have to make a trade-off between the advantages and the adaptations they have to make. However, it is not clear how they make these tradeoffs and what features or attributes of the solar cooker give them the most utility. A quantification of different solar cooking characteristics is therefore needed. We will address this issue in our central research question for this case study: *How do people tradeoff benefits of solar cooking with features of traditional cookstoves?*

What we already illustrated in our literature study is that most likely there will be regional and individual differences in the users' preferences and in the way they tradeoff different solar cooking features. These differences are explained by the second and the third level of our framework and we will address them with the two following sub-research questions.

Firstly, concerning solar cooking adoption, there is proof that users in for instance refugee camps, who live in critical situations without access to fuels [88], adapt themselves more easily to the solar cooker. They use the solar cooker more frequently and sustainably [88-90]. Moreover, according to Tucker [26], the success of solar cooking in refugee camps can even be extended to all (also non-refugee camp) areas where the critical character of their situation (e.g. scarcity of fuels, high fuel prices, deforested areas…) forces inhabitants to use solar cookers and to accept the inconveniences of it. He notes that people in those areas are more than willing to alter their habits and traditions to be able to use the solar cooker. Their situation created a demand that otherwise might not have existed [26]. An example of this is that in Tibit, at high altitudes, solar cookers are used by the locals because there is no wood available [13]. Gundimeda and Köhlin [91] as well recognized in their study on fuel demand elasticities that the availability of resources such as forests had a significant impact on the shaping of the demand. As GTZ [13] calls this "all-or-nothing-at-all" decisions. The availability of resources such as forest consequently has an influence on choice behavior [91]. *This leads us to wonder whether people from fuel scarce regions give more utility or higher weights to advantages of the solar cooker, than people from less fuel scarce areas.* As the necessity of the solar cooker is undeniable in fuel scarce areas, *we hypothize that they give higher utilities and weights to benefits of the solar cooker*.

Secondly, when explaining the diffusion of innovation theory, we illustrated the importance of information in the adoption process. We also illustrated how information can change attitudes and perceptions. Furthermore, Troncoso et al. (2007, 2011) [37, 38] taught us that solar cooker users have had a real opportunity to experience the benefits of solar cooking which renders them more aware of the benefits of solar cooking. *This makes us wonder whether there is a difference in tradeoff behavior and weights assignment between solar cooker owners (of whom we assume to be better informed about the solar cooker) and non-solar cooker owners (of whom we assume to be not or less informed about the solar cooker). And if there is a difference, what is the difference?* Given the fact that information is important to correctly value solar cooker features, *we hypothize that solar cooker users give higher utilities and weights to benefits of the solar cooker.*

Finally, we also wonder which socio-demographic variables and which product-specific variables distinguish or discriminate best between the different clusters.

Table 2 gives an overview of the research questions. It should be noted that we indeed do not ask research questions about the influence of organizational variables on preferences. This is because our research will only attempt to identify potential influences. Later, these potential influences can be researched further in future studies.

Table 2. Research questions

Research Question	**How do people tradeoff benefits of solar cooking with features of traditional cookstoves?**	
Sub-RQ 1	Do people from fuel scarce regions give more utility or higher weights to advantages of the solar cooker, than people from less fuel scarce areas?	
	Hypothesis:	Yes
Sub-RQ 2	Is there a difference in tradeoff behavior and weights assignment between solar cooker owners and non-solar cooker owners? If yes, what is the difference?	
	Hypothesis:	Yes, solar-cooker owners give higher utility values to benefits of the solar cooker
Sub-RQ 3	Which socio-demographic variables and which product-specific variables distinguish or discriminate best between the different clusters?	




2. Methodology

In what follows, we apply the framework from Figure 3 to the real-life solar cooking case study. As illustrated, the goal of this framework is bifold. First, we elicit tradeoff behavior of different users. Second, tradeoff behavior is explained based on user specific variables (e.g. the fuel scarcity of the area he/she lives in, the solar cooking experience he/she has, and other socio-demographic and contextual variables). We start with the first level where we have to elicit what preferences users have for certain product-specific characteristics. In section 2.1 we determine which methodology we will use for doing this. In section 2.2 we further explain this methodology and present all the steps that we need to run through to prepare a questionnaire with this methodology. In section 2.3, we develop the questionnaire and integrate it with questions from level 2 and 3. In section 2.4 we discuss how the data will be collected and finally in section 2.5 we discuss how the data will be analyzed.

2.1. Examining tradeoff behavior

We firstly need a mean to elicit the relative strengths or utilities of different solar cooking features in a household's cookstove choice. A frequently used term for these strengths and weights are "part-worth-utilities" [31] which can be elicited by means of Stated Preference (SP) Methods. SP Methods [92, 93] use hypothetical situations to reveal information about decision makers' preferences. This is different from Revealed Preference studies where real choice situations are implemented [94]. Within SP Methods, there are different ways of measuring preferences of a list of characteristics, for instance rating-, allocation- and ranking tasks [95, 96]. Yet, rating tasks lack discriminating power because respondents have an opportunity to indicate that simply everything is important [97]. There consequently is a lack of discrimination among the different attributes and there is a risk of scale use bias (i.e. respondents using the scale in different ways) [96]. Ranking- and allocation tasks on the other hand are difficult for respondents when the number of items increases. In addition, having to allocate a certain number of points might obstruct respondents of revealing their real preferences [98]. In case of for instance Likert-type scales, respondents might have difficulties distinguishing important and very important. This might cause them to delimit the extreme positions [99]. In line with this, scales can be interpreted differently by different respondents (from different countries or cultures) which makes comparison sometimes difficult.

For the purpose of this study we consequently only consider stated choice methods as best suited. Firstly because, in contradiction with the ranking methods, stated choice models force people to make tradeoffs and thus to express their preferences [31]. Secondly because Pattanayak and Pfaff [68] pointed out that examining behavioral choices is critical for further research to the valuation of environment and health in developing countries. Stated choices are modeled within a behavioral framework and model stages in users' choice behavior that can be inter-linked [64, 72].

Within the stated choice methods, we focus on Best-Worst Scaling (BWS) and Discrete Choice Experiments (DCE), which are two principal questionnaire-based preference elicitation techniques [100]. Best-Worst Scaling is also called maxdiff scaling. Earlier both terms were used interchangeably but recently one started distinguishing between them depending on how the scores were estimated [96]. As we will use the Sawtooth software, and as they use the Best-Worst approach to code the data, we will continue using the term Best-Worst scaling.

BWS is a reduced form of DCE [101]. Both BWS and DCE describe a scenario that presents a service, product or application that the researcher wants to examine by a number of factors or attributes. These factors or attributes have different levels (also called items) and by changing the levels, different combinations and therefore different scenarios can be made. The difference between the BWS and the DCE method lies in the fact that DCEs ask respondents to compare different scenarios with each other and to pick only that one scenario from the set that they prefer. BWS on the other hand doesn't ask to compare the utility of entire scenarios. It asks to compare utilities of the different items of only one scenario [102]. This characteristic equips BWS with some unique advantages compared to DCE. Firstly, according to the latter author, the difference in collecting data enables BWS to determine the impact of all but one factor/attribute because it puts the items on a common scale. This implies statements purely about attributes can be made. With a DCE on the other hand, relative impacts of factors cannot be compared because this requires a common scale for the given items [102, 103]. Yet, it should be noted that even though Flynn et al (2007) [102] say DCEs should not be used for this latter purpose, researchers still use the method to elicit this kind of information. In this respect a more recent article of Louviere et al (2010) [72] depicts that in some simple specifications where the ratio of the parameters and the price coefficient is taken, the scale effect drops out by calculating the marginal WTP of a change in attribute level. Yet, given the fact that this research takes place in very poor regions, monetary-related items are likely to be irrational seeing that respondents engaged in strategic behavior which originates from their focus on short term financial possibilities. Therefore, we don't want to rely too much on WTP estimates and in this respect, BWS is more suited for our research. A second advantage of BWS is that, next to statements about the attributes themselves, the common utility scale can separate effects of attribute impacts from the position of levels (items) [104]. This means that the researcher can learn as well from the utility gained or taken away when an attribute possesses a certain specific level. Regression estimates display the change in utility of moving between the different items [102]. As we want to examine which features of the solar cooker motivate people, a research on item-level is interesting. A third advantage of BWS is that it is possible to examine individual-level respondent utility scores [105]. This is not possible with DCEs where only average results for the entire sample are presented.

At first sight, BWS seems to be a more appropriate methodology than DCE for our research. In addition, when normalized or rescaled, the preference weights from BWS and DCE do not show significant differences [100]. Yet, it should be noted that evidence on the comparability of results from BWS compared to other methods is scarce [106]. Therefore it is important that other differences between the two methods are taken into account as well. In this respect, Potoglou et al (2011) [100] suggest that when respondents are not experienced in making choices, it might be difficult to keep two or more profiles in mind (which is the case in DCE). Consequently, cognitively, BWS seems to be easier as respondents only have to look at one profile or scenario. This is a major argument given the fact that our respondents can't read. Questions will be transferred orally and as a result the least cognitively demanding method is thought to be most appropriate. Comparing two (or more) profiles might become an issue when respondents can't read. Furthermore, they only have to judge items at the extremes (best or worst) which is easier than choosing between items of middling preference [96]. This also helps reducing the size of the random utility component [100]. In addition, as in Senegal in some villages different ethnicities are present, a method that allows cross-cultural comparisons is necessary. Cohen [107] and Auger et al (2007) [108] state that BWS supports this need. This is because respondents do not have to express the strength of their preference (only the extreme cases best or worst). This means that there is no way for scale use bias to appear, as all items are measured on a common scale [96, 108]. Finally, BWS is appropriate for segmenting users and to classify them in homogenous groups [104]. This is necessary to answer our research questions. For these reasons we prefer BWS to DCE.

As we choose BWS, we will now develop a bit further the methodology itself and run through all the steps we need to do, before we start designing the questionnaires.

2.2. Best-Worst Scaling

BWS is developed by Louviere and Woodworth in 1990 [109]. It is rooted in the Random Utility Theory (RUT) [102] and probabilistic models for BW choice data are recently proved by Marley and Louviere [110]. RUT states that in the head of each person there is an invisible latent construct called "utility" [72]. This utility consists of both a systematic and a random component [64]. The systematic component V_{in} is the part of utility of respondent n for an alternative i, that can explain differences in choice behavior of different individuals. The random component ε_{in} on the other hand comprises utility that is unexplainable because of for instance biases, inconsistent choice behavior or unknown influencing factors. Utility can be presented as [72]:

$$U_{in} = V_{in} + \varepsilon_{in}$$

Even though utility can't be derived directly, it can be estimated as there is a systematic component in it [72, 111]. RUT namely assumes that a person's utility is derived from attributes of a certain product [72, 102, 111]. Consequently, BWS can elicit the utility for different attributes by presenting each respondent with hypothetical scenarios that present a certain product. All these scenarios are described by a number of attributes of which the levels are changed over the different scenarios. In each scenario, the respondent then has to indicate the best and the worst item. For the development of the questionnaire, this implies the researcher has to decide first which attributes and attribute levels to include in the questionnaire, how many items to include per scenario (or question set) and how many question sets to be asked per respondent. Then all these question sets can be presented to the respondents.

The choice tasks cognitively imply respondents iteratively choose two items of a set of three or more items so that the differences in utility on an underlying continuum they perceive between the items is maximized [109]. This implies respondents evaluate the differences in utility between *all* the items in a question set and then choose the best-worst pair that maximizes the difference in part-worth utilities between the two chosen items [102]. This is the pair of which the items lie furthest apart on the latent utility scale [104]. With this information, BWS tries to estimate the probability of respondent's choice for the different attribute pairs (best-worst) in the experiment by assuming they think rationally and maximize their utility [96, 109, 111]. This means that BWS assumes that the relative choice probability of a best-worst pair is proportional to the difference between the best and worst attribute levels on the latent utility scale [102]. BWS is thus actually a difference model which explains why it is sometimes referred to as Maximum Difference Scaling.

For the analyses of the data, this implies that the higher the probability an item is chosen, or the higher the utility of the item, the more impact this item has on the decision [112]. All items' utility scores are measured on a common scale as there is only one way in which something is most or least important [108]. However, since BWS takes all the estimated pair differences together, estimated utilities are always relative to a single attribute level [103]. This implies that we can estimate the impact of all except one attribute. That one attribute will be the reference case. For the entire scale, values can be calculated relatively [102]. In addition, by looking at the ranking of all the items, we do not know at which point utility becomes positive as the scale has an unknown anchor [104].

Finally, there are different ways to model the Best-Worst scaling data. Flynn et al (2007) [102] and Flynn et al (2008) [104] present four possible regression models in the random utility framework. The researcher can for instance choose to do the analysis on the level of the unique best-worst pairs (paired analysis models) [102]. In that case each unique best-worst pair is seen as a unique choice outcome and in total there are $2 * \sum_{i=1}^{K-1}\left[n_i * \sum_{k=i+1}^{K} n_k\right]$ possible pairs[2]. The utility difference from each pair can be estimated with a conditional multinomial regression model (logit analysis) [104]. Since common statistical packages do not have standard commands for best-worst data [102], we rely on the Sawtooth software for the analysis of our best-worst experiment. For the individual-level scores per respondent, Sawtooth estimates the Multinomial Logit Model with Hierarchical Bayes (HB) Estimation [113].

However, concerning the analyses of BWS, it should be noted that there isn't know a lot about BWS experiments in developing countries. Next to additional design challenges (e.g. literacy rate) [114], the fact respondents might use certain decision-making heuristics, has to be taken into account [115]. An example of the later phenomena is within DCEs recognized as lexicographic preferences and it may occur for different reasons [116-119]. The choice tasks might have been too complex for the respondent [116], or the attributes or items chosen might have been inappropriate [117]. In addition, respondents can apply certain decision rules out of protest to emphasize a certain strong negative or positive preference [118]. In that case respondents give a zero or infinite value to the item. Furthermore, there also exist special types of lexicographic preferences such as cut-off variables where respondents require attributes to fulfill a certain threshold or minimum level before they consider them in their tradeoff decisions [120]. People will never tradeoff minimum levels such as food and shelter. These threshold levels can exist because depending on culture, background, social settings and broader contexts, people may have other substance needs, wants for self-realization or ethical commitments who need to be satisfied before any other higher wants can be reached [119]. For BWS experiments, it is consequently important to know what the influence on results is if respondents do not trade-off all attributes. Unfortunately, the issue is largely under-examined [115]. Furthermore, some authors criticize theory of utility maximizing in

[2] Where K is the number of attributes, n_k is the number of levels of attribute k

the context of switching fuels or technologies in developing countries as it can't explain all the different technical, social, behavioral, and psychological factors or anticipate behavior [121, 122]. We indeed agree economic theory *on its own* cannot explain choice behavior, but emphasize again the fact that it is part of the broader framework. As Takama et al (2012) [31] remark, an economic approach such as ours is necessary to evaluate and consider different cookstove attributes, trade-offs and household preferences *within* a consistent analytical framework. BWS is consequently possible, but we certainly need to take into account the context our research takes place in.

To answer our research questions, we have to run through the steps illustrated above. A summary of all the steps is provided in Figure 6. For the development of the BWS design (blue frames), we have to choose the attributes and attributes levels, the number of items per scenario and the number of scenarios per respondent. We run through these steps in section 2.3. Since RUT assumes utility consists of both a systematic and a random component, our questionnaire does not only contain the BWS experiment. Socio-demographic questions (green frame) are also included as these data – representing the second level of our framework – will help capturing the variation in the systematic utility component. In addition, we add some semi-structured and open questions that allow us to learn more about organizational influences (variables in the third level) and to identify possible decision-making heuristics or other issues not encountered in developed countries. Then, we choose our sample and collect our data (grey and pink frame). We further develop these later steps in section 2.4, 2.5 and 2.6. Finally, we discuss how we analyze the data in section 2.7.

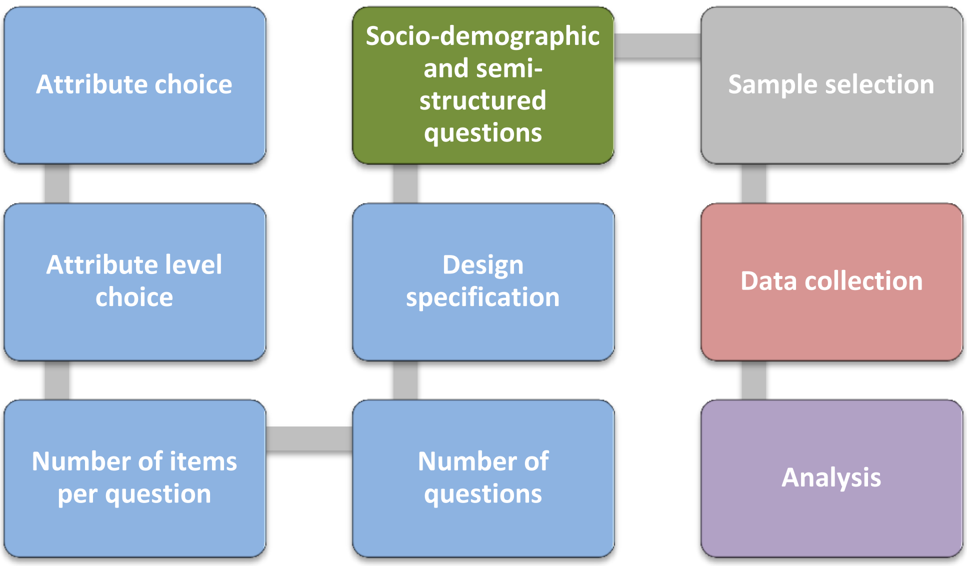


Figure 6. Different steps in a BWS experiment

2.3. Questionnaire development

2.3.1. BWS Design

We firstly go through the blue steps in Figure 6 and create the BWS design. The design of a BWS experiment shows all combinations of items that respondents will be confronted with over all the question sets [96]. For the decisions we have to take, we keep in mind our illiterate respondent and the fact that the questionnaires will all be done orally. We will consequently attempt to decrease the length of the questionnaire and the burden on the respondent where possible. To create the BWS design, we use the Sawtooth Software SSI Web.

2.3.1.1. Attributes

As explained, we wonder how users when perceiving the solar cooker, weight advantages and characteristics of their traditional cookstoves (or necessary adaptations they have to make when using the solar cooker). Concrete, we will examine which characteristics of the solar cooker motivate the users the most to switch to solar cooking, and which characteristics of the solar cooker motivate the users the least. As a result, in this case study, the underlying continuum we spoke about earlier is the degree of motivation an item gives to switch to solar cooking.

To determine the attributes and attribute levels to be included in the questionnaire, the researcher has a number of options. In our case, we already identified a number of attribute candidates in our solar cooking literature study. However, attributes important for one solar cooking project or for one type of solar cooker, are not necessarily important for another solar cooking project. Our attributes are consequently not predefined and a preliminary investigation using group discussions, focus groups with respondents and relevant experts, individual interviews and/or direct questioning of individual subject is needed [111, 123].

However, due to time and money restrictions, we could not do a pre-investigation on the field. Fortunately, the head office of Sol Suffit is in Belgium, which allowed relying on the expertise of volunteers that have frequently been present on the field during the last 4 years. In addition, Sol Suffit recently introduced a new solar cooker to tackle limitations of the previous solar cooker. This implies they are informed about the needs and worries of solar cooker users. Conversations with two Sol Suffit volunteers helped us in identifying a list of main factors that were thought to influence solar cooking usage in the regions where Sol Suffit is engaged. To make sure the questionnaire was not too long and fatiguing for our uneducated respondents, we had to settle on which attributes to include in the BWS experiment. Especially since Troncoso et al (2011) [37] noted that women in developing rural Mexico became tired of their studies. Together with Sol Suffit, we decided to include the attributes indicated in two or more levels from the same attribute in the same choice set. As a result, it is for instance not.

2.3.1.2 Attribute levels

With respect to the attribute levels, Flynn et al (2008) [104] demonstrate that the number of levels for all the attributes does not have to be the same. In total we finally end up with 15 items (attribute levels) who are summarized in two or more levels from the same attribute in the same choice set. As a result, it is for instance not. Each attribute has two levels, except for price, which has three levels. Having three price levels namely allows us to determine potential non-linear effects [111]. We realize that there might be a risk of drawing more attention to this attribute because it is the only one who has three levels, yet, no research in BWS substantiates this concern [98]. The minimum price level, 10000 CFA is based on the price respondents have to pay for the solar cooker, the maximum price level (50000 CFA) is based on the estimated minimum cost Sol Suffit has from the solar cooker.

Table 3. Research attributes and attribute levels

	Level 1	Level 2	Level 3
Price	10000 CFA	30000 CFA	50000 CFA
Money/Fuel savings	A little bit	A lot	
Time savings	A little bit	A lot	
Health Benefits	Current health condition doesn't get worse	Current health condition improves	
Capacity	Up to 4-5 persons	Up to 8-10 persons	
Traditional Dish	Not possible to prepare traditional dish	Possible to prepare traditional dish	
Indoor/Outdoor cooking	Only outdoor cooking	Both inside and outside cooking is possible	

Next, there are the attributes money and time savings. The choice of levels for these attributes is highly challenging given the fact that there are huge differences between the different families. A family that uses a combination of fuels will have less time savings than a family that only relies on the collection of firewood. Also, families that use gas will have more money savings than families relying mostly on cheap fuels such as charcoal or collected wood. As a result, creating a time savings level of for instance five hours a week would be totally unrealistic for respondents who never collect wood, and might be not a lot for respondents who collect wood four hours a day. To overcome these differences, adapted levels for each household have to be used such as done in Achtnicht [124]. There, the levels were specified as percentages of respondents' fuel or time spendings. Yet, given the fact that uneducated respondents will not understand percentages, it is necessary to calculate the customized levels ourselves per respondents in order to be able to use them in our BWS experiments. However, in that case we need to ask first to users what their fuel and time spendings are and we fear bias to occur in our results if people don't know their exact spending, yet try to provide us with estimates. Furthermore, as our research is done during the rainy season and the Ramadan, fuel expenditures might be different from regular periods which might bias our results. Ideally, respondents thus have to state their average annual expenditures but we doubt whether they are capable of doing this. Finally, users already having a solar cooker, should state their time and fuel spendings before they used the solar cooker in order to understand what motivates them to use the solar cooker. However, relying on respondents' memory is again a pathway to introduce bias. Therefore, we conclude calculating the different levels on the field, based on data respondents give us, is too risky as at this point, we don't know the respondent well enough. Yet, given the huge differences between the respondents, customized levels are necessary and we use extreme values for our attribute levels. We opted for "a little bit" and "a lot of" time and cost savings because respondents can determine for themselves how much this is for them.

Concerning the health level, it is true that when using a solar cooker, there is no more smoke. The health condition of the respondent can consequently improve a lot, or will at least not get worse due to cooking activities. For the traditional dish, the levels are also more straightforward: you can make it, or you can't. Finally, there is still the capacity attribute and the indoor/outdoor cooking attribute. For the capacity attribute, we took as a minimum level the capacity of the CooKit (up to 4-5 persons), while for a maximum capacity we took the capacity of the Eco3 (up to 8-10 persons). However, Sol Suffit already pointed out that the capacity of 8-10 persons is still not sufficient for many families. Yet, increasing the capacity of the solar cooker would make the solar cooker much less safe to use and we consequently do not include higher capacity levels in our questionnaire. In this way, we can get a clear image of the utility the current capacity levels provide to the users and evaluate the improvement Sol Suffit made with the new SolarCooker Eco3. Concerning the possibility to cook inside, we refer to the collector cooker described in GTZ [13]. This type of solar cookers exists of two parts. One part is the collector for gathering heat, the other part is where the heat is transferred to and where one puts the casserole. Such a solar cooker could allow cooking in the shadow or indoor as long as the collector part is put in the sun. The levels chosen for this attribute are the possibility to only cook outside, or to cook both inside and outside.

2.3.1.3. Design specification

Having decided on the different attributes and levels, we can start designing our BWS experiment. Firstly, we included a total of 9 prohibitions in our questionnaire. These make it impossible to have two or more levels from the same attribute in the same choice set. As a result, it is for instance not possible to specify a solar cooker that costs 10000 and 30000 CFA at the same time.

Concerning the number of items to be presented to our respondent per question set, Orme [125] and Chrzan and Patterson [126] strongly suggests increasing the number of questions and lowering the number of items per question. They recommend 4 to 5 items per question set. Keeping our respondents and the fact that the questionnaire is done orally in mind, we opt for 4 items per question set.

We also have to decide on the number of questions (or question sets) to be asked to each respondent. Given our 15 items, and given that we present 4 items per question set to our respondents, Orme [96] recommends asking between 12 to 19 questions. This calculation is done with the following formula

$$\frac{3K}{k} \text{ and } \frac{5K}{k}$$

where K is the total number of items (15 in our case) and k the number of items shown per question set (4 in our case). We did not find any further suggestions in choosing the number of questions. Orme [125] shows that increasing the number of questions (when the number of items is not too big), improves relative hit rates. However, he also showed that even more questions gave diminishing returns in hit rates. Probably this is due to fatigue and we consequently opt for the minimum of 12 question sets per respondent.

2.3.1.4. Final questionnaire design

After having decided on the number of attributes levels, the number of question sets, the number of items per question set and the number of questions, we can continue with the final design of our BWS experiment. A good questionnaire design implies that each item is shown about an equal number of times across all question sets and that each attribute appears about an equal number of times with every other attribute [96]. We ran 100.000 iterations and the 79.865th attempt was chosen as having the best quality (meaning it is the most balanced of all the iterations).

In total we made four different questionnaire versions. The different versions will reduce context effects that might arise when respondents all have the same combination of items and it will increase stability of the item scores [96]. It should be noted that in case of internet surveys, many more than four different versions of questionnaires might be created (even over 1000 versions). Yet, for a pencil and paper study, this is not practical. The different versions allow us to increase the number of choice sets, implying each item was used 12 or 13 times over the four different versions. This means all items are shown almost an equal number of times, which is a nearly one-way balanced design. The one-way balance has a standard deviation of 0.40000 across the frequencies (appendix 2.1). The lower the standard deviation, the higher the quality of the design. The design algorithm of Sawtooth looks at this one-way balance to select the best design.

In addition, the software looks at frequency balance – considering both one- and two-way frequencies –, positional balance and connectivity. In case both one- and two-way frequencies are balanced, we have orthogonality [96]. However, since we included prohibitions (e.g. a solar cooker can't cost 10000 and 30000 CFA at the same time), we can't have a perfect two-way balance design (appendix 2.2), meaning all items appear equally together with all other items in the question sets. Yet, all items appear between 2 and 4 times together and the standard deviation is only 0.41, which is good. Finally, we also almost have positional balance (appendix 2.3), implying all items are shown about equally in all four positions in the question sets. Note that it is not necessary to have a balance here, but that it will help reducing psychological order effects [96]. We also have connectivity in our design. This means that all items are linked and this is indispensable to scale items relative to one another.

In our case, we can conclude the design is reasonably sufficient since we have almost frequency balance (i.e. one-way and two-way frequencies are nearly equivalent [127]), positional balance and connectivity. An example of a final question set is displayed in Figure 7. The colors were used because it allowed to visualize the concept somehow to our respondent. A full version of version 1 of the questionnaire can be found back in appendix 2.4.

2.3.2. Socio-demographic and Open Questions

Remember the framework used in this case study. Currently we only designed the part of our questionnaire that elicits preferences for product-related characteristics. Yet, these preferences have to be complemented with socio-demographic data of the respondent. These data – representing the second level of our framework – also have an influence on preferences and are useful to distinguish between, and explain and understand differences in individuals' tradeoff behavior. In this way we can capture more variation in the systematic utility component [111].

1.1B	It is possible to prepare your traditional dish	1.1W
1.2B	You can save a lot of money per week	1.2W
1.3B	Your current health situation will not get worse	1.3W
1.4B	With this solar cooker, you can cook both inside and outside	1.4W

Figure 7. Example question set

Furthermore, there is still our third level, indicating that organizational variables also influence trade-off behavior. As explained, this third level is not part of the main research goal of this study as no related research questions are asked on these variables and we will not directly examine

the relationship between respondents' tradeoff behavior and organizational variables. However, given the fact that only limited published research is done concerning these variables, and given the fact that they do have an influence on preferences, it is important to identify them. In this way, we will also guide future research concerning organizational influences.

2.3.2.1. Socio-economic data: closed questions

In order to explain differences in trade-off behavior we include questions revealing socio-demographic data. For each respondent, independent of the fact whether he or she has a solar cooker or not, and independent of the fact whether he has already heard of solar cooking or not, we will ask the questions given in appendix 2.5. These questions concern general questions about:

- the number of people the respondent has to cook for (relevant for explaining the importance of the capacity attribute in our BWS questionnaire);
- the fuels the respondent uses, whether he or she collects wood, and the fuel and time spendings the respondent has (to explain the importance of time and cost savings);
- the education the respondent has had;
- the village the respondent lives in (telling us something about fuel scarcity and availability or frequent fuel supplies, and about the fact whether respondents already got a solar cooker, a solar cooking introduction or whether they never heard about solar cooking).

We consequently use an objective measurement for fuel scarcity in villages. We will obtain information of leaders in villages who can teach us about the frequency of fuel supplies in their village, and we will use own observations about the degree of deforestation in the direct neighborhood of the village. Ideally, we should measure respondents' perceived fuel scarcity, since it might for instance be that big households in areas without fuel scarcity, do experience fuel scarcity because it is simply hard to obtain the necessary fuels for such a big household size. However, if we would directly ask whether they believe there is fuel scarcity, we will most likely influence their answers and we consequently decided to stick to our observed fuel scarcity.

Furthermore, as we include a price attribute in our BWS experiment, it would be of added value to have a good measure of the respondent's living standard to test for possible correlations. Yet, while in developed countries, income is an appealing variable, this is less straightforward in developing countries [128]. Especially in rural areas, where income can be very irregular. Given the fact that we do a short-term study where we inquire only once about the respondent's situation, we have to take into account these possible seasonal income fluctuations. As we work with face-to-face interviews, it might also be confronting if we ask directly to the height of their income level. In addition, men are mostly responsible for the household income. Since we target mostly women for our questionnaire, bias can occur when women don't know the real income but still try to answer.

A better variable might consequently be consumption. First of all because in most cases, women go to the market and are responsible for household tasks. They are in the right place to tell how much they spend on consumption of food and fuels. Secondly Deaton and Zaidi [128] mention several advantages of consumption over income. Earlier studies showed that on the short-term, consumption is not largely affected when income fluctuates. Consumption is more stable, even if fluctuations like holidays and festivals are taken into account [128]. However, when using consumption, it should be noted that it is more difficult to compare different household sizes. Simply dividing consumption by the number of household members is not ideal because large households can have economies of scale in their consumption. Deaton and Zaidi [128] also point out that household members might have different needs. Men might for instance eat more than women and kids and when kids go to school they demand additional expenditures.

Given these difficulties, and given the subject of our study (cooking), we decided not to take income or consumption, but instead to rely on fuel expenditure as an economic measure. Households with higher fuel expenditure might be more attracted by the economic advantages of the solar cooker. Choosing for fuel expenditure is consequently justifiable. Yet, fuel expenditure is definitely not a good measure for the living standard of the household. In the regions where we do our research, not all fuels are always obtainable. Rich families, who are capable of using gas every day, might be forced to use 'lower' fuels when there is a gas shortage or when there is no gas.

2.3.2.2. Specific group characteristics: semi-structured questions

After the general socio-demographic questions, more specific questions, that will differ depending on the group targeted, will be asked. The questions are divided in optional questions that will be asked to as many respondents as possible – unless the respondent seems to be too tired or is less open or willing to answer-, and questions that will consistently be asked to all respondents belonging to one of the three groups. The questions are also semi-structured so that there is space for additional more deep diving questions and focus conversations, allowing a more thorough understanding of the background of the project and respondents, of the local culture, habits, religion, and other factors. For the semi-structured questions, we divide our sample in three groups: solar cooking users, non-solar cooking users that have already had an introduction in solar cooking, and non-solar cooking users that have never heard of solar cooking.

Firstly, there are the non-solar cooking users who have already had demonstrations and/or information sessions about solar cooking. We present them the questions from appendix 2.6 where we learn more about their perceived solar cooking benefits and inconveniences, their traditional way of cooking, the demonstrations given and the implementation of the project in the village.

Secondly, there are the uninformed non-solar cooking users. In order not to influence them, we will only elicit the general socio-demographic data that we ask to all our respondents. These general questions will confront them shortly to their traditional ways of cooking and warm them up sufficiently to our BWS experiment. Only leaders of the non-informed villages will be interviewed concerning more detailed questions about important factors to introduce a solar cooking project in their village (S1-S7 from appendix 2.6).

Finally, there are the solar cooking users. For these respondents, we cannot include a very important variable in our research. It is namely of high added value to make the link between preferences for solar cooking characteristics, and effective solar cooking usage. But a solar cooker is a non-fuel technology and fuel savings and usage can't be measured directly [129]. There is a lot of uncertainty in determining solar cooking use rates. Possible ways to measure usage of solar cookers are household surveys, questionnaires, observations and other traditional methods [36]. Yet, those methods are resource intensive, rely on respondent's memory [36], and might change respondent's behavior because they know they are part of a research. Unfortunately, in our research, relying on respondent's memory and honesty is the only option we have. We can't observe their usage since we go during the rainy season when solar cooking can't be done regularly. In this respect, question SC1 in appendix 2.7 tries to elicit solar cooking usage based on respondents' own answers. However, for future researches, a solution is on its way. Sensor-based tools combined with IT-technology can imply a huge progress in solar cooking monitoring studies. A specific solar cooking metering device, presented by Grupp et al (2009) [130], is the Synoptic Use Meter (SUM), that automatically monitors cooking time, cooking cycles and more. The meter indicates the quantity of food successfully cooked and calculates fuel savings and GHG emission reductions compared with the cooking technology that has been replaced by the solar cooker [130]. In appendix 2.7, other questions to be asked to solar cooker owners are presented. In this way we can learn more about their solar cooking experiences, the advantages and inconveniences they perceived, the organization of the project…

2.4. Data collection

Once we had our questionnaire, we could start the data collection. The fieldwork took place during the summer of 2012 (July-August). This is the rainy period in Senegal and consequently not appropriate to solar cook. In addition, during that period, the Ramadan takes place. This implies people didn't eat during the day, increasing fatigue of respondents. However, we anticipated fatigue when taking decisions concerning the development of our questionnaire. We now briefly discuss the sample size we took, and how we prepared respondents for the questionnaire.

2.4.1. Sample size

With respect to sample size, there is no good answer. Some researchers use very small samples (20 or 30 questionnaires) while other use very big samples of 1000 or more questionnaires. In our case, we wanted to compare four different groups, so we focused on a minimum number of questionnaires per group of respondents that we wanted to compare.

Kumar [131] summarizes in his book that a sample of 30 reduces the probability of missing a significant behavior or perception to less than 5% in case of random sampling. In addition the author refers to Sudman (1976) who suggests to use subgroups of 20 to 50 respondents in case the researcher wants to distinguish between different respondent groups. We opt for a number in between and choose for 30 respondents per subgroup. This is also justified by the fact that many statistics' handbooks use the value 30 as a rule of thumb. With 30 respondents, the sample is big enough to be reasonably sure that one can compare means without having to worry about assumptions in normal distributions. In addition that sample is small enough to be obtainable.

Concerning the total size of the sample, we consequently needed to make sure we have 30 respondents who have a solar cooker, 30 respondents who don't have a solar cooker but did have a demonstration, 30 respondents that have never heard about solar cooker, 30 respondents that live in an environment where fuel scarcity is high and finally 30 respondents from an environment where fuel scarcity is less critical. The exact villages we visited were determined on the field. This allowed us to select the villages that suit best the characteristics we needed in our sample.

2.4.2. Preparing the respondent for the interview

Since our respondent was not used to answer questionnaires like ours, we took the necessary time to introduce ourselves so that they felt more comfortable. In addition, all the interviews were done individually in the usual environment the respondent lives in (see Figure 8). We approached our respondents by saying we were students doing an independent research about solar cooking that has nothing to do with the Sol Suffit project. In this way, we hoped respondents would not try to influence us because they believed we are part of the project.

Then, we started the real interview. We first asked the socio-demographic questions, then continued with the semi-open questions and afterwards started the BWS experiment. For the BWS experiment, we first went through and explained all the different items in the BWS so that they were familiar with them and so that they would interpret them correctly. We explained how it worked, showed the questionnaire (the colors helped them understanding the fact they had to choose twice per question set) and gave them an example so they could practice. We gave the same example to all respondents in order not to influence them. In appendix 2.8 a standard introduction given about the BWS experiment is presented. Furthermore since the BWS experiment is done orally, each question set was repeated as many times as the respondent needed. In addition, we asked randomly to some respondents why he or she made a certain decision or choice. This let to additional insights. For the rest, we did not interact in the experiment. Only in case we realized a respondent was interpreting an attribute wrongly, we interacted to correct this.

Figure 8. Data collection

In general, we noted that respondents were very capable of answering the questions we asked. They could for instance state their fuel expenses and even their total consumption expenses almost immediately. This makes sense as most of our respondents were women who do the household as a full-time job. However, female respondents seemed reluctant to say how much they spend on fuels when their men was in the neighborhood of the interview. This explains why we don't have these data from a minority of our respondents. Concerning the best-worst scaling experiment, most of our respondents complained the questionnaire was way too long, even though we minimized the number of questions. Yet, except for that, most of them liked the questions. They liked being offered a choice and were very pleased that we came from so far just to listen to their opinion.

2.5. Analyzing BWS Results

Finally, before we start discussing the results, we explain how the data will be analyzed once we have collected them. Within Sawtooth, there are still several ways to approach our analysis. For our case study, a combination of methodologies, some already more advanced than other, is used to come to a conclusion concerning the importance of the different items and attributes. In addition, part of the analysis will be done with SPSS. We present the different analyses below.

2.5.1. Counting Analysis

The least advanced way is to use a sort of Counting Analysis. It simply counts how many times each item was picked as best and as worst, taking into account the number of times the item was displayed to the respondent. The results show the probability an item is chosen when it is displayed in a question set [96]. The higher the probability an item is chosen, the more impact this item has on using/buying the solar cooker [112]. This can result in some interesting insights. Yet, only if an experiment is perfectly balanced, the results will almost be similar to more advanced methods that estimate utilities. In our case, due to the prohibitions, we do not have a perfectly balanced design. For this reason, we present the results of the counting analysis only briefly as more "advanced" estimation techniques, where utilities for each individual are calculated, are needed. In addition, one should note that, even if we had a perfectly balanced experiment, the counts would be less accurate than the utilities [95].

2.5.2. HB estimation Average Scores

Since the Counting Analysis alone is not sufficient, we rely on a number of other methods as well. We start with an estimation of the average probability of choice for all the different items for the entire sample. For this, we use the Multinomial Logit Model estimated with the Hierarchical Bayes (HB) Estimation that the Sawtooth software uses [113]. The Multinomial Logit model assumes that the Best-Worst choices of the respondents are utility-maximizing decisions.

The HB modeling initially gives us raw utility scores that follow directly from the Multinomial Logit Analysis [132]. Concrete, HB estimation can borrow information from other respondents to calculate scores for another respondent [96]. The Sawtooth Software automatically zero-centers the parameters so that they are easier to interpret [113]. The multinomial logit weights can thus be positive and negative. Positive scores imply that those items are preferred to the threshold item (0). However, since these scores are on an interval scale [96], they make it more cumbersome to compare different items and we do not use them in this work. Instead, we look at the rescaled probability scores. These are on a scale from 0-100 and if for instance item A has a score of 2, and item B a score of 1, then item A is double as important as item B. This allows us to compare the items more easily with each other. Taking the zero-centered item scores, the raw weights are converted on a 0-100 point scale by using the following formula:

$$\frac{e^{U_i}}{e^{U_i} + a - 1}$$

where U_i is the zero-centered raw logit weight from item i and a is the number of items shown per set [112, 113]. Note that, while the rescaled Sawtooth output is very appealing for analysis, it still requires a subjective interpretation because we don't know what is a high and what is a low score. This depends of the number of attributes included in the experiment. To solve this, it is possible to make a second scale from 0-1500 because we have 15 attributes. Now 100 is always the average and we can objectively say whether respondents give more or less utility than the average to a certain level [133]. Yet, it should be remembered that in any case there is no easy way of understanding the absolute importance of an item and one should always interpret levels relatively [134]. We also don't know when utility becomes positive.

2.5.3. Aggregate Logit Analysis

Next to the HB Estimation, we also did an Aggregate Logit Analysis to estimate the Aggregate scores in a different way. Yet, for us, this approach didn't have a lot of value since the results are about the same as the normal Hierarchical Bayes Estimation. In this case it would only be of added value if HB estimations were not possible because respondents didn't see each item enough times [112]. As a result, we will not present or discuss these results.

2.5.4. Clustering of individual-level rescaled estimate scores

However, until now we only discussed analyses that provide us with average results that do not allow to distinguish between respondents. In order to be able to answer our research questions, we have to distinguish choice probabilities and utilities for different groups of respondents. We will again use HB modeling, but this time to estimate the Individual-Level Scores per respondent. HB here is very useful because our BWS questionnaire does not provide enough information to make item scores converge to one value for each individual. This is because each respondent is only presented to a limited number of question sets. HB borrows information from other respondents to estimate the respondents' scores and allows a stabilization of the scores for each individual [135]. Afterwards, these individual rescaled scores will be applied to a cluster procedure to make or compare different groups of respondents [95].

For the clustering method, we follow the two-stage clustering method of Punj and Stewart [136] and execute first a hierarchical and afterwards a nonhierarchical cluster analysis. The hierarchical clustering procedure is useful in identifying a set of preliminary cluster solutions. In this way potential outliers can be detected and a candidate number of clusters can be determined. Cluster centroids can be determined, serving as a nonrandom starting point for iterative nonhierarchical partitioning methods. Afterwards a cluster refinement by means of K-means will be used to find the optimal number of clusters.

As a hierarchical clustering procedure, we use Ward's Method, with the squared Euclidean distance as a similarity measure. Ward's method takes the sum of squares within the different clusters summed over all variables [137]. This implies that the result is more easily influenced by potential outliers. Therefore, it is important to look for these potential outliers. We have to determine the average dissimilarity of all the respondents by computing for each clustering variable the difference between the respondents value for this variable and the variable mean. Then all the differences are squared and summed per value. Finally the square root of this sum is taken and this is the dissimilarity per respondent. The higher the dissimilarity, the higher the possibility that that observation is an outlier. However, in any case respondent should not be deleted based on only one measure [137].

Next, we determine a range of clusters by looking at the agglomeration coefficient in the agglomeration schedule. If a huge proportional increase in heterogeneity between clusters can be found, it implies that heterogeneity between clusters and homogeneity within clusters increases when we take at least two clusters. In that case, it is better to take one extra cluster instead of keeping the entire sample as one group. To compare the latest clusters that are formed, we will calculate the percentage change in heterogeneity and present it on a scree plot. We will also take a closer view on the agglomeration schedule to further examine potential outliers.

Afterwards a nonhierarchical KMEANS clustering procedure is used to determine the most ideal, final cluster solution with a minimum of variance within the different clusters [137]. Once we have the clusters, we identify the main socio-demographic characteristics of the clusters by means of crosstabs in SPSS. Adjusted residuals will be used in addition to check for significant relationships. Furthermore, we also use Post-Hoc tests to examine how the different clusters give significant different utilities to certain solar cooking items. We also execute some discriminant analysis to see which variables discriminate the most between the different clusters. For the discriminant analysis it should be pointed out that when there is more than one significant discriminant function, the potency index has to be calculated. This is a relative measure over all the variables and it says something about the discriminating power of the variable [138]. The potency value of variable I on function j can be calculated by the following formula:

$$(Discriminant\ loading\ ij^2) * relative\ eigenvalue\ of\ function\ j$$

Afterwards, the composite potency value of the entire variable i can be calculated by taking the sum of all potency values of variable i across all significant discriminant functions [138].

In addition, we maintain the possibility to form our own groups to examine something in case the cluster analysis itself does not reveal what we are aiming for.

Finally, we also attempt to distinguish between different clusters by looking at importance scores of entire attributes. Up till now, we only discussed the analysis of attribute levels. For comparison, we also subject our cluster analysis to a discriminant analysis based on the importance scores of the different attributes. Importance scores of entire attributes can be calculated with the standalone Sawtooth CBC/HB software which we don’t have. All attributes would be calculated with respect to one reference item that the software initially constrains to have a utility of zero [112]. Fortunately, according to Sawtooth Software [139], for conjoint analysis, the relative attribute importance can be calculated by taking the difference in the range of the attribute’s utilities and then calculating the percentages from relative ranges. Yet, since the ranges between our attribute levels within one attribute are naturally already different from each other, attributes with bigger ranges get a higher relative importance, even if in reality the respondent gives a higher importance to another attribute. As a result, calculations of the attribute utilities are less meaningful since the results are highly influenced by our previous choice of attribute levels. Advantages of the solar cooker, who have a naturally smaller range, can never get a high relative attribute importance. However, we can use the importance of different attributes for comparison between the different clusters to see whether the ranking of the attributes is different for the three clusters. To do this we calculate per respondent, all the relative importances and subjected them to a discriminant analysis in SPSS.

2.5.5. Latent Class

However, a possibly better way than clustering HB calculated scores, is using Latent Class to find subgroups with different preferences (or segment respondents with similar utilities), while in mean time estimating the part worth utilities for the different segments of respondents. Many authors recommend Latent Class instead of a normal clustering of HB calculated scores [95, 101, 125, 140]. The difference with a normal cluster analysis is that there is no assignment of respondents to certain groups [99]. Instead, probabilities of belonging to each different group are calculated. If the solution fits that data very well, then probabilities converge to either 0 or 1 [140]. More concrete, the Latent Class estimation process implies firstly determining random estimates of each group's utility values. It initially starts with random numbers as respondents utilities. Then one estimates the relative probability that a respondent will be assigned to a certain group. Finally, the respondent will be assigned to the group with the highest probability and the utility/weight for each group is calculated again. Since the Latent Class criterion uses a maximum likelihood criterion, each time the log-likelihood over all groups is calculated. This log-likelihood increases with each iteration and the process is iterated until the log likelihood does not improve with a substantial amount anymore [99, 140]. Optimally, the Log Likelihood is 0. The Latent Class technique generates more accurate cluster solutions and it provides in addition a less arbitrary and statistically more correct segmentation criterion [101]. Also when data are sparse, Latent Class is very useful [135].

In this work, we will utilize the built-in Latent Class estimation routine for MaxDiff within SSI/Web. This allows us to calculate Latent Class group utilities and discover respondent segments in one time. Yet, information about significance of differences between the item means of the different segments is missing within the software, which makes it impossible to see which items differ significantly between the different Latent Class groups. As a result, we will not discuss our Latent Class results in detail but use the Latent Class groups to compare them with the previous Cluster solution.

2.5.6 ME>XL

Finally, we also executed a similar analysis in ME>XL. This software allows for latent class clustering based on the founded part worths calculated by Sawtooth HB Modeling. However, before we start the ME>XL analysis, it should be noted that our solar cooking items are highly correlated. This requires for some statistical programs to firstly execute a factor analysis. For SPSS this is not necessary but in case of ME>XL we do have to start with a factor analysis. Afterwards, we do a non-hierarchical KMEANS analysis. In this way, we go after the most optimal solution with a minimum within group variation. We add this analysis to indicate that potentially more clusters were possible than we initially used for our cluster analysis.

3. Analysis

3.1. Sample characteristics

We frequented a total of eight villages with varying characteristics, allowing us to cover as much variation as possible. In Table 4 a summary with the main characteristics of all the villages is given. For clarity, we describe the characteristics below.

Table 4. Sample characteristics

		# Respond-ents	Solar cooker	Fuel scarcity	Higher living standards	Moor	Mostly buying wood
LANGUE BARBARIE	**Rimbahk**	9	Never heard of				√
	Darau Salam	10	Never heard of	√		√	√
	Mbao	14	Never heard of	√√√			Collecting
	Mouit	30	Demonstrations		√		√
DJOUDJ	**Rone**	15	√		√	√	√
	Diadiam 3	15	√	√			Collecting
	Tiguèt	18	√	√√√			√
	Débi	15	√	√√√			√

The first column tells how many respondents in each village have been interviewed. As can be seen, we have 33 respondents who have never heard about solar cooking, 30 who only had a solar cooking demonstration, 33 who live in very fuel scarce regions, and 63 who have a solar cooker. We consequently have the required minimum respondents per subgroup of respondents.

In the second column, it can be seen we included four villages where people already had a solar cooker (the Djoudj region: Rone, Diadiam 3, Tiguèt, and Debi) and four villages where people did not yet have a solar cooker (the Langue Barbarie region: Mouit, Rimbahk, Darau Salam, and Mbao). The second column also tells whether the non-solar cooking villages already had a solar cooking demonstration (Mouit) or whether they haven't heard of solar cooking yet (Rimbahk, Darau Salam and Mbao). As explained, we asked solar cooker owners whether they used their solar cooker frequently, and most respondents told us they used the solar cooker each time the sun was shining. Yet, after some deep diving questions it became sometimes clear that the person did not always know how to use the solar cooker or that he or she had specific reasons not to use the solar cooker. We noted that Troncoso et al (2011) [37] also noted that respondents didn't always say the truth or that respondents just said what they believed the interviewer wanted to hear. As a result, we can't use their answers on the question whether they used the solar cooker. We can only objectively divide them in one of the three groups but can't elicit usage heterogeneity in the group.

The third column shows which villages face total deforestation (meaning that there is no single tree left around the village such as in the left picture in Figure 9) or not. Debi and Tiguèt face total deforestation and suffer from the high fuel scarcity. They even burn plastic to have energy to prepare their food. Mbao also faces high fuel scarcity, yet this is caused by the fact that the village is very remote and that supply of fuels such as charcoal or gas is rare. They consequently have to collect wood which becomes harder and harder. Villages Darau Salam and Diadiam 3 also face fuel scarcity but visibly less. The other villages realize they have to change their unsustained wood usage but live in the least fuel scarce environments (the right picture in Figure 9).

Figure 9. A totally deforested village and a village with low fuel scarcity

Then there is the fourth column. Two villages in our sample were used to more "luxury" than the other villages. In Mouit, most people had electricity and some of them even had a television. The village also had access to water. Rone is another village that is used to more luxury. Yet, this was in the sense that the village was very organized, with no garbage spread around and more houses from stone. In the other villages, people lived in small sheds, spread randomly over the village.

In the fifth column, we indicate the ethnicity of the villages. We included only two ethnicities in our sample. There are two Moor villages and all the rest is Wolof. It would have been more ideal to have had more Moor respondents, but we didn't manage to reach them. One characteristic that makes Moor villages unique is the fact that Moor people like to have more comfort and discretion than other people. This implies that the solar cooker has a big inconvenience for them since they have to cook in more open areas where there is sun and where everybody can see them.

In addition, we made sure we had a sample where respondents used different fuels (such as gas, charcoal, wood). Two villages in the sample even mostly collected wood instead of buying fuels (Mbao and Diadiam 3). This can be derived from the final column. A more detailed description about fuel usage in our sample can be found back in Table 5.

In total, 126 respondents answered the BWS experiment and with the majority of these respondents we had some additional discussions concerning our semi-structured questions. Moreover, about twenty additional people, such as local school teachers, eco-guards, leaders of local women groups, husbands of respondents interviewed, Imams, solar cooking responsibles and chefs of the villages, were interviewed to elicit additional information.

Table 5. Main fuels used by respondents in the different villages

		Collected wood	Bought wood	Charcoal	Gas	Solar cooker
Village	**Darau Salam**	10%	100%	0%	40%	0%
	Mbao	93%	36%	0%	14%	0%
	Mouit	14%	72%	10%	48%	0%
	Rimbahk	33%	100%	0%	0%	0%
	Deby	0%	87%	40%	33%	100%
	Diadiam 3	87%	13%	53%	27%	100%
	Rone	100%	0%	73%	80%	100%
	Tiguètte	17%	72%	28%	28%	100%

3.2. Analysis BWS experiment

In what follows, we start analyzing the BWS data as described in section 2.5. The third and the fourth column of Table 6 contain the counting analysis, indicating how many times each item was picked as best and as worst while taking into account the number of times the item was shown to the respondent. When an item is picked multiple times, it probably has a high impact on the decision the respondents take. The table shows that the item chosen most of all items is the maximum capacity of 4-5 persons. The fact that there is that much consistency in the answers, proves it is of high concern for the respondent. Yet, note that it is chosen as worst, implying it has a negative impact on the utility a solar cooker with this characteristic gives to the respondent. This is in line with Table 7 where respondents before the BWS experiment started indicated that the low capacity was an inconvenience of the solar cooker. However, when looking at the maximum 8-10 persons capacity item, we notice there is significantly less consistency in the answers respondents provide. From all the items, the best frequency of this item resembles the worst frequency the most. Respondents opinion consequently seems to be divided.

Secondly, items related to "health" are also important. The table shows that an improvement of respondent's health condition is chosen about 70% of the times as best. Yet, this is in contradiction with Table 7 where respondents only rarely indicated health as a motivation to use or buy the solar cooker. Furthermore, respondents also agree on the fact that 30000 and 50000 CFA for a solar cooker is too expensive.

Yet, best-worst scaling is about considering the differences in utilities between items and the best and worst frequencies have to be interpreted simultaneously. It is therefore necessary to further look at the utilities of the different items. This can also be found back in Table 6. We look for interpretation purposes only at the last column, containing the rescaled scores. Column five, contains the by Sawtooth automatically zero-centered scores. Positive scores imply that those items are preferred to the threshold 0 item. However, these scores are not on an interval scale, while rescaled scores are. The rescaled scores are on a scale from 0-100 and an item with a score of 2 gets double as much utility as an item with a score of 1. We consequently can see that health

Table 6. Average Best-Worst Scaling results

Item	Final Ranking	Best-Worst Counted		Best-Worst Weighted	
		Best Frequency	Worst Frequency	Raw Scores	Rescaled scores (1-100)
Health condition improves	1	0.7056	0.0025	4.3768	14.4444
Health condition not worse	2	0.6650	0.0051	3.7694	14.0033
Both indoor and outdoor	3	0.5550	0.0205	3.5624	13.5981
A lot of money savings	4	0.3959	0.0076	2.5718	12.0086
A little bit of money savings	5	0.3706	0.0025	2.3865	11.5802
Traditional dish possible	6	0.3053	0.1298	1.6038	8.9596
Max capacity 8-10 persons	7	0.3520	0.2526	1.2070	8.1953
A lot of time savings	8	0.1497	0.0457	1.1069	7.6762
A little bit of time savings	9	0.1511	0.0522	0.8526	6.8802
Price is 10000 CFA	10	0.0178	0.3969	-1.8993	1.1480
Only outdoor cooking	11	0.0178	0.3020	-1.9827	0.8298
Traditional dish not possible	12	0.0026	0.4808	-3.5438	0.2329
Max capacity 4-5 persons	13	0.0127	0.7386	-5.3413	0.1684
Price is 50000 CFA	14	0.0000	0.6915	-4.3905	0.1523
Price is 30000 CFA	15	0.0028	0.6749	-4.2795	0.1226

Table 7. Advantages and inconveniences cited by respondents before the BWS experiment

	Advantages			Inconveniences					
	Less tired-some	Eco-nomic	Health	No	Sun expo-sure	Weather depen-dence	Capa-city	Slow	Slow but I am patient
Deby	20%	53%	20%	0%	0%	80%	93%	60%	13%
Tiguètte	22%	83%	11%	0%	6%	61%	67%	22%	11%
Diadiam 3	40%	60%	20%	0%	13%	67%	67%	47%	13%
Rone	60%	67%	40%	0%	20%	47%	73%	20%	33%
Mouit	28%	79%	31%	21%	3%	28%	31%	7%	0%

items get the highest utility. This is such as expected from the counting analysis. After health items, the possibility to cook inside gets the most utility. This is a characteristic of respondents' traditional cookstoves that they can place wherever they want. At the fourth and the fifth place, money or fuel savings are placed as giving the most utility. This is good since it means that respondents highly value this solar cooking benefit. At the sixth place, users value the possibility to prepare their traditional dish.

However, as the counting analysis indicated that not all respondents agreed on the importance of some items, it is more meaningful to further discuss the results on individual-level by making more homogenous clusters. Yet, before we can discuss these clusters, we need to check whether there are outliers in our sample, and we need to determine the number of clusters.

3.2.1. Outliers and cluster determination

We determined the utilities per respondent as explained in section 2.5. Then we subject the rescaled individual-level scores to a cluster analysis as described. We firstly determine the dissimilarities of all 126 respondents to identify potential outliers and a fairly wide range of dissimilarities is found back: [2,40 - 22,16]. In addition the dissimilarities are quite high. This makes it hard to say that the dissimilarity of one respondent is significantly higher than the dissimilarity of another respondent and we don't have enough evidence to delete respondents as outliers. Yet, for convenience, appendix 3.1 represents the top 10 dissimilarities in case they would cause trouble in further analyses.

Next, we determine a range of clusters. When looking at the agglomeration coefficient in the agglomeration schedule (appendix 3.3), we notice a huge proportional increase in heterogeneity between clusters when going from 1 to 2 clusters (appendix 3.2). This means that heterogeneity between clusters and homogeneity within clusters increases when we take at least two clusters. It is thus better to take at least two clusters instead of keeping the entire sample as one group. To compare the ten clusters who were formed the latest, we calculated the percentage change in heterogeneity. In appendix 3.2, this percentage change and the corresponding scree plot is presented. Yet, it doesn't give us a clear idea of the number of clusters that should be taken.

Furthermore, in order to further identify potential outliers, we took a closer view on the agglomeration schedule (appendix 3.3). We found out that observation 3 is only combined for the first time with another cluster in the 102th iteration. This is fairly late. In a yet later iteration, iteration 112, observation 1 is added for the first time to cluster 3 and finally in iteration 115 observation 2 is added to this cluster as well. Note that we already found these observations 1, 2 and 3 to be in the top 5 of potentially biggest outliers. It now really seems that we have some outliers or an underrepresented group in our dataset.

When making 2 clusters, SPSS creates two groups of respectively 4 and 122 respondents. The group of 4 contains observations 1, 2 and 3. When making 3 clusters, SPSS creates 3 groups of respectively 3, 39 and 73 respondents. Again, the group of 3 respondents consists of the same observations as before. When making 4 clusters, SPSS creates 4 groups of 5, 3, 49 and 69 respondents. Again cluster 2 only includes observations 1, 2 and 3. When using crosstabs we do not see a lot of communalities between respondents 1, 2 and 3. They do come from the same village, but that is probably the only thing they have in common. As a result, we don't believe they present an underrepresented group and we are convinced we have sufficient evidence that they should be deleted. After deleting respondents, we re-ran our scores in Sawtooth. This is necessary because since all values are on the same scale, deleting respondents who differ a lot from the average, might influence our results on this scale significantly.

Then we restarted our analysis and decided to delete an additional two respondents (respondent 132 and 102). These respondents immediately formed a cluster together but had the interesting similarity that both respondents were indicated by us as "fanatic solar cooker users". As explained, we did not have an objective way of measuring respondents solar cooking usage. Yet, in some cases our open questions brought a lot of clarity. We didn't find a lot of people who used the solar cooker for 100% and respondents 132 and 102 are probably an underrepresented group. We come back to this in section 4 during the further discussion of the results. For now, we continue our research with a database of 121 respondents instead of 126. We continue with nonhierarchical KMEANS clustering. By observing the clusters in more detail, we can take more informed decisions about the number of clusters needed.

We create a two, three and four cluster solution but in the end we opt for the three-cluster solution. The two-cluster solution is already quite good and we could see clear patterns appearing. However, the size of the clusters is still 71 and 50 respondents and there was space left to make an additional cluster. What concerns the four-cluster solution, we face the issue that we 'only' have 121 respondents. As a result, when we attempt to make four clusters, we see it is much more difficult to distinguish between the four clusters and the practical relevance of creating four (or more) clusters is very low. Therefore we chose for the three-cluster solution which we detail in what follows. However, this choice does not mean there are not more clusters possible. The sample is simply not big enough to make meaningful clusters based on visually distinguishable characteristics (socio-demographic characteristics). After our Latent Class analysis, we will shortly represent a six cluster analysis to demonstrate that there are probably more groups hidden in our data.

3.2.2 Cluster analysis

Finally, we can have a look at the three-cluster results. These will help us formulating an answer to our research questions. We start with sub-research questions 1 and 2. The item cluster centers and the ranking of the different items per cluster are presented in Table 8. Table 9 indicates where these cluster centers differ significantly from one another. The test of homogeneity of variances that determines which test to use in Table 9, can be found back in appendix 3.4.

All clusters value an improvement in health condition the most, indicating the role health benefits can play in solar cooking disseminating projects. Apart from that, there are some clear differences between the clusters. First of all we come back to our remark about the highest capacity level which only seemed to have an average utility for the entire sample, even though it was mentioned numerously by our respondents in Table 7. It appears that cluster 3 places the maximum capacity of 8-10 persons at the fourth highest place, giving almost nine times as much utility to it than cluster 1 who places it only at a ninth place. Cluster 2 as well places the item only at the ninth place although it gives significantly more utility to it than cluster 1. In addition, it is noted that, when looking at the maximum 4-5 persons capacity level, cluster 1 places the item on the lowest level. This indicates that cluster 1 is less averse buying an expensive solar cooker instead of buying a solar cooker with a low capacity. Furthermore, as explained, the rescaled scores are not helpful in seeing which scores are high and which scores are low. We therefore calculated a second scale from 0-1500. This means that 100 is the average per scale. We now can objectively say that respondents from cluster 1 are the only ones in our sample to whom the maximum 8-10 persons capacity gives a utility lower than the average utility cluster 1 gives (all items in orange in Table 8 are below the average utility of that cluster). As a conclusion, cluster 1 receives a very low utility from both capacity levels. Hopefully socio-demographic variables will tell us how this comes.

Table 8. Cluster centers of the three clusters on a scale from 0-100

	Cluster 1		Cluster 2		Cluster 3	
Health condition improves	1	15.6599	1	13.4419	1	13.7288
Health condition not worse	2	15.3872	2	12.7622	3	13.2687
Both indoor and outdoor	3	14.1048	4	11.4570	2	13.5605
A lot of money savings	4	13.5142	7	9.37373	5	11.5064
A little bit of money savings	5	13.4329	8	8.47944	6	11.2387
Traditional dish possible	6	9.04534	3	12.3426	8	8.16617
A little bit of time savings	7	8.13862	6	9.44484	9	5.35112
A lot of time savings	8	6.21673	5	10.1927	7	8.53656
Max capacity 8-10 persons	9	1.48561	9	6.99768	4	12.8199
Price is 10000 CFA	10	1.23653	10	2.34049	11	0.62784
Only outdoor cooking	11	0.98575	11	1.45729	10	0.67918
Traditional dish not possible	12	0.27474	15	0.12111	12	0.19258
Price is 50000 CFA	13	0.24893	14	0.18421	14	0.11607
Price is 30000 CFA	14	0.23362	13	0.33307	15	0.07547
Max capacity 4-5 persons	15	0.03492	12	1.07173	13	0.13204

Table 9. Posthoc test cluster centers

		Cluster number of case		Mean Difference
Dependent Variable		**(i)**	**(j)**	**(i-j)**
Price is 10000 CFA	Dunnett C	1	2	-0.71334
			3	**0.67005**
		2	3	**1.3834**
Price is 30000 CFA	Dunnett C	1	2	0.02102
			3	**0.10059**
		2	3	**0.07956**
Price is 50000 CFA	Tukey HSD	1	2	0.08489
			3	0.09299
		2	3	0.0081
A little bit of time savings	Dunnett C	1	2	-0.39459
			3	**2.80664**
		2	3	**3.20123**
A lot of time savings	Tukey HSD	1	2	**-3.9182**
			3	**-1.83846**
		2	3	**2.07974**
A little bit of money savings	Tukey HSD	1	2	**4.70237**
			3	**1.88111**
		2	3	**-2.82126**
A lot of money savings	Tukey HSD	1	2	**4.09094**
			3	**1.80352**
		2	3	**-2.28742**
Health condition not worse	Dunnett C	1	2	**2.86032**
			3	**1.97988**

		2	3	-0.88044
Health condition improves	Dunnett C	1	2	**2.70108**
			3	**1.68911**
		2	3	-1.01198
Traditional dish not possible	Dunnett C	1	2	**0.20994**
			3	0.05647
		2	3	-0.15347
Traditional dish possible	Dunnett C	1	2	**-3.93495**
			3	1.59995
		2	3	**5.53491**
Max capacity 4-5 persons	Dunnett C	1	2	-0.6167
			3	-0.0779
		2	3	0.5388
Max capacity 8-10 persons	Dunnett C	1	2	**-7.12429**
			3	**-11.32262**
		2	3	**-4.19833**
Only outside	Dunnett C	1	2	-0.25635
			3	**0.32341**
		2	3	**0.57976**
Both inside and outside	Dunnett C	1	2	**2.28785**
			3	0.23526
		2	3	**-2.05259**

(The mean difference is significant at the 0.05 level)

On the other hand, while cluster 1 and 3 differ significantly with respect to the capacity items, cluster 1 and cluster 3 highly resemble each other in the sense that they strongly prefer cooking inside. They also highly value cost savings although cluster 1 still gives significantly more utility to it than cluster 3. Cluster 2 on the other hand gives more attention to the possibility of cooking their traditional dish and time savings. Cluster 2 even places the impossibility of preparing their traditional dish at the place with the lowest utility. They consequently would consequently rather choose for an expensive solar cooker that can prepare their national dish, than for a solar cooker that cannot prepare their national dish. In this respect, we also see that cluster 3 is more averse paying for the solar cooker than the other clusters. In a brief summary, the following points became clear from the significant differences in cluster centers of the three clusters:

To keep in mind:

- Cluster 1 receives a very low utility from all capacity level
- Cluster 1 and 3 highly value cooking inside
- Cluster 1 gives significantly more utility to cost-savings
- Cluster 2 gives significantly more utility to time-savings
- Cluster 2 gives significantly more utility to the possibility of preparing the traditional dish
- Cluster 3 seems more averse paying for the solar cooker than the other clusters

We now examine whether these facts can be explained by second-level variables. Taking a look at the socio-demographic variables in Table 10, we see the Pearson chi-square value indicates that some of our socio-demographic variables (number of people to cook for, fuel expenses, whether wood is collected or bought, whether the respondent has solar cooking experience, the village the respondent comes from, ethnicity and luxury, and whether he faces fuel scarcity) can explain the differences in preferences we briefly discussed. We summarize in Table 11 the most distinguishing characteristics of the different clusters. The variable age is not used in the analysis as respondents sometimes increased their age for different reasons, or because not everyone knew their age.

Table 10. Socio-demographic variables

	Pearson Chi-	**Significance**
Age	Not included because of biases in answers	
Number of people to cook for (=<10, >10)	**22.994**	**0.0000**
Education	5.087	0.8850
Type of fuels used		
Collected wood	**11.296**	**0.0040**
Bought wood	**11.239**	**0.0040**
Charcoal	0.297	0.8620
Gas	0.699	0.7050
Fuel expenses (<10000, <20000, <30000, >30000)	**24.687**	**0.0000**
Having heard of solar cooking (Yes, Yes and has a solar cooker, No)	**10.075**	**0.0390**
Moor or higher standard village (Yes, No)	**12,632**	**0.0020**
Village	**45.704**	**0.0000**
Fuel scarcity (least, more, a lot)	**17.216**	**0.0020**

Table 11. Main socio-demographic characteristics of the cluster

		Fuel scarcity	**# persons to cook for**	**Wood**	**Fuel exp**	**Solar Cooking Experience**	**Moor or higher standard village**
Clus 1	**Variable**	**A lot**	**>10**	**Buying**	**<10000**	**Has SC**	**No**
43 resp	Count	20	32	33	5	24	26
	% in clus	46.51%	74.40%	76.70%	14.30%	55.80%	60,5%
	Adj Res	1.43	3.9	3.1	-4.2	0.9	0,4
Clus 2	**Variable**	**A lot**	**>10**	**Collecting**	**<10000**	**Not heard**	**No**
20 resp	Count	13	13	14	11	9	18
	% in clus	65%	65%	70%	64.70%	45%	90%
	Adj Res	2.72	1.4	2.8	2	2.4	3,2
Clus 3	**Variable**	**Least**	**=<10**	**Buying**	**<10000**	**Has SC**	**Yes**
58 resp	Count	33	41	30	29	27	32
	% in clus	56.90%	71.90%	52.60%	55.80%	46.60%	55,2%
	Adj Res	3.34	4.7	-1.2	2.6	-0.8	2,8

As can be seen, the socio-demographic characteristics can describe the three clusters very well:

- Cluster 1 represents people that suffer the most from fuel scarcity. This is mostly caused by the fact that over 74% of the respondents in this cluster have to cook for a lot of people – making it necessary to find more fuels. Furthermore, respondents in this cluster live in an environment where free fuels are less available. This can be derived from the fact that 76,70% of the respondents buy wood, indicating that collecting is not possible or forbidden in the village. 46,51% of the respondents also live in a fuel scarce environment but this variable is, as can be seen by looking at the adjusted residual, not significant for this cluster. Note that these factors also explain the fact that less than 15% of the respondents has a monthly fuel expenditure under 10000 CFA. More than 50% of the respondents need more than 20000 CFA a month to buy fuels.

- Cluster 2 is the smallest cluster and contains the most people who have never heard about solar cooking. This is partly explained by the fact that most respondents come from very remote villages. A majority of them lives in a very traditional and inexpensive way by collecting free wood. 70% of the respondents collects wood and 40% even only collects wood without combining it with other fuels. Only 35% of the respondents buys wood. As a result almost 65% of the respondents need less than 10000 CFA for their monthly fuel expenses. However, it seems that this traditional way of living puts pressure on their local environment as 65% of the respondents in this cluster come from a very fuel scarce region.

- Cluster 3 represents respondents who feel fuel scarcity the least. 72% of the respondents have to prepare dinner for less than 10 persons and they consequently have lower fuel costs. In addition, it should be noted that this cluster contains 60% of the respondents of Darau Salam, 71,43% of the respondents from Rone, and almost 60% of the respondents from Mouit. Darau Salam and Rone are the only Moor villages in the sample and contain almost 30% of cluster 3. Mouit and Rone are the villages with the most luxury (e.g. electricity, TV, less garbage in the village), corresponding together for almost 35% of the sample. In total 55,2% of the respondents in cluster 3 come from "higher" standard or Moor villages.

Given these clear socio-demographic differences between the clusters, we now understand part of the differences in preferences between the clusters as well. Since cluster 2 contains respondents who mostly collect wood, it makes sense that they value time savings higher than cluster 1 and 3. Furthermore, people from cluster 2 also seem to stick more to traditional habits such as the possibility of cooking their traditional dish. This can be explained by the fact that they come from very poor or remote villages (Diadiam 3 and Mbao), and/or by the fact that 45% of the respondents hasn't heard about solar cooking. It consequently seems that they are still rather inflexible towards solar cooking.

In addition, we now understand why respondents from cluster 1 give such low utilities to both capacity items. The capacity of the solar cookers is way too low for them. Furthermore, given the fact that they have difficulties gathering fuels and given the fact they have high fuel costs, it is clear why they value money savings higher than cluster 3. Considering their context, the cookstove decision seems more serious and important for them. Yet, having said this, it seems illogic that they value cooking inside higher than money savings. Cluster 3 as well highly valued the cooking inside item, but had a clear reason for it. People here come from Moor villages and/or villages that are used to more luxury. Moor people highly value privacy, discretion, and comfort. They consequently didn't like to cook outside because then everybody would see them. People from more luxury villages wanted to cook inside because they saw it as a sign of modernization and development: "You white people also only cook inside, except when you barbeque." Furthermore, respondents in this cluster also wanted a solar cooker because it is less tiresome: "You don't have to make a fire", "You don't have to fan the fire", "You don't have to look for matches", "You don't have to stir a lot and you can stay in the shadow, looking at your solar cooker"… Cluster 3 consequently can be seen as a cluster who likes the solar cooker because of its "status" and comfort, or who don't like the solar cooker because it doesn't give enough comfort (e.g. you have to adapt yourself and you can't cook inside). This is in contradiction with cluster 1 that values the solar cooker more for its status as "an alternative" fuel that can help them in saving fuels.

However, even though the variable solar cooking experience is significant in explaining differences between clusters, it is not entirely clear how they differ exactly in their preferences. It is also not clear whether there is a difference between people who only had a demonstration and people who have never heard about solar cooking. We therefore segment our respondents manually: once based on the fact whether they have or have not a solar cooker, and once based on the fact whether they have had a solar cooking demonstration or whether they don't.

An ANOVA test (Table 12) teaches us that people who don't have a solar cooker value advantages of the solar cooker (time and money savings), significantly higher than people who already have a solar cooker. Furthermore, we also see that people who do not yet have a solar cooker are more averse to paying for the solar cooker. Note that in the table, only significant values are presented.

Concerning the possible difference between non-solar cooker owners who already had a demonstration and non-solar cooker owners who never heard about solar cooking, we see that an ANOVA test (Table 13) again finds significant differences between the two groups. Respondents who had had a demonstration gave more utility to money savings than respondents who hadn't had a demonstration, but they gave less utility to time savings than respondents who hadn't heard about solar cooking. Yet, these differences are related to the fact that in our sample, people who never heard of solar cooking by coincidence collected more wood. Explaining why they value time savings high and money savings lower. Consequently, based on our sample, we can't really conclude whether there is a difference in tradeoff behavior between respondents who had had a demonstration and respondents who didn't have a demonstration.

Concerning the third sub-research question, we used a discriminant analysis that teaches us which items and variables discriminated best between the initial three clusters. The results are presented in Table 14 and Table 15. From the items, a maximum capacity of 8-10 persons can distinguish best between respondents, followed by a little bit of money savings. From the socio-demographic variables, fuel expenditures, the number of people to cook for, fuel scarcity, the fact whether respondents bought wood and whether the respondent came from a Moor or higher standard village, were the most discriminating variables.

Table 12. ANOVA test preferences solar cooker owners versus non-solar cooker owners

	Cluster (1 = no solar cooker, 2 = solar cooker)	Mean	Significance
Price is 10000 CFA	1	0,839161	**0,006**
	2	1,451805	
Price is 50000 CFA	1	0,073533	**0,003**
	2	0,229798	
A little bit of time savings	1	7,541269	**0,005**
	2	6,22989	
A lot of time savings	1	8,193647	**0,021**
	2	7,167155	
A little bit of money savings	1	12,0977	**0,016**
	2	11,07128	
A lot of money savings	1	12,45113	**0,031**
	2	11,57335	
Traditional dish not possible	1	0,328582	**0,000**
	2	0,138762	
Traditional dish possible	1	7,238468	**0,000**
	2	10,65262	

Table 13. ANOVA test differences demonstration versus never heard of solar cooking

	Cluster (1 = had a demonstration, 2 = didn't have a demonstration)	Mean	Significance
A lot of time savings	1	7,220785	**0,001**
	2	8,989624	
A little bit of money savings	1	12,9482	**0,008**
	2	11,40184	
A lot of money savings	1	13,29356	**0,005**
	2	11,76186	
Health condition not worse	1	14,68552	**0,014**
	2	13,57402	
Health condition improves	1	15,09569	**0,001**
	2	13,75837	
Traditional dish possible	1	5,459975	**0,002**
	2	8,6936	
Both inside and outside	1	14,02103	**0,017**
	2	12,62358	

Table 14. Discriminant analysis based on item utilities

Attribute importance	**Discriminant function 1**	**Discriminant function 2**	**Potency value of variable function 1**	**Potency value of variable function 2**	**Composite potency of variable**
Max capacity 8-10 persons	**0,8970**	-0,2043	0,5922	0,0110	0,6032
A little bit of money savings	-0,2797	**-0,5070**	0,0576	0,0679	0,1255
Health condition not worse	**-0,3470**	-0,2724	0,0886	0,0196	0,1082
Health condition improves	**-0,3180**	-0,3032	0,0744	0,0243	0,0987
A lot of money savings	-0,2576	**-0,4140**	0,0488	0,0452	0,0941
A little bit of time savings	-0,2309	**0,3330**	0,0393	0,0293	0,0685
A lot of time savings	0,2218	**0,3290**	0,0362	0,0286	0,0648
Traditional dish possible	-0,0479	**0,3940**	0,0017	0,0410	0,0427
Price is 10000 CFA	-0,0884	**0,3000**	0,0058	0,0238	0,0295
Only outdoor cooking	-0,1034	**0,2840**	0,0079	0,0213	0,0292
Both indoor and outdoor	-0,0609	**-0,3140**	0,0027	0,0260	0,0288
Traditional dish not possible	-0,0846	**-0,2300**	0,0053	0,0140	0,0192
Price is 30000 CFA	**-0,1130**	0,0962	0,0094	0,0024	0,0118
Max capacity 4-5 persons	0,0333	**0,1550**	0,0008	0,0063	0,0072
Price is 50000 CFA	**-0,0680**	-0,0104	0,0034	0,0000	0,0034

- Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions
- **Largest absolute correlation between each variable and any discriminant function**
- Each discriminant loading was weighted by respectively 73,6% and 26,4% for discriminant function 1 and 2

Table 15. Discriminant analysis based on socio-demographic variables

Attribute importance	**Discriminant function 1**	**Discriminant function 2**	**Potency value of variable function 1**	**Potency value of variable function 2**	**Composite potency of variable**
Fuel expenses	**0,6360**	0,4721	0,2229	0,1001	0,3230
# people to cook for	-0,5810	**0,2214**	0,1860	0,0220	0,2080
Fuel scarcity	0,4284	**-0,4810**	0,1011	0,1039	0,2050
Uses bought wood	0,3430	**0,4300**	0,0648	0,0830	0,1479
Moor or higher stand	-0,2623	**0,4170**	0,0379	0,0781	0,1160
Uses collected wood	**-0,1462**	-0,3890	0,0118	0,0679	0,0797
SC experience	0,0093	**0,2560**	0,0000	0,0294	0,0295
Education	0,1500	**-0,1425**	0,0124	0,0091	0,0215
Uses gas	**-0,1900**	-0,0390	0,0199	0,0007	0,0206
Uses charcoal	-0,1245	**0,1530**	0,0085	0,0105	0,0191

- Each discriminant loading was weighted by respectively 55,1% and 44,9% for discriminant function 1 and 2

3.2.3 Differences in attribute importance between clusters

Even though we have all the information to formulate the answers to our research questions, it is worthwhile to discuss some additional features. We start in this section by discussing attribute importances, then we continue with section 3.2.4 where we briefly discuss a latent class clustering and we end with section 3.2.5 where we execute a ME>XL segmentation analysis.

Up till now, we only analyzed item or attribute level utilities. For comparison, we also subject our previous three-cluster analysis to a discriminant analysis based on the importance scores of the different attributes. As explained, simply calculating the attribute importance of the different items is less meaningful for us since the ranges between our attribute levels within one attribute are naturally already different from each other. Attributes with bigger ranges (such as capacity, traditional dish and the place where they have to cook) will automatically get higher relative importances, even if in reality the respondent gives a higher importance to another attribute. This can be seen in the table in appendix 3.5 where we calculated the relative importances of the different attributes. As can been seen, advantages of the solar cooker, who have a naturally smaller range, can never get a high relative attribute importance.

Yet, we can use the importances of different attributes for comparison between the different clusters to see whether prioritizations or the ranking of the attributes is different for the three clusters. In order to do this we calculate per respondent, all the relative importances and subject them to a discriminant analysis in SPSS. The potency values per attribute can be found back in Table 16. The capacity attribute is the most important in discriminating between our 3 clusters.

Table 16. Discriminant analysis based on attribute importances

Structure matrix

Attribute importance	**Discriminant function 1**	**Discriminant function 2**	**Potency value of variable on function 1**	**Potency value of variable on function 2**	**Composite potency of variable**
Capacity importance	**0,8240**	-0,3689	0,6308	0,0097	0,6404
Traditional importance	-0,5205	**-0,8210**	0,2517	0,0479	0,2995
Inside importance	**0,4120**	0,0969	0,1577	0,0007	0,1584
Price importance	-0,3416	**0,7070**	0,1084	0,0355	0,1439
Money importance	-0,2696	**0,4680**	0,0675	0,0156	0,0831
Health importance	-0,0058	**0,2380**	0,0000	0,0040	0,0041
Time importance	**0,0300**	0,0098	0,0008	0,0000	0,0008

- Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions
- **Largest absolute correlation between each variable and any discriminant function**
- Each discriminant loading was weighted by respectively 92,9% and 7,1% for discriminant function 1 and 2

Also when doing a Post-Hoc test (appendix 3.6), we see that the attribute capacity is able to explain differences between all our three clusters. Furthermore, remember that when discussing the utility of the cooking inside item, we discovered that cluster 1 and 3 devoted significantly more utility to the cooking inside item than cluster 2. However, we could not distinguish between cluster 1 and 3. When looking at the relative importance of the place where one has to cook, we do see that cluster 1 gives a higher relative attribute importance to this solar cooking characteristic.

3.2.4. Latent Class

In the following analysis, another cluster analysis is done. This one is based on a Latent Class. As explained, with a Latent Class, probabilities that respondents belong to one group or another are calculated and the log likelihood of each solution / iteration is calculated. This log likelihood increases with each iteration and in appendix 3.8 a summary of these iterations can be found. In our case, a total of 100 reruns has been done and the 48th replication has been chosen as fitting the data best. Here 11 iterations were necessary to obtain an improvement in Log-likelihood that was smaller than 0,01. We look at the CAIC (Consistent Akaike Information Criterion) to decide on the number of clusters. The lowest CAIC indicates we need to take the three group solution (appendix 3.7). This solution also seems to be the most valid when looking to the division of respondents over the different groups (appendix 3.8). Furthermore, when creating 4 or 5 groups, there is always one smaller less represented group of respondents. In addition, in case we took more than 4 groups, it became very hard to form practically relevant respondent groups that we could explain with our socio-demographic variables. Our dataset is probably too small to make more than 3 actionable segments. We are confident the three segment solution is the most appropriate for us. As with HB modeling, there are different scales we can use to present our data. For reasons discussed earlier, we rely on the rescaled scores in appendix 3.9 where items are on a ratio scale from 0-100 so that 2 is twice as good as 1.

When looking at the results in appendix 3.9, we see there are quite some similarities between the SPSS cluster analysis and the Latent Class clustering. Based on socio-demographic data, we saw that cluster 1 of our Latent Class Clustering, resembles cluster 3 of our SPSS clustering, that cluster 2 of our Latent Class Clustering resembles cluster 1 of our SPSS clustering and that cluster 3 of our Latent Class Clustering resembles cluster 2 of our SPSS clustering. This can be measured more objectively by looking at the crosstabulation in Table 17 where the similarities between the cluster analyses are confirmed. Given the fact that the output of the Latent Class Analysis in SSI/Web does not provide us with a measure of significance of differences in utility that different clusters give to the different solar cooking items, we won’t detail our analysis in this respect.

Table 17. Crosstabulation Latent Class * Three cluster SPSS

		Three cluster SPSS			**Total**
		1	**2**	**3**	
Latent Class	**1**	11	1	40	**52**
	2	31	3	0	**34**
	3	1	16	18	**35**
Total		**43**	**20**	**58**	**121**

3.2.5 ME>XL Analysis

Finally, we illustrate a segmentation analysis of the rescaled utility values, executed with ME>XL. We opt here for a six cluster solution. This solution has a hit ratio of 53,78% and this is significantly better than the proportional chance of 18,98% (p value is 0,0000). In addition, within the 6 clusters, significant differences in utility means of the different solar cooking items can be found. The cluster means can be found back in appendix 3.10 where values in red are significantly smaller, and values in green significantly bigger than the other cluster means.

Since we focused already on the SPSS three cluster solution, a detailed discussion of these six cluster results is not the purpose anymore. What we do want to point out is the variety of respondent groups that can be found in our data. Because our data set is relatively small, we can't, on the basis of socio-demographic variables, discriminate well between 6 clusters. From an actionable standpoint, a three cluster solution was consequently the better choice for us. But, it should be clear that our three cluster analysis can be elaborated to an analysis with more clusters. We will further discuss this point in section 4.

4. Discussion

We segmented the respondents in our sample based on their preferences and proofed distinct market segments were present with significantly different preferences. In addition, these segments are characterized by clear socio-demographic characteristics. However, a deficit of BWS is that it measures trade-off behavior without understanding the reasons behind it. Even though part of the trade-off behavior and preferences can be explained with socio-demographic characteristics, the context-dependent reasoning behind it should -especially in developing countries- be considered as well. Consequently, the BWS experiment is only meaningful when the researcher understands how respondents interpret the scenarios and the experiment.

In this respect, some comments have to be taken into account. We noted that (1) our respondents had different attribute references frames, (2) paid a lot of attention to the speed of the solar cooker, (3) and were not aware of health benefits. In addition, the BWS results above showed that respondents who had a solar cooker, gave less value to the benefits of it than respondents who don't have a solar cooker. From these data, it consequently can be derived that it is more motivating to buy a solar cooker than to continue using it. This can be explained by the fact that (4) users possibly had an unrealistic image of the solar cooker before they bought it, making them be disappointed once they have the solar cooker, that (5) the motivation to use the solar cooker for its economic benefits vagues away because solar cooker owners were not really capable of telling how much fuel savings they had thanks to the solar cooker, and (6) not all solar cooker owners used their solar cooker properly. It also appeared that our respondents (7) used decision rules and heuristics, and (8) were influenced by the context they were in. Finally, it should be noted that (3), (4) and (6) are influences on preferences that are within the control of solar cooking organizations themselves. Respondents' tradeoff behavior is influenced by decisions and actions of the solar cooker organization and these influences also should be taken into account. Therefore, in section 4.1 points (1) to (8) will be discussed, followed by section 4.2 where we discuss organizational influences. An overview of section 4.1 can be found back in Figure 10.

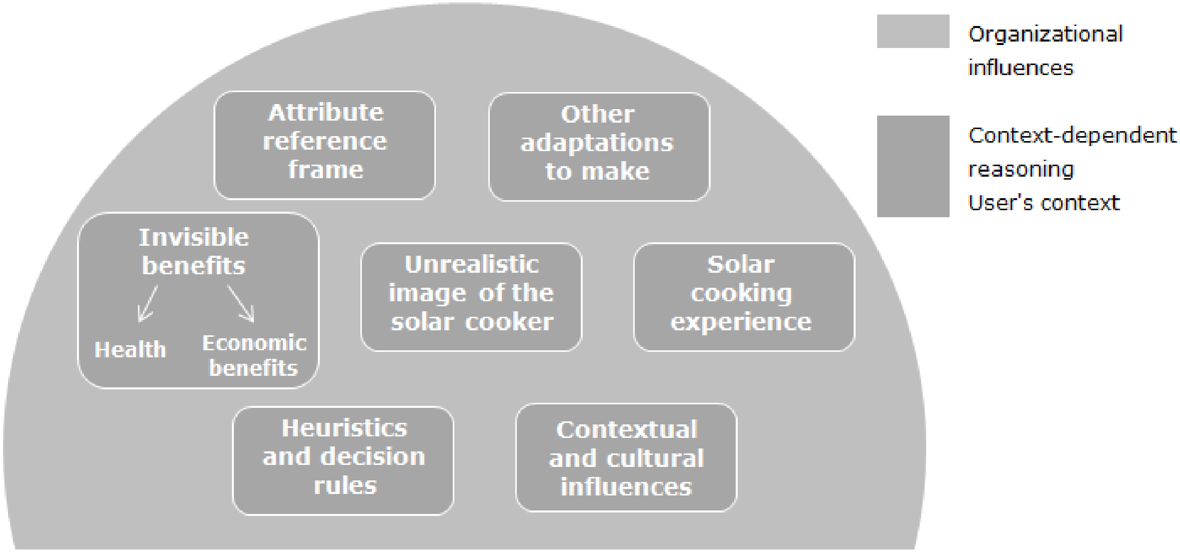


Figure 10. Overview section 4.1

4.1. Context dependent reasoning

When discussing our results, it was already indicated that SPSS cluster 3 was looking for more modern and less fatiguing aspects of the solar cooker, while SPSS cluster 1 was looking for fuel savings and an alternative fuel. These kind of nuances were possible thanks to complementary open and semi-structured questions. We now run through the eight comments given in Figure 10 as they further help nuancing and understanding some of the findings in section 3.

Attribute reference frame

Firstly, respondents had different reference frames or expectations with respect to their required or threshold capacity levels (see section 2.2). The 4-5 persons capacity item was under the threshold level of all clusters while the 8-10 persons capacity item was only above the threshold level of cluster 3. Cluster 1 and 2 consequently didn't include the capacity items in their decisions, explaining why they are not highly ranked in their preference list. As a result, capacity is very important for them, but the items used in the experiment were not meaningful to them, explaining the low utility these items received. A solution would have been to increase the range of capacity levels, but this would have made the interval less realistic and meaningful for cluster 3. Therefore it is hard to correctly compare cluster 1 and 2 with cluster 3. In any case, it is clear that the capacity is a huge bottleneck for cluster 2, and especially for cluster 1. The extra utility that the capacity improvement that the SolarCooker Eco3 gives according to the BWS experiment, is consequently not very large for these later groups, although we noted on the field that these respondents did use the solar cooker already for small dishes or parts of bigger dishes.

Other adaptations to make

Secondly, to internally test the BWS results, all respondents who had a solar cooker or who had had a demonstration, were asked before the experiment to state what the benefits and inconveniences of the solar cooker were for them. The results were earlier in this work, in Table 7, already presented and they highlight the fact that the speediness of the solar cooker was also an important concern of the respondents. Yet, this was an attribute not included in the experiment and it would have been worth to include it as well. Quite some respondents thought it was important that the solar cooker had the same speed as their traditional cookstoves, although some people mentioned that it wasn't the main priority and that they were willing to wait longer to finish cooking. Weather dependence of the solar cooker is also an often mentioned inconvenience of the solar cooker, but this was not included in the experiment as this research focused on more actionable design-attributes for solar cooking organizations. As long as solar cookers don't have a cheap way of conserving the energy of the sun, users have to adapt themselves to the weather dependency of the solar cooker. This is partly their own responsibility, partly the responsibility of solar cooking organizations to which we come back in section 4.2.

Invisible benefits
↓
Health

The same internal validity test also showed a discrepancy between the BWS results and what respondents told us in the beginning. Before the experiment, respondents only rarely mentioned health as a benefit of the solar cooker while it gets the most utility in the BWS experiment. In addition, some of the answers in table 7, classified under "health" were more related to the fact that respondents liked it that they didn't smell bad anymore because the solar cooker doesn't emit smoke. It is consequently probable that respondents were not aware of the positive correlation between solar cooking and their health situation. This made our hypothetical scenarios more attractive to the respondent than the real-life case where they stand in front of a solar cooker and where they are most likely more influenced by the more visual characteristics of the solar cooker (cooking outside, capacity…). The BWS scenarios might have rang a bell with most unaware respondents, making them pay more attention to the invisible health items that they normally might not consider in their cookstove decisions. As a solar cooking disseminator, it is therefore important to understand that benefits of the solar cooker that are clear and evident for people in developed countries, are not necessarily clear to uneducated people in undeveloped countries.

In addition, our results also showed that solar cooking owners gave significantly less utility to all solar cooking benefits than non-solar cooking owners. Based on our data, it seems that people are more motivate to buy a solar cooker when they don't have one, than to use it when they have one. This is the contrary of what we had expected in our hypothesis and we found within this research, three main reasons for this result.

Unrealistic image of the solar cooker

One reason is the fact that apparently users had an unrealistic image of the solar cooker before they bought it. They weren't properly informed about possible inconveniences or adaptations they had to make[3] and saw the solar cooker as a miracle that could change their life. As a result, once solar cooker owners had the solar cooker, they were disappointed or felt betrayed because they for instance didn't know about the capacity limitation: "If I had known in advance that I could only cook for five persons, I would never have bought the solar cooker!" These persons did not plan in advance to "adapt" themselves to the solar cooker and were consequently less willing to do so. For our research this implied that out of their disappointment, these people valued benefits of the solar cooker suddenly lower because the contrast with the "inconveniences" had become very large in their eyes. On the other hand, people who do not yet have a solar cooker were still very optimistic about it, possibly making them give higher utilities to benefits of it.

Invisible benefits
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Economic benefits

Another reason why solar cooker owners give lower utilities to benefits of the solar cooker, is the fact that some of these benefits, namely economic benefits, might become less clear to them once they are using the solar cooker. Before the BWS experiment, numerous respondents replied economic benefits were the main reason of buying/using the solar cooker (see table 7). Unlike health benefits, they consequently were aware of this benefit. Yet, we noted that most solar cooker owners couldn't say how much fuels they saved by using the solar cooker which can explain why economic benefits become less motivating. In this respect, a variable that is worth examining in future research is the frequency respondents buy fuels. We namely discovered that when solar cooker owners were capable of indicating that they saved fuels, they always did this with an example. For instance: "Each time I prepare "la bouillie", I save 500 CFA because I normally always use two kilo charcoal for that dish." Or, "I always save 300 CFA when I prepare tea with my

[3] This can for instance be seen in table 7 where respondents from Mouit, could tell us significantly less solar cooking inconveniences.

solar cooker." Respondents differed from each other in the sense that some of them bought their fuels in bulk for an entire month or week (e.g. a huge bag of charcoal or they asked a person to cut an entire tree for them), while others bought fuels per day or even per meal. We assume economic benefits are more visible and motivating for the later respondents. Yet, this variable should be examined further as it wasn't measured in this research.

Solar cooking experience

Finally, a third reason why our results show solar cooker owners value benefits lower, is the fact that not all solar cooker owners used the solar cooker. This was because some of them were very disappointed. Yet, some respondents also simply didn't know how to use the solar cooker. Reasons for this will be discussed in section 4.2 as it was mainly caused due to the way the project was organized. It is understandable that in that case they value benefits of the solar cooker lower. In addition, this also implies that the variable "solar cooking experience" is biased as it assumes that a solar cooker owner has more experience with the solar cooker than a non-solar cooker owner. Unfortunately, as explained in section 2, we could not objectively identify the respondents who really used their solar cooker and who didn't. This flattens out potential differences between real experienced solar cooker users and non-solar cooker users. However, when looking back at our last two outliers (respondent 102 and 132), it becomes clear that variations in solar cooking experience seem to influence tradeoff behavior. They were two of the few respondents that used the solar cooker for the full 100% (meaning that they started solar cooking before noon to have an entire dinner prepared in several parts that they only had to heat it up shortly during the evening).

Heuristics and decision rules

Seventhly, another important fact to take into account when interpreting the results, is that respondents used some decision rules and heuristics to make their decisions. They often told us right from the start, without wanting to know the alternative items, to indicate health items immediately as best, or capacity items as worst when they appeared in a scenario. As most of our respondents were perfectly capable answering the BWS questions, the reason for these simplified rules should not be sought within the "complexity" of the experiment. Instead, respondents most likely used heuristics or decision rules because they displayed strategic behavior. They were for instance convinced we would adapt the design of the solar cooker if they emphasized enough that the capacity should be higher, giving capacity items a zero utility, even though they did have more utility form it than the CooKit (e.g. protest bids). An example of this is a solar cooker owner who used the solar cooker frequently, and who apologized to us for the fact that she always indicated capacity as worst. She told us she wanted to make us clear that she wanted more capacity so that she could use the solar cooker not only for the smaller dishes as she did now.

In addition, it is also understandable that financial problems obstructed respondents from revealing their true willingness to pay. A lot of people indicated price as worst because they hoped the project then would lower the price. This probably also explains why non-solar cooker owners were more averse to pay for the solar cooker than solar cooker owners: they hoped that they could buy a solar cooker that was as cheap as possible. On top of that, decision rules and strategic behavior also existed out of social and other considerations. Some respondents told us they could pay the most expensive solar cooker but that they wanted their friends to be able to buy a solar cooker as well, making them indicate all price-related answers as worst.

While these heuristics can be seen as a critic on choice modeling, it is interesting to see that users also use certain decision rules and strategic behavior in their real-life behavior. We for instance met some respondents telling us they didn't use the solar cooker because then Sol Suffit would see they don't use it and then they will develop a better solar cooker. Understanding decision rules is consequently not only important to well interpret the BWS result, but also their real-life behavior.

Contextual and cultural influences

Finally, we also found that in many cases, a cultural, religious or contextual reason grounded preferences. Concerning the cooking inside attribute, we indicated already that it was seen as bringing people closer to the modern world, giving them more status and comfort. It was also preferred because then the warm sun wouldn't shine on their heads anymore. However, for certain dishes, there was also a cultural reason behind their preference to cook inside. Tea for instance, is a dish that certain ethnicities like preparing together with friends while discussing and talking. Everybody consequently has to sit comfortably together and this mostly happens in the shadow or indoor as they take their time for the preparation (minimum one hour as there are three services). Small dishes are sometimes also preferably cooked inside because their religion says that if a person passing their house smells what they are making, that person will get hungry. Then the household has to invite that person to eat with them. But if there isn't a lot, this can be an issue. In that case the household will prepare the dish inside to make sure nobody can see or smell what they are preparing. The later reason also explains why small households sometimes indicated that capacity wasn't enough: they would like to have some kind of buffer capacity in case unexpected guests come and join dinner. Contextual reasons to cook inside were goats and sheep running over the solar cooker, or kids that like the shiny surface of the solar cooker which can create dangerous situations…

4.1.1 Future research

For these and other reasons, a BWS research in a developing context obligatory has to be combined with additional questions in order to nuance the results and complement the data, and maybe even with additional methods to control for bias. Future research further needs to focus on better eliciting influencing variables on preferences and on their exact influence on preferences. This research only included a limited amount of socio-demographic variables, but suggested immediately a new socio-demographic variable (i.e. frequency of fuel buying) and numerous other variables (respondents with an unrealistic solar cooking image, organizational variables, visibility of benefits or awareness…).

Concerning these variables, it also should be taken into account that the cookstove decision process is a repeated process and not a once-in-a-life-time decision. Users decide each day and even multiple times a day which cookstove to use or not to use. The quest to influencing variables therefore also has to focus on "daily" variables (such as the frequency of fuel buying that we identified) that might play a significant role in the decision process.

In addition, the influence of preferences over time and how these preferences change over time should be examined by including a time factor (e.g. repeated BWS experiments). In this respect, we noted a significant difference between solar cooker owners and non-solar cooker owners. However, there is much more heterogeneity in these two groups than we were able to elicit. Some solar cooker owners namely had more experience than other solar cooker owners. Therefore, larger samples are needed, and once available, objective tools to measure solar cooking frequency should be included.

Also, even though we emphasized the importance of product-specific preferences in this work, they should not be seen as a means to an end. The relationship between preferences and the final decision is not necessarily straightforward and one should also wonder how decisive preferences are for the final cookstove decision as they are influenced by many other variables. From our open interviews, we noticed for instance that respondents from cluster 1 used the solar cooker more frequently than the other clusters, even though the solar cooker was the least adapted to them (i.e. the capacity problem). So maybe, preferences fall away in certain contexts? Future research can get better insights in this by including the objective measurement tools of cookstove frequency that will be on the market soon. Examining the relationship between frequency of usage and product-specific preferences will give more insights in the exact role of preferences in the decision process. Moreover, a defeat of this study is that all BWS scores are put on a scale with unknown anchor. We consequently do not know at which point utility becomes positive. This extra information could give additional insights as well and it will teach us more about minimum requirements a cookstove might have. Finally, concerning the BWS experiment itself, more research is needed about how the results are influenced when respondents do not consider all items.

4.2. Organizational variables

We now end our discussion by giving some extra insights on the influence organizations have on the success of the solar cooker and on users' preferences. During the field study and the data collection, we were confronted with some organizational variables that were of high concern to our respondents and that had a large impact on the solar cooking project. However, even though we emphasize the importance of these organizational factors, we believe it is not only up to the organization to make the project successful. In our opinion, the role of the solar cooking organization and organizational variables in general are especially important at the beginning of the project. In the beginning, a solar cooking organization should attempt to create the most optimal situation so that barriers to accept the solar cooker are as low as possible. After the beginning period, the project should be able to stand on its own with a minimum interaction of the solar cooking organization. The solar cooker is namely not sustainable if people continuously have to be convinced (pushed?) to use the solar cooker. Consequently, the final responsibility to use the solar cooker lays with the end-user.

Within the Sol Suffit project, this study identified some variables (summarized in figure 11) that

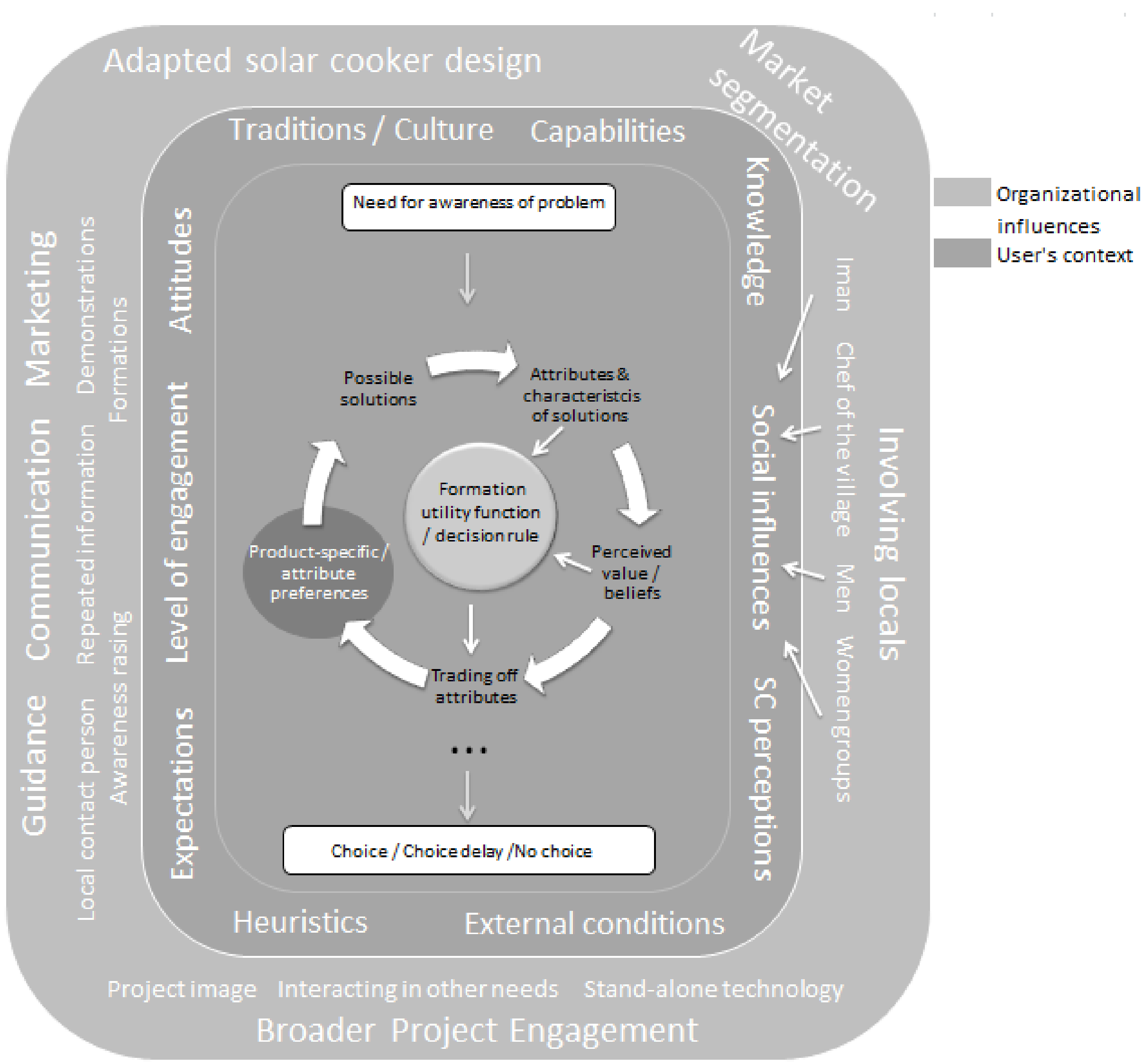

Figure 11. The organizational variables in the framework

influenced the creation of such an "optimal" situation in the beginning phase. Firstly, there is the importance of (1) the communication within the project and the demonstrations and formations given. Yet, as already indicated, the project faced some communication problems due to which some people didn't know how to use the solar cooker or had an unrealistic image of the solar cooker. Much of these communication problems were related to the fact that (2) the project highly involved the wrong locals within the solar cooking project. Yet, despite this problem, (3) the involvement of locals in the project did seem to be very important because of social reasons. Furthermore, (4) the image villagers have from the project, and the (5) involvement of the project in other needs of the villagers also seemed to be of high influence. Finally, (6) marketing within the project, (7) distinguishing between different users with different preferences and (8) a well-adapted and easy-to-use solar cooking design are also very important to lower barriers to solar cooking. It also should be pointed out that we only discuss variables that we identified within our own field study and that had a direct impact on users. Variables that we didn't identify or other variables such as financing, logistics, production… are also important and the fact that we don't mention them, doesn't mean they are less relevant in a cookstove program. We now discuss these variables below.

Communication & Demonstrations

Firstly, we have to look at the project context before we can continue discussing organizational variables. Sol Suffit is a project with Belgian volunteers that are not all the time on the field. They often return home for business or private matters. To make sure that there is always a person available in the project, they highly involved the local eco-guards. These eco-guards were also involved because involving locals in the project increases a project's success likelihood as people in the village might have more confidence in people they know.

Eco-guards are some villagers who form a group to protect the regional environment. Sol Suffit taught them how to use the solar cooker and gave them the responsibility to inform villagers, to sell the solar cookers, and to teach them how to use the cookers. However, the eco-guards failed in well-informing villagers on the solar cooker and its usage and focused more on selling the solar cookers. This is one of the reasons why a lot of respondents didn't use the solar cooker or didn't use it well. Some people didn't know how to use the solar cooker, some thought they knew how to use it but in fact didn't use it correctly, making them lose faith in the solar cooker as it didn't work. Other people did know how to use the solar cooker but didn't know all the possibilities of it. They for instance thought the solar cooker could only be used to boil water as they only saw a demonstration where demonstrators cooked water in the solar cooker. Still other people didn't know they needed sun to solar cooker: they just thought that when it was warm outside, they could solar cook.

The project therefore clearly didn't succeed in well-educating the end-users. It appeared that demonstrations and formations had to be repeated more, with multiple dishes that are prepared in different sizes, and in multiple weather conditions. However, even though good communication and information is an essential part of the acceptance of a new technology, the well-execution of it should not be underestimated. The two later examples in the previous paragraph already illustrated why giving good demonstrations is that hard. Even the simplest things have to be explained. Some people even asked us how to shut down the solar cooker. It is not always easy not to forget to say such simple things. Moreover, the demonstrations that were given were sometimes accidently given to the wrong people. Numerous women, who let their daughters cook at home, joined the solar cooking demonstrations out of social considerations or to stay updated about everything that happened in the village. Yet, they didn't cook and at home, they simply told their daughters to use the solar cooker, without always well explaining how they should use it.

Involving locals
↓
Local women groups

The fact that the eco-guards were not capable of identifying all these problems, made us wonder whether involving local people in the project does lead to a higher success probability. Indeed, even from our open interviews, it became clear that local people are very important and probably even indispensable in this type of projects. Yet, it appeared that in this project the *wrong* local people have been involved. In Senegal, local women groups instead of the eco-guards should have gotten more responsibility as they stand closer to the final female end-users. Women part of these groups can exchange and share information with each other, they take the time to discuss issues and experiences together and they can teach each other new dishes. Indeed, a recent publication of ICS in Senegal found in a sample of 227 households that 73% of the mothers was member of an association [141].

Involving locals
↓
Who?

However, we noted that next to these local women groups, there are still other local villagers that should play a role in the project. In Senegal, the chef of the village and the president of the women groups are for instance very important. In addition, projects have to make a distinction between men and women and finally, the Imam with his religious background also appeared to be important.

Concerning the chef of the village and the president of the women groups, it appeared that villagers expect both persons to be informed about a project when it comes to their village. They want these people to support the project and to inform and convince them. In Mouit for instance, the president of the women groups was Fatou, and almost all women told us that the solar cooker was a "good thing" because "Fatou said so". In addition, the habit in the Senegalese region we visited is that those people (the chef and/or the president) introduce the project first to the entire village instead of an organization introducing itself. Otherwise people might feel less comfortable with the project. For instance, when we went to Darau Salam, a village that had never heard about solar cooking, we did not want our respondents to be influenced and we started interviewing the respondents without allowing a leader to introduce the project. When we returned the day afterwards, one of the reactions one of our respondents gave was: "*The other day when you came, I wasn't informed about that. I am a little bit confused. I would like that the president had introduced the project.* » In addition, we also noted that villagers themselves influenced each other or looked at what their friends and neighbors were doing. All respondents for instance told us that it is important for them that other people in the village also have a solar cooker. Other important social considerations in the project were whether to involve or not involve men in the project. For the case of Senegal, in many traditional villages, the man has always been privileged compared to the woman. So if the woman now knows something or is more involved in a project, the man can get frustrated, counteracting the project. To avoid this, it was in this project sufficient to inform the man and to make clear that cooking is a female activity that they should support. Some of our male respondents emphasized the importance of the Imam in bringing over this message since their religion says that when a man marries a woman, he should do everything to facilitate the woman's tasks in the household.

The social influences in this project, whether it comes from villagers themselves or from "important" people in the village, was consequently very high. An organization therefore needs the get more grip and control on these social variables. This can be done by knowing and respecting the structure or hierarchy in the village, by involving the correct people, and by giving them a correct place in the project. If a project can identify the most influencing people and it can convince those persons to help in the project, the project is probably one step closer to a successful implementation of the solar cooker.

Marketing and awareness raising

In addition, our field study and even the BWS results also confronted us with the impact of marketing and awareness (or no-awareness) raising. We indicated already that respondents apparently weren't really aware of the correlation between health benefits and solar cooking. Though, from our data health benefits seemed to be highly motivating for them and marketing consequently should be better adapted to bring this benefit to the front and to increase users awareness about these benefits. Actually, the same can even be said for economic benefits. From our data, it seemed that respondents knew very well that the solar cooker gave the economic benefits, but once they were using the solar cooker, this motivation seemed to fall away with some of our respondents. They didn't know how much they economized and this was less (or even not) motivating. A solar cooking organization can guide people and show them that they do save money.

In addition, marketing or solar cooking promotions also have to make sure a realistic image of the solar cooker is shaped to make sure people stay motivated using the solar cooker once they have it. In the regions we visited, potential users seemed to be very easily convincible to buy a solar cooker. Some of them only saw a demonstration where one putted a piece of paper on the solar cooker and it started burning immediately. They talked to us about a wonder and a miracle and they instantaneously forgot to wonder whether they have to adapt to the solar cooker, whether there are inconveniences or whether the solar cooker differs a lot from their traditional cookstove. One should therefore we careful with the information given and make sure respondents are aware of what is expected from them as well.

Project image

Moreover, on top of this rather informative role of solar cooking organizations, we also noticed that the image the project has with the villagers is also very important. Senegalese people devote a lot of attention to personal and social aspects and for them it is of high value to know that Sol Suffit really cares about them and not merely about profit or something else. A respondent for instance told us she didn't like the project because they cared more about the environment and less about the inhabitants of Mouit. Even though she was the only person in our sample who thought this, it makes clear that the project image is also important to get commitment from the villagers to adapt themselves to the product and to be more engaged in the project. Some people for instance bought and used the solar cooker "to help Sol Suffit helping them".

Involvement in local needs

In this respect it is also important to keep in mind that inhabitants most likely have bigger concerns and priorities than fuel scarcity. They are looking for job creation, constructions of roads so that their village is better accessible, materials for their schools, health posts and health care, water… These concerns might hinder them from engaging themselves in the solar cooking project. Sol Suffit did a great job in Djoudj concerning this comment. They equipped the health post with little materials, a sterilizer, medicines, blood pressure meters… This takes away one concern of the villagers, allowing them to think less restrained about solar cooking. In addition, it was a great way of building up the project image by showing Sol Suffit is there to help them. Solar cooking organizations can also help villagers by taking the initiative to look for alternative fuels during periods the solar cooker is not usable. As the solar cooker is not a stand-alone product, partnerships with other nontraditional cookstove organizations can be helpful. Or, in some cases it might be needed to teach people how to plan their cooking activities in order to optimally balance their different cooking methods to each other. When we asked a woman in Débi for instance why she didn't try using her solar cooker during the day to prepare a dinner, she replied: "*Oh, but I actually never thought about that. I am going to take your suggestion into consideration next time I start cooking!*"

Solar Cooking design

Finally, there is still the organizational variable on which this work focused: the solar cooking design. From our field study, it became clear that in our sample there are different groups of respondents with different preferences and with different needs and desires. This highlights the issue that one type of solar cooker is probably not adequate for all respondents. In order to reach a bigger solar cooking audience, it is therefore important that the solar cooker is more adapted to the different users and that multiple solar cookers are introduced in one solar cooking project.

Yet, as it might be less practical for solar cooking organizations to introduce multiple solar cookers so that all respondents with similar preferences have an adapted solar cooker, it is important to distinguish between end-users. Some end-users namely do not have the intention to use the solar cooker. They buy the solar cooker because it is shiny and because it draws the attention of other people in the village who pass their houses. Other people just buy the solar cooker because it is a mean to stay more informed and up-to-date about everything that happens in the village. One should therefore adapt the design of the solar cooker to the people that do have the intention to use the solar cooker.

Unfortunately, from our BWS results and from the open interviews, it became clear that the SolarCooker Eco3 design is not yet well adapted to this end-user. The two most stringent points brought through the front were the limited capacity and the fact that the solar cooker is not easy to use. Yet, the first point is something that is not immediately within the control of the project as a larger solar cooker, with a larger capacity is less safe. However, it was noted that respondents who really wanted to use the solar cooker, and who probably received sufficient utility from the benefits of the solar cooker, adapted themselves to the capacity issues and to the fact that the solar cooker was not perfect to them. They spread their meals over several cookstoves or cooked a dinner in different steps on the solar cooker. Yet, given the fact that we could not objectively distinguish these solar cooker owners from the other solar cooker owners, we can't say more about these respondents.

However, as explained in the beginning of this section 4.2, a solar cooking organization has to make sure that after a while, the project can stand on its own. In this respect, the fact that users thought the solar cooker was not easy to orient and to use, was a huge problem. Sol Suffit already reacted on this by developing a new version of the SolarCooker Eco3. Such a reactive and pro-active behavior is in the beginning phase very important because this will increase the product chances to stand alone after a while.

"Getting irritated with users because they are not using an improved stove helps no one, especially since it is probably the design of the stove which is inadequate."

GTZ (1996)

5. Conclusion

This work highlighted in the first place that the cookstove choice process should not be simplified and that numerous influences have to be taken into account if cookstoves want to become successful and if one wants to understand households' decision process. Unfortunately, past research didn't manage taking all different influences into account. In addition, research faces the obstacle that there is no objective measurement tool available to determine cookstove usage frequency. This later issue hindered this research a lot by the fact that it couldn't directly link its results to the frequency households use their cookstove. Fortunately, objective measurement tools are underway and these will give many insights in the cookstove adoption process.

Nevertheless, even without these tools, this study shed a new light on some aspects of household's decision process and preferences concerning their cookstove choice. It presented a framework where household's preferences for cookstove-characteristics are centralized. The logic behind this is that households look at these characteristics to see what the cookstove can offer to them. The cookstove that replies sufficiently to their needs has a higher chance to be chosen in their cookstove decision process. In a second level, the framework explains the preferences in the first level by eliciting information from the user's context such as its culture, social environment, and socio-demographic variables. In this way, a cookstove disseminating organization can better understand why a certain cookstove is not sufficient for the locals. Finally, the outer-level of the framework explains what a cookstove disseminating organization can do to foster the uptake of a cookstove. Even though the final responsibility to use the cookstove lays with the end-user, the later level proves that one cannot only blame the end-user when a cookstove project fails.

When using the framework in a real-life rural Senegalese solar cooking project, it gave some interesting insights into reasons why households choose or do not choose the solar cooker. Looking at the end-user preferences in Djoudj and la Langue Barbarie (Northern Senegal), it became clear there are significant differences in what villagers expect from their cookstove. Some villagers were looking more urgently for fuel savings and alternative fuels, other were looking for a solar cooker that had a lot of characteristics of their traditional cookstoves and still other wanted a cookstove that gave them more comfort and status. This points out the fact that one solar cooker design might not be perfect for all end-users or that some people will never accept the solar cooker. In the latter case, other nontraditional cookstoves such as LPG might be better in fulfilling their needs. In this respect it should be noted that if one really wants to solve global energy problems in developing countries, nontraditional cookstoves should not be seen as competitors from each other, but as substitutes. Especially for the solar cooker as it is not a standalone technology. Ideally the solar cooker even should be complemented with another nontraditional cookstove so that there is also a solution in case weather is not appropriate to solar cook.

Our study also noted that, concerning the current solar cooker design, capacity appeared to be a huge bottleneck. Furthermore, as users gave a lot of utility to the possibility to cook inside, it might be that users have difficulties adapting themselves to the fact that they have to cook inside. In addition, they complained that the solar cooker was difficult to use. These inconveniences explained why some people did not use the solar cooker. However, the inconveniences did not necessarily imply that when the solar cooker is not perfect, it won't be used or accepted. In contrary, on days the weather was better, we could even find some "ideal" examples of solar cooker owners who used the solar cooker during the day to prepare dinner for the end of the day.

The later point, whether they will use the solar cooker or not if it is not perfect, depends on numerous factors. Coming back to the cookstove design, the solar cooker certainly has to be easy to use. Solar cookers can't become sustainable if tasks can't be delegated to local contact persons. Yet, probably the most important factor that influences whether they will use the solar cooker, is the fact whether users are well-informed about the solar cooker. They have to know how to use it and they have to know the benefits of the solar cooker. The respondents in our sample were clearly not aware of health benefits of the solar cooker – even though they valued these items the highest from all items – and they didn't know sufficiently how to use the solar cooker. In addition, we noticed it is possible that benefits of the solar cooker of which users were aware before they used the solar cooker, become less clear to the user once they are using the solar cooker. Furthermore, the amount of information that respondents had had apparently also influenced their willingness to adapt themselves to the solar cooker as respondents from more traditional villages, who hadn't yet heard about solar cooking, valued traditional cookstove characteristics higher than people who had already heard about solar cooking. Finally, the type of information that has been given to users before they received or bought the solar cooker also had an impact on users behavior. When users had an unrealistic image of the solar cooker, they had the tendency to become disappointed and not to use the solar cooker once they found out that the image they had was wrong. Other reasons that influenced whether people would use the solar cooker or not, could be found in cultural, religious, contextual and social influences that have to be taken into account in the project. In this respect it turned out that involving the correct local people in the village, and understanding the structure or hierarchy of the village, was very important, and had an important influence on the project and on the (potential) end-users.

As a conclusion, it can be said that the developed framework was very well capable of explaining preferences and reasons to use or not to use the solar cooker. Yet, probably the most striking insight came from the fact that the influence of organizations on the success of a solar cooking project was very large. Depending on numerous actions of cookstove organizations, end-users can change their attitude, perceptions and motivation, that influence their preferences for certain cookstove characteristics and cookstoves.

As a result, given the fact that we mentioned in our literature some examples of solar cooking projects that were a success and given the fact we interviewed some very enthusiastic solar cooker owners, we believe solar cooking still has a lot of growing possibilities if solar cooking organizations behave as proactive, dynamic, reactive and adaptive as possible. As research has not yet the knowledge to guide these organizations, it will for be a process of trial-and-error for the organizations which explains why adapting strategies is that important. This means that organizations have to identify local issues and habits and social and cultural influences, and adapt the implementation of the project to this. It also means solar cooking projects should differentiate more between users, adapting marketing, design and strategies to the different groups of end-users, and that they have to make sure that their communication is clear and repeated when necessary.

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Appendixes

Appendix 2.1: one way frequencies BWS design

```
One Way Frequencies:
 Item  Times Used
-----------------
    1      13
    2      12
    3      12
    4      12
    5      13
    6      13
    7      13
    8      13
    9      13
   10      13
   11      13
   12      13
   13      13
   14      13
   15      13
```

Appendix 2.2: two way frequencies BWS design

Two Way Frequencies:

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	13	0	0	2	3	3	3	4	3	3	3	5	3	3	4
2	0	12	0	3	3	3	3	3	3	3	3	3	3	3	3
3	0	0	12	2	3	3	3	3	4	3	3	3	3	3	3
4	2	3	2	12	0	3	3	3	3	3	3	2	3	3	3
5	3	3	3	0	13	3	3	3	3	3	3	3	3	3	3
6	3	3	3	3	3	13	0	2	3	3	3	3	4	3	3
7	3	3	3	3	3	0	13	3	3	3	3	3	2	4	3
8	4	3	3	3	3	2	3	13	0	3	3	3	3	3	3
9	3	3	4	3	3	3	3	0	13	3	3	3	3	3	2
10	3	3	3	3	3	3	3	3	3	13	0	3	3	3	3
11	3	3	3	3	3	3	3	3	3	0	13	3	3	3	3
12	5	3	3	2	3	3	3	3	3	3	3	13	0	2	3
13	3	3	3	3	3	4	2	3	3	3	3	0	13	3	3
14	3	3	3	3	3	3	4	3	3	3	3	2	3	13	0
15	4	3	3	3	3	3	3	3	2	3	3	3	3	0	13

Off Diagonal Non-prohibited Elements
Mean = 3.000000
Std Dev. = 0.408248

Appendix 2.3: positional frequencies BWS design

Positional Frequencies:

Item	Pos. 1	2	3	4
1	4	3	3	3
2	3	3	3	3
3	3	2	4	3
4	3	3	3	3
5	3	3	4	3
6	3	3	3	4
7	3	4	3	3
8	3	4	3	3
9	3	4	3	3
10	3	3	4	3
11	3	3	3	4
12	3	4	3	3
13	3	3	3	4
14	4	3	3	3
15	4	3	3	3

Appendix 2.4: Questionnaire Version 1

Which element in the list motivates you the most to replace your traditional cooking techniques/fuels by a solar cooker?

Which element in the list motivates you the least to replace your traditional cooking techniques/fuels by a solar cooker?

1.1B	It is possible to prepare your traditional dish	1.1W
1.2B	You can save a lot of fuels/money per week	1.2W
1.3B	Your current health situation will not get worse	1.3W
1.4B	With this solar cooker, you can cook both inside and outside	1.4W

2.1B	Your current health situation will not get worse	2.1W
2.2B	You can prepare food for up to 8-10 persons at once	2.2W
2.3B	It is not possible to prepare your traditional dish	2.3W
2.4B	You can save a little bit of time per week	2.4W

3.1B	You can save a little bit of time per week	3.1W
3.2B	Your current health situation will improve	3.2W
3.3B	You can prepare food for up to 4-5 persons at once	3.3W
3.4B	The price is 10000 CFA, payable in pieces	3.4W

Which element in the list motivates you the most to replace your traditional cooking techniques/fuels by a solar cooker?

Which element in the list motivates you the least to replace your traditional cooking techniques/fuels by a solar cooker?

4.1B	With this solar cooker, you can cook both inside and outside	4.1W
4.2B	The price is 50000 CFA, payable in pieces	4.2W
4.3B	You can prepare food for up to 8-10 persons at once	4.3W
4.4B	You can save a little bit of fuels/money per week	4.4W

5.1B	You can prepare food for up to 8-10 persons at once	5.1W
5.2B	The price is 30000 CFA, payable in pieces	5.2W
5.3B	You can save a lot of fuels/money per week	5.3W
5.4B	With this solar cooker, you can only cook outside	5.4W

6.1B	Your current health situation will improve	6.1W
6.2B	With this solar cooker, you can cook both inside and outside	6.2W
6.3B	The price is 50000 CFA, payable in pieces	6.3W
6.4B	You can save a lot of time per week	6.4W

Which element in the list motivates you the most to replace your traditional cooking techniques/fuels by a solar cooker?

Which element in the list motivates you the least to replace your traditional cooking techniques/fuels by a solar cooker?

7.1B	The price is 30000 CFA, payable in pieces	7.1W
7.2B	It is possible to prepare your traditional dish	7.2W
7.3B	You can save a little bit of fuels/money per week	7.3W
7.4B	Your current health situation will improve	7.4W

8.1B	The price is 10000 CFA, payable in pieces	8.1W
8.2B	You can prepare food for up to 4-5 persons at once	8.2W
8.3B	With this solar cooker, you can cook both inside and outside	8.3W
8.4B	It is not possible to prepare your traditional dish	8.4W

9.1B	With this solar cooker, you can only cook outside	9.1W
9.2B	Your current health situation will not get worse	9.2W
9.3B	The price is 30000 CFA, payable in pieces	9.3W
9.4B	You can prepare food for up to 4-5 persons at once	9.4W

Which element in the list motivates you the most to replace your traditional cooking techniques/fuels by a solar cooker?

Which element in the list motivates you the least to replace your traditional cooking techniques/fuels by a solar cooker?

10.1B	You can save a little bit of fuels/money per week	10.1W
10.2B	You can save a lot of time per week	10.2W
10.3B	It is not possible to prepare your traditional dish	10.3W
10.4B	With this solar cooker, you can only cook outside	10.4W

11.1B	It is not possible to prepare your traditional dish	11.1W
11.2B	The price is 50000 CFA, payable in pieces	11.2W
11.3B	You can save a little bit of time per week	11.3W
11.4B	You can save a lot of fuels/money per week	11.4W

12.1B	You can save a lot of time per week	12.1W
12.2B	It is possible to prepare your traditional dish	12.2W
12.3B	The price is 10000 CFA, payable in pieces	12.3W
12.4B	You can prepare food for up to 8-10 persons at once	12.4W

Appendix 2.5: general questions to all respondents

CHARACTERISTICS OF THE RESPONDENT			
Respondent	A1	Number	
	A2	Sex (F/M)	
	A3	Age	
	A4	Village	
	A5	Education: 1. No education 2. Can read or write 3. Can read and write 4. Primary school 5. School Arabe 6. More than primary school	
Family	B1	With how many people do you live in your household?	
	B2	For how many people do you cook?	
Fuel	C1	What are the main fuels you use for cooking?	
	C2	How much do you spend on fuels per month?	
	C3	Do you collect wood?	
	C4	How often do you collect wood?	
	C5	How long does it take you each time to collect wood?	

Appendix 2.6: questions to informed non-solar cooker owners

NON-SOLAR COOKING BUT INFORMED RESPONDENT			
Solar cooking	SC1	Have you ever heard about solar cooking?	
	SC2	Have you ever seen a solar cooker?	
	SC3	Have you ever seen people using a solar cooker?	
	SC4	What are the benefits of the solar cooker?	
	SC5	What are inconveniences of the solar cooker?	
	SC6	Are you interested in the solar cooker?	
	SC7	Are you going to buy a solar cooker?	
Optional Household	SC8	Who is going to finance the solar cooker?	
	SC9	Did you talk about the solar cooker with your husband? If yes, does he want to finance the solar cooker ?	
	SC10	Is it important for you that other people in the village have a solar cooker as well ?	
	SC11	What worries you the most in your village? According to you, what is the problem the most important that has to be solved?	
	SC12	Do you have a separate kitchen? Do you cook inside? Why? Would you have a problem with the solar cooker if you can only use it outside?	

	SC13	Do you like your traditional combustibles? Do you use your traditional combustibles for some specific dishes?	
	SC14	Are you prepared to adapt yourself to the solar cooker?	
	SC15	Is it important for you to use your traditional casserole or don't you have a problem with using the adapted solar cooking casserole?	
Optional Demonstrations	D1	Was the demonstration that you got clear? Do you need additional information?	
	D2	Do you have confidence in the solar cooker?	
	D3	What should have been better?	
Optional Sol Suffit	S1	What could Sol Suffit have done better in introducing the solar cooking project here?	
	S2	Which persons should Sol Suffit have had contacted?	
	S3	Which elements are important for a good implementation of a solar cooking project in your village?	
	S4	Does the project have to make a distinction between men and women? Should Sol Suffit include men in the project?	
	S5	Which persons should Sol Suffit had had involved in the solar cooking project?	
	S6	How long thus Sol Suffit need to guide the project here?	

	S7	What is the importance of this project in your village?	

Appendix 2.7: questions to solar cooker owners

SOLAR COOKING RESPONDENT			
Solar cooking	SC1	Do you use the solar cooker each time the sun shines? (Why not? How many times do you use the solar cooker a week?)	
	SC2	What are benefits of the solar cooker?	
	SC3	What are inconveniences of the solar cooker?	
	SC4	Which suggestions do you have to improve the solar cooker?	
	SC5	Which dishes do you prepare with the solar cooker?	
Optional Solar Cooking	SC6	Do you know how much money you economized with the solar cooker?	
	SC7	Did you have enough information concerning the solar cooker and its usage? Was everything clear for you?	
	SC8	Are you happy you have bought a solar cooker?	
	SC9	Did you know in advance that the solar cooker wasn't capable of preparing for more than 5 persons?	
Optional Sol Suffit	S1	What could Sol Suffit have done better in introducing the solar cooking project here?	
	S2	Which persons should Sol Suffit have had contacted?	
	S3	Which elements are important for a good implementation of a solar cooking project in your village?	

	S4	Does the project have to make a distinction between men and women? Should Sol Suffit include men in the project?	
	S5	Which persons should Sol Suffit had had involved in the solar cooking project?	
	S6	How long thus Sol Suffit need to guide the project here?	
	S7	What is the importance of this project in your village?	

Appendix 2.8: description attributes and explanation to respondents

In what follows, you will get 15 sets of questions. In each set, we ask you to indicate "**Which point of the set is the most motivating for you to switch from your current cooking technique(s) to solar cooking?**" and "**Which point of this set is the least motivating for you to switch from your current cooking technique(s) to solar cooking?**"

Let's have a quick glance at all the question sets! … Look, as you can see, each set of questions will have 4 items/rows between which you can choose. The items between which you can choose will differ between the different sets. In that way we can learn more about what is important for you when you choose which cooking technique you want to use. Don't worry if it looks complicated right now. We will explain it more deeply and it will all become clear!

You will see that we have seven big groups of items and as we said already you will always have to choose between four of them in each set. We will now explain you which items you might have to choose between. This will help you later to choose between the items!

You might for instance get a set where you have to choose between the following 4 items:

1.1B	The price of the solar cooker	1.1W
1.2B	How much time you can save with the solar cooker	1.2W
1.3B	How much money you can save with the solar cooker	1.3W
1.4B	What will happen with your health when you use the solar cooker	1.4W

Now you have to choose which of these four items is the most motivating for you to switch to solar cooking, and which of the four items is the least motivating to switch to solar cooking. Now, let's explain what those points can be exactly!

1) In this question set, you find an item that will tell you what the price of the solar cooker might be. There are three different possible prices that can come back in the items, namely: 10000, 30000, and 50000 CEFA. But we will only show one price at once! Then you should memorize that price and look to the next item.
2) The other item you see here is the time you can save by using solar cooking. Time savings fluctuate between "a little bit of time savings" and "a lot of time savings".
3) Then we look to the next item. This item tells you how much money or fuel you can save by using a solar cooker. Here as well you can save "a little bit of money" or "a lot of money".

4) Also, we will tell you how your health situation would be if you use a solar cooker. It might be that your health improves or that it will at least not become worse.

So look, now we know what those 4 items can be, it might be that our set looks like this:

1.1B	The price of the solar cooker is 1000 CEFA	1.1W
1.2B	You can save a lot of time	1.2W
1.3B	You can save a little bit of money/fuels	1.3W
1.4B	Your health will not become worse	1.4W

Now let's try it: which point of this set is the most motivating for you to switch from your current cooking technique(s) to solar cooking? (… Wait for the answer. We can repeat the items if they ask for that.) Good! And which point of this set is the least motivating for you to switch from your current cooking technique(s) to solar cooking? (… Wait again for the answer. We can repeat the items if they ask for that.) Well done! Now, we still have 4 other items that might come back! So we introduced already price, time savings, money savings and your health condition.

5) Now you might see that there are also items that will tell you if the solar cooker is able to prepare your traditional dishes. There are two possibilities: it is possible to prepare your traditional dish with the solar cooker, or it is not possible.
6) Furthermore there is also an item that might tell you how many persons can be served with one solar cooker. Sometimes we might tell you that the solar cooker can make at once food for 4-5 persons and sometimes it can make food for up to 8-10 persons.
7) Finally, there is still a last characteristic the solar cooker might have. Some solar cookers are only utilizable outside, while others can be used both inside and outside. The way it works is simple. You will have a solar cooker consisting of two parts: one part that collects the heat, and another part to which this heat is transferred and where you can cook. If the collector part stand outside and the cooking part inside, you can cook inside. Yet, note that you are still dependent on the sun.

In summary, we have eight different groups of characteristics: the price of the solar cooker, the time savings you can get from not having to collect fuels anymore, the money savings from not having to buy fuels, your health condition, whether you can prepare your traditional dish with the solar cooker, the number of people for who you can prepare food at once, and whether the solar cooker allows to cook inside or not.

But as we told you already, you will only have to compare 4 points with each other. We will always make different combinations. For instance, which item of the following set is the most motivating for you to switch from your current cooking technique(s) to solar cooking and which item of this set is the least motivating for you to switch from your current cooking technique(s) to solar cooking?

1.1B	You cannot prepare your traditional dish	1.1W
1.2B	You can save a lot of money/fuels	1.2W
1.3B	The price is 30000 CFA	1.3W
1.4B	The solar cooker can make food for 8-10 persons	1.4W

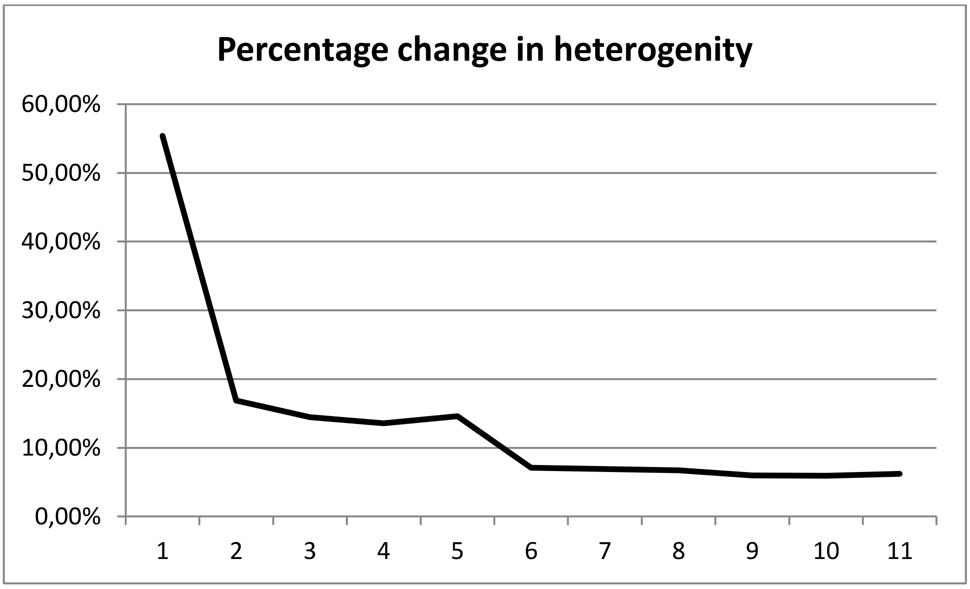
Are you ready? If you would have any questions during the questionnaire or if something is not clear, feel free to ask us! We will help you. Yet, note that we will not help you in choosing between the different items. For us it is important that you tell us what is important for you!

Appendix 3.1: top ten highest dissimilarities respondents

	Dissimilarity
1	22,16006
2	19,74171
132	18,87315
102	16,77809
3	16,62631
129	15,72215
69	14,8389
100	13,95487
98	13,8193
9	12,65942

Appendix 3.2: scree plot

	Percentage change in heterogenity
11848,49	-
7625,98	55,37%
6523,71	16,90%
5699,75	14,46%
5018,21	13,58%
4379,97	14,57%
4089,53	7,10%
3825,43	6,90%
3584,07	6,73%
3382,22	5,97%
3192,75	5,93%
3005,68	6,22%



Appendix 3.3: agglomeration schedule

Agglomeration Schedule						
Stage	**Cluster Combined**		**Coefficients**	**Stage Cluster First Appears**		**Next Stage**
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	105	114	0,44	0	0	26
2	26	43	1,228	0	0	52
3	98	104	2,347	0	0	30
4	19	125	3,467	0	0	44
5	89	95	4,943	0	0	45
…			…			…
101	23	29	1509,79	65	90	108
102	3	30	1564,949	**0**	**0**	111
103	36	51	1620,245	83	70	108
…			…			…
110	57	61	2286,572	106	95	112
111	1	3	2449,914	**0**	**102**	115
112	57	75	2634,065	110	86	121
113	14	23	2819,524	87	108	118
114	50	113	3005,68	98	91	122
115	1	2	3192,746	**111**	**0**	123
116	6	24	3382,221	105	71	119
…			…			…
124	4	5	7625,98	119	122	125
125	1	4	11848,49	123	124	0

Appendix 3.4: homogeneity of variances

Test of Homogeneity of Variances

	Levene Statistic	Sig. **(5%)**	
Price is 10000 CFA	8,953	**0,0000**	Dunnett C
Price is 30000 CFA	4,546	**0,0130**	Dunnett C
Price is 50000 CFA	2,19	0,1160	Tuckey
A little bit of time savings	6,59	**0,0020**	Dunnett C
A lot of time savings	0,516	0,5980	Tuckey
A little bit of money savings	2,352	0,1000	Tuckey
A lot of money savings	2,573	0,0810	Tuckey
Health condition not worse	5,508	**0,0050**	Dunnett C
Health condition improves	9,288	**0,0000**	Dunnett C
Traditional dish not possible	9,06	**0,0000**	Dunnett C
Traditional dish possible	9,539	**0,0000**	Dunnett C
Max capacity 4-5 persons	10,007	**0,0000**	Dunnett C
Max capacity 8-10 persons	21,236	**0,0000**	Dunnett C
Only outside	9,462	**0,0000**	Dunnett C
Both inside and outside	5,539	**0,0050**	Dunnett C

Appendix 3.5: attribute importance

Label	**Attribute**	Rescaled Average Scores	Range extreme utilities	Attribute importance
Price is 10000 CFA	**Price**	1,22113	1,08462	3,31%
Price is 30000 CFA		0,13651		
Price is 50000 CFA		0,17949		
A little bit of time savings	**Time savings**	6,7561	0,95454	2,92%
A lot of time savings		7,71064		
A little bit of money savings	**Money savings**	11,40442	0,57523	1,76%
A lot of money savings		11,97965		
Health condition not worse	**Health**	13,90327	0,52194	1,59%
Health condition improves		14,42521		
Traditional dish not possible	**Traditional dish**	0,2654	8,61869	26,33%
Traditional dish possible		8,88409		
Max capacity 4-5 persons	**Capacity**	0,1634	8,01342	24,48%
Max capacity 8-10 persons		8,17682		
Only outside	**Cooking inside**	0,91697	12,95994	39,60%
Both inside as outside		13,87691		
			32,72838	

Appendix 3.6: post-hoc test attributes

Multiple Comparisons

Attribute Importance		(I) Cluster Number of Case	(J) Cluster Number of Case	Mean Difference (I-J)
Health Importance	Dunnett C	1	2	-0,00287
			3	-0,00384
		2	3	-0,00097
Traditional Importance	Dunnett C	1	2	-0,0061
			3	**0,16379**
		2	3	**0,16989**
Capacity Importance	Dunnett C	1	2	**-0,13913**
			3	**-0,28474**
		2	3	**-0,14562**
Inside Importance	Dunnett C	1	2	**0,23913**
			3	**0,20252**
		2	3	-0,03661

The mean difference is significant at the 0.05 level.

Appendix 3.7: latent class analysis (1)

Null log-likelihood -4025,79882

Summary of best replications

Groups	Replication	Log-likelihood	Pct Cert	AIC	CAIC	BIC	ABIC	Chi-Square	Relative Chi-Square
2	41	-1904,85941	52,68369	3867,71882	4069,96030	4040,96030	3948,81671	4241,87883	146,27168
3	48	-1836,65237	54,37794	3761,30474	4068,15389	4024,15389	3884,34982	4378,29291	99,50666
4	61	-1798,58974	55,32341	3715,17948	4126,63630	4067,63630	3880,17174	4454,41817	75,49861
5	83	-1761,79440	56,23740	3671,58879	4187,65327	4113,65327	3878,52824	4528,00886	61,18931

# of respondents per group

	1	**2**	**3**	**4**	**5**
2 groups	**84**	37			
3 groups	52	34	35		
4 groups	48	34	**6**	33	
5 groups	21	22	32	40	**6**

Groups	**Percentage Certainty**	**Change**
2	52,68356	
3	54,37544	3,21%
4	55,12609	1,38%
5	56,22844	2,00%

Appendix 3.8: latent class analysis (2)

Iteration	Log-likelihood	Gain	Segment 1 Size	Segment 2 Size	Segment 3 Size
0	-4025,79882				
1	-2086,34701	1939,45181	16,7	50,7	32,6
2	-1999,44256	86,90445	18,3	48,3	33,4
3	-1896,69094	102,75162	28,1	40,9	31,0
4	-1853,64117	43,04977	36,0	34,5	29,5
5	-1841,37657	12,26461	40,5	30,7	28,8
6	-1837,69530	3,68127	42,5	29,0	28,4
7	-1836,86538	0,82991	43,3	28,4	28,3
8	-1836,70633	0,15905	43,5	28,1	28,3
9	-1836,66779	0,03854	43,6	28,0	28,4
10	-1836,65633	0,01145	43,6	27,9	28,5
11	-1836,65237	0,00396	43,6	27,9	28,5

Appendix 3.9: utility scores latent class analysis

Rescaled Scores (0 to 100 scaling)	Segment 1	Segment 2	Segment 3
Price is 10000 CEFA	0,54207	1,63958	2,31696
Price is 30000 CEFA	0,11152	0,38705	0,43357
Price is de 50000 CEFA	0,09486	0,38011	0,39245
A little bit of time savings	6,37949	7,42371	6,29820
A lot of time savings	7,84670	5,46545	8,44176
A little bit of money savings	11,69542	12,61866	8,70759
A lot of money savings	12,57173	12,74406	9,11861
Health condition not worse	13,85602	15,80851	11,69955
Health condition improves	14,31501	16,51003	12,44424
Traditional dish not possible	0,73039	0,33850	0,14622
Traditional dish possible	5,22697	11,18678	12,61654
Max capacity 4-5 persons	0,16162	0,05047	0,15300
Max capacity 8-10 persons	11,51508	0,39896	13,44597
Only outside	0,93702	1,21413	1,18642
Both inside and outside	14,01612	13,83401	12,59894

Appendix 3.10: ME>XL Analysis

Segmentation variable / Cluster	Overall	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Price is 10000 CFA	1,2	**0,461**	1,22	1,55	***3,71***	0,927	**1,84**
Price is 30000 CFA	0,125	***0,0428***	0,0899	***0,213***	***0,365***	0,109	0,171
Price is 50000 CFA	0,166	0,0303	0,0977	0,164	***1,35***	0,143	0,148
A little bit of time savings	6,77	6,89	7,88	7,25	***4,01***	***4,22***	***8,87***
A lot of time savings	7,75	8,41	***10,2***	***5,6***	***4,59***	7,52	7,58
A little bit of money savings	11,4	***12,8***	***8,93***	***13,8***	***9,13***	**10,1**	10,9
A lot of money savings	12	**13,1**	***9,94***	***14,4***	***8,52***	**10,9**	11,8
Health condition not worse	13,9	14	***11,7***	***16***	13,9	13,4	14,1
Health condition improves	14,4	14,4	***12,4***	***16,3***	***15,3***	14	14,5
Traditional dish not possible	0,267	***0,469***	**0,112**	0,376	***0,0426***	**0,111**	**0,133**
Traditional dish possible	8,86	***5,16***	**11,4**	7,56	***14,7***	9,21	***13,3***
Max capacity 4-5 persons	0,0789	0,0743	***0,237***	0,0197	0,0323	0,0702	0,0183
Max capacity 8-10 persons	8,25	9,47	***12,2***	***1,01***	9,24	***14,3***	***2,12***
Only outside cooking	0,913	0,897	0,862	0,911	***0,538***	0,718	***1,38***
Both inside and outside cooking	13,9	13,8	12,7	14,9	14,6	14,2	13,2

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Datum: **1/06/2013**