THE ROLES OF EDUCATION FOR SUSTAINABLE DEVELOPMENT AND NAMIBIAN YOUTH IN THE ADVANCEMENT OF SUSTAINABLE HOUSEHOLD COOKING ENERGY

BY

SAMANTHA BONNELL LINDGREN

DISSERTATION

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Doctoral Committee:

Professor J. Bruce Elliott-Litchfield, Chair
Professor Tami Bond, Colorado State University
Professor Alan Hansen
Professor Timothy Johnson, University of Illinois at Chicago
Associate Professor Luis Rodriguez

Abstract

Improved and efficient cooking is a popular solution in the international development community for its presence in multiple Sustainable Development Goals (SDGs). However, in the last forty years of cookstove research and dissemination programs, adoption and sustained use have failed to meet expectations in low- and middle-income countries. Among the known barriers that limit adoption is effective communication. Rarely are all stakeholders within a home purposefully engaged in activities meant to support initial cookstove uptake and long-term use.

Situated in rural Namibia, two studies were undertaken to examine household energy consumption patterns and the agentive capacity of youth in influencing energy-related behaviors and decisions within the home, and across communities. A stratified survey of two rural communities, and a series of surveys given to one thousand Namibian children who attended a weeklong Education for Sustainable Development (ESD) program, point to the importance of the inclusion of youth in energy development efforts.

Conducted in collaboration with the Namib Desert Environmental Education Trust (NaDEET) these studies examine how ESD-focused programming for youth changes their environmental- and energy-related knowledge and attitudes, and their ability to affect change within their own homes and communities. Findings indicate that the topics taught to youth at NaDEET not only increase the children's awareness and sensitivity to environmental and energy-related issues, but also those of their family members'. The transmission of knowledge and attitudes leads to positive changes community-wide.

Households that have a family member with prior experience with NaDEET's programming are significantly more knowledgeable and receptive to sustainable energy topics,

including solar cooking, as compared to a control group. Further, these households also exhibit a higher degree of electric cookstove adoption, and are less committed to their open fires, than similar households. For homes unable to afford electricity, the evidence suggests that NaDEET's influence shifts attitudes and increases knowledge related to sustainable energy, in the absence of a behavior change. ESD was found to be an effective tool for communicating about energy-related topics to communities via youth education.

In addition to improved energy- and sustainability-related attitudes and knowledge, students exhibit a significant increase in preferences for *cleaner* cooking fuels (e.g., electricity, gas, solar) after spending a week at the camp. Youth from households that primarily rely on firewood for cooking demonstrate the largest increase. Further, preliminary findings from a six-month follow-up study indicate that these gains hold, pointing to the long-term benefits of this educational experience.

Taken together, the results of the two studies indicate that youth-oriented ESD has the potential to shift energy attitudes and behaviors, generationally and at the community level. The explicit inclusion of youth as a stakeholder is a new area of energy development research and has broad implications for the ways in which sustainability-related education is incorporated into behavior change communication frameworks for efficient cookstove and energy development programs.

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CHAPTER 1

Introduction

The United Nations Sustainable Development Goals (SDGs) address the most pressing global concerns by identifying a collection of seventeen specific aims, that if realized, would remake our planet into a more prosperous and verdant world by alleviating hunger, poverty, and inequality (United Nations, 2015a). The goals overlap each other, and thus development actors operate at the nexuses of goals, in an effort to exact maximum change on multiple fronts. Household cooking energy has long been a focus of international development work for its presence in several SDGs including Good Health and Well-Being, Gender Equality, Affordable and Clean Energy, and Climate Action among others. However, the transition to *cleaner*, or *improved*, fuels and cooking innovations, has presented seemingly more challenges than successful solutions.

Like the interdisciplinary nature of the SDGs, so too is the improved cooking field. Academic researchers, entrepreneurs, non-governmental organizations (NGOs), funding agencies, and local governments each play a part in designing and distributing new cooking innovations to those who need it most. Four decades of research has been conducted to examine the efficiency of designs, the marketing and messaging to potential users and consumers, and the adoption and efficacy of these solutions. Yet, to date, few randomized, controlled studies of cookstove adoption report high uptake rates (Rosa et al., 2014). Commonly acknowledged barriers to adoption include household economics and affordability, and a mismatch of technology to user. However, when economic barriers are removed and the technology appears to be appropriate, adoption remains elusive (Romieu et al., 2009; Rosa et al., 2014; Troncoso et al., 2007), suggesting that the transition away from biomass is more complex than the acquisition

of a new stove, and pointing to the presence of other factors influencing human behaviors and decisions (Muneer, 2003; Ruiz-Mercado et al., 2011), a challenge that cannot be solved with technology alone.

Since the first wave of cookstove dissemination programs in the 1970s, little has changed in terms of the objectives and methods of the cookstove research being done. The bulk of published cooking-related studies are tech-centric (Johnson et al., 2009; Mobarak et al., 2012; Rehfuess et al., 2014; Sovacool, 2014) with a narrow focus on lab-controlled efficiency and performance testing (Arnold et al., 2003; Eckholm, 1975; Thacker et al., 2014). Comparatively few studies focus on the human aspects of adoption and sustained use (Agarwal, 1983; Hessen et al., 2001; Pandey & Yadama, 1992), and when they do, typically present behaviors, traditions, and culture as obstacles rather than information to incorporate into design and strategy (Iessa et al., 2017). This is, to an extent, not surprising. Energy is a scientific concept, and one might expect technological solutions. However, the *use* of energy is comprehensive and cannot be entirely explained by science and engineering. Despite calls for broadening energy studies to more prominently include human dimensions of consumption (D'Agostino et al., 2011; Kempton & Schipper, 1944; Lutzenhiser, 1992; Pine et al., 2011; Rosa et al., 2014; Stern, 1992), few changes in methodology and perspective have resulted, and low adoption rates have persisted (Rosa et al., 2014).

While the absence of widespread uptake in new cooking technology has been discouraging, it should not suggest that the work is not worth doing. Rather, it provides an opportunity to view the literature more broadly, looking for new ways forward that do not repeat misguided implementation strategies of the past. It is clear that if we want improved cooking interventions to succeed at scale, then we need to adopt broader perspectives that include the

human reasons that contribute to technical solution adoption successes and failures. This dissertation examines cookstove adoption from a generational perspective with a focus on communication and education alongside engineering design.

Chapter 2 of this dissertation reviews the literature of the global use of solid fuels for residential energy needs, including a brief overview of the economic, health, and environmental concerns associated with indoor air pollution. The rest of the chapter is devoted to the challenges associated with adoption at scale of technical cooking solutions, as well as key findings. A discussion of behavior change theory and the use of behavior change communication techniques is presented to illustrate that technical innovation and purposeful communication are in fact two-sides of the same problem. Gaps in the literature are discussed, particularly those related to broadening participation in communication efforts in order to improve engineering and development fieldwork methods and policy in the service of innovation adoption. This serves as the rationale for the objectives and research questions of this dissertation: *How do children's knowledge and attitudes about new cooking technologies, such as improved cookstoves and solar cookers, impact their parents' knowledge, attitudes, and decisions to adopt these technologies? How does informal Education for Sustainable Development affect the development of children's knowledge and attitudes about household energy and sustainability?*

Chapter 3 outlines the study carried out in two Hardap communities of central Namibia, including a brief overview of the country's demographics and economy, and in particular the locations in which data collection was conducted. The research questions, methodology, findings, and a discussion of the results are presented. In Chapter 4, a survey of approximately 1000 students in Namibia who, with their classes from school, attended Education for

Sustainable Development programming at a camp in the Namib Desert is discussed. Chapter 5 synthesizes the two studies, identifies limitations of the research, and future work.

CHAPTER 2

Review of the Literature

2.1 The Global Use of Biomass as Cooking Fuel

Across low- and middle-income countries (LMICs), 3.1 billion people cook and heat their homes by burning solid fuels such as firewood, charcoal, and crop and animal waste (International Energy Agency, 2018b; World Health Organization, 2016). Approximately 80% of rural communities in LMICs rely on biomass (Birol, 2006) for their energy needs, of which basic cooking tasks can require a family to burn up to two tons of firewood annually (Sovacool et al., 2013). Most of the world's poor are rural, young, undereducated, and employed in agriculture, and half live in sub-Saharan Africa (Gebreegziabher et al., 2017; World Bank, 2018).

The emissions of these fires, including carbon monoxide and particulate matter, result in indoor air pollution that cause both acute and chronic illnesses such as upper respiratory illness (CBD 2013 Fisk Factors Collaborators, 2013; Smith et al., 2000), low birth weight and cancer (Bruce et al., 2015; Schwela, 1997), and heart issues (McCracken et al., 2007; Norris et al., 2016; Smith-Sivertsen et al., 2004) that lead to nearly three million premature deaths each year (CBD 2016 Fisk Factors Collaborators, 2017; Forouzanfar et al., 2016; Smith et al., 2014), and is a leading cause of death in children under the age of 5 in LMICs (International Energy Agency, 2018a; Lim et al., 2012). Women and children are disproportionately affected by indoor emissions both because of their prolonged exposure at the hearth (Bonjour et al., 2013; Evans et al., 2018; Listo, 2018; O. Masera et al., 2007; Muchiri, 2008) and because they are also largely responsible for fuel procurement (Lewis et al., 2016).

Fuel collection is an arduous task associated with time and economic burdens (Clancy et al., 2012; García-Frapolli et al., 2010; Sovacool, 2014). Depending upon location, women and children can spend between 1 and 5 hours a day collecting firewood (Sovacool, 2014), preventing women from undertaking other productive or paid work, and keeping children absent from, or unenrolled in, school (Carmody & Sarkar, 1997; Kelly, 2018; Levison et al., 2018). In some regions, particularly those afflicted by conflict and humanitarian crises, or where deforestation requires increasingly long walks to woody resources, fuel collection jeopardizes the personal safety of women and their children (Global Alliance for Clean Cookstoves, 2010). Where fuel is not free, the cost of firewood and charcoal can consume a significant proportion of a household's monthly income (Reyes et al., 2019; Samuel et al., 2018; Women's Refugee Commission & World Food Programme, 2010), depressing economic mobility, and perpetuating poverty.

While individual residential cooking fires are small, cumulatively they have a significant impact on the global environment. In countries with high rates of deforestation, as firewood reserves dwindle, people often allocate increased time to gather less preferred woody resources such as scrublands or weeds, rather than decreasing the household's energy consumption (Palmer & MacGregor, 2009). Animal dung is a common alternative to fuelwood, however the removal of dung from agricultural land degrades soil quality and decreases agricultural production, which contributes to impoverishment (Gebreegziabher et al., 2017). The environmental impact of residential cooking fires is not limited to land; in addition to greenhouse gas emissions (J. Arnold et al., 2006; Hutton et al., 2006), a significant proportion of all global atmospheric black carbon is attributed to the combustion of residential solid fuels (Bond et al., 2013).

2.1.1 Improved Cooking Technologies Descriptions and Definitions

The environmental and social concerns that occur as a result of residential biomass combustion have positioned improved cooking technologies, such as improved cookstoves (ICSs) and solar cookers (SCs), as a socio-techno strategy for reducing these economic, health, and environmental effects (e.g., Bazilian et al., 2011; Cordes, 2011; Ezzati et al., 2004; O. R. Masera et al., 2005). The World Bank (2011) defines "improved" as decreasing household air pollution (HAP), and improving fuel economy and ease of use.

Improved cookstoves are those that more completely combust fuels, simultaneously requiring less fuel and producing fewer emissions. For the purposes of this study, ICSs include only those that use biomass (e.g.,, rocket, forced air, gasifier or top lift updraft stoves, addition of a chimney), excluding liquid petroleum gas (LPG) or electric induction stoves. Solar cookers directly convert sunlight into thermal energy that is used for cooking, and as such, require no fuel and produce zero emissions. Solar cookers, however, require high solar insolation and, unless the SC has the rare ability to store energy (Alonso et al., 2017), can only be used during the day and with abundant sunshine, dictating where and when the user may cook.

Unless otherwise noted, hereafter "cookstove," "stove," and "improved cooking technology" may refer generally to either an improved cookstove or a solar cooker, unless the distinction between the two needs to be made explicit. It should also be noted that this study uses widely accepted phrases such as "improved" and "clean" to distinguish between "traditional" cooking practices and fuels, and those that are more efficient. Though there is an ongoing debate about these terms and their appropriateness (Chatti et al., 2017; Goodwin et al., 2015), these terms are used to be consistent with the current literature base. It should be noted, however, that these phrases have been problematized for their implicit bias toward the fuels, systems, and

infrastructures of "developed" nations. The phrases themselves are at odds with *emic*, or user, perspective-taking of cooking-related issues and technologies and imply that Western culture and its progress are those to which all others strive, a passé element of neocolonialism (Pieterse, 2010).

2.2 The Potential Benefits of Improved Cooking Technologies

Improved cookstoves and solar cookers seek to demonstrably improve health, household economics, and environmental impact - an aspirational trifecta of goals set by the broader development community (Bielecki & Wingenbach, 2014). Indeed, there is evidence of improved health when a cookstove is introduced into the household (e.g., Alexander et al., 2013; Bautista et al., 2009; Burwen & Levine, 2012; Clark et al., 2009). Yet, the health benefits from improved combustion are smaller than originally theorized based on lab results (Khandelwal et al., 2017; Quansah et al., 2017), and many other studies have shown that there is, in fact, no improvement in health conditions after the introduction of an improved stove (e.g., Hanna et al., 2016; Mortimer et al., 2017; Smith et al., 2011). The impact that SCs have on health outcomes remains theoretical as there have been no medical studies undertaken to evaluate a solar cooker program in this way (Iessa et al., 2017).

Similarly, to date, no published research has been able to document drastic reductions in the emissions of fine particulate matter, a leading exposure concern for pneumonia, cardiovascular diseases, stroke, and lung disease (Forouzanfar et al., 2016), after the introduction of an improved cookstove or solar cooker (Aung et al., 2016; Iessa et al., 2017; Pope et al., 2017; Smith et al., 2011). This indicates that open fires are not completely abandoned in favor of newly acquired improved cooking technology. Just one hour of traditional stove use a week can

increase HAP above the World Health Organization's (WHO) Indoor Air Quality recommendations (Johnson & Chiang, 2015). Therefore, major shifts in cooking behaviors and practices must then be required in order to meet the WHO's HAP standards (Rosenthal & Borrazzo, 2015).

While ICSs and SCs are often lauded for their potential economic benefits (García-Frapolli et al., 2010; Habermehl, 2008; Hutton et al., 2007; Mehta & Shahpar, 2004), there is little evidence that shows long-term economic benefits realized by households. Modeling analyses show that personal economic benefits may actually be negative after the introduction of a cookstove, most likely due to the acquisition of the stove, but not adoption, and therefore the continued costs of purchasing fuel (Cundale et al., 2017).

2.2.1 Adoption of New Cooking Technologies: Predictors and Barriers

"Advanced technology will not have an impact if the stoves are not sustainably used" (Clark et al., 2015). In order for cookstoves to impact HAP and diminish their impact on anthropogenic climate change, improved cookstoves and solar cookers must first be acquired by households, and then *adopted*, taken here to mean used correctly, as intended by the designer, and consistently (Shankar et al., 2014). Yet despite decades of cookstove research, adoption at scale has remained unrealized (Shankar et al., 2014). Compared to biomass fuel and cookstove design and efficiency studies, there are relatively few investigations that look specifically at adoption of these technologies, particularly in resource-limited regions (Johnson et al., 2009; Mobarak et al., 2012; Rehfuess et al., 2014) where adoption rates have typically been the lowest (Rhodes et al., 2014).

Correct and consistent use often occurs during the initial stages of a cookstove trial or intervention, but may diminish over time (Kay, 2012; Shankar et al., 2019). Compounding these issues is the way in which adoption metrics are reported. More often than not, adoption is reported by the number of units disseminated with the underlying, but false, assumption that acquisition will lead to sustained use (Lindgren, 2020; Pine et al., 2011). There are no widely accepted metrics for reporting adoption though most typically report how frequently the new stove is being used within a specific period of time (Lindgren, 2020), either based on user self-reporting, stove usage monitors (SUMs), or both. The Global Alliance for Clean Cookstoves (GACC) commissioned the development of an Adoption Index for quantifying rates of adoption based on four variables easily ascertained in follow-up interviews (Troncoso, 2013; Troncoso et al., 2013). Yet, if cookstove programs are using this algorithm, it is rarely reported. In a recent literature survey, no adoption study published after 2013 reported the adoption index, nor reported enough data for the index to be calculated in a meta-analysis (Lindgren, 2020). There is also no guidance on when follow-up surveys should be conducted to assess adoption or sustained use. For this reason, most studies report adoption rates within months of dissemination. It is rare for a study to assess sustained use (Hanna et al., 2016), largely due to the feasibility of conducting longitudinal, long-term studies. However, in the absence of rigorous studies that examine the adoption and sustained use of cookstoves it is not possible to estimate the direct and indirect impacts of their implementation, nor determine which of the potential benefits are being realized (Lewis & Pattanayak, 2012; Von Schirnding et al., 2002). S*ustained use,* rather than adoption, is the challenge that the cookstove research community should be working to address (Tigabu, 2017; Yadama, 2013).

In spite of the lack of well-specified metrics and measures, published studies examining improved cookstoves and solar cooker use almost exclusively report low adoption rates (Lindgren, 2020; Rosa et al., 2014). This has been explained, in part, by recurring themes in the literature including economics, design and cultural acceptability, and household dynamics (Jeuland & Pattanayak, 2012; Malla & Timilsina, 2014; Miller & Mushfiq Mobarak, 2015; Mobarak et al., 2012; Rehfuess et al., 2014), each of which is briefly discussed below.

Economics

Research in household cooking energy is dominated by socio-economic models that prioritize demographic variables (Jagadish & Dwivedi, 2018; Muneer, 2003; Pine et al., 2011; Takama et al., 2012), and indeed poverty is the largest obstacle to cookstove acquisition. Higher household income, and therefore more expendable income, is positively correlated with cookstove acquisition (Rehfuess et al., 2014). However, when economic barriers for low-income households are removed through subsidies, gifts, and financing models, cookstove adoption rates do not increase (Romieu et al., 2009; Rosa et al., 2014; Troncoso et al., 2007), indicating that economics might be a barrier to acquisition, but not to long-term use.

Design

The importance of cooker designs that are inclusive and sensitive to traditional cooking methods of the specific target market has long been understood, yet the cookstove value chain before it reaches the users, including the research, design, distribution and implementation, often peripheralizes these practices (Bielecki & Wingenbach, 2014; Manibog, 1984; Ruiz-Mercado et al., 2011). Cookstove design is often focused on efficiency and technical performance, while

users may prioritize features such as fast-cooking times and convenience over fuel economy and health benefits (Adkins et al., 2010; Gill, 1987). Cookstoves that incorporate traditional stove design aspects, or those developed through participatory design or are made by local artisans (Barnes et al., 1994) are more likely to be adopted than those that do not (Rhodes et al., 2014; Rosa et al., 2014). A cookstove's design can ultimately hinder its own ability to be adopted if it is unstable, difficult to use or ignite, is the wrong size for the household or for the cooking utensils, is not portable or durable, and if it cannot be used to safely and efficiently prepare traditional foods (Barnes et al., 1994; Gill, 1987; World Bank, 2011). Solar cookers, in particular, are criticized for their limited ability to support local culture and traditional cooking practices (Beltramo & Levine, 2013; Mercy et al., 2008; Vanschoenwinkel et al., 2014; Wilson & Green, 2000). Yet, even as designs become more robust and human-centered, improved cookstoves and solar cookers alike continue to experience low adoption rates (Iessa et al., 2017; Shankar et al., 2014).

Cultural Considerations

One stove design is unlikely to satisfy all of a household's cooking needs, as this is beyond the role that even traditional cookstoves play. Households use a variety of cooking methods and fuel sources in a single meal preparation (e.g., oven, grill, and stove), in a process known as *stove-stacking* (Lewis & Pattanayak, 2012; Masera et al., 2000; Pine et al., 2011; Puzzolo et al., 2013; Ruiz-Mercado et al., 2011), a common practice in rural areas in LMICs, as it is in kitchens across the globe. Even during cookstove trials in which new stoves were provided, households rarely exclusively used the new stove (Rhodes et al., 2014). "Successful cookery requires a thousand things done well" (Symons, 2003), and this combination of tasks is unlikely to be performed by

one stove alone (Ruiz-Mercado & Masera, 2015). Additionally, if food is perceived to taste differently when prepared on an improved cookstove or solar cooker, it is unlikely to be adopted, especially by older users (Bhojvaid et al., 2014).

Fires are also used for more than just cooking (e.g., light, heat, insect repellant, water heating), often acting as a social gathering space or may have important religious significance to a community (Gill, 1987; Muneer, 2003; Ruiz-Mercado & Masera, 2015). Smoke can create a "safe space" in which women can freely discuss personal issues in an environment unattractive to men (Sovacool, 2014). Similarly, cookstoves are often promoted to women for their ability to save them time collecting fuel, but for many women this task is the one part of their day marked by social interactions with other female friends and family members, and is not always considered a burden (Green, 2001; Hollada et al., 2017; Iessa et al., 2017). Many programs that have promoted fuel-efficient technologies with little success failed to consider the "variations in cultural preference, local cooking needs, patterns of household fuel use, and other social and economic factors" (Pine et al., 2011).

Household Gender Dynamics

The majority of cookstove users in LMICs are women, and thus cookstoves are typically promoted to women. Women, however, are rarely the primary decision-maker in their household or have parity in household purchasing power (Green, 2001; Khamati-Njenga & Clancy, 2005; Ogunlela & Mukhtar, 2009; Tucker, 1999). Failure to recognize gender dynamics and the associated division of labor and household roles has long been a hindrance to cookstove adoption (Kammen, 1995; Muneer, 2003). For instance, in early cookstove development and dissemination programs in Africa, cookstoves and associated training demonstrations targeted

men (Kammen, 1995), though men are traditionally less willing to pay for products perceived to primarily benefit women and children (e.g., Ashraf, 2009; Duflo & Udry, 2003; Kay, 2012; Meredith et al., 2013; Miller & Mobarak, 2015; Thomas, 1990; Ueyama, 2007). In LMICs, women reinvest 90% of every dollar earned back into their family (e.g., education, nutrition) whereas men reinvest 30-40% (Shankar et al., 2015), indicating the promotion strategies must vary with stakeholder.

It is also important to note that while household dynamics are often presented as a universal obstacle to cookstove adoption, these dynamics are not uniform across regions, or even between households. For example, nearly all cookstove literature presents fuelwood collection as women's drudgery. Indeed, across sub-Saharan Africa women spend twice as much time on unpaid chores, such as fuel and water collection, as men (Ferrant et al., 2014). In rural parts of Mexico, however, men traditionally collect the firewood (Troncoso et al., 2007).

Time Constraints

Once a stove is acquired new household barriers to adoption arise. Learning to use the stove, or adjusting to the use of a new fuel, requires a large upfront input of time (Jeuland & Pattanayak, 2012), which may dissuade some users where time is already a precious commodity (Rhodes et al., 2014). Women have a large number of domestic responsibilities, and have little room for adjustment to their daily routines. A change in technology that requires additional chores or more intensive maintenance of the cooking fire prevents women from accomplishing other household duties (Rhodes et al., 2014). And while improved cooking technologies can potentially save women and girls time by requiring less fuel collection, and may be a reason women are willing to adopt a cookstove or solar cooker (Otte, 2013), there is little evidence that any time savings is

used for the activity of their choice, or is directly converted into income-generating activities. This is particularly true in rural communities that are largely agrarian and lack access to labor markets (Cundale et al., 2017). Whereas, there are studies that demonstrate that when women gain more time in their day due to the introduction of a new cooking innovation or electricity, husbands expect more work from their wives, ostensibly decreasing the quality of a woman's life with a product intended to improve it (Cecelski, 2000; Green, 2001; Grundy & Grundy, 1994; Iessa et al., 2017; Sovacool, 2014; Wilson & Green, 2000).

This is in no way an exhaustive discussion of the barriers and predictors of cookstove adoption and sustained use, rather it is presented to underscore that one of the most significant elements to cookstove adoption is an understanding of human behavior. Contextual factors such as culture, norms, religion, social networks, and education are not changed by the introduction of a new technology, but do affect perceptions (Rhodes et al., 2014) and influence "entrenched complex behaviors" (Goodwin et al., 2015) that impact the technology's ability to be taken up. Because there is no one universal reason why cookstoves are adopted or not, context-specific evaluations to match stoves to communities and local behaviors are necessary (Cundale et al., 2017). And these evaluations must address the social and cultural processes of adoption, or the potential benefits of cookstoves cannot be realized (Clark et al., 2015; Pine et al., 2011; Ruiz-Mercado et al., 2011; Shankar et al., 2014; Troncoso et al., 2007).

2.3 Perspectives in Energy Studies

Lutzenhiser & Shove (1999) argue that the focus on techno-economics, in cookstove studies and energy studies as a whole, has created a "blind spot" that obscures the "human elements" of energy technology and its use. Rather than viewing human choice as a critical component of energy use, mechanical systems have been emphasized, and human factors are typically limited

to considerations about safety and misuse of the technology. In some ways, this is explained by examining the origins of the literature base. The typical author of an energy-related study in the three major peer-reviewed energy journals, *Energy Policy*, *The Energy Journal*, and *Electricity Journal*, in the last fifteen years are North American white males, trained in science, engineering, or economics with a university affiliation (Sovacool, 2014). It would be untrue to imply that these studies represent anything but sound, meaningful scholarship, but it does highlight how "unreasonably narrow" the boundaries of energy studies are (Mitcham & Rolston, 2013). Sustainability researchers, as described in Sovacool (2014), have warned that this narrow scope is "problematic for research and policy, and is inadequate" for addressing contemporary issues related to energy (Minsch et al., 2012), which echoes Caldwell's (1976) assertion that "if there is a comprehensive energy problem, it is a problem of choice and value in a world of finite capabilities. It is therefore also a moral and political problem, and for this reason will not yield to a purely technical solution."

Sovacool's (2014) literature review of energy studies described above found that of nearly 10,000 authors and co-authors in this fifteen year period of time, 0.4% had training in development studies, and 0.1% and 0.04% had affiliations in communication and anthropology, respectively. Missing entirely are authors that have training or affiliations in education or in women's or gender studies (though approximately 15% of contributing authors were women). These figures are counterintuitive for several reasons including that approximately 150 papers regarding energy and development in LMICs were published, in this timeframe, and that in LMICs women comprise the majority of the energy impoverished (Sovacool, 2014). The nexus of energy and poverty also overlaps gender issues: of the world's poor, 70% are women (Bauer et al., 2008).

This is presented in order to highlight the incompleteness of our understanding of energy-related issues, including the use of biomass in LMICs. Nearly 40% of the global population burns solid fuels for residential energy use (World Health Organization, 2016) yet biomass studies account for just a few percent of all articles in the most reputable energy journals during the last decade and a half (Sovacool, 2014). Additionally, only 2.2% of all published studies examined energy end-use behaviors (Sovacool, 2014). The exclusion of energy-behaviors from the literature base implies that any forecasting about energy may be limited because of our poor understanding of patterns of energy use (Stirling, 2014). Mixed-methods, including those taken from social sciences, are necessary to "uncover the multidimensional role that attitude, habit, and experience have in shaping energy consumption" (Sovacool, 2014), and their inclusion has been recommended in energy studies for more than two decades (Lutzenhiser, 1992; Stanistreet et al., 2015). Yet in the last fifteen years, just 12.6% of published articles in leading energy journals employ any method taken from the social sciences, surveys being the most common. Very few make use of interviews, focus groups, or other ethnographic approaches to field research (Sovacool, 2014). These methods are essential to understanding how humans consume energy and make choices related to their use of energy in the home (Lutzenhiser, 1992; Stern, 1993, 2014; Stirling, 2014).

2.4 Behavior Change and Communication

This next sections outline the role of communication in technology diffusion promoting sustainable energy behaviors, the predominant social science presence in cookstove studies. Following that is a brief background of behavior change techniques and an argument for how broadening stakeholders in cookstove dissemination efforts may aid in long-term adoption and sustained use.

2.4.1 The Role of Communication in Cooking Technology Adoption

The rhythms and practices of a household's kitchen are habituated behaviors, some of which are deeply rooted in family tradition and culture. The introduction of a new cooking technology is an attempt to change or disrupt the social structure or function of a household, community, or region (Rogers & Shoemaker, 1971). Communication, the exchange of information by which new ideas are propagated between individuals and groups of people, is the very heart of *diffusion of innovations* (Rogers, 1985), and relies upon social networks to diffuse the information to broad audiences (Rogers & Kincaid, 1981). As a new physical innovation or idea is introduced, information must be communicated to and between members of the society. And as a result of that communication, the decision to adopt or reject the idea or product is made (Rogers, 1985), which can motivate social change (Kumar & Best, 2007). In *Communication of Innovations: A Cross-Cultural Approach*, the diffusion of innovations and ideas is defined as a "subset of communication," because it is central to a society's decision to take up a new idea or innovation. "Social change is therefore an effect of communication" (Rogers & Shoemaker, 1971), such that, in the absence of purposeful communication, technical solutions are rarely adopted (Rogers, 1985; Rogers & Shoemaker, 1971).

There is a small but growing body of literature in economics that demonstrates how information, education, and communication can influence the uptake of environmental and health technologies such as taps, toilets, bed nets, and cookstoves (Pattanayak & Pfaff, 2009). The underlying premise of this literature is that the poorest households would likely benefit the most from such technologies, but may not be aware of, or have access to, information about these products' benefits (Madajewicz et al., 2007; Opar et al., 2007). Information provision can

help households overcome reluctance to invest in costly goods, allowing users to weigh the upfront costs, and perceived risk, against the potential benefits (Conley & Udry, 2010; Hazra et al., 2014; Shankar et al., 2014).

Within the cookstove sector, new cooking innovations are more likely to be adopted if the implementing organization has a strategic plan for communication (Kreuter et al., 2004), and when local social networks are leveraged (Beltramo et al., 2015; Bielecki & Wingenbach, 2014; Brown & Ashman, 1996; Miller & Mushfiq Mobarak, 2015; Ramirez et al., 2014; Shankar et al., 2014).

2.4.2 Behavior Change Theory

"Changing behaviours - in particular motivating more sustainable behaviours - is far from straightforward. Individual behaviours are deeply embedded in social and institutional contexts" and is the centerpiece of sustainable development policy (Jackson, 2005).

Similar to work in sanitation, improved cooking requires a significant two-step change in user behavior (Rhodes et al., 2014); first, a new hardware or technology is acquired, followed by new behaviors supplanting the old ones (Klasen et al., 2013; Mukhopadhyay et al., 2012). Behavior Change, as it has manifested in the cookstove domain, stems from the field of health communication and provides frameworks for addressing the complex human behaviors that must be changed to support personal, community, and/or global health (Goodwin et al., 2015; Jackson, 2005; Maio et al., 2007). Historically, behavior change theory was based on rational cognitive models of behavior which assumed that an individual attends to new information, adjusts attitudes, and then changes behavior accordingly (Goodwin et al., 2015; Maio et al., 2007). More recently, social and health psychologists recognize the highly influential role that non-cognitive

factors, such as emotions, and social and environmental interactions, have on behavior (Bandura, 1986; Biran et al., 2014; Heider, 1944; Heider, 1946; Jackson, 2005; Loewenstein et al., 2001). Energy studies, though they often make use of behavior change communication theory, have not followed this same trajectory. In fact, household energy consumption models are still largely based on the premise of rational choice (Wallenborn & Wilhite, 2014).

Behaviors can be explained, in part, by social cognitive theory, which argues that behaviors are performed in the context of three influences: behavioral, personal, and environmental (Bandura, 1986). When individuals perform or observe a behavior, they gain skills and confidence which can increase the behavior's frequency, while personal factors influence one's willingness to perform the behavior. People are influenced by their environment including the ways in which they interact with others. In short, people learn behaviors and attitudes by observing others, and as they gain confidence performing actions, they become more likely to continue doing so (Bandura, 1977, 1986). Environmental factors have been shown to have a large impact on energy and environmental behaviors (Cialdini & Goldstein, 2004; McKenzie-Mohr, 2002; McKenzie-Mohr, 2000). For instance, a young woman may observe and emulate her female elders, learning traditional cooking from a young age, which ultimately becomes a habit. She may also be more likely to adopt an improved cookstove or solar cooker if other women in her social network (e.g., family members and friends, peers in women's groups, respected female members of the community) are using or adopting the same cooking innovation (Beltramo et al., 2015; Bielecki & Wingenbach, 2014; Rogers, 1985; Vulturius & Wanjiru, 2017). Social cognitive theory has successfully been used by public health researchers to explain the ways in which individuals in a community transmit ideas, beliefs, behaviors, and values to others via direct social learning (Bandura, 1994; Bricker et al., 2010; Lopez et al., 2009).

In order to change a behavior, both the context and the individual's role in producing the behavior must be modified (Maio et al., 2007). To do so, interventions must simultaneously provide information, shift attitudes and motivations, and provide the skills necessary to maintain the new behaviors long-term (Fisher & Fisher, 1992; Maio et al., 2007). This task is considerably more difficult when working to overcome *habits*, past behaviors that are automatic and require little conscious intention (Verplanken & Aarts, 1999; Verplanken & Wood, 2006; Wood et al., 2005). Once adults form habits, they are less likely to notice new information, especially if it is not consistent with the habitualized behavior itself (Betsch et al., 2001; Verplanken et al., 1997), suggesting that information alone is unlikely to change a habit. Whereas, learning a new behavior is guided by attitudes and intentions, and done with deliberation (Webb & Sheeran, 2006).

Cooking is a habit and deeply ingrained in cultural significance (Wrangham, 2009). Cookstoves that are dissimilar to traditional stoves require more habits to be overcome, and behaviors to be changed or added (e.g., fuel preparation, utensils, lighting/heating process, maintenance, etc.). Users are asked to perform new behaviors in an environment which supports previous habits, requiring psychological effort to make a change (Baumeister & Newman, 1994), which can cause the user uncertainty or stress (Kruglanski & Webster, 1996; Muraven & Baumeister, 2000), decreasing the users' self-efficacy (Bandura, 1986) and the likelihood of sustained use.

2.4.3 Cookstove Behavior Change Communication Techniques

For the last 60 years, behavior change methods have been a prominent piece of the strategy to address pressing global health challenges (Evans et al., 2018). Techniques to change behaviors

and habits related to cooking include a range of interventions such as social marketing campaigns, economic incentives, shaping knowledge, utilizing change agents for social support, and changes to policy, regulations, or the physical environment (Goodwin et al., 2015). These techniques are utilized along all points of the cookstove value chain (Hart & Smith, 2013).

There is evidence that demonstrates the efficacy of these approaches in changing behaviors in a variety of health-related fields across subject matter, populations, and global settings (Michie et al., 2013; Snyder et al., 2004). In LMICs, behavior change efforts have had success in modifying health behaviors related to HIV, tuberculosis, and maternal and child health (Modi & Firestone, 2014), and improving knowledge and perceptions (precursors to behavior change) regarding sanitation (Evans et al., 2018; Goodwin et al., 2015). In industrialized countries, behavior change efforts have been successful at scale in a variety of public health domains including seat belt use, oral health, heart disease prevention, women's health, sexual health, and mitigating risky behaviors associated with alcohol and tobacco use (Snyder et al., 2004).

The most common behavior change techniques used in cookstove adoption programs are those that address the user directly (as opposed to influencing the user via regulation or through market-based solutions): Shaping Knowledge, appearing in 85% of examined cookstove behavior change studies, and Social Support, present in 65% (Goodwin et al., 2015). Activities that fall under Shaping Knowledge include public cooking demonstrations and training sessions, often coupled with health education campaigns, and are useful tools for communicating about a cooking product to a community. Social Support techniques are also instrumental in communicating cookstove products directly to the users by consulting with community leaders, and working with sales agents, community health leaders, peer educators and other change

agents in the users' social networks (Goodwin et al., 2015). In the PATH project in Uganda, it was found that "peer-led promotion," which involved current users of a new stove speaking about their personal experiences with the product at public cooking demonstrations was effective at improving stove uptake (Shell Foundation, 2013), echoing results from other public health efforts (Valente & Pumpuang, 2007).

To be clear, shaping knowledge does not mean simply disseminating health information. Health education campaigns have not been found sufficient by themselves to change cooking behaviors (B. Barnes et al., 2015; Jackson, 2005) for a variety of reasons including health being prioritized lower than other household needs (Wang & Bailis, 2015) and a low understanding of the relationship between smoke and illness (Edelstein et al., 2008; Gordon et al., 2007; Hollada et al., 2017; Matinga et al., 2013; Rhodes et al., 2014). Furthermore, decades of public health failures have taught us that appeals of "do this because it is good for you" rarely succeed (B. Barnes et al., 2015), in part because people are reluctant to feel vulnerable when it comes to their personal and family's health (Ditto et al., 2003; Ditto & Lopez, 1992). Thus, providing information related to health in the absence of new skill instruction and social support is unlikely to motivate changes in behavior.

Cookstove field studies that intentionally make use of a theory of change or use behavior change techniques report higher adoption rates than those with no framework for behavior change (Kreuter et al., 2004). There have been recent calls for more papers examining behavior change communication and cookstoves utilizing mixed-methods (Stanistreet et al., 2015) as there are relatively few of these studies. Rarer still are those that employ rigorous methodologies in conjunction with behavior change theory (B. Barnes, 2014), and with a focus on the user's perspective to understand the change (Chatti et al., 2017). As an illustration of this, in a recent

literature review of 144 improved cookstove and solar cooker adoption studies, only 18 (13%) made any reference to a specific behavior change technique used to address social or community factors. Most of these studies solely targeted women as their behavior change communication audience, despite their lack of parity in household decision-making. Just two studies purposefully engaged youth, in addition to their mothers, in the behavior change activities, despite the fact that youth are, or soon will be, users of cookstoves themselves (Lindgren, 2020).

2.5 Cookstove Technology Adoption and Age

The longer one performs a behavior, and the more entrenched the habit, the harder it is to change, especially if that change is expected to occur in an environment that supports the original behavior (Baumeister & Newman, 1994; Maio et al., 2007; Verplanken & Aarts, 1999; Verplanken & Wood, 2006; Wood et al., 2002, 2005). Young people have had fewer years to form habits, suggesting that youth may be an important audience for cookstove promotion who could increase the acceptance of these new technologies (Hollada et al., 2017).

Indeed, there have been calls to more closely examine age in cookstove adoption studies (e.g., Troncoso et al., 2007), as there is evidence from multiple regions suggesting that young women are significantly more likely to adopt a new cooking technology than their female elders (Molnar, 2017; Muneer, 2003; Wolf et al., 2017). Relatedly, households with children, particularly those who are educated (Muneer, 2003) are also more likely to adopt a new cooking technology than other households in the community (Jeuland et al., 2015; Mohapatra & Simon, 2017). This follows technology adoption studies across communication and consumer science domains. The transmission of technology within households with children outpaces that of those without children, and is well documented (Correa, 2016; Correa et al., 2015). Based on diffusion of innovation theory (Rogers, 1985), studies examining mobile phone use and internet

connectivity in the United States, and in LMICs (Correa et al., 2015; Kiesler et al., 2000), show that children act as intermediaries for their adult relatives, brokering new technologies (Correa, 2016; Katz, 2010). Consumer research also tells us that adolescents are more likely to be early adopters of new ideas and innovations (Cornelius et al., 2014), and when adolescents are well informed about a product that they consider important, they exert some influence in the family decision-making process (Beatty & Talpade, 1994; Belch et al., 1985; Foxman et al., 1989).

2.6 Education for Sustainable Development

Education is communication, in that the purpose of both is to transmit information (Prozesky, 2000). It could be argued that education and behavior change communication, within the context of improved cooking technology dissemination, are indistinguishable from each other in terms of purpose, and indeed they are closely related. However, there are two key differences. The first is that the goal of education is to equip an audience with requisite information and skills such that they are able to make savvy decisions, including those about one's own behavior. Whereas, in behavior change communication a decision about an audience's desired behavior has been made by an external group or entity before the audience is involved (as an exception, Lewis et al., 2015). The second key difference is in the target audience itself. Behavior change communication efforts in the improved cooking field, are narrow in that they are typically aimed at adults. Education, on the other hand, especially those programs that are focused on sustainability, include a more diverse audience, particularly in terms of age. This last section focuses on youth as agents of change through a discussion of the role that sustainability-focused education plays in changing attitudes and behaviors within a household.

2.6.1 Energy & Environmental Knowledge, Attitudes, and Behaviors

Attitudes of children are markers for long-term social change (Zukin et al., 2006). Children begin acquiring knowledge and attitudes about the environment around the age of five (Bryant & Hungerford, 1977). These early attitudes shape their later thinking about these topics (Leeming et al., 1995), solidifying environmental attitudes in the teenage years (Eccles & Roeser, 2011; McBeth & Volk, 2009).

Factors that affect energy and environmental attitudes, knowledge, and behaviors are complex and can be difficult to measure (Damerell et al., 2013; Heimlich & Ardoin, 2008; Steg, 2008; Stern, 2000). Behavior, in particular, is not easily measured because of the time and resources that need to be allocated for observations. Domain-specific knowledge is thought to be a necessary antecedent to behaviors that are done for the benefit of the environment (Heimlich & Ardoin, 2008; Kaiser et al., 2008; United Nations Educational Scientific and Cultural Organization, 2008), and is more easily assessable. Various studies have found that environmental knowledge does have a positive influence on pro-environmental behavior (Frick et al., 2004; S. Geiger et al., 2014, 2018; S. M. Geiger et al., 2019; Hines et al., 1987; Kaiser & Frick, 2002; Meinhold & Malkus, 2005).

Attitudes and environmental self-concept are constructs more easily assessed and though not a perfect proxy for behaviors (Cornelius et al., 2014), some attitude and self-concept instruments exhibit a high degree of statistical reliability and validity, and have been shown to be associated with, and have predictive ability for, pro-environmental behaviors (Dunlap et al., 2000; Nisbet et al., 2011). Measuring how connected one feels to nature, for example, has been demonstrated to predict future environmental concern (Dutcher et al., 2007; Mayer & Frantz, 2004; Schultz, 2000).

Adolescents are more motivated than adults to make energy-related behavior changes, in part because they are at a stage in which they are beginning to establish their own identities, beliefs, and behaviors (Cornelius et al., 2014). Developing pro-environmental behaviors at a young age allows those behaviors to become habits, which, along with the broader social networks of youth (e.g., school, sports, clubs, etc.) (Cornelius et al., 2014), greatly magnifies their potential to influence others over time.

2.6.2 Changing Behaviors through Education for Sustainable Development

The United Nations declared 2005-2014 as the Decade of Education for Sustainable Development (DESD). Education for Sustainable Development (ESD) encompasses the well-defined field of *environmental education* (EE), which is a discipline that focuses on humans' relationship with the natural environment in an effort to promote conservation and responsible stewardship of natural resources, but expands to include socio-cultural factors including equity, poverty, democracy, and quality of life (UNESCO, 2005). According to the United Nations,

> ESD equally addresses all three pillars of sustainable development - society, environment and economy - with culture as an essential additional and underlying dimension. By embracing these elements in a holistic and integrated manner, ESD enables all individuals to fully develop the knowledge, perspectives, values and skills necessary to take part in decisions to improve the quality of life both locally and globally on terms which are most relevant to their daily lives. (United Nations Educational Scientific and Cultural Organization, 2008)

Education for Sustainable Development was born out of the Earth Summit in Rio de Janeiro in 1992, and was further developed in a series of UN conferences about sustainable development in the 1990s (e.g., World Summit for Social Development in Copenhagen (1995), the Fourth World Conference on Women in Beijing (1995), the Second World Conference on Human Settlements in Istanbul (1996)). These summits stressed the need for basic human rights

and emphasized the importance of social and human development alongside economic development, the advancement of women's empowerment, and sustaining natural resources and the environment for future generations, among other objectives. All reports identified education as the critical piece to achieving the SDGs (Hopkins & McKeown, 2002).

There are many ways that ESD is implemented. In the United States, ESD primarily takes the form of education *about* sustainable development, focusing on information about conservation of natural resources (Hopkins & McKeown, 2002). Internationally, education *for* sustainable development often refers to the intentional use of education to advance sustainable livelihoods and recognizes the necessity of basic education for all. Studies have demonstrated that education is the key to a country's ability to "develop," or make progress toward sustainability goals, shifting toward a knowledge-based economy which relies more on local innovation than on international technology (UNESCO Principal Regional Office for Asia and the Pacific, 1998). Education has been shown to lead to improved agricultural production, women's empowerment, reduction in population rates, and purposeful environmental conservation (UNESCO Principal Regional Office for Asia and the Pacific, 1998), including the adoption and sustained use of improved cooking technologies (e.g., Edelstein et al., 2008; Gordon et al., 2007; Jan et al., 2017; Lindgren, 2020; Mobarak et al., 2012; Mohapatra & Simon, 2017; Pandey & Yadama, 1992; Shen et al., 2015).

Sustainable development is difficult to envision. *Sustainabl*e is defined one way in the United States, but is applied differently in other locations. And what "sustainable" means today will almost surely be different in the future. Because of this, ESD is a place-based approach to advancing sustainable development, where the principles emphasized (e.g., environment, gender, etc.) vary with context. Just as health behaviors are unmoved by information alone, scientific

information and awareness campaigns are also insufficient for changing energy-related behaviors (Abrahamse et al., 2005; Bandura, 1986; Corner & Randall, 2011; Geller, 1983; D McKenzie-Mohr, 2002; Stern, 2000; Zelezny, 1999). Effective ESD is issue-based, coupling information with skills, values, perspectives, and worldviews (Hopkins & McKeown, 2002).

Short-term ESD experiences have been shown to have positive, long-term effects that last into adulthood (Broom, 2017; Jaus, 1984) on energy and environmental knowledge (Trewhella et al., 2005; Vaughan et al., 2003), attitudes (Aipanjiguly et al., 2003; Bradley et al., 1999; Ramsey & Rickson, 1976) and behaviors (Cornelius et al., 2014; Damerell et al., 2013; Flora et al., 2014; Puttick et al., 2015). This positions youth-oriented ESD not only as an important motivator of sustainability and future development, but also as a vehicle for communicating about energy issues and solutions.

This is not to suggest that educational institutions, whether they be schools or informal institutions such as camps, should be co-opted for marketing innovations directly to youth. Just as this does not imply that designers can rely on education to gloss over ineffective cookstove designs. Rather, educational contexts that implement environmental ESD curriculum and principles promote behaviors and attitudes that are already aligned with the goals of the improved cookstove sector, and of the larger sustainable development community.

The importance of the transfer of knowledge when introducing a new product, such as a cookstove, has been noted by many authors (Grundy & Grundy, 1994; Wilson & Green, 2000). Education and training are essential at any age for the uptake of a new idea. Students who are exposed to ESD may solidify pro-environmental attitudes, beliefs, and behaviors that they will carry throughout adulthood (Broom, 2017), making youth an important audience that has been

traditionally overlooked in cookstove dissemination and communication efforts (Lindgren, 2020).

2.6.3 Youth Agency and Bidirectional Learning Within a Household

"Household energy use is a family affair" (Boudet et al., 2016) is as true in LMICs as it is in high-income countries working to enact sustainable, energy-saving behaviors (Gladhart & Roosa, 1982; Kleinschafer & Morrison, 2014). There is a growing base of research that indicates that learning within a family is bidirectional, that is, children and their parents learn from each other rather than the traditional view that children alone learn from their parents (Boudet et al., 2016; Damerell et al., 2013; Duvall & Zint, 2007; Knafo & Galansky, 2008; Legault & Pelletier, 2000; Rimal & Flora, 1998; Robinson & Borzekowski, 2006; Vaughan et al., 2003). There is evidence that child-focused EE/ESD programs can be "transferred between generations and indirectly induce targeted behavioural changes" (Damerell et al., 2013). When trying to change family and household behaviors, it may be more effective to target the children than the parents (Robinson & Borzekowski, 2006) because of the flexibility of youth attitudes and behaviors, as previously discussed.

In fact, many household habits in high-income countries that are now commonplace (e.g., seat belt usage and recycling) were once behaviors that needed to be promoted. Schools were enlisted by public health and environmental professionals to teach these behaviors to children, enacting social change via youth (Maio et al., 2007). In Peru, information provided to children played regarding the prevention diseases for livestock was shown to be an integral role in their fathers' decision-making (Maruyama et al., 2013). There are also a handful of studies that have been conducted in sub-Saharan Africa that demonstrate not only a link between ESD and

increased sensitivity toward environmental conservation (Ajiboye & Silo, 2008), but also improved sustainability practices within the home (Kioko & Kiringe, 2010). In Ghana, for example, students were taught to use sophisticated water testing equipment, which equipped them to share better hygiene and safer drinking water practices with the elders in their homes (Okyere et al., 2017).

While energy-related education programs for youth and their families are becoming an increasingly popular way to focus energy conservation efforts in the United States (Kandpal & Broman, 2014; Lane et al., 2014; Ntona et al., 2015), few studies have been undertaken to assess their impact. As an exception, a recent study conducted in Northern California demonstrated that informal education for girls about energy conservation translated to energy-saving behaviors performed by adults at home (Boudet et al., 2016). The recommendations borne out by this study include designing programming that engages the entire family as target audiences, encourages parents to make sustainable behaviors visible to their children, and provides both children and their parents with tools and strategies to foster within-family discussions about sustainability (Boudet et al., 2016), common elements of ESD. There is little known about specific energy attitudes and behaviors of youth in the United States, and even less in LMICs, making this a ripe area for future research.

In 2015, a series of workshops were held to discuss children's roles in sustainable development. The product of these seminars is a collection of papers compiled in *Children and Sustainable Development: Ecological Education in a Globalized World*, which highlights the bottom-up successes of the inclusion of youth in sustainable development. This book emphasizes the importance of education to combat climate change, and the vast potential of youth if their *agency* is developed. Given that more than a quarter of the world's population is under 15 years

of age (United Nations, 2015b), there is significant potential for large scale change. This, combined with recent evidence of children's agentive capacity in development projects in Ghana and Peru (Maruyama et al., 2013; Okyere et al., 2017; Ramanathan et al., 2017), indicates that children may occupy a "catalytic" space within development work (Davis, 2009).

More than an entire generation of people have been born and grown to adulthood since cookstoves were first introduced in LMICs. Cookstove adoption efforts targeting adults should continue, but it is also time to involve the future users of cookstoves in the sharing of information and in the communication about sustainable development. Young people, equipped with knowledge and pro-environmental behaviors are well-positioned to make sustainable choices and to take up efficient products and systems in the near future.

As such, the focus of this research is to broaden our understanding of youth's role in advancing efficient cooking practices in the home in rural Namibia. This study seeks to understand how children's attitudes about energy affect household energy behaviors such as the use and adoption, or sustained use, of solar cookers or improved cookstoves. This study further aims to capture how these attitudes change after spending time in an informal educational setting, such as a camp focused on conservation and the United Nations Sustainable Development Goals (United Nations, 2015a). This work builds upon the existing research done in cookstove adoption and ESD, viewing children as agents of change.

2.7 Research Questions

Therefore, the research questions addressed by this study are: *How do children's knowledge and attitudes about new cooking technologies, such as improved cookstoves and solar cookers, impact their parents' knowledge, attitudes, and decisions to adopt these technologies?*

How does informal Education for Sustainable Development affect the development of children's knowledge and attitudes about household energy and sustainability?

CHAPTER 3

A Survey of Household and Community Energy Patterns

Abstract

To determine whether, and to what extent, children's knowledge and attitudes about energy and the environment impact parents' knowledge, attitudes, and behaviors regarding the adoption of improved cooking technology, a comparison of two towns in rural Namibia was undertaken. The first town, Stampriet, has a long relationship with NaDEET, a camp focused on Education for Sustainable Development (ESD). The second town, Gibeon, has no formal relationship. This chapter describes the methods used to evaluate the two towns both for differences along key variables, as well as across demographics in an effort to justify Gibeon as a control. There is evidence that children who have attended NaDEET bring their learning back into the home, and that this new information is transmitted through both the household and the community. Findings indicate that households with exposure to NaDEET's programming score significantly higher on an attitude and knowledge inventory about solar energy, have a higher mean level of electric stove adoption, and a lower mean level of traditional cookstove adoption than similar homes in their community and in the control group.

3.1 Introduction

In order to answer the central research question of this study, *How do children's knowledge and attitudes about new cooking technologies, such as improved cookstoves and solar cookers, impact their parents' knowledge, attitudes, and decisions to adopt these technologies*, the premise of this study, that learning within the home is in fact bi-directional, needed to be established. Subsequently, and based on this premise, two sub-questions about whether there is

any evidence of the students' learning being utilized within the home or being transmitted throughout the community was examined. The findings in this chapter are organized according to this logic.

3.2 Study Context

3.2.1 Namibia

This study began in January 2019 in the Hardap Region of Namibia. Namibia is a young country, having gained its independence from South Africa in 1990. A German colony from 1884 through the first world war, there is still evidence of German influence in architecture, infrastructure, and culture throughout the country. Germany's genocide of the Herero, Nama, and San peoples, was committed in the early 20th century, and to date, no official apology has been issued to the people of Namibia (Wallace, 2014). The population of Namibia is 97% black and 3% white, most of the latter being of German or Afrikaner descent. Despite the end to political Apartheid 30 years ago, there is obvious segregation between the two races, and incredible wealth disparity.

Home to approximately 3 million residents (World Bank, 2019), Namibia is one of the least densely populated countries in the world, with an average population density of just 2.6 person/km^2. The Hardap Region is located in the south of the country, where communities are separated by vast distances and the population density is less than 0.7 person/km^2 (Namibia Statistics Agency, 2011). Nationally, access to quality education on par with international standards continues to be a priority (Keding, 2016), especially given a high dropout rate at Grade 10. Of the fourteen regions in Namibia, the Hardap Region is at the bottom of education rankings (Ministry of Education, 2014). There is high unemployment in the Hardap (Namibia Statistics Agency, 2011) with few prospects, especially for those who left school early (Melber, 2015).

The Hardap is one of the poorest regions in Namibia. A quarter of the houses are improvised, or informal, and more than 35% of dwellings are constructed of corrugated metal. Half of Hardap residents cook with electricity provided by the national grid (48%), while 46% burn solid fuels for their energy needs. Less than half of all Hardap residents have access to waste management services (Namibia Statistics Agency, 2011).

Household Energy Demographics in Namibia

In Namibia, 60% of the population lives outside of the major city centers. Ninety percent of rural households rely primarily on firewood for cooking (Namibia Statistics Agency, 2011), making it a fast degrading natural resource. As woody resources are depleted, rural Namibians tend to allocate additional time for fuel collection, rather than seeking alternatives or decreasing consumption (Palmer & MacGregor, 2009). The majority of Namibians cook indoors or in a semi-enclosed space, and more than half are affected by household air pollution (Global Alliance for Clean Cookstoves, 2017). A combination of the state of infrastructure in rural areas as well as a depressed economy, makes cooking with electricity, an energy-intensive task, economically unavailable to many households.

3.2.2 Namib Desert Environmental Education Trust (NaDEET) Centre

This research was conducted in collaboration with NaDEET, an NGO based in Swakopmund, Namibia, whose mission is to protect Namibia's environment through Education for Sustainable Development (ESD). The NaDEET Centre is a unique residential camp located on the NamibRand Nature Reserve in the Hardap and has been serving communities from the region and across Namibia since 2003. NaDEET is one of few organizations in Africa recognized by

UNESCO as advancing the Education for Sustainable Development goals, and is affiliated with Namibia University of Science and Technology's Nature Conservation department, where the director of NaDEET, a Namibian Climate Change and Conservation Ambassador, serves on the curriculum board. NaDEET primarily works with schools in communities in the rural Hardap region where people are the most economically disadvantaged, infrastructure lags, and the education level is the lowest in the country.

NaDEET offers both primary and secondary programs for school groups (see Appendix H for program itineraries), as well as teacher professional development workshops. As part of camp activities, all visitors to NaDEET Centre participate in sustainability programming which includes a mix of classroom-based activities, preparation of all meals using efficient stoves and solar cookers, and living a sustainable lifestyle including the use of bucket showers, long-drop composting toilets, recycling and composting, and monitoring of water, waste, and energy usage throughout the week (see Figures 1 and 2). Students participate in dune walks to become more familiar with the desert's biodiversity and to instill a deeper appreciation for Namibia's natural resources. The NamibRand Nature Reserve is Africa's first Dark Sky Reserve (International Dark-Sky Association, n.d.), and as such, students are also engaged in an evening of astronomy and light pollution education.

Figure 1 *NaDEET Centre. Some of the structures at NaDEET Centre including student cabins and showering facilities with a solar powered water heater (left). Students learning about solar electricity generation and storage in preparation for weeklong energy usage monitoring (right).*

Figure 2 *NaDEET Centre student activities. Students at NaDEET Centre on a morning dune hike aimed at increasing awareness and appreciation of the Namib desert's biodiversity (left). Students learning how to measure their daily electricity and water usage, and waste generation (right).*

3.2.3 Hardap Communities

Two communities in the Hardap Region were surveyed via household visits; Gibeon and Stampriet. Both towns are within driving distance of NaDEET but not geographically close to each other. Through its 16 years of operation in a sparsely populated region, NaDEET has engaged with nearly all Hardap communities at least once through grants from the national government and private donors. In 2011, Gibeon sent one school group of 35 primary school children to NaDEET Centre. Those children would now be between 18 and 20 years old. In

contrast, the Stampriet community has a long history of working with NaDEET. Stampriet has sent a school group for 9 of the last 10 years, and 11 adults were part of a solar cooking program in 2011. Gibeon and Stampriet are approximately 100 km from each other geographically, as shown in Figures 3 and 4. Vehicle ownership in both communities is low, and while many households in Gibeon own donkey carts, they are not allowed on the 2-lane freeways. The local network of small roads considerably increases the distance between the two towns. There is little migration between the towns specifically (Namibia Statistics Agency, 2011), though both communities travel to markets in Mariental, the nearest big town. Gibeon was used as the control group in this study.

Figure 3 *Geography of Research Sites within Namibia. Image Source: Google Earth. (2019).*

Figure 4 *Proximity of NaDEET Centre to Stampriet and Gibeon. Image Source: Google Earth. (2019).*

Stampriet

Formally founded in 1898, Stampriet has a population of 1947 individuals with 482 households (Namibia Statistics Agency, 2011), according to the 2011 census, the most recent population data. The majority of the population in Stampriet lives in the *location*, a planned section of permanent housing, initially built to house the black population during Apartheid, and temporary housing structures, known as an *informal settlement*, in an adjacent area and in open spaces within the community. The majority of Stampriet residents speak Afrikaans or Khoekhoegwab, also known as Nama or Damara (Namibia Statistics Agency, 2011). Electricity is supplied via Namibia's national grid. All households can have access to the grid, provided that they purchase their own connection box with a pre-paid meter available for purchase in Mariental (Keding, 2016). Groundwater is their primary source of water (Hardap Regional Council, n.d.), managed by the Stampriet council which shuts off water access daily at 3 p.m. Many residents use the public toilets for N$1 ($0.07 USD) per visit. Stampriet has four schools within its borders; Stampriet Primary, Jakob Soul Primary, St. Konrad Primary, and Witkrans Primary. A fifth

school, an expensive private residential school for Afrikaners, is also located in Stampriet, and is not engaged with NaDEET nor were they approached for this research. In addition to the schools, Stampriet contains a medical clinic and the town council building. The primary grocery store, a gas station, and a few other small businesses make up the town center and are approximately 1.5 km from the main entrance to the location.

Gibeon

The town of Gibeon is an old town, formally founded in approximately 1850, with historic ties to the German-Herero and Nama wars of the early 20th century. It is a small village, and like the *location* of Stampriet, its inhabitants are black and multiracial, as imposed during Apartheid rule. The most recent population data puts the community's population at approximately 2244 with an unknown number of households (Namibia Statistics Agency, 2011). Like in Stampriet, electricity is supplied by the national grid via pre-pay meters, and the water is from the aquifer. Gibeon has 2 primary schools and 2 secondary schools, and a town council building. There are several small businesses throughout the town, but there is no gas station, dedicated grocery store, or town center. Vehicle ownership is low, and petrol is purchased directly from a private citizen, a donkey butcher, who fills a small tank in his yard with petrol that he purchases in Mariental. The majority of housing in Gibeon is permanent and of block construction.

3.3 Ethics Approval

The protocol and measures used in this study have been approved by the University of Illinois Institutional Review Board under protocol #17037 *Cooking with Stored Solar Energy*, see Appendix A. Three Namibian research assistants were hired to help conduct, translate, and transcribe the interviews needed for this study. These individuals were added to the IRB protocol. The study has also been approved by Namibia Commission for Research, Science, and Technology under permit #RPIV00452018. See Appendix B for documentation of Namibian research approvals.

3.4 Study Methods

3.4.1 Survey Design

Household interviews in Stampriet and Gibeon, consisting of survey questionnaires and open-ended interview prompts, were conducted in March and April 2019. A stratified design with random walk was utilized. Census enumeration maps available online from Digital Namibia and Google Earth images were used to create the segments.

Based on aerial images available, each community was divided into 12-16 segments along naturally occurring divisions such as streets, dry river beds, etc. that were easily recognizable on the ground (Eckman, Himelein, & Dever, 2018) (See Figures 5 and 6). Before interviews commenced in each segment, the enumeration maps were checked for accuracy using a handheld GPS and existing maps during a walk through the segment. This process checked for gross inaccuracies in terms of segment size. Because of the ways in which temporary structures are erected throughout the community, including on property belonging to permanent homes, an accurate enumeration of households was not possible. Maps were found to be relatively accurate.

That is, while the population may have grown, the on the ground realities appeared to proportionally match the aerial maps.

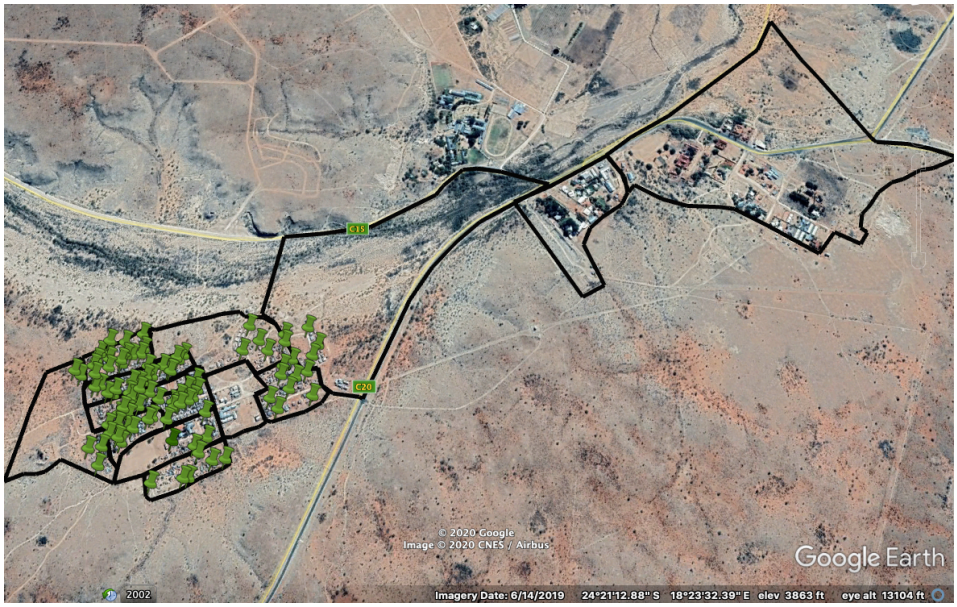

Figure 5 *Stampriet sampling segments. Segments are outlined in black. Green markers indicate each residence sampled. Image Source: Google Maps. (2019).*

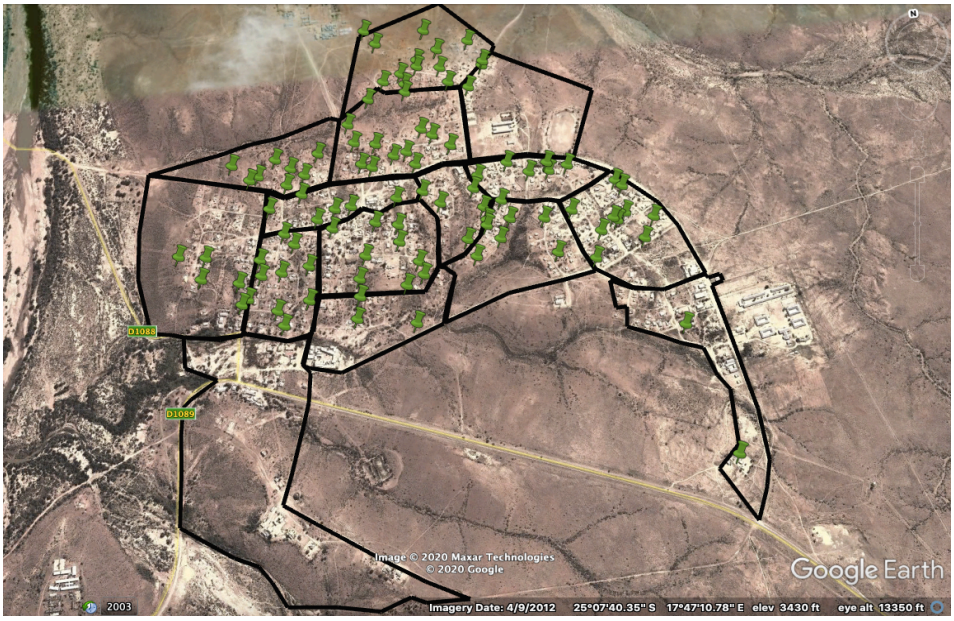

Figure 6 *Gibeon sampling segments. Green markers indicate each residence sampled. Segments are outlined in black. Image Source: Google Maps. (2019).*

Households were selected using a systematic sampling method accomplished via random walk. The research assistants started in the southwest corner of each segment and surveyed every 5th household. Abandoned homes were not counted. Four households declined to participate, and in their place, the next household was surveyed. One hundred households in each community were surveyed. Without knowing the exact population size, a power analysis was run before the interview took place to determine the sample size needed to detect a difference in means of 17 percentage points or greater. A total sample size of $n = 200$ has enough power (approximately 80%) to detect this difference.

Systematic sampling was used because of its advantages over simple random sampling (SRS) in that it is easy to apply, and less laborious than using tables of random numbers. This was especially true in this context where the sampling frame is unlikely to represent the communities as they currently exist, and where updating the sampling frame may be difficult, or nearly impossible, in some areas due to access, as it was in Stampriet and Gibeon. The limitation of this sampling method is that the probability of different elements being in the sample are not equal. For instance, households 2 and 3 can never both be in the sample using systematic sampling, whereas using SRS this would be possible. Nevertheless, systematic sampling behaves as simple random sampling and typically has the same precision for variables involving human populations (Sudman, 1976).

All segments were sampled ensuring that the survey results are as representative of the entire community as possible. At the time of the research design and segment designation, the social structure and organization of each community was unknown to the researcher (e.g., stratification based on wealth, religion, or ethnicity), but it was assumed that stratification within the community exists, and that there is a high degree of homogeneity within each segment (Lohr,

1999). For this reason, all segments were sampled, with the exception of sections 1 and 2 in Stampriet which, upon a walk-through prior to sampling, contained business and guest houses for tourists, yielding a more precisely calculated sample mean for each variable.

Two research assistants were hired for the enactment of household interviews. A female interviewer was employed to maximize comfortability and ease of conversation with household participants, who were predominantly women and children. A male interpreter and driver was hired to assist with the enactment of household interviews which were conducted primarily in Afrikaans or Khoekhoegwab. Both research assistants were added to the IRB protocol for this study.

During pilot interviews it was clear that, even when the research assistants conducted the interviews and the researcher listened from a few steps away, the responses to the research questions were skewed in the hopes that the visiting American would be bringing resources to them after the interview or in the near future. In an effort to minimize *social desirability bias* (Nederhof, 1985), and gather the most reliable data possible, the research assistants conducted the interviews on their own from that point forward (Moses & MacCarty, 2018; Weiss, 1994). The pilot interviews were not included in the data set used for this study. The assistants followed a daily accountability plan (daily written summaries, uploaded audio files when possible, photos of the cover page of each survey completed, and household photos where permitted) to ensure that interviews were occurring according to schedule and protocol.

Interviews followed a set protocol, beginning with consent procedures. The interviewers were instructed to ask follow-up questions throughout to allow for a more conversational tone. The interview questions were comprised of demographic information about the household, household preferences for cooking fuel and methods, and whether children or adults have ever

attended a youth session at NaDEET Centre. Some questions on the survey are taken from validated instruments. It is important to note that these instruments were not developed, and may not have been previously validated, in a rural sub-Saharan community. Therefore, their use was exploratory. Specific measures are discussed below.

The interviewers requested to speak to the primary cook, and respondent answers were recorded manually during the interviews. Interviews were audio recorded, with participant permission, to allow for post-interview checking of respondent answers and for context. Half of the respondents permitted recordings, which were then later translated, transcribed, and coded by a third research assistant, who was also added to the formal IRB protocols associated with this work. Consent was received verbally, and documentation of consent was waived. Consent procedure and survey questionnaires can be found in Appendices C and D.

3.4.2 Questionnaire Pilot

The demographic portion of the household survey was piloted in two resource-limited settings that had been previously visited; on the Navajo Reservation near Winslow, AZ (n = 6) and in Les Cayes, Haiti (n = 7). This pilot was to check for timing and meaning only. Questions deemed as unnecessary for the rural Namibian context were deleted, combined or reworded, based on the *Seasonal Kitchen Performance Tests* developed by the Berkeley Air Monitoring Group and the recently released *Cookstove Usability Testing Protocol* (Moses & MacCarty, 2018). The *Seasonal Kitchen Performance Test* instrument streamlined some demographic questions, and the *Cookstove Usability Testing Protocol* questions are worded neutrally to capture the user-perspective. The questionnaire was reviewed by NaDEET staff for cultural relevance and piloted with 10 adults before use in the Stampriet and Gibeon communities.

3.4.3 Household Survey Specific Measures

The specific instruments included in the household questionnaire were chosen to make use of existing measures whenever possible. The aim of these instruments was to gather information about the primary cook's knowledge, attitudes, and behaviors toward improved cooking technology and sustainability practices within the home. These instruments were not necessarily intended for non-Western contexts, and are thus used in an exploratory way only. This is described further in subsequent sections below. Efforts have been taken to ensure that key dependent variables are measured in numerous ways. For instance, participant responses about types of fuel use was asked in two different ways, both in terms of the frequency of use of each stove within the household as well as the number of meals prepared on the traditional stove each week. A photograph of the kitchen or cookstove(s) in situ, with participant's consent, was used to confirm responses about stove types and usage, including where the traditional stove is located (e.g., by a window, with a chimney, etc.). Brief descriptions of each instrument is explained below.

Adoption Index Survey

This survey is part of a toolkit developed for the GACC (Troncoso, 2013; Troncoso et al., 2013). The survey included in this toolkit includes 8 questions regarding the user's perceptions and reported use of an improved cookstove, as well as a visual observation of the stoves used to confirm the participant's responses. These questions were asked for each type of cookstove or fuel in the home and occurred throughout the interview, rather than as a discrete set of questions. Based on the responses, the adoption index was calculated. The adoption index (AI) is calculated as a function of four variables: the frequency of use of the cookstove (FCCS), overall condition

of the cookstove (CCCS), level of satisfaction with the cookstove (LSC), and her interest in replacing the cookstove with a similar one at the end of the cookstove's lifetime (IRS).

Each variable mentioned above was given a score, defined by a rubric, based on visual observation of the stove and the respondent's answers to the questions. Based on a cluster analysis of several case studies, the variables were weighted and the following adoption equation for an individual stove was developed (Troncoso, 2013; Troncoso et al., 2013).

$$AI=4(FCCS)+3(CCCS)+2(LSC)+1(IRS) \quad (1)$$

Photographs were taken of each stove in situ, with participant consent at the end of the interview. Where possible, dwelling exteriors were also photographed to provide additional context if needed (e.g., construction or size of home, type of property, presence of animals, etc.), though residents in Gibeon largely declined these photos.

Revised New Ecological Paradigm (NEP)

The original NEP instrument was developed in the 1970s as a way to measure pro-environmental orientation, or the public's concern for "environmental quality" (Dunlap et al., 2000). This scale has since been updated to reflect the environmental concerns, priorities, and language of today and has been one of the most widely used instruments to assess the ecological worldview and attitudes of the general public, as well as with specific groups such as farmers (Dunlap et al., 2000). It has been demonstrated that the NEP possesses both predictive and known-group validity (Dunlap et al., 2000). This instrument comprises 15 Likert-scale items designed to tap into five areas associated with an ecological worldview: the reality of limits to growth, anti-anthropocentrism, the fragility of nature and its balance, the rejection of human exemptionalism, and the possibility that an eco-crisis is imminent (Dunlap et al., 2000). There is debate about the

appropriateness of using scales developed in high income countries in LMIC contexts (e.g., Adeola, 1996; Ogunbode, 2013) due to differences in values, economic means, and cultural and traditional differences. However, this instrument has recently been used in LMICs including India and Turkey, and across Latin America (Bechtel et al., 1999; Dunlap et al., 2000; Khan et al., 2012; Leung & Rice, 2002; Rauwald & Moore, 2002; Wesley Schultz & Zelezny, 1999), and as such was used here in an exploratory way. NaDEET reviewed both this instrument and a similar measure, the Nature Relatedness Scale (Nisbet et al., 2011), for use in the communities, and recommended that the NEP be used for its content and brevity.

Attitudes about Solar Cooking

Mercy et al. (2008) developed a short questionnaire for assessing women's perceptions and knowledge about solar cookers in Mali. These 10 questions are based on a 5-point Likert scale, similar to other measures included in the questionnaire. Minor adjustments have been made to the survey to replace references to Mali, the location of the instrument development, with Namibia.

Six Americas Short Survey (SASSY)

The Six America's Global Warming survey consists of 36 questions which assess a respondent's knowledge and attitudes about global warming and climate change. This survey has been used since 2008 to segment the American population into six groups based on their beliefs, attitudes, and level of concern about global warming (Chryst et al., 2018). The results of this instrument have been used in a variety of ways by researchers, educators, and policy makers. Most recently there is interest in its use for tailoring communication about climate change to specific audiences

(Chryst et al., 2018). Several other countries have used or adapted this instrument for their own citizens, and the BBC recently conducted a survey of 33,000 residents from six countries in Asia with the explicit goal of improving their communication strategies (BBC Media Action, 2013). The instrument has also been used on small, sub-groups such as farmers in the corn belt of the United States (Arbuckle et al., 2013), but to date, no studies exist in which rural residents of LMICs have been surveyed. Recently, a subset of four questions was used to reliably assess an individual's perceptions about global warming risks, expected harm to future generations, and how important the respondent finds these issues, as accurately as if the entire instrument was used (Chryst et al., 2018). These four questions were asked at the very end of the survey as to not introduce bias into NEP responses.

3.5 Findings

3.5.1 Sampling Weights

Sampling weights were calculated to account for differential probabilities of selection based on unequal segment sizes in terms of number of households per segment, to improve precision of mean estimations. The sampling frame and data from the Namibian 2011 census was used to determine the population size in individual, or groups, of segments used in this study to calculate the weights. For instance, according to the census, there were 513 people living in areas 1, 2, 3, and 4 in Gibeon in 2011. This data, combined with household size data collected during the study, was used to calculate sampling weights for each segment. The total number of people in the houses sampled in these four areas was $n = 196$, yielding a base weight, the inverse of probability of selection, $w_i = 2.62$.

There were 4 nonresponses; 1 in Stampriet, and 3 in two different segments in Gibeon. Nonresponse weights,

$$w_{nr} = \frac{S_s}{S_p} \quad (2)$$

where S_s is the number of cases sampled for the segment and S_p is the number of responses obtained for the segment, were calculated for segments containing a nonresponse. Nonresponse weights were multiplied by the base weight for an adjusted base weight. The relative weights, were then found by dividing the adjusted base weights by $\overline{w}$, the mean of all adjusted base weights for the community,

$$\overline{w} = \frac{[\Sigma(w_i)(n_i)]}{n} \quad (3)$$

to yield the total sampling weight. When the survey design was declared in Stata, these total sampling weights were then used for all mean estimations using Stata's *svy* commands which more precisely estimates means and confidence intervals. Unless specifically discussing the sample, weighted data was used for all analyses.

3.5.2 Gibeon as a Control

Gibeon was chosen as a control group to Stampriet at the suggestion of the director of NaDEET. Both towns are located approximately equidistant to the nearest large town, Mariental, are rural, and similar in population size. To confirm the appropriateness of Gibeon as a control group for the treatment group, Stampriet, several key variables were measured and compared across the towns. This section describes the justification for Gibeon as a control group by examining demographics, electricity access and use, household cooking fuel patterns, and socioeconomic status.

Demographics

In Stampriet, 34 of the households interviewed had at least one member of the household that had been to NaDEET Centre at some point in the past. Two households in Gibeon reported similar experiences. One of these respondents stated that her daughter attended NaDEET Centre with the 2011 school group. The other respondent is a young woman who moved to the control town for marriage, and who had attended NaDEET herself as a student from a different Hardap town.

Several key variables were measured to compare the two towns, including household size, average adult education, language spoken, number of children per household and whether the children in the household have the appropriate number of years of schooling based on their age[1], electricity, and fuel use. Independent samples t-tests were used to determine that there were no significant differences across these variables, indicating that the two towns are similar demographically, Table 1 below.

	Stampriet	**Gibeon**	***t*(198)**	***p***
Total household size	5.88	5.34	1.35	0.177
Number of children in household	2.67	2.55	0.39	0.695
Average adult education	7.49	8.20	1.90	0.059
Children have appropriate level of education	0.90	0.88	0.46	0.645
Female Head of Household	0.45	0.58	1.85†	0.066
Age of Respondent	43.6	46.7	1.27	0.204
Female Respondent	0.87	0.94	1.69†	0.092
Afrikaans Speaker	0.87	0.79	1.51†	0.133

Table 1 *Demographic comparisons of treatment and control towns. T-test results used to confirm demographic similarities between Stampriet and the control, Gibeon.*

† Indicates z-scores from a non-parametric proportion test of means due to the dichotomous nature of these variables. A t-test produces the same test statistic and p-values.

[1] Nationally, many Namibian students drop out of school at Grade 10, and thus adults and teenagers who completed grade 10, or above, were considered to have the appropriate amount of schooling.

Access to and Use of Electricity

More homes in Stampriet (97%) have access to electricity than do in Gibeon (81%), however *access to* is not equivalent to *use of* electricity. In both towns, electricity is the primary light source if the house is connected to the grid, and thus more Stampriet households use electricity for their lighting needs. However, these grid-connected households in Stampriet use their electric lights considerably less (M= 2.72 hours, SD = 1.83) than those in the control (M = 3.52, SD = 1.08), as measured by an independent samples t-test, $t(168) = 3.38$, $p = 0.009$, with a medium effect size as defined by Cohen (1988), $d = 0.52$.

Households in Gibeon with grid access own, and use on a daily basis, similar numbers of electrical appliances as Stampriet houses. Likewise, electric stove ownership across both towns is approximately 70%, despite the disparity in access to electricity. For reasons which will be explored later in this section, just 72% of Stampriet households with access to electricity use it for cooking, an energy-intensive task, as compared to 85% of such households in Gibeon. It follows, then, that grid-connected households in Gibeon spend significantly more on monthly electricity costs than households in Stampriet, as shown in Table 2.

	Stampriet (n = 97)	**Gibeon (n = 81)**	***t***	***df***	***p***
Electricity as primary light source	0.96	0.79	3.92†	197	0.001*
Electric stove ownership	0.70	0.71	0.16†	176	0.877
Monthly electricity expenditures (N$)	270.21	384.11	2.46	173	0.015
Number of electrical appliances owned (excluding stoves)	4.05	4.30	0.67	198	0.504
Number of electrical appliances used daily (excluding stoves)	2.96	3.45	1.83	169	0.068

Table 2 *Respondents' electricity usage in Stampriet and Gibeon. T-tests to compare electricity usage in Stampriet and Gibeon for households connected to the municipal grid.*

** Indicates p-values less than 0.001*

† indicates z-scores as a result of proportion tests, rather than t-tests

Cooking Fuel

Despite nearly ubiquitous access to electricity in Stampriet, more than half of the surveyed households use firewood as their primary cooking source, while just a third primarily uses electricity. In Gibeon, where 81% of sampled households have access to electricity, half of all respondents report using electricity as their primary cooking fuel, and 44% use wood. Primary fuel use by town is shown in Figure 7.

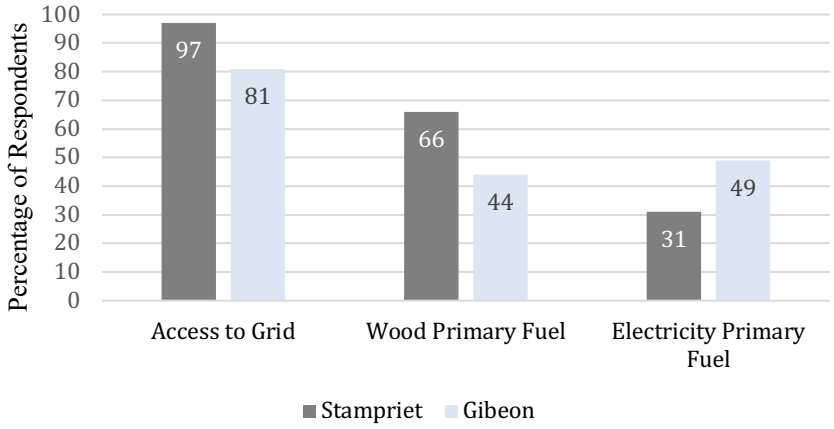

***Figure** 7 Access to electricity and primary cooking fuel used across Stampriet and Gibeon.*

Namibia is the fifth largest producer of charcoal globally, formally employing nearly 10,000 people across the charcoal value chain, in large part due to bush encroachment and efforts to remove an invasive tree species (Staff Reporter, 2019). And while charcoal is commonly used throughout Namibia for traditional cooking as well as for *braais*, or barbecues, it was seen in just two households in Gibeon, and not at all in Stampriet. Charcoal can be purchased from most grocery shops, and from roadside sellers. This is confirmed by the energy demographics described in the 2011 census report (Namibia Statistics Agency, 2011).

Looking at all cooking fuel usage across the two towns, there is not a significant difference between the number of households who use firewood or electricity for at least some of their cooking needs. In both towns, 92% of respondents cook with an open fire at least some of the time. Likewise, there is no significant difference between households who use electricity for at least some cooking events, as measured by a two proportions z-test, $z = 0.31$, $p = 0.758$. The ways in which households in both towns *stack* cooking fuels is also similar. Two fuels, usually wood and electricity, is the most common stack. Just one household in Stampriet and five in the control reported using three fuels, four of which reported LPG use and two charcoal. LPG use is less common in Namibia's interior, ostensibly because petroleum-based fuels increase in price the farther inland a town is located in relation to Walvis Bay, Namibia's only port city (Government of the Republic of Namibia, 2017). Additionally, two sampled households in Stampriet owned parabolic solar cookers, but neither respondent in either household made mention of it when asked about the households' energy sources for cooking.

Firewood Collection

In terms of fuel procurement, there is no significant difference between the two towns in the proportions of residents who collect firewood (Table 3). More people in Stampriet purchase firewood than those in Gibeon, though it is useful to know that many households in Gibeon are situated close to the bush, while residents in Stampriet report a longer walk to woody resources. Perhaps for this reason, more households in Stampriet report purchasing firewood than in Gibeon. Further, 27% of Stampriet households and 16% of those in the control, reported that the household both collects and purchases firewood. The price of firewood varies across the country and by place of sale. For instance, in the larger cities like Windhoek and Swakopmund, a sack of

wood at the grocery store consisting of five or six pieces of hardwood sells for between $5-7 USD.

	Stampriet	**Gibeon**	***z***	***p***
Collect	0.64	0.68	0.62	0.533
Purchase	0.65	0.48	2.38	0.017

Table 3 *Firewood procurement in Stampriet and Gibeon. Two proportion z-test results comparing firewood procurement methods in Stampriet and Gibeon, the control town, as percentage of respondents who use firewood.*

In contrast to most cookstove literature which positions fuelwood collection as women's and children's drudgery, men collect firewood as frequently as women in these two rural Hardap towns (see Table 4). These variables are dichotomous, and thus a two proportion z-test was performed which indicates that more adults are responsible for this task than children, $z = 6.11$, $p < 0.001$. Households in Gibeon spend, on average, 12.55 hours ($SD = 6.81$) collecting fuel each week which is significantly more than Stampriet's 9.65 hours ($SD = 8.32$) as measured by an independent samples t-test, $t(108) = 2.00$, $p = 0.047$, Cohen's $d = 0.38$.

	Stampriet	**Gibeon**	***z***	***p***
Adults	0.89	0.80	1.38	0.167
Men	0.63	0.53	1.08	0.280
Women	0.53	0.43	1.00	0.314
Children	0.35	0.38	0.30	0.768

Table 4 *Responsibility for fuel collection. Results of two proportion z-tests comparing percentages of residents in sampled households responsible for collecting firewood in each town.*

Firewood as Primary Cooking Fuel

Respondents who indicated that they primarily cook with firewood, were asked to explain why it was their first choice. This is of special interest in Stampriet where nearly all dwellings have access to electricity. Responses were coded using Grounded Theory (Glaser & Strauss, 1967) and seven themes emerged, as shown in Table 5.

Firewood as Primary Fuel Code	**Stampriet n (%)**	**Gibeon n (%)**
No electricity	6 (9)	2 (4)[2]
Cost savings/save electricity	39 (57)	38 (84)
Custom, habit, and tradition	7 (10)	1 (2)
Speed and convenience	5 (7)	3 (7)
Preference	6 (9)	0 (0)
Fear of electricity	3 (4)	1 (2)
Availability of wood	2 (3)	0 (0)

Table 5 *Respondents' reasons for choosing firewood as the primary household cooking fuel.*

While more households in Gibeon, the control town, lack access to electricity than in Stampriet, and thus truly do not have any other option, 9% of Stampriet respondents also stated that they have no access to electricity, even though all but 3% of houses were connected to the grid, formally or informally via a neighbor's house. Through interviews it became clear that electricity was carefully managed, and this may account for the discrepancy; it is not that they do not have access, it is more that it is impractical, or cost prohibitive, for them to use electricity for such an energy-intensive task. In Namibia, nearly all household electric meters are pre-pay. In both towns, numerous respondents mentioned that when the electricity "ran out" they used

[2] A note of interest, nearly 20% of sampled residents in the control town do not have access to electricity, all of whom report firewood as their primary cooking fuel, with the exception of 2 who cook with electricity at a neighboring household. Yet, only 2 of the expected 19 households state that the reason firewood is used is because their home lacks access to the grid.

candles for lighting and firewood for cooking. In other households it was clear that in order to make the electricity last longer for lighting, phone charging, and other small tasks, firewood was used for cooking.

Socioeconomic Status

The key difference between the two towns is the overall socioeconomic status (SES). This was observed initially as a visual assessment of the communities (Figure 8). While Gibeon has one segment (Segment 3, n = 13 households) that contained some *informal* dwelling units (e.g., those made from found materials including sheet metal, tarps, and scrap wood), large areas of Segments 10-14 (n = 60 households) in Stampriet are largely informal.

Figure 8 *Dwellings in Stampriet. Clockwise, from top left: a permanent home of block construction, a permanent house with an informal room off the back, and an informal dwelling unit.*

A variable was created as a proxy for socioeconomic status. Five other variables – segment is mostly *permanent housing*, *electric stove ownership*, the presence of an *indoor tap*, primary cooking fuel is *not firewood*, and *television ownership* – were selected as indicators of higher SES for the types of amenities and conveniences they afford households. The five variables had adequate internal consistency, as measured by Cronbach's alpha, $\alpha = 0.71$, an index of reliability (Cronbach, 1951). To ensure these variables were associated with a single construct, an unrotated factor test was performed producing one eigenvalue over 1.0 accounting for 95% of the variance with all items loading at 0.5 or higher.

An independent samples t-test comparing the two towns reveals that households in Gibeon have a higher mean SES ($M = 3.47$, $SD = 1.34$) than those in Stampriet ($M = 2.10$, $SD = 1.79$), $t(198) = 6.13$, $p < 0.001$, with a large effect size, Cohen's $d = 0.87$. This confirms visual observations made during drive- and walk-throughs. SES is used in the many of the analyses that follow. As such, it is important to note that there is no correlation between NaDEET experience and SES. That is, households across the socioeconomic spectrum are represented in the subsample of houses with NaDEET experience. Since NaDEET's participants are from government, or public, schools, and because the experience, including travel to and from the Centre, is subsidized or provided freely, there is no bias toward higher or lower SES households.

3.5.3 Evidence of NaDEET's Impact

In order to answer the research question posed by this study, the premise that bi-directional learning occurs within the household when children bring home information learned from an external source, such as ESD programming from NaDEET, needed to be established. If this is true, then the hypothesized answers to the research sub-questions were that the parents of

children with NaDEET experience would be more knowledgeable about the topics addressed by the ESD programming than those without, and that this would make a community more knowledgeable and receptive to change over time (e.g., This last section of the study's findings is structured in this way.

Additionally, three primary comparisons are made between, and within, the two communities. To support the first point above, NaDEET households are compared against similar households in Stampriet, that is, households with school-aged children who are eligible to attend NaDEET, but have not yet participated in that experience. The second and third points are addressed by analyses that compare households who have a family member with NaDEET experience against all households without such experience, and the two towns directly. The comparisons described here are primarily conducted using t-tests, two proportions z-tests, and their nonparametric equivalents, including Kruskal-Wallis ANOVAs, Mann Whitney or Wilcoxon rank-sum, and Wilcoxon signed rank tests.

For ANOVAs, Stampriet households are assigned to two groups, a within-community group and an across-community group. The within *Stampriet groups* consist of NaDEET households, and non-NaDEET households with and without children living in the residence. The across *community groups* consist of all control group households, Stampriet households with and without NaDEET experience.

An emphasis is also placed on households that primarily cook with wood in each of these analyses for two reasons; one because cooking with wood is highly correlated with a lower socioeconomic status ($r = 0.75$), which can keep modern fuels out of reach, and two because it is fuelwood users whose behaviors the larger cookstove community seeks to change. Firewood as a

primary cooking fuel was inversely related to the five other variables that were used to construct the latent SES variable.

Family Knowledge of NaDEET Centre Activities

Respondents who either themselves attended, or had a family member attend, NaDEET Centre at some point in the past were asked what they remembered about the experience at NaDEET. This question was asked at the beginning of the interview, immediately after collecting demographic information (e.g., age, gender, level of education) of all residents in the household. Responses were coded, and all but one naturally fell under NaDEET's four foci; energy, water, waste, and biodiversity. The topic that did not group with the others referenced "evening programming," understood here to mean the astronomy session.

Of the 36 households with NaDEET experience, which includes the two from the control group, 69% of households could report at least one topic or activity in which the participant engaged. 31% of households (n = 11) reported that they could not remember, or did not know, about the family member's time at NaDEET. Of these respondents, three were siblings of the NaDEET participant, and wouldn't necessarily be expected to know or recall specifics. Nor would one expect this of a grandparent (n=2) or a mother-in-law (n=1). The other five were parents of a child who attended NaDEET, however with the exception of one household, multiple years had passed since the child's participation; 2, 3, 8, and 10 years. Two of the mothers mentioned that their sons tell them "nothing," and thus their unknowingness has less to do with NaDEET and more to do with their relationships with their children.

Of the remaining 25 households, the mean number of topics or activities recalled was 1.89 (SD = 1.14). An average of 9.28 years (SD = 2.29) has passed for the 8 individuals who

attended NaDEET themselves. The remaining 17 respondents who were able to recall specifics about a family member's experience at NaDEET were parents (n = 10), siblings (n = 4), and older relatives like an aunt (n = 1) and grandparents (n = 3). This is presented to highlight that 71% of respondents who were parents of former NaDEET participants were able to name at least one topic or activity their child had engaged in, despite 3.5 years (SD = 0.64 years) being the average length of time since participation.

Topics in household energy (e.g., solar cooking, solar energy, efficient cookstoves, energy conservation) accounted for nearly half (43%) of all remembered items, significantly more than topics of NaDEET's other themes; water (21%), waste (8%), biodiversity (28%), and astronomy (2%). The activity that received the most mentions during interviews was solar cooking, with four past participants, and seven family members, recalling the topic. Solar cooking accounted for 21% of all responses (past participants n = 4, other family members n = 7) and nearly half of the energy-related responses.

Future Cookstove Decision-Making

Respondents were asked with whom they would discuss future cookstove purchases. If the respondent was a parent and they did not mention their children, they were asked if they would discuss it with their children. Approximately half of all respondents in both towns said that they would indeed gather their children's input. This is true for parents of school-aged and adult children.

Each respondent was also asked if they knew where they could buy an efficient cookstove. Just four respondents, one in the control group and three in Stampriet, were able to offer an answer for this question. The Stampriet residents stated that efficient cookstoves could

be purchased in Windhoek, the capital. The respondent in Gibeon suggested Swakopmund, a small coastal town. No responses were more specific than naming one of the largest towns in the country. That said, no improved cookstoves or solar cookers were observed in grocery stores or camping goods stores in either of these cities, though an exhaustive search was not undertaken.

3.5.4 Adoption of Cooking Devices Across Towns

Using Troncoso (2013), adoption indices were calculated for each cookstove, including traditional cooking fires, in each residence. The four variables used in determining a score for each cookstove was based on the rubric shown in Table 6. Each variable is weighted, and adoption scores are out of 10 points; 1 indicating "very bad adoption" and 10 indicating "very good adoption" (Troncoso, 2013). The *condition* term was dropped for electrical devices since tinkering or making modifications to an electrical device is outside the expertise of most users. This term, as well as the *interest in replacing* term has no meaning in the context of traditional stoves, and was thus also eliminated. Adoption scores ranged from 0 to 7 for electric stoves, and up to 6 for traditional cookstoves (Table 7). A one-point difference between scores, based on the variables and weightings used, represents an additional two or three days of cookstove use per week, or an increase from ambivalence to high satisfaction with the stove's performance.

	Value				
	0	0.25	0.5	0.75	1.0
Frequency of use (FCCS)	Never	Once per week or less	2 to 3 days per week	4 to 6 days per week	Every day
Condition (CCCS)	Destroyed or in disuse	Modifications; performance impairment	Modifications; no performance impairment	Working with low maintenance	Perfect with good maintenance
Level of satisfaction (LSC)	Unsatisfied	Low satisfaction	Regularly satisfied	Satisfied	Very satisfied
Interest in replacing (IRS)	No		Maybe		Yes

Table 6 *Troncoso's rubric for scoring adoption index variables (Troncoso, 2013).*

Original Scale	Electric Cookstoves	Traditional Cookstoves	Adoption Description
9 – 10	6.3 – 7	5.4 – 6	Very Good Adoption
8.5 > 9	5.95 > 6.3	5.1 > 5.4	Good Adoption
7 > 8.5	4.9 > 5.95	4.2 > 5.1	Regular/Moderate Adoption
5 > 7	3.5 > 4.9	3 > 4.2	Bad Adoption
1 > 5	1 > 3.5	1 > 3	Very Bad Adoption

Table 7 *Modified versions of Troncoso's adoption scoring guide for use in this study (Troncoso, 2013).*

Electric Stove Adoption

Electric stove adoption was measured by the following equation,

$$4(FCCS) + 2(LSC) + (IRS) \quad (4)$$

where FCCS is the frequency of use, LSC is level of satisfaction, and IRS is interest in replacing the stove at the end of its lifetime. Table 8, below, describes mean electric cookstove adoption scores across Stampriet. A one-way ANOVA of households in Stampriet with NaDEET experience, and those without NaDEET experience and with or without children in the house, is also significantly different, $F(2, 97) = 3.22$, $p = 0.044$. The effect size of this difference is moderate, $\eta^2 = 0.06$.

Stampriet Group	*n*	*Mean*	*SD*
NaDEET Experience	31	3.81	2.68
Household with Children	51	2.48	2.50
Household without Children[3]	18	3.64	2.17

Table 8 *Electric cookstove adoption scores across Stampriet. A higher mean indicates higher frequency of use and/or satisfaction with cooking with an electric stove.*

[3] Households without children in Stampriet are largely single male residents or the elderly. The elderly receive a monthly pension from the government which is used for their expenses, including the cost of electricity. The single men reported disinterest in needing to collect firewood or start a fire after being at work all day. Single men appear to favor electric hot plates.

Independent samples t-tests were done to further examine the differences between the groups, and found that within Stampriet, households with NaDEET experience have higher mean adoption scores for their electric stoves than similar homes with children and without NaDEET experience, $t(80) = 2.27$, $p = 0.026$, and Cohen's $d = 0.52$.

In Gibeon, electricity is more commonly the primary fuel, and thus these households have adopted their electric stoves at a higher degree than households in Stampriet. An independent samples t-test comparing the two towns shows that Gibeon does indeed have a higher electric cookstove adoption rate than in Stampriet, $t\ (138) = 4.08$, $p < 0.001$, with a large effect size, Cohen's $d = 0.69$. However, there is not a significant difference between Stampriet's NaDEET households and those in Gibeon, $t(95) = 1.34$, $p = 0.184$, indicating that NaDEET households, in a town that primarily cooks with firewood, are actually more similar to the town that primarily cooks with electricity (Figure 9).

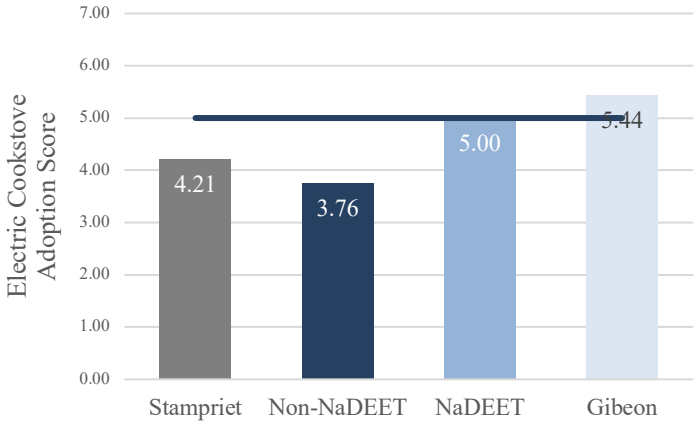

Figure 9 *Electric cookstove adoption scores across both towns. Non-NaDEET and NaDEET categories represent subsamples of surveyed Stampriet respondents. The horizontal blue line indicates the minimum value to be considered an acceptable adoption score.*

A multiple regression analysis was performed to predict the value of electric stove adoption based on several demographic variables known to affect adoption in other studies,

namely SES and the respondent's highest level of education. NaDEET experience was also added as a covariate. The overall model is significant, but only SES is a significant predictor, as shown in Table 9.

	B	*SE*	*β*	*t*	*p*
Socioeconomic Status	1.25	0.08	0.78	14.85	0.001*
Level of Education	- 0.05	0.05	- 0.06	- 1.04	0.301
NaDEET experience	- 0.17	0.61	- 0.02	- 0.29	0.773
$F(3, 193) = 95.98$, $R^2 = 0.57$					

Table 9 *Summary of regression analysis for variables predicting electric cookstove adoption.*

** Indicates p-values less than 0.001*

Traditional Cookstove Adoption

There is no published literature that examines the degree to which a household or community has "adopted" their open fire, or traditional cookstove. In the context of an open fire, "adoption" is taken to mean the degree to which a household is *committed* to their traditional cookstove. While poverty remains the largest obstacle to efficient cooking, it has long been understood that there is no universal reason for households choosing to adopt, or dis-adopt, a new cooking technology (Cundale et al., 2017). It stands to reason then that understanding what these factors are, and attempting to identify or quantify their predictors, may shed some light on how receptive a household, or community, may be to a new cooking device. If recipients of cookstove implementation programs are chosen based on the community's willingness to use a new technology in their kitchens, rather than out of logistical convenience (e.g., on the ground partners with existing relationships in the community, ease of access to the community, etc.), it is rarely, if ever, reported in the literature. Because there are no current mechanisms for measuring the degree to which a household has "adopted" their open fire, Troncoso's (2013) adoption index

was used, as described earlier. Using the same weights and rubrics, each household's adoption of their traditional cookstove was measured. Adoption scores range from 0 to 6, with Troncoso's adoption scores adjusted to reflect the smaller scale used here (Table 7).

A one-way ANOVA of the Stampriet groups (NaDEET households, and non-NaDEET households with and without children), shows significant differences with a large effect size as shown in Table 10, $F(2, 96) = 6.74$, $p = 0.002$, $\eta^2 = 0.12$.

Stampriet Group	*n*	*Mean*	*SD*
NaDEET Experience	31	3.72	2.22
Households with Children	51	5.55	0.91
Households without Children	17	5.06	2.08

Table 10 *Traditional cookstove adoption scores in Stampriet. A higher mean indicates higher frequency of use and/or satisfaction with cooking over an open fire.*

T-tests were performed to further detail the differences between these groups of households. When comparing households with NaDEET experience to other households with children in Stampriet, findings indicate that NaDEET households are less committed to their open fires, and therefore, potentially more open to a new cooking device, $t(80) = 5.22$, $p < 0.001$. The effect size of this analysis is large, $d = 1.19$.

Similarly, a significant difference is indicated in a one-way ANOVA comparing traditional cookstove adoption scores between Stampriet households with and without NaDEET experience and in Gibeon, $F(2, 192) = 4.78$, $p = 0.009$, $\eta^2 = 0.05$. When comparing just the NaDEET households sampled in Stampriet to those in Gibeon, the NaDEET households have adopted their traditional cookstoves less than Gibeon ($M = 4.55$, $SD = 2.00$), but the difference is not quite significant, $t(123) = 1.95$, $p = 0.053$. This again suggests that NaDEET households

cook more similarly to Gibeon where electricity is most commonly used, rather than like Stampriet and its culture of firewood (Figure 10).

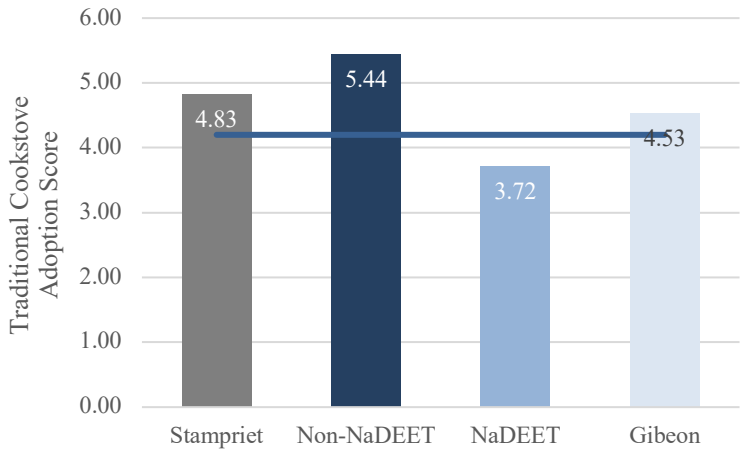

Figure 10 *Traditional cookstove adoption scores by town. The horizontal blue line indicates the minimum score for acceptable adoption, 4.2. With the exception of NaDEET households in Stampriet, all groups demonstrate a mean adoption score indicating sufficient adoption, or commitment, to the household's open fire.*

A multiple regression was calculated for the same covariates as used in the electric cookstove adoption analysis. The overall model is significant, as shown in Table 11. All three independent variables – SES, average adult level of education, and NaDEET experience are significant predictors and are negatively associated with a higher traditional cookstove adoption score. $F(3, 188) = 13.42$, $p < 0.001$, $R^2 = 0.25$.

	B	*SE*	*β*	*t*	*p*
Socioeconomic Status	-0.39	0.10	-0.33	-3.77	0.001*
Level of Education	-0.15	0.07	-0.21	-2.11	0.036
NaDEET experience	-1.03	0.50	-0.18	-2.09	0.038
$F(3, 188) = 13.42$, $R^2 = 0.25$					

Table 11 *Summary of regression analysis for variables predicting traditional cookstove adoption.*

** Indicates p-values less than 0.001*

Scaling the adoption scores in order to compare traditional and electric cookstove adoption reveals that across both towns, respondents are significantly more committed to their traditional cookstove than to their electric stoves, $t(194) = 7.91$, $p < 0.001$, with a large effect size, Cohen's $d = 0.92$. The difference between electric and traditional cookstove adoption is the smallest for NaDEET households, who have the lowest average score for traditional cookstove adoption and electric stove adoption score similar to those in Gibeon. In fact, after scaling the scores for comparison, there is not a significant difference between NaDEET households' adoption of their electric cookstoves and their open fires (Figure 11), which is not true for any other group in the treatment or control town (Table 12).

	n	*t*	*p*	*d*
Stampriet	99	6.82	0.001*	1.15
NaDEET Experience	34	1.62	0.115	–
Household with Children	49	9.37	0.001*	2.09
Gibeon	96	4.40	0.001*	0.71

Table 12 *Scaled adoption indices for electrical and traditional cookstoves. Paired t-test results comparing scaled adoption indices for electric and traditional cookstoves for survey respondents in each group.*

** Indicates p-values less than 0.001*

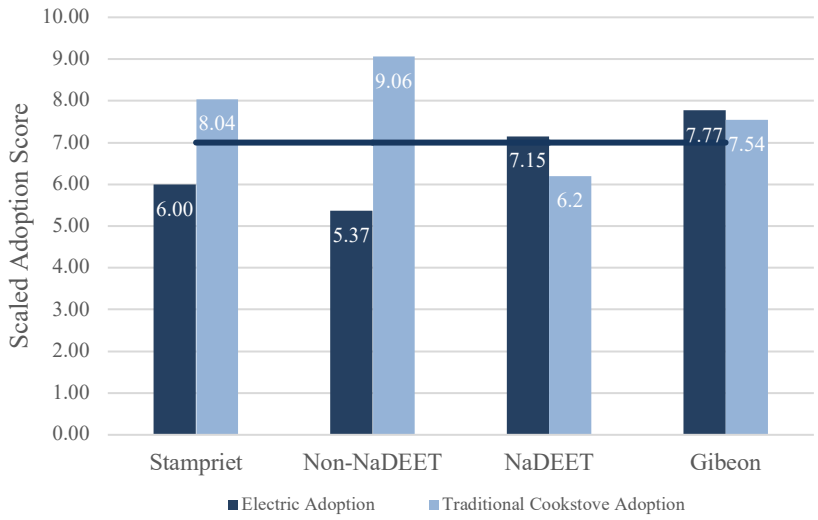

Figure 11 *Comparison of cookstove adoption scores. A comparison of scaled adoption scores for electric and traditional cookstoves in Stampriet and Gibeon. The horizontal blue line indicates the minimum to be considered an "acceptable" level of adoption.*

The role of poverty in the adoption of cookstoves in these two communities cannot be ignored. Households that can afford electric cookstoves, regardless of regularity of use, have mean traditional cookstove adoption rates that are significantly lower ($M = 4.23$, $SD = 2.14$) than households without electric stoves ($M = 5.59$, $SD = 0.82$), as measured by an independent samples t-test, $t(193) = 4.76$, $p < 0.001$. The effect size of this analysis is moderately-high, Cohen's $d = 0.74$. Similarly, an independent samples t-test examining only the respondents who live in informal settlements, or who primarily cook with wood, and thus those who are among the poorest, shows that there is not a significant difference across communities, regardless of NaDEET experience.

Recycled Fireballs

While solar cookers are used for lunch and dinner preparation at NaDEET Centre, the morning meal, typically *mielie pap*, a maize porridge, and hot water for coffee and tea is prepared over

fuel efficient stoves. As part of NaDEET's energy programming, school groups make recycled fireballs for use in these stoves. All used paper is saved at NaDEET for this purpose, simultaneously teaching children how to decrease fuelwood consumption and eliminate paper-based rubbish, which often becomes litter due to few municipal waste management programs nationally. Paper is soaked in water, children shred the wet paper into small bits, and then press handfuls together to form a tight ball (Figure 12). Each fireball is then dried on a rack for one week. Fireballs made during the previous session are used in the stoves during the children's camp visit. Approximately ten fireballs are needed to heat a pot of water using a purchased efficient cookstove, and 10-15 are needed in the handmade equivalent constructed at NaDEET[4].

Figure 12 *Recycled fireballs at NaDEET. An 8th grade student making a recycled fireball (left), an efficient cookstove made at NaDEET that is used to boil water each morning (right).*

NaDEET is aware of an organization in Sesriem, the town at the entrance to the most visited part of the Namib-Naukluft National Park, that has made recycled firebricks in the past,

[4] NaDEET held workshops for Hardap communities (not those included in this study) to learn to make this style of efficient cookstove in the past. Efficient cookstoves are not common in the Hardap, but are more so in northern regions of Namibia.

but it is unknown whether this still occurs. Sesriem is two and a half hours by car north of NaDEET Centre over rough terrain (see maps in Figure 3), and approximately five hours to both Gibeon and Stampriet. NaDEET staff knows of no other organization that makes these or a similar product.

Naturally, households with NaDEET experience report knowledge or use of fireballs at a significantly higher proportion than do sampled households without such experience as measured by a two-sample test of proportions, $z = 4.53$, $p < 0.001$. All respondents who attended a session at NaDEET themselves (n=8), reported using or making fireballs in the past. In comparing the two towns directly, regardless of NaDEET experience, 18 sampled Stampriet households report knowledge of recycled fireballs as compared to 5 in in the control group, which is again an unsurprising significant difference, as measured by a two-sample test of proportions, $z = 2.88$, $p = 0.004$.

Though a small subsample ($n = 7$ in Stampriet, $n = 4$ in Gibeon), it is the non-NaDEET households' knowledge and/or use of recycled fireballs that provide some insight into the transmission of information throughout the communities. In Stampriet, where school groups have been regularly attending NaDEET's programming for a decade, information about recycled fireballs is spread by both children and adults in public spaces. With the exception of two respondents, all reported knowledge of these recycled fireballs came from within the community; the majority report learning about it directly from a child or family member, while others heard it discussed "around town" and "in the shops." When looking at it from this perspective, nine of the ten non- NaDEET households who have heard of recycled fireballs learned of it locally, and 40% made them at home. In the control town, just one respondent of the four, a teacher, learned of recycled fireballs from a local source, a colleague. The other four respondents in Gibeon

learned about recycled fireballs from a magazine or at a workshop, though where this workshop occurred and who it was sponsored by remains unknown.

3.5.5 Attitudes and Knowledge

Solar Cooking

Mercy et al.'s (2008) solar cooking instrument was used to evaluate what respondents knew about solar cooking and their attitudes toward it. The 10-questions span both understanding and attitude questions (e.g., The sun can be used to cook food; solar cookers are accepted in my culture) to questions about their availability and affordability. This scale showed an adequate degree of internal consistency as measured by Cronbach's alpha, $\alpha = 0.73$. Using factor analysis, three factors emerged with eigenvalues over 1. However, the first factor had a significantly higher eigenvalue, 3.17, as compared to the other two, 1.11 and 1.07, and all but one item loaded on to the first factor at 0.4 or above indicating that it is a dominant factor. The item that did not load on to the first factor, *Solar cookers do not burn food*, is ambiguous in that it does not differentiate between solar cookers. While it is unlikely that food will burn in a solar oven, which operates effectively like a slow cooker, it is entirely possible to burn food when using a solar parabolic. Both types of solar cookers are used at NaDEET and both can be found in Namibia. Dropping this item from the scale does not appreciably affect the scale's internal consistency, $\alpha = 0.75$.

The composite score, the mean of all items excluding the item about burning food, is significantly higher for respondents whose households have NaDEET experience ($M = 4.15$, $SD = 0.60$) than households without ($M = 3.80$, $SD = 0.72$), as determined by a two-samples t-test, $t(186) = 2.64$, $p = 0.009$, with a moderate affect size as measured by Cohen's $d = 0.49$.

Examining respondents who are parents across both towns, parents of children who attended NaDEET Centre in the past score significantly higher on this instrument than other parents in Stampriet or Gibeon, $t(163) = 2.40$, $p = 0.018$, and Cohen's $d = 0.63$. Evaluating only the households that rely primarily on firewood for their cooking energy, NaDEET households score higher than similar non-NaDEET households in Stampriet and those in the control town, $t(108) = 3.84$, $p < 0.001$, Cohen's $d = 0.75$.

Scores on this instrument are significantly higher in Stampriet in general ($M = 4.00$, $SD = 0.61$) than in Gibeon ($M = 3.74$, $SD = 0.77$) as measured by a two-samples t-test, $t(186) = 2.48$ at $p = 0.014$, with a slight effect size, Cohen's $d = 0.36$. For households that rely primarily on firewood for cooking fuel, Stampriet households have significantly more positive attitudes about solar cooking than those in Gibeon, $t(100) = 3.72$, $p < 0.001$, with a large effect size as measured by Cohen's $d = 0.75$. In the poorest residences, there was no association between NaDEET experience and higher electric adoption scores or lower traditional cookstove scores. There is evidence, however, that NaDEET's programming has positively shifted knowledge and attitudes for this group.

While this instrument about solar cooking is meant to be a scale, and thus no single item is likely to measure a specific construct, there are three items on the scale that are of high interest in terms of their relevance to criticisms of the viability of solar cooking and/or cookstoves, and thus worth examining. Of these three items, the first asks about the participant's understanding of cooking with solar energy, while the other two inquire after their personal beliefs about a solar cooker's utility in meeting local and global energy needs. Because these three items are Likert-type, nonparametric tests were used to test for significant differences (Cooper & Johnson, 2016). Each item is discussed briefly below.

Energy from the sun can be used for cooking. A Kruskal-Wallis ANOVA for households in Stampriet with and without NaDEET experience, and in Gibeon, reveals a significant difference, $\chi^2(2) = 6.41$, $p = 0.041$. Examining Stampriet first, 97% of NaDEET households (n = 33) agreed or strongly agreed that solar energy can be harnessed for household cooking, with just one respondent, an older sister to the family member who attended NaDEET, expressing disagreement that solar energy can cook food. This is compared against the 77% (n = 50) of non-NaDEET households who expressed similar answers ($p = 0.020$, Fisher's exact test). The majority of Stampriet respondents understand that solar energy can be used for cooking, regardless of experience with NaDEET. Because of the small number of observations included in this, and subsequent analyses, Fisher's exact test was used in lieu of a chi-square test.

Significant differences exist between respondents in Stampriet and in Gibeon in their responses to this prompt. In Stampriet, 91% of sampled households agreed or strongly agreed that solar energy can be utilized for household cooking, as compared to 70% in Gibeon ($p < 0.001$, Fisher's exact test). For sampled households that primarily cook with wood, 91% of Stampriet respondents agree or strongly agree with this statement, while 59% of Gibeon households answered similarly ($p = 0.002$, Fisher's exact test).

Solar cookers are accepted in my culture. Solar cookers are frequently critiqued for their inability to meet the local cultural context into which they are introduced (Iessa et al., 2017), and so of interest is whether the respondent believes solar cookers are culturally acceptable. A Kruskal-Wallis ANOVA using the groups defined in the previous prompt demonstrates the effect of these community groups on their beliefs about the cultural acceptability of solar cookers was significant, $\chi^2(2) = 8.15$, $p = 0.017$.

Fisher's exact tests were performed to further elucidate these differences. In Stampriet, NaDEET houses find solar cookers more acceptable than non-NaDEET houses ($p = 0.048$, Fisher's exact test). 80% of Stampriet respondents stated that the agreed or strongly agreed with the statement that solar cookers are culturally acceptable, as compared to 54% in Gibeon, the control group ($p < 0.001$, Fisher's exact test).

Even more telling, however, is a comparison between households that cook primarily with fuelwood, a "traditional" energy source, across both towns. As with the general Stampriet population, 80% of households who cook primarily with wood find solar cookers to be compatible with their culture as compared to 41% of similar respondents in Gibeon ($p = 0.001$, Fisher's exact test). When examining just these households in Stampriet, there is not a significant difference between the households with and without NaDEET experience ($p = 0.578$, Fisher's exact test), indicating that this view is held by the majority of this community, even the most socioeconomically disadvantaged.

Solar cooker usage can solve energy problems. Solar energy is not uncommon throughout Namibia. Households were asked to what extent they believed solar cooking could be used to solve some of Namibia's energy problems. The type of solar cooking was not specified and thus the respondents could reasonably have taken this to mean solar box cooking, solar parabolic cooking, or cooking with electricity produced by solar photovoltaic cells. Both towns agree that solar cooking can alleviate some of Namibia's energy burden, with no significant difference between Stampriet and Gibeon ($p = 0.057$, Fisher's exact test).

As with the previous two prompts, when comparing households who primarily cook with firewood, significant differences do arise. For these households, a greater proportion of sampled Stampriet households (86%) believe that solar cookers can solve energy problems than those in

Gibeon (64%) ($p = 0.044$, Fisher's exact test). Similarly, 94% of households who have experienced NaDEET programming believe that solar cookers can solve energy problems as compared to 71% of those without across both towns ($p = 0.039$, Fisher's exact test). Comparing Stampriet households with NaDEET experience (94%) to similar homes with children (77%), the null hypothesis cannot be rejected ($p = 0.156$, Fisher's exact test).

Solar Cooker Availability and Affordability. Residents in both towns disagree that solar cookers are readily available ($p = 0.945$, Fisher's exact test) or affordable ($p = 0.836$, Fisher's exact test), regardless of NaDEET experience. Grocery, sporting goods, and camping stores, as well as establishments meant for equipping tourists on safaris, were visited across Namibia. No solar cookers were observed in any of these shops, though an exhaustive search was not undertaken.

Finally, what makes the differences in attitudes and knowledge about solar energy between the towns more stark is that there is not a significant difference between the residents' general environmental attitudes. One might expect that a higher score on an inventory about solar cooking would be correlated with a higher score on inventories about the environment and climate change, but this is not the case. This indicates that an external factor, such as exposure to solar cooking at NaDEET, is responsible for the difference between the communities. General environmental and climate change attitudes are explored in the next section.

General Environmental Attitudes

Participants were asked questions from two scales, as described earlier, to assess their general environmental attitudes. The NEP scale was not found to be a suitable instrument for this context. The internal consistency of the scale was low, $\alpha = 0.29$. The majority of respondents

needed help understanding at least one question, particularly the more abstract questions such as "*The earth is like a spaceship with very limited room and resources."* During pilot interviews the word *spaceship* was replaced with *ship* for understandability, but even so, many respondents struggled with the meaning of this prompt. Similarly, hypothetical prompts regarding humans interfering with nature or abusing nature were too esoteric. Many respondents answered this question locally, rather than from a global or theoretical perspective. For instance, in response to the prompt, *Humans are severely abusing the environment*, one respondent said, "I don't know what they're doing." When pressed by the interviewers to elaborate, she explained that she did not know what all of the people in other Namibian towns were doing, and thus she could not possibly answer this question.

The transcripts of the audio recorded interviews revealed that the interviewers struggled to make the meaning of several of these prompts clear to respondents. In an effort to speak more plainly, or perhaps due to the translation from English to Afrikaans or Khoekhoegwab, some nuance was discarded. The interpreter also explicated some of the prompts for some, but not all, respondents. For example, in the prompt *The earth has plenty of natural resources if we just learn how to develop them,* the interpreter offered specific examples of what is meant by "natural resources," primarily water, to respondents who did not understand the question. This is problematic. Positioning water as *the* natural resource to a respondent living through a drought in the desert changes the emphasis of the prompt. Instead of this prompt gauging a respondent's views about human dominion over the earth's and Namibia's vast natural resources, and whether humans should develop them for all of their needs, many respondents naturally focused on water. "There is no water" was a common refrain, and one that rings true especially in Stampriet where the town council turns off municipal water supplies at 3 p.m. Taken together, the results from

this instrument are not useful for furthering our understanding of these communities and supports Adeola's (1996) and Ogunbode's (2013) assertions that scales created for one context may not work in another.

A survey of environmental attitudes with plainer language would potentially make for a better instrument for use in this context. The Six Americas Short Survey (SASSY) consists of four simply stated questions regarding a respondent's concerns about global warming: *How much do you think global warming will harm future generations of people? How important is the issue of global warming to you personally? How worried are you about global warming?* and *How much do you think global warming will harm you personally?* In contrast to the NEP, which was asked first, respondents had little trouble with these questions. Based on the responses to these questions, respondents were scored and assigned to one of six categories; Alarmed, Concerned, Cautious, Disengaged, Doubtful and Dismissive. Individuals who fall in the Alarmed and Concerned categories are those that are the most concerned and potentially the most motivated to act, whereas the Doubtful and Dismissive categories are associated with less concern, motivation, and in the United States, the lowest belief that global warming is occurring and due human action (Leiserowitz et al., 2014).

Interestingly, the 200 adult respondents in Namibia are significantly more *alarmed* or *concerned* about global warming and its effects than the general American population (Table 13), as reported in Chryst et al. (2018), and as measured by a one-sample t-test, $t(198) = 2200$, $p < 0.001$. There are no significant differences between towns or within groups. A higher categorical score on this instrument, and thus more concern about climate change, is not correlated with the respondent's level of education nor his or her SES.

	Alarmed	Concerned	Cautious	Disengaged	Doubtful	Dismissive
Stampriet & Gibeon	63	25	0	7	1	4
United States	22	30	20	4	10	12

Table 13 *Percentage of respondents in Stampriet and Gibeon in each scoring category of the Six Americas Short Survey, as compared to the general American population.*

3.6 Discussion

This study seeks to determine if children exert some influence over energy-related knowledge, attitudes, and behaviors in the home as a result of their own education. The data collected in these two communities provide support for the view that learning within a household is *bi-directional.* The evidence suggests that children who attended NaDEET brought their learning back into their homes upon their return. The majority of respondents who are parents of children who have attended NaDEET could name specific activities, or topics, in which their child was engaged when at the Centre, despite the average length of time since the child's attendance being 3.5 years (SD = 2.55).

Having established that children do share their educational experience at NaDEET Centre with their parents, it was necessary to then determine whether and how this experience influenced the household, or the community, over time. The data collected from respondents regarding their energy-related knowledge, attitudes, and behaviors points to NaDEET's impact both at the household and community level.

For instance, on an inventory of solar cooking knowledge and attitudes, households in Stampriet scored significantly higher than those in Gibeon. And within Stampriet, households with NaDEET experience scored highest of all. One might expect that this understanding and a

more favorable view of solar cooking, which is not a common practice in Namibia, might be correlated with higher attitudes about the environment in general, but this is not the case. Both towns are equally concerned about global warming, as shown by the analysis of SASSY scores. And while one might expect Stampriet to score higher on the SASSY than Gibeon, this follows previous findings that "critical environmental experiences can accelerate change in environmental worldview" (Arcury & Christianson, 1990). Residents in both Stampriet and in Gibeon live in a desert and are experiencing the effects of a severe drought. Climate change is not a politicized topic in Namibia, as seen by its inclusion in their constitution. Reducing the vulnerability of poor rural communities to the negative consequences of climate change and improving communities' adaptive capacity is a priority in Namibia (Republic of Namibia, 2011).

Neither a concern for global warming, nor a positive view of solar cooking, is correlated with the respondent's level of education, SES, nor the average adult level of education in their community. This then suggests the presence of an external source of information. This also points to children's exposure to NaDEET's programming as an external source which influences both household knowledge and attitudes. Stampriet as a whole, regardless of exposure to NaDEET, scores higher on the solar inventory, thus providing evidence of the child's learning being transferred not just within the house, but throughout the community as well.

Further evidence of the way that children's learning has impacted the community comes from the analysis of recycled fireball knowledge and use. Children who attend NaDEET learn to make these as part of the primary and secondary school programs. While it is true that the residents in Gibeon would have fewer opportunities to encounter these alternatives to firewood, there were a handful of residents who were aware of them. These adults learned about recycled fireballs primarily from print and media sources. In Stampriet, residents without any firsthand

NaDEET experience report learning about recycled fireballs from a child in the neighborhood, family members, and in public spaces in the town. This local sharing of knowledge is evidence of the way in which children's learning is shared within their households and across their community.

Behaviors are both difficult to change and difficult to quantify. In an effort to determine whether experience at NaDEET affects energy-related behavioral change at the household level, the degree to which households adopt their electric and traditional cookstoves was examined, where adoption score was used as a proxy for behavior. The majority of residents in Gibeon use electricity as their primary energy source for cooking, whereas in Stampriet, fuelwood is most common. Thus, electric cookstove use and satisfaction is higher in Gibeon. However, a comparison of Gibeon to NaDEET households in Stampriet indicates that both groups have similar electric cookstove adoption scores. Additionally, compared to all other households, in both towns, households with NaDEET experience have the lowest adoption scores for their traditional cooking fires. And while electric stove adoption is positively, and strongly related to SES, and traditional cookstove adoption is negatively, though weakly, associated with SES. There is no correlation between SES and NaDEET experience.

However, when examining the poorest households in both towns, those who report using wood as their primary fuel source or whom live in informal dwelling structures, there is no difference between towns, or households with and without NaDEET experience, in terms of their traditional cookstove adoption scores. This is likely a function of poverty, which remains the largest obstacle to implementing changes to cookstoves and fuels. Yet NaDEET experience does positively impact knowledge and attitudes, even when there is no evidence of behavioral change.

This study finds evidence of children's ESD learning being transmitted throughout the household and community. Significant differences between the NaDEET households and the Stampriet community, as contrasted against Gibeon, indicate that energy-related knowledge and attitudes are increased as a result of NaDEET's programming. Furthermore, households with NaDEET experience have higher electric cookstove adoption and lower traditional cookstove adoption scores than other households in the treatment town.

Taken together, this study points to the effectiveness of Education for Sustainable Development programming for children as a way to improve household energy-related sensitivities and behaviors. And while the results of this study do not indicate strong widespread adoption of electric cookstoves, it is important to note two things; first, that NaDEET's programming was not designed to specifically change parents' behaviors. That is, while students learned about efficient cookstoves and the health, environmental, and economic injustices of residential biomass for cooking, they were not equipped with stoves nor talking points for their return home. Regardless, significant differences were observed in some behaviors, and in knowledge and attitudes. And two, in the absence of a cookstove implementation program, poverty will continue to keep modern fuels inaccessible to those who could seemingly benefit the most. As such, this study recommends that ESD be part of future cookstove fieldwork and research.

3.7 Specific Contributions

The findings of this study contribute to the cookstove community's multidisciplinary body of research in two primary ways. The first is in terms of its importance to cookstove development efforts, particularly as it relates to adoption. The call for increased attention to education as a vehicle for advancing improved cooking behaviors and technologies has been raised periodically.

In practice, very little research or published evidence exists to support this agenda. The results of this study indicate that education, specifically youth orientated-ESD, can change behaviors, attitudes, and knowledge about residential cooking energy. This is of importance because cookstove adoption is behavior-dependent, and changing behavior has been a centerpiece of household energy development projects for decades. The type of education described in this study is a potential mechanism for supporting cookstove adoption efforts.

The second contribution, eluded to above, is that this study demonstrates the importance of broadening the definition of stakeholder in cookstove research, particularly in implementation and adoption studies, to include children. The findings of this study strongly point to youth sustainability education as positioning the children as agents of change within their own homes and communities. The findings are also likely to be of interest to researchers in the international field of Education for Sustainable Development.

3.8 Limitations

As in any study, there are limitations. While every effort was taken to systematically sample the entire town to achieve a representative sample of each community, it is possible that groups of households were missed due to the random walk method employed during sampling, interviewer errors, or households that were inaccessible due to lack of roads or were unobservable and far from the primary residential areas. This may be especially true for informal settlements outside of the neighborhood centers.

Namibian research assistants conducted the household interviews to minimize *social desirability bias*, but given how long the assistants were in each community, it is possible that some respondents, especially those interviewed later in the process, knew who the research assistants were and which organizations they represented.

Human behaviors and attitudes are informed by a tapestry of interwoven variables and influences. While there is evidence that points to NaDEET's impact at the household and community level, there is no way to know for certain if observed differences are due to learning accrued at NaDEET, or if there is some other factor that was not uncovered by the interview or during the time spent in these communities. This could also be compounded by the fact that the researcher and her research assistants were outsiders to the communities. Some nuance in responses may have not been detected due to a lack of understanding of cultural context, shared experience, and interpretation.

Additionally, the measures used in this study have their own limitations attached to them. The general environmental attitude inventory, the NEP, was not found to be culturally, or linguistically, useful and thus some context about the community may have been overlooked that a more appropriate questionnaire may have detected. Troncoso's adoption index was used because it was already developed and promoted by the Clean Cooking Alliance, but there are some issues with it as an instrument, and though its developers advocate for its flexibility in use, it was heavily adapted for this study. One criticism of this index is that adoption as a construct is complex, and this formula considers just four factors. For instance, it touches on fuel stacking by incorporating frequency of use of the cookstove in question, but does not necessarily consider the degree of fuel stacking within the household. The instrument does not capture what the cookstove is replacing, or how many other fuels and stoves are used. That said, it is the only attempt to quantify adoption of a cookstove at this point, and represents a necessary start.

CHAPTER 4

Youth Energy and Environmental Attitudes

Abstract

To determine to what extent children's knowledge and attitudes about energy and the environment change as a result of programming at NaDEET, a camp focused on Education for Sustainable Development (ESD), a six-month study was undertaken. This chapter describes a series of surveys used to evaluate the energy and environmental-related knowledge and attitudes of nearly 1000 Namibian students. Students took a survey before and after a week at NaDEET Centre, and again six months later. Findings indicate that children who attended NaDEET exhibit significant increases in their energy knowledge and attitudes, are more receptive to solar energy and solar cooking, and state a preference for cleaner burning fuels, after camp and as compared to the control group. Some of the largest gains are attributed to students whose families primarily burn biomass in their homes. At the time of writing, data is still being collected from the six-month follow-up surveys, but initial findings indicate that the gains hold.

4.1 Introduction

NaDEET was founded in 2003 on the NamibRand Nature Reserve in the Namib Desert (see Figures 3 and 4). Covering nearly 500,000 acres, NamibRand is thought to be the largest private nature reserve in Africa (NamibRand Nature Reserve, n.d.). Originally a collection of 17 individual livestock farms, the nature reserve was founded in 1992 and more than 1600 km of fencing was removed permitting the local zebra, giraffe, ostrich, cheetah, and antelope populations to freely roam (Tindall & Shaw, 2016). The reserve is committed to preserving the Namib Desert's ecology through conservation, eco-tourism, and education. Within the reserve,

there are several eco-lodges, a hot air ballooning tour company, a hiking company, a research center, and NaDEET.

Since 2003, NaDEET has hosted 403 groups at their Centre at NamibRand. Of these programs, 233 were primary (Grades 1-7) school groups, 63 were secondary (Grade 8-12) school groups, and 17 were extra-curricular youth groups. NaDEET has also offered 90 programs for adults, including teacher professional development and community workshops. While NaDEET's target audience is school groups, and primarily from the Hardap Region, they also host private schools from the Windhoek and Swakopmund areas. These schools pay their own way to the camp and are one of the many ways that NaDEET is able to offer free or heavily subsidized programming to underserved government schools. Programs at the Centre are residential in nature, typically beginning on Monday afternoons and ending on Friday mornings.

Students visiting NaDEET participate in a variety of sustainability education activities including preparation of meals using efficient cookstoves and solar cookers, and lessons about solar electricity, climate change, household fuel, and drought (Figure 13). Students are also engaged in lifestyle behaviors that are not explicitly taught including the use of long-drop composting toilets, "tippy taps" to improve sanitation while reducing water wastage during hand-washing, and cups of water for brushing teeth. Students are tasked with the monitoring of their waste, water, and energy usage while at the camp.

Figure 13 *Students learning to use the solar cookers at NaDEET Centre.*

Namibia is one of the only countries in the world, and the first in Africa, to include conservation and sustainability in its constitution. In *Article 95: Promotion of the Welfare of the People*, the Namibian constitution outlines the state's support for six entities; children, the elderly, disabled, and unemployed, the right to a reasonable standard of living, and the protection of the environment.

> The State shall actively promote and maintain the welfare of the people by adopting, inter alia, policies aimed at the following … maintenance of ecosystems, essential to ecological processes and the biological diversity of Namibia and utilization of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future (Republic of Namibia, 1990).

There are many EE or ESD service providers across Namibia, many situated within national parks or conservation organizations. NaDEET is recognized as an exemplary organization, most recently by the UNESCO-Japan Prize on Education for Sustainable Development, for its commitment to sustainability and the effectiveness of its programming. Unlike many EE/ESD organizations, NaDEET "practices what it teaches," in that the staff engages in the same behaviors and activities that they teach to visiting learners. Even when there is no school group at the Centre, NaDEET staff cook with solar cookers and efficient cookstoves,

use long-drop composting toilets, and monitor their waste and water usage. It is NaDEET's belief that this approach to ESD is what makes them successful. They believe and engage in the lifestyle that they promote.

The purpose of this study conducted at NaDEET is to address the second research question, *How does informal ESD affect the development of children's knowledge and attitudes about household energy and sustainability?* This study also seeks to understand how the changes in a young person's knowledge and attitudes about sustainability are maintained over time. Particular attention is paid to changes in knowledge and attitudes regarding household energy, especially for students who rely on biomass at home, as it is this population that the cookstove community seeks to make changes within.

4.2 Ethics Approval

The protocol and measures used in this study have been approved by the University of Illinois Institutional Review Board under protocol #17844 *Cooking with Stored Solar Energy in Educational Settings* (Appendix A). A research assistant hired to assist with survey distribution and data entry was added to this IRB protocol. The study has also been approved by Namibia Commission for Research, Science, and Technology under permit #RPIV00452018. Permission to work with schools and children was granted by the Ministry of Education. See Appendix B for documentation of Namibian research approvals.

4.3 Methods

All students who attended NaDEET Centre in 2019 were invited to participate in this study, which consists of a series of three surveys. Approximately one month prior to their scheduled arrival at NaDEET, schools were contacted by email or telephone, informed about this research

project, and given the opportunity to participate. Participating teachers were tasked with administering the surveys during the school day on a prescribed schedule, described below. See Appendix E for recruitment and consent documents.

4.3.1 Pre-Survey

Two weeks before the students' visit to NaDEET Centre, surveys as well as consent/assent letters and teacher instructions were sent to the schools via NamPost Courier, the courier arm of national postal service. Teachers were instructed to read the questionnaire out loud to students as a group in English, the language of instruction throughout Namibia, or in the children's primary language, as needed. Students recorded their answers on the questionnaire provided. Teachers were asked to check the questionnaires for completeness as the students turned them in to minimize missing data. Completion of the surveys was completely voluntary, both for the students and the teachers. The pre-survey consisted of a written questionnaire to establish the students' baseline knowledge and attitudes about residential energy and other sustainability-related concerns (see Appendix F). The questionnaire is a mix of existing instruments and original questions written for this specific study in collaboration with NaDEET leadership. Teachers were provided with a pre-paid envelope to return the completed surveys via courier.

4.3.2 Post-Survey and Follow-Up Survey

Students again completed the questionnaire one week after their time at NaDEET, upon return to their school. The follow-up questionnaire is a shorter version of the pre-survey, plus four open-ended questions asking about their experience at the camp, included at NaDEET's request, and

as shown in Appendix G. Teachers returned the post-survey in the same pre-paid courier parcel as the pre-survey.

Follow-up surveys were, and continue to be, sent to schools four to six months after their visit to NaDEET. Because the national school calendar ends in December, school groups that visited NaDEET in July or later would receive the follow-up surveys after the students had moved up a grade. To maximize participant retention, all schools who attended NaDEET Centre prior to the end of August were sent their follow-up surveys before the end of December. As the new school year commenced in January, the remaining follow-up surveys were couriered to teachers, but attrition is expected. Most data discussed in this chapter includes just the pre- and post-surveys. Analyses conducted with the six-month follow-up surveys will be discussed in future publications.

Many of the participating schools' visits fell outside the window of time that the researcher was based in Namibia. As such, data entry of surveys, as they were returned, was managed by a NaDEET staff member who has been added to the IRB for this study. Data are password protected and stored in secure Box folders. All identifying information is deleted from individual observations once the follow-up surveys are matched to the pre- and post-surveys.

4.3.3 Control Group

Each participating school was asked to identify a class of students one grade below the students scheduled to attend NaDEET to serve as a control group. This ensures that the control group is similar to the NaDEET participants, eligible for the same opportunities, but without prior NaDEET experience. Surveys were administered to both NaDEET learners and the control group

on the same schedule. With the exception of four open-response questions that applied to the NaDEET learners only, all students answered the same questions.

4.3.4 Pilot

Early pilots of the questionnaire with students at a nature camp in Illinois during the summer of 2017 demonstrated the importance of having an adult read the questions aloud to the students to aid in the students' understanding and ability to complete the questionnaire. NaDEET staff edited the surveys for cultural appropriateness and alignment to current NaDEET curriculum.

The first teacher to receive the questionnaires was consulted during their visit to NaDEET about the logistics of the survey implementation, and to check for any sensitivity issues or confusion about the questions themselves. No such issues were reported, but some formatting changes were made to improve the ease of use of the document.

4.3.5 Specific Instruments Included in the NaDEET Youth Questionnaire

New Ecological Paradigm with Revised Language for Children

This version of the NEP includes modified, age-appropriate language, and consists of 10 questions, rather than the 15 on the adult version (Manoli et al., 2007). This instrument can be used to find a single composite score (after reverse-scoring negatively worded items) representing where youth fall on the anthropocentric to ecocentric scale (Manoli et al., 2007). This instrument does not have a history of use in non-Western countries, and as such, is used in only an exploratory manner.

Attitudes about Solar Cookers

Students answered the same questions about solar cookers as the adults surveyed in Stampriet and Gibeon (see Chapter 3). The prompts about the economics of solar cookers were eliminated from the set of questions given to students in an effort to be age-appropriate.

4.4 Findings

4.4.1 Participants

In 2019, 20 school groups from 18 different schools attended the NaDEET Centre. Each school was invited to participate in this study. Of these schools, 16 participated in this research. A summary of the participating schools are found in Table 14.

Participant Inclusion Based on School Location

All but two participating schools are either located within the capital city, Windhoek, or in the Hardap region (Figure 14). In each location, the schools can further be separated into two groups. For instance, in Windhoek, there are socioeconomic divisions between the government and private school households. The same is true between larger, more urban Hardap towns, such as Mariental and Rehoboth, and those that are smaller or more geographically isolated.

	n		School Type	Region	Program	Prior NaDEET participation (years)
	Treatment	Control				
St. Paul's College	80	50	Private	Windhoek	Secondary	3
Waldorf School	19	18	Private	Windhoek	Primary	6
Amazing Kids	40	36	Private	Windhoek	Primary	3
Deutsche Hohere Privatschule	80	25	Private	Windhoek	Primary	15
Cimbebasia	38	35	Government	Windhoek	Primary	0
Khomasdal	34	--	Government	Windhoek	Primary	0
Ruimte	38	33	Government	Hardap	Primary	7
Danie Joubert	62	56	Government	Hardap	Primary	14
Stampriet Primary*	29	27	Government	Hardap	Primary	7
Jakob Soul*	27	38	Government	Hardap	Primary	5
AA Denk	22	22	Government	Hardap	Primary	3
N. Mutschuana	33	--	Government	Hardap	Primary	3
Reverend P.A. Schmidt	30	--	Government	Hardap	Primary	1
St. Joseph	31	--	Government	Hardap	Primary	1
Privatschule Swakopmund	34	--	Private	Erongo	Primary	4
Kahenge Combined School	20	--	Government	Kavango West	Secondary	0
Total	617	315				
	932					

Table 14 *List of schools participating in NaDEET study.*

*** Denotes schools located in Stampriet, one of the two communities discussed in Chapter 3.*

Figure 14 *Locations of participating schools. Kahenge Combined School is in the north, near the Angolan border, and is not pictured. Private School Swakopmund is on the Atlantic coast. All other schools are located in Windhoek and in the Hardap regions of Namibia. Retrieved from Google Earth. (2020).*

Two schools, Private School Swakopmund (PSS) and Kahenge Combined School (KCS) are from Swakopmund in the Erongo region and the Kavango West region, respectively, (Figure 14) and differ considerably from the rest of the students enrolled in this study. These schools are included in general, overall results of the study (e.g., *The average score across all participants was 3.76 (SD = 0.54)*), however they are not part of any specific comparisons between government and private schools, due to cultural and ethnic dissimilarities to the locations of the other schools. Neither Kahenge Combined School nor Private School Swakopmund are similar to the Hardap where approximately half speak Afrikaans and the other half Nama-Damara (Namibia Statistics Agency, 2011), nor are they necessarily similar to Windhoek. The capital describes its 431,000 residents (Macrotrends, 2020) as "an ethnic cross-section of Namibia. Indigenous groups include the Owambo, Herero, Damara, Nama, Kavango, Caprivian, San,

Batswana and Baster communities, as well as Afrikaners, Germans and other international groups" (City of Windhoek, n.d.).

Of the remaining 14 schools, a private German school in Windhoek, Deutsche Hohere Privatschule, returned anonymous surveys prohibiting the matching of any subsequent surveys and were thus not included in any results. All schools sent primary grade students with the exception of St. Paul's College, a Windhoek private school, and KCS from Kavango West. St. Paul's sent two groups of Grade 8 students. Given that these students are just one year older than some of the primary grade participants, and that NaDEET's primary and secondary programs are similar, these students are included in key analyses. The KCS students were upper secondary school students and are only included in demographic analyses unless explicitly stated otherwise.

Participant Demographics

Of the 852 surveys that were returned and identifiable, 537 (63%) were NaDEET learners, while 315 were students in the control group (37%). The majority of students, 94% (n = 798), are from Windhoek or the Hardap. Most (68%) attend government schools, and just over half (56%) identify as female. Table 15 describes the NaDEET participants and the control group across several key demographical variables including age, gender, type of school attended, family size, and access to indoor plumbing and electricity.

	NaDEET	Control	*t*(779)	*p*
Age	12.93	11.93	19.95	0.001*
Female Student	0.56	0.54	0.50†	0.616
Government School	0.68	0.67	0.24†	0.810
Family Size	6.08	6.09	0.07	0.942
Indoor Tap	0.88	0.83	0.62	0.534
Electricity	0.93	0.98	2.85†	0.004

Table 15 *Overview of all NaDEET participants and students in the control group across key demographical variables.*

** Indicates p-values less than 0.001*

† z-test scores as a result of two-proportion tests of means of binary variables

Significant differences between Hardap and Windhoek schools exist across the demographical variables described above. For instance, while nearly all Windhoek students have indoor plumbing, only 79% of Hardap students report the same. Table 16 below demonstrates these differences for each region, and includes responses from both the NaDEET participants and the control groups. Because schools across these two contexts significantly vary, most of the analyses that follow in this chapter report results disaggregated by location.

	Hardap	Windhoek	*t*(475)	*p*
Age	12.86	12.11	8.78	0.001*
Female Student	0.58	0.54	1.15†	0.249
Government School	1.00	0.31	21.15†	0.001*
Family Size	6.68	5.43	6.81	0.001*
Indoor Tap	0.79	0.95	6.32†	0.001*
Electricity	0.93	0.97	4.61†	0.001*

Table 16 *Comparison of participants from the Hardap and from Windhoek, across key demographical variables. Both NaDEET participants and students in the control group are included.*

** Indicates p-values less than 0.001*

† z-test scores as a result of two-proportion tests of means of binary variables.

The cost per person paid by each school to attend NaDEET Centre is highly correlated with Windhoek schools, r (796) = 0.82. The average price per student paid by Windhoek schools was N$828 ($58 USD), where all private schools paid the full N$980 per person weekly rate and the government schools paid, on average, N$516 per student. This is significantly different than the average rate of N$207 ($14.50 USD) that Hardap schools paid, $t(796) = 39.98$, $p < 0.001$, and as indicated by a large effect size, Cohen's $d = 2.85$. Within the Hardap, the cost per person is highly correlated with schools from the larger, more urban towns, $r(446) = 0.61$. One of these towns, Rehoboth, is a small city an hour south of Windhoek from which many people commute. The other town, Mariental, is popular with tourists as a launching point for safaris in the Kalahari desert. Three of the participating schools are from these towns; St. Joseph's and Ruimte in Rehoboth, and Danie Joubert Primary in Mariental. The other four Hardap schools are from the rural towns, Stampriet, Mariental, Gochas, and Kalkrand. Many of the analyses presented in the remainder of this chapter sort and compare students by *cost per person* as a proxy for socioeconomic status.

Student responses on the questionnaires were entered into an Excel spreadsheet for analysis that was then imported into Stata version 15, a statistical software package. The NEP and attitudes about solar cooking were scored according to their published instructions. Because the study with students includes pre- and post-test questionnaires, students' questionnaires were matched. The baseline survey scores for each participant were used as a covariate to adjust for group differences in attitudes or knowledge using ANCOVA or multiple regression procedures (Dugard & Todman, 1995).

4.4.2 Baseline Survey

Past Experience with NaDEET

In its fifteen years, NaDEET has engaged nearly every school in the Hardap and multiple schools in the Windhoek area. Of the 754 students who took the pre-survey, 47% report having a family member who has attended NaDEET Centre in the past. There is not a significant difference between the control (M = 0.52, *SE* = 0.03) and the NaDEET learners (*M* = 0.47, *SE* = 0.02) in this regard, *z*= 1.95, *p* = 0.051. If a child reported that a family member has previously attended NaDEET, it was usually a sibling (67%) or a parent (18%). In the Hardap Region, 63% of NaDEET participants and 71% of the control group report that someone in their family has had past experience with NaDEET programming, *z* = 1.48, *p* = 0.140. Nineteen (5%) of Hardap students report having been to NaDEET at some prior time themselves, and 10 (3%) Windhoek students state the same. Children who report having a family member with NaDEET experience exhibit slightly higher initial scores on the solar energy attitude scale and questions ascertaining prior knowledge about topics in household energy or environmental issues, but not significantly so. This is examined more in the Discussion section.

Youth as Energy Stakeholders

An underlying assumption of this dissertation is that youth are already energy stakeholders within the home. To establish the veracity of this claim, students were asked about their responsibilities for cooking and fuel procurement.

While the majority of students report that their mothers are the primary cooks in the household, 73% of students report cooking at least once a week, and 40% report engaging in this

task multiple times a week. There was no difference between the treatment and control groups, $z = 0.44$, $p = 0.661$. However, females in both groups report cooking significantly more often than their male peers, $z = 3.36$, $p < 0.001$.

A series of Mann Whitney tests were conducted between groups within and across the Hardap and Windhoek to give a clearer picture of household cooking dynamics. Hardap youth are expected to help with the cooking at home more than their peers in Windhoek $z = 3.85$, $p < 0.001$. In Windhoek, there is not a significant difference between the government and private school children. But, in the Hardap, the children in the rural towns report helping with meal preparation significantly more often than the children in the urban towns, $z = 4.92$, $p < 0.001$.

Similarly, students from the Hardap region report enjoying cooking more than their Windhoek peers, $z = 9.14$, $p < 0.001$. And within Windhoek, the government school children also enjoy cooking meals more than the students who hail from private schools, $z = 7.50$, $p < 0.001$.

Just 8% of all respondents report no responsibility for any cooking duties within the home, significantly less than the youth who do, as measured by a one-sample test of proportion, $z = 27.50$, $p < 0.001$. This highlights both that youth are in fact stakeholders in terms of household cooking energy, and that energy use within the home is a family affair.

Energy Access in the Home

Students were asked about their family's access to energy and energy choices within the home. As shown in Table 15, the majority of students have access to electricity. Using electricity for cooking is common across Namibia, particularly in larger towns. The majority (75%) of the youth participants reported an electric stove in their home, but this varies across regions, as shown in Figure 15.

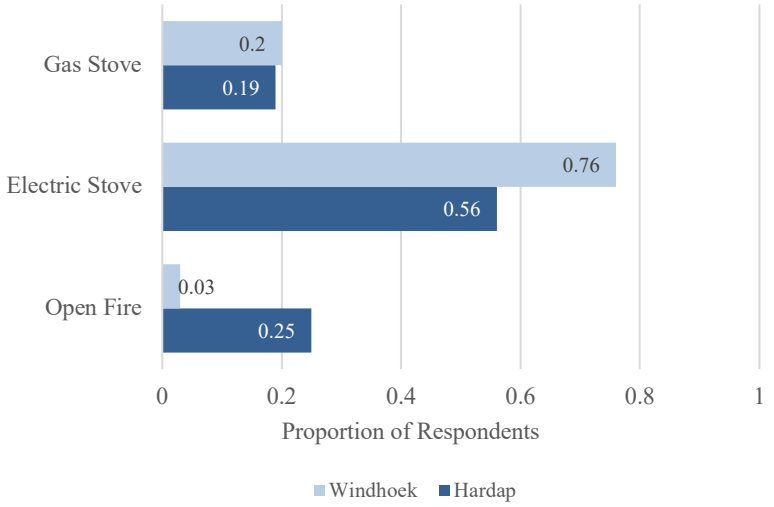

Figure 15 *Primary cookstoves used in the homes of Hardap and Windhoek participants.*

Most students reported having one or two stoves in their family's residence. Just 9% had three stoves, and less than one percent had four or five stoves. Of families with just one type of stove, 68 % use electric stoves, 18% use gas stoves, and 13% use open fires. The most common combination of two stoves is a traditional open fire and an electric stove (52%), followed by an electric and gas stove (31%), and an open fire and gas stove (13%). Just 2% of students report having a solar cooker (either box type or parabolic) at home, most of these students reside within the Hardap. However, 44% of all respondents report having used a solar cooker either at home, school, or at a friend or family member's house. More than half of these students are from the Hardap.

Traditional fires, either as the primary stove or in combination with other devices, are reportedly used in 36% of respondents' homes. If a student indicated that their open fire was actually a *braai*, or grill, it was not counted as such. Of these traditional open fires, 62% of them occur within the Hardap.

Because the cookstove community seeks to change the attitudes and behaviors of traditional cookstove users, special attention is paid to this subset of youth participants in the remaining analyses presented this chapter.

Stove used most often. The primary stove, as reported by youth in the Hardap and in Windhoek, mirrors the frequency of ownership described in the previous paragraph. Electric stoves are the primary stove in just 65% of participants' households, despite nearly 95% of all respondents having access to electricity at home. Gas stoves are the primary stove used in 19% of respondents' households, while open fires account for 14%.

Across the Hardap, similar to Windhoek, an electric cooker is the most commonly used stove as reported by 56% of participants. However, more rural Hardap students report open fires as the primary cookstove (43%) than electric stoves (36%), furthering the rationale for the disaggregation of data within this region.

How often do you collect firewood? Approximately half of all youth respondents indicate that they participate in firewood collection for their families' energy needs. These students were instructed to choose a response that best matched the frequency of which they engaged in this activity. Choices ranged from never (score of 1) to daily (score of 5). Given that the majority of open fires occur in the Hardap, it is unsurprising that 41% of Hardap children report collecting wood weekly or daily, while just 13% of the children in Windhoek report the same. Within the Hardap, 66% of rural students report collecting firewood weekly or daily, while only 15% of the students from the larger towns are expected to do the same. This follows stove usage patterns in which rural households are more likely to use open fires than the urban households. There is not a significant difference between male and female youth being tasked with firewood collection.

The survey asked the participants how much they enjoyed collecting firewood. The answer choices were a series of five faces ranging from a deep frown indicating "not at all" to a big smile meaning "very much." Students were instructed to select the face that most closely matched how they feel about the task of firewood collection. A significant proportion of Hardap children enjoy the task of collecting firewood, as indicated by smiley faces, as compared to children in Windhoek who enjoy this chore less, $z = 3.41$, $p < 0.001$. Further, in the Hardap, the rural students enjoy collecting wood more than the students who live in urban areas, $z = 6.99$, $p < 0.001$. Interestingly, in the Hardap, children whose parents have attended NaDEET in the past significantly like collecting firewood less than those whose parents do not have such experience as measured by a two proportions z-test, $z = 2.68$, $p = 0.008$.

Ideal cooking fuel

Students were asked to state their ideal cooking fuel. They were given the choices ranging from electricity, firewood, animal dung, charcoal, etc., and had the opportunity to write in other alternatives. Choosing electricity, gas, or solar was scored as a 1, and indicated a preference for a "modern," or healthier fuel for indoor cooking. Whereas firewood, charcoal, and animal dung were scored as zeroes. As the surveys were administered via paper and pencil, nothing prohibited a student from indicating more than one answer. If the student chose one clean fuel in combination with a solid fuel (e.g., firewood, charcoal, or dung), they were given a score of 0.5. Overall, there was no difference between students attending NaDEET ($M = 0.62$, $SD = 0.47$) and the control group ($M = 0.57$, $SD = 0.49$) in these preferences, $t(764) = 1.34$, $p = 0.180$. Nor were there differences between Hardap students ($M = 0.58$, $SD = 0.49$) and those in Windhoek ($M =$

0.64, $SD = 0.47$), regardless of whether they attended a private or government school, $t(710) = 1.54$, $p = 0.124$

For students with access to electricity at home, 76% of Windhoek students report electric cookstoves as their household's primary stove, and 56% of Hardap students report the same. This is a significant difference as measured by a two proportions z-test, $z = 5.66$, $p < 0.001$. However, of these students, only 66% from Windhoek, and 58% from the Hardap, express a preference for cleaner energy sources even though their families *primarily cook with electricity* (Figure 16) Of all 488 participants, NaDEET learners and the control group, who report electric stoves as the primary cooking device, 70% prefer that energy source.

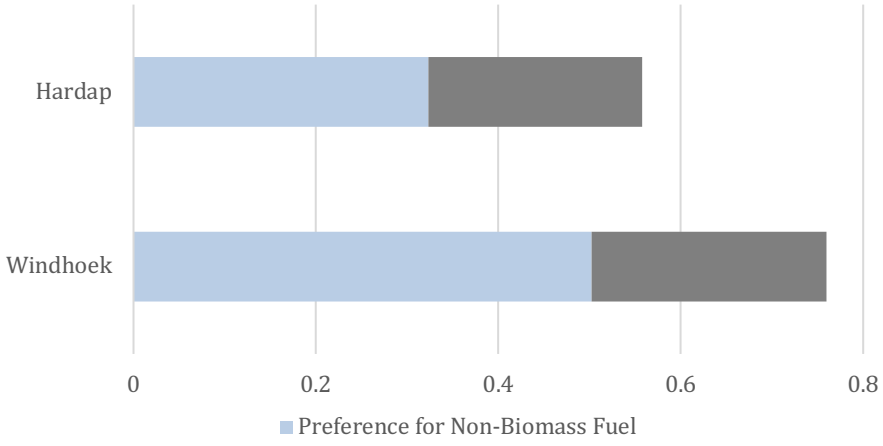

Figure 16 *Proportion of students whose families primarily cook with an electric cookstove, and of those, the proportion who state a prefrence for a modern, or clean, cooking fuel source.*

In the Hardap, 20% of students' households *primarily cook with an open fire*, and 31% of those students prefer a clean energy source for cooking. This is significantly less than Hardap students who do not primarily cook with wood, $z = 5.82$, $p < 0.001$. However, this follows the same pattern above, in that approximately 70% of the students prefer the energy source of which they are most familiar.

Overall, participants from the urban towns in the Hardap significantly prefer clean sources of cooking energy ($M = 0.71$, $SD = 0.45$) as compared to students in the rural towns ($M = 0.46$, $SD = 0.50$), $t(388) = 5.29$, $p < 0.001$, Cohen's $d = 0.54$. Table 17 describes comparisons between rural and urban Hardap participants and their preference for a clean energy source for cooking in terms of their access to electricity, primary stove use in the home, and whether they have had a family member attend a session at NaDEET in the past. The cost per person to attend NaDEET is included to provide context to these comparisons. The significant difference between the urban and rural students disappears when examining families who have had past experiences at NaDEET.

	Rural	**Urban**	***df***	***t***	***p***
Cost per person (N$)	109.32	307.45	446	16.28	0.001*
Has access to electricity	0.46	0.72	356	5.24	0.001*
Primary stove: electric	0.61	0.75	210	2.05	0.041
Prior family NaDEET	0.64	0.77	121	1.54	0.127
No access to electricity	0.43	0.50	25	0.23	0.817

Table 17 *Comparisons between rural and urban Hardap students and their stated preferences for a clean cooking fuel by demographical variables.*

** Indicates p-values less than 0.001*

Baseline Attitudes

Students were asked a series of questions, and answered two instruments, described earlier in this chapter, to gain an understanding of their beliefs and concerns about the environment. In this section, each instrument or attitude item will be briefly discussed.

How worried are you about plastic and other rubbish in your environment? This question was scored on a three-point Likert scale, 1 indicating "not at all" and 3 meaning very worried.

Students preparing to attend NaDEET were significantly more worried than the control group, as measured by Mann Whitney test, $z = 4.42$, $p < 0.001$.

A Kruskal-Wallis ANOVA indicates that significant differences exist between school locations, $\chi^2(4) = 50.56$, $p < 0.001$. Examining participants from just the Hardap and Windhoek, the focus of this study, a Mann Whitney test reveals that Hardap youth are significantly more worried about plastic and other rubbish in their environment, $z = 3.35$, $p < 0.001$, as shown in the figure below.

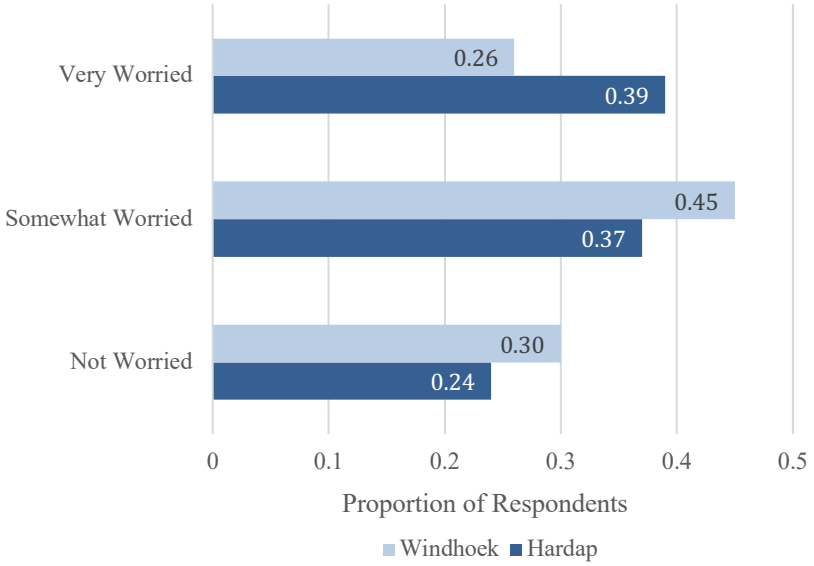

Figure 17 *Degree of concern for plastic and rubbish in the environment. Proportion of students by region in terms of how concerned they are about plastic and other trash in their environment.*

What do you do to save water at home? Approximately 75% of all students, both treatment and control, report that their families engage in at least one water-saving behavior. This was an open-ended question and responses were coded 1 if the respondent listed a specific behavior (e.g., "we use the shower water to flush our toilet") and 0 if the response was nonspecific (e.g., "we use less water"). If a student did not respond to this question, it was assumed that there were no water saving activities performed at home and was thus was also

scored as zero. There is not a significant difference between the treatment group and the control group overall, as measured by a two-means proportion test, $z = 1.73$, $p = 0.084$. Results of a Kruskal-Wallis ANOVA by region indicate that there are significant differences between the regions in terms students' reporting water conservation at home, $\chi^2(4) = 10.54$, $p = 0.032$. However further analysis indicates that while there is no overall significant difference between Windhoek and Hardap students, this is only the case because the majority of the government school children in Windhoek (86%) report water saving strategies at home. A significantly smaller proportion of private school students in Windhoek (70%) state that their family intentionally saves water, as measured by a Mann Whitney test, $z = 3.20$, $p = 0.001$.

In the Hardap region, 76% of students report at least one water saving effort in the household. This is similar to students from the coastal Erongo region (76%), and in the Kavango West region (79%).

New Ecological Paradigm

Students took the New Ecological Paradigm inventory adapted for children, which consists of ten items meant to measure their pro-environmental outlook. The internal consistency of this instrument used with this population was not strong, Cronbach's $\alpha = 0.52$. The developers of the scale state that the mean of all items, after reverse-scoring negatively worded items, yields a value which indicates a respondent's pro-environmental outlook. Three subscales have also been identified by the developers, and in subsequent studies by other researchers with North American populations. A factor analysis revealed the presence of three factors with eigenvalues over one. However, the first two factors had eigenvalues of 2.11 and 1.49, while the third was just 1.03. Two items loaded onto the third factor as well as the first. Upon rotation it was clear

that only the first two factors were significant, will all questions loading at 0.45 or higher. The items that loaded on to the second factor did align with the *human exemptionalism* subscale, an indicator of how much the respondent agrees that humans are exempt to the laws of nature, or superior to nature. However, given the overall weak internal consistency of the scale as a whole, the subscale will not be addressed in any meaningful way.

Students who did not answer these ten questions were dropped from the analyses (n = 140, 17%). These students were primarily from schools who attended NaDEET Centre on short notice when another school cancelled, or did not receive the surveys due to the reliability of the national courier system, or potentially, a miscommunication with the participating schools. An analysis of the remaining missing data shows that 74% of students had complete data, and 9% had one or more missing items. There were no patterns in the data, and it is assumed that the missing data is missing at random (MAR).

Students with missing items received a total instrument score based on the number of items that were answered. For instance, if a student answered all items on the instrument with the exception of item 5, their average score is as if the scale contains nine questions only.

The mean total score on the NEP for all students who took the pre-survey is 3.72 (SD = 0.50). The authors of the scale state that a score of 3 is the boundary point between a pro-environmental world outlook and the Dominant Social Paradigm, which describes attitudes and beliefs that are anthropocentric, that nature exists to serve human needs (Manoli et al., 2007). A score above 3 indicates a pro-environmental attitude. There are no significant differences between the students attending NaDEET and the control group. With the exception of one rural Hardap school, there is also not a significant difference in initial NEP scores between students with a family member who has previously attended NaDEET and those who have not.

Consistent with this scale's literature in the North American context, urban respondents have a significantly higher total score than rural respondents. Respondents in Windhoek (M = 3.86, SD = 0.45) score significantly higher than students in the Hardap overall (M = 3.60, SD = 0.51), $t(655) = 6.69$, $p < 0.001$, Cohen's $d = 0.52$, as measured by a two-samples t-test. Likewise, urban Hardap students score higher than rural students, $t(332) = 11.77$, $p < 0.001$, and with a large effect size, Cohen's $d = 1.30$. Urban participants in the Hardap and students in Windhoek have similar scores, $t(508) = 0.14$, $p = 0.888$.

Solar Cooker Attitude Inventory

Adapted from the solar cooker inventory given to adults in the community survey, students were asked eight of the ten items on the instrument, excluding two regarding solar cookers and household economics. The internal reliability of this instrument, which is used in an exploratory way, is acceptable but weak, $\alpha = 0.56$. An examination of missing data for the items in this inventory reveal that 72% of the cases are complete, and that like before, 17% of participants did not answer this portion of the survey. There are no patterns of missingness in the remaining data, and thus it is again assumed that the data is MAR. Missing data was handled as described in the previous section. A factor analysis of these 8 items indicate that there is one factor, with all items loading at 0.45 or higher.

Obtaining a total score was done by calculating the average on all answered items. The mean total score for all participants is 3.76 (SD = 0.54), with no significant difference between gender or whether a family member has ever attended NaDEET. Students from the Hardap have significantly higher views of solar cooking (M = 3.84, SD = 0.54) than students from Windhoek (M = 3.70, SD = 0.52), $t(654) = 3.33$, $p < 0.001$, with a small effect size as measured by Cohen's

$d = 0.26$. In the Hardap, students from the urban areas of the Hardap are significantly more positive about solar cooking than the students from more rural areas, $t(332) = 3.39$, $p < 0.001$, and as indicated by a moderate effect size, Cohen's $d = 0.37$.

There is a significant difference between the students who are about to attend NaDEET ($M = 3.79$, $SD = 0.52$) and the control group ($M = 3.69$, $SD = 0.56$), as measured by a two-samples t-test, $t(708) = 2.38$, $p = 0.018$, with a small effect size, Cohen's $d = 0.20$. It is likely that students preparing to attend NaDEET have knowledge about the solar cooking at NaDEET as their schools and families work out logistics and meal plans with NaDEET Centre.

Opportunity to Attend NaDEET Centre

Each student was asked how important the opportunity to attend NaDEET Centre is to them personally. A Mann Whitney test shows that students who were about to attend NaDEET value this opportunity more than the control group $z = 1.97$, $p = 0.049$, but this difference is just significant. There is not a significant difference between NaDEET participants located in Windhoek as compared to the Hardap, but there are differences within each. For instance, students at the government schools in Windhoek find the opportunity to attend NaDEET more important than the students from the private schools, $z = 5.42$, $p < 0.001$. The same is true of urban students in the Hardap, $z = 2.79$, $p = 0.005$.

4.4.3 Results from Post-Survey

Within two weeks of their NaDEET Centre visit, teachers were instructed to give their students, as well as the associated control group, the post-camp survey. The results discussed in this section will focus on changes in attitudes and knowledge. The behaviors inquired about by this

survey focus on household energy patterns, and while it is not impossible that children may influence these household behaviors, and in fact there is compelling evidence that children do in fact do this (Chapter 3), fuel-switching is not expected to occur in the short-term, without readily available alternatives and intentional supports.

Preference for Modern Fuels

A greater proportion of the children stated a preference for a modern fuel after NaDEET attendance, than before their arrival at the Centre (Figure 18). There is no change in the control group. Overall, the proportion of students who prefer modern fuels after camp increased by 17%, $z = 5.72$, $p < 0.001$. This increase is largely driven by private school students in Windhoek where 25% more of the students selected a modern cooking fuel, $z = 4.03$, $p < 0.001$. Students enrolled in the government schools in Windhoek did not exhibit a significant change, however, 93% of these students stated a preference for a modern fuel on the pre-survey. The 94% who now state this preference is still significantly larger than the proportion of private school students, $z = 2.53$, $p = 0.011$.

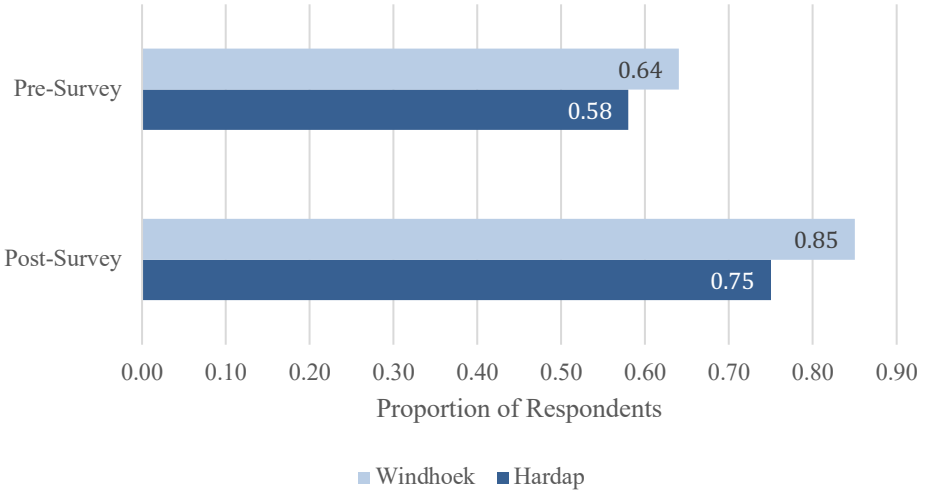

Figure 18 *Proportion of Hardap and Windhoek students who prefer a modern fuel before and after NaDEET experience.*

On the pre-survey, approximately 60% of Hardap students reported a preference for a modern fuel as compared to the 75% on the post-camp survey, $z = 2.92$, $p = 0.004$. Students in the urban areas of the Hardap exhibited a 15% increase, $z = 2.60$, $p = 0.009$, while the rural towns demonstrated an increase of 10% which was not quite statistically significant.

Perhaps most tellingly, is that for students who attended NaDEET and whose family primarily cook with wood, 70% now state a preference for a modern fuel as opposed to just 41% before camp. This is a significant increase as measured by paired t-test, $t(42) = 3.03$, $p = 0.004$, with a moderate effect size, Cohen's $d = 0.49$ (Figure 19). Similar, but slightly smaller, gains are also seen in households in which electric stove users are most commonly used. For instance, before camp, 68% of students stated a preference for electricity, gas, or solar energy as compared to 83% after camp, $t(259) = 5.00$, $p < 0.001$, Cohen's $d = 0.37$.

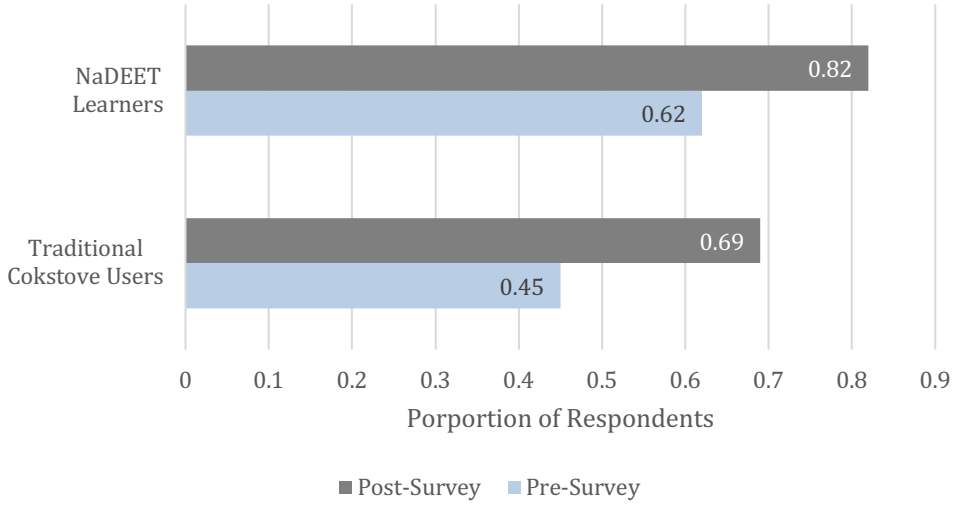

Figure 19 *Proportion of respondents preference for a clean cooking fuel before and after their visit to NaDEET. Data for all NaDEET learners, and just those whose families primarily cook with traditional cookstoves.*

Plastic

On the post-camp survey, all students, both NaDEET learners and the control group, expressed more concern about plastic and rubbish in the environment as compared to the pre-survey. While both groups exhibited an increase in concern, NaDEET students demonstrate a change in concern that is significantly greater than the control group, $z = 3.75$, $p = 0.002$, as shown by a Wilcoxon signed rank test. Windhoek students who attended NaDEET, regardless of the type of school attended, exhibited no change in concern about rubbish in the environment.

A Mann-Whitney test indicates that Hardap students were significantly more concerned about plastic and rubbish after their NaDEET experience, $z = 4.31$, $p < 0.001$. This increase in sensitivity is largely due to gains in the urban learners' attitudes, $z = 2.27$, $p = 0.023$.

New Ecological Paradigm

Immediately after camp, students do not exhibit significant changes in their score on the New Ecological Paradigm. This is true for the students who attended NaDEET as well as the control group. The test-retest reliability of the NEP was calculated using the control group and was found to be adequate, $\alpha = 0.76$. The internal consistency of the NEP the second time it was given to students remains low, $\alpha = 0.53$ for both NaDEET students and the control group.

Solar Cooker Attitudes

After cooking with solar cookers for four days at NaDEET Centre, students exhibit a marked change in their attitudes toward the devices as measured by a paired t-test, $t(393) = 4.30$, $p < 0.001$, with a slight effect size, Cohen's $d = 0.24$. Students in both Windhoek and in the Hardap demonstrate positive gains on this scale, mostly driven by private school students and urban students, respectively. Interestingly, students who report that their families primarily cook with open fires have the biggest gains, as measured by an independent samples t-test, $t(392) = 3.19$, $p = 0.002$, and as shown by a moderate effect size, Cohen's $d = 0.51$, as shown in Figure 20.

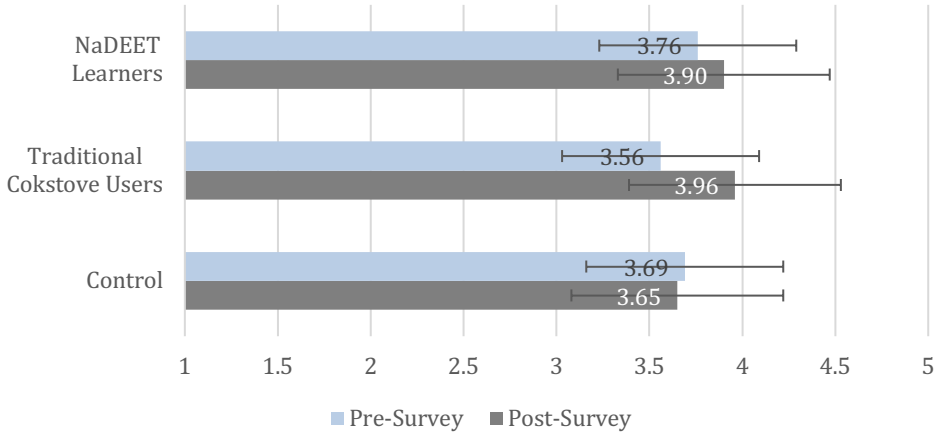

Figure 20 *Participant pre- and post-scores on the solar attitude inventory by group; all NaDEET learners, NaDEET learners whose families primarily cook with traditional cookstoves, and the control group.*

A multiple linear regression model was run to examine the effects of the NaDEET experiences, as well as other demographical variables, in predicting students' scores on the second taking of the solar cooker attitude inventory. Baseline attitudes were added as covariates, as shown in Table 18 below.

	B	*SE*	*β*	*t*	*p*
NaDEET Learner	0.22	0.06	0.17	3.92	0.001*
Cost per Person	-0.00	0.00	-0.10	-1.49	0.137
Gender	0.06	0.05	0.05	1.22	0.224
Windhoek Learner	0.07	0.08	0.06	0.90	0.369
Prefer Modern Fuel Baseline	0.09	0.05	0.07	1.87	0.062
Solar Attitude Baseline	1.93	0.05	0.40	9.60	0.001*
$F(6, 462) = 24.48$, $R^2 = 0.24$					

Table 18 *Summary of regression analysis for variables predicting students post-camp solar energy attitudes.*

While this item is a scale and thus no particular item is likely to measure an entire construct, there are a few questions on this instrument that are of interest. Because they are individual Likert-type questions, nonparametric tests were used to evaluate changes in responses.

Using a solar cooker can solve energy problems. Wilcoxon Signed-Rank tests were used to determine changes in students' agreement to this statement. More NaDEET learners agree or strongly agree with this item after camp (85%) than before (77%), $z = 2.45$, $p = 0.014$, while the control group shows no change. This gain is mostly explained by a positive change in attitude of Hardap students, $z = 2.55$, $p = 0.011$, and those whose families primarily cook with traditional cookstoves, $z = 2.00$, $p = 0.045$.

Solar cookers can cook all types of food. Before participating in NaDEET programming, 53% of students agreed or strongly agreed with this statement. During camp, students made

pizza, roast chicken, bread, and macaroni salad, among other dishes, on solar cookers. After participation, 68% agree with this statement, representing a significant, positive change in attitude, $z = 6.33$, $p < 0.001$. The control group again exhibits no change. All groups of students from Windhoek and the Hardap show an increase, though the largest gains are attributed to urban students in the Hardap where 40% more students now agree with this statement post-camp for a total proportion of 78%. While this is a large change, it is not significantly larger than the rural students' initial or post-camp attitudes about this statement, both of which were approximately 80%.

Among students who report that their families primarily cook with a traditional stove, a significantly larger proportion of students agree with this statement post-camp (83%) than before (63%), $z = 2.00$, $p = 0.046$.

The sun's energy can be used for cooking. Before arriving at NaDEET, nearly 90% of all students agreed or strongly agreed with this statement. After a school week at NaDEET, 94% of the students agree or strongly agree, representing a significant gain in attitudes, $z = 2.31$, $p = 0.021$. There is no change in the control group measured for this item.

4.4.4 Preliminary Six-Month Follow-Up Results

At the time of writing, 9 of the 16 schools returned their six-month follow-up surveys, accounting for approximately 40% of all participants. These schools do represent both the Windhoek and Hardap regions, and include students from the control group (Table 19). While the analysis using this smaller subset of students is preliminary, some early findings of interest can be reported.

	NaDEET Learners	Control Group
Hardap	168	60
Rural	113	46
Urban	55	14
Windhoek	77	53
Government School	34	–
Private School	43	53
Total	245	113

Table 19 *Description of participating students who have returned their six-month follow-up survey and the pre-survey and/or post-survey.*

Preference for modern fuels. The gain in proportion of students who prefer a modern cooking fuel after their camp experience persists six months later. No significant change occurs for NaDEET learners in the interim, $t(143) = 0.20$, $p = 0.844$, but continues to be a significant gain from the pre-survey, $t(206) = 3.12$, $p = 0.002$, Cohen's $d = 0.26$. There are less than 80 observations in the control group that can be used for comparison. However, the control group continues to exhibit no changes in their preference for modern fuels across the three surveys.

Concern about plastic and rubbish in the environment. Interestingly, there is a significant decrease in students' concern about plastic and rubbish in the environment in the six-months after the NaDEET experience. Not only is this a decrease from the post-survey to the six-month survey, but it is also significantly less than the pre-survey values. This was confirmed using a series of Mann Whitney and Wilcoxon Signed Rank tests, and is true for both the students who attended NaDEET and for the control group.

Opportunity to Attend NaDEET Centre. Students were again asked on follow-up surveys to state how much they agreed or disagreed with the statement "*The opportunity to attend NaDEET Centre is important to me*." A Mann Whitney test indicates that students who attended

NaDEET Centre continue to find this educational opportunity significantly more important than students in the control group, $z = 5.21$, $p < 0.001$.

New Ecological Paradigm. Preliminary results indicate that there is a small, but significant overall gain in pro-environmental attitudes between the post-camp survey and the six-month follow-up. This was measured using a paired t-test for these students, $t(145) = 3.63$, $p < 0.001$, which exhibits a small effect size, Cohen's $d = 0.28$. While the increase in scores is small, it is not known if this gain is attributed to the NaDEET experience, or on-going support of that learning at school or elsewhere. However, the control group, consisting of 79 students with complete records at this time, do not show any significant changes in their scores over this same period. Because of the low overall internal consistency of this instrument used in this context, the importance attached to this finding is minimal.

Solar Cooking Attitudes. When examining students' scores on the solar cooking attitude inventory six months after their visit to NaDEET, there is no significant change, $t(145) = 0.54$, $p = 589$. This represents a sustained increase in attitudes toward solar cooking and solar energy. Once again, the control group's scores remain unchanged, $t(76) = 0.24$, $p = 0.811$.

4.5 Discussion

After attendance at the NaDEET Centre, students exhibited gains in general environmental attitudes, preferences towards modern fuels, and openness to solar cookers, an uncommon cooking device in Namibia. Students in the control group demonstrate no such changes, which provides compelling support for the capacity of effective ESD to have a positive impact on students' worldviews.

From an energy perspective, the increases in students' attitudes and knowledge about energy and cooking fuels are of the most importance. Fewer than 5% of girls and 14% of boys

report *never* being asked to do any cooking at home, and 76% of girls state that they are responsible for cooking meals at least once a week. Given this activity in their kitchens, it is reasonable to describe these children as *cookstove stakeholders*.

In the Hardap, the average maternal age for a first birth is 20.9 years old (Namibia Statistics Agency, 2011). The average age of female students attending NaDEET in 2019 was 12.8 years old, meaning that in just a few short years, many of these girls will be caring for their own children, making decisions about their households' energy needs. This makes ESD when the students' attitudes are malleable, timely and important.

Before attending NaDEET, students had preferences for fuels that appear to be largely a function of the fuels they are accustomed to at home. For instance, 69% of students from households that primarily cook with firewood, preferred firewood as an energy source for cooking. The same is true for students whose families primarily cook with electricity; 70% preferred electricity or LPG. From this perspective, the familiarity with a cooking fuel influences the respondents' preferences, and thus puts youth who are primarily accustomed to biomass at an initial disadvantage. However, after the camp experience, the majority of students with a traditional cookstove background now state a preference for a modern fuel, exhibiting slightly higher gain than peers who do not cook with traditional cookstoves. Most importantly, this shift persists six months later. This suggests that long-term changes in fuel choice attitudes is possible, and that youth are a key demographic for realizing this change.

NaDEET's energy programming consists of two primary activities, neither of which passes judgement on the types of fuels used in students' homes. The first activity is simply that students are expected to help prepare their own meals using efficient cookstoves and solar cookers. Unless it is cloudy, solar cookers are used for the mid-day and dinner meal. The

efficient cookstoves are used early in the morning. Students are taught how to use the solar cookers the morning of their first full-day at camp, and shortly thereafter make their own pizzas for lunch which bake in solar ovens.

Later in the program, before learning to make recycled fireballs, students read an article about the consequences of using firewood in Namibia, and then are engaged in a relay race (Figure 21) that simulates the disadvantages of those who must spend a significant portion of their day collecting firewood. Students are randomly assigned to one of three groups representing individuals who are able to afford modern fuels, those who can purchase solid fuels such as firewood or charcoal, and the poorest, who must collect the firewood themselves. The first group has the shortest distance to run and does not need to collect, nor carry, a sack of firewood. While each member of the second team must carry a heavy bag of firewood during their leg of the race, the bag is conveniently placed as to not slow down the team. The first runner of the third group must make a significant detour away from the race route to fill a sack with firewood. By the time the first student has completed this and returned to the starting line to begin racing, the other teams' second and third runners are likely running. Especially in the secondary program, NaDEET makes explicit links between poverty and fuel use.

While students learn about the environmental impacts of cooking with fossil and solid fuels, and the benefits of cooking with solar energy, recycled materials, and cleaner-burning fossil fuels, at no time are students told that cooking with firewood is wrong. Yet shortly after camp had concluded, on the post-survey, the majority of students, including those who are accustomed to biomass at home, chose a modern fuel with which they would prefer to cook, if all things were equal.

Figure 21 *Grade 8 students at NaDEET Centre participating in a relay race simulating the inherent disadvantages of reliance on firewood for household energy needs. March 12, 2019.*

Similarly, gains are noted in the students' overall attitudes toward, and knowledge of, solar cookers and solar energy. The use and subsequent findings of the solar cooking attitude instrument is interesting for a couple of reasons. First, several items on the inventory allow us to ascertain how well the participant understands the capabilities of a solar cooker. On the second and third administration of the survey, students who attended NaDEET understand that solar energy can be used to cook food at a significantly higher proportion than those in the control group. Second, solar cookers are by no means common. In fact, they are unusual devices both in terms of their relative rarity in usage, and the different types of cookers that fall under the solar cooker umbrella. NaDEET uses the two most common forms of solar cookers, parabolic cookers and solar box ovens. The behaviors involved in using most solar cookers have little in common with the practice of using a traditional or improved cookstove, a primary criticism of these devices. For students who attend NaDEET to overwhelmingly find solar cookers not only capable of cooking all types of food but that they are also *culturally acceptable* indicates that an efficient cookstove, a device more similar to the cookstoves already in homes, might have an even easier time being accepted by this audience.

It is true that students who reported having a parent or sibling with previous NaDEET experience have slightly higher scores on the solar attitude inventory and other knowledge and attitude questions (e.g., importance of opportunity to attend NaDEET Centre, there is a water crisis in Namibia), however the differences are not significant. This is unexpected, especially given the findings discussed in Chapter 3. While there is evidence that student learning influences parent attitudes, it is useful to remember that for most students in this study, any past familial experience with NaDEET was most likely to be had by a sibling. It is entirely possible for a child to know that his or her sibling had been to NaDEET in the past and not be aware of any specifics. This seemed to be true when siblings of past NaDEET participants were interviewed in Stampriet, described in Chapter 3. It is also possible that significant differences do exist and that the questions and measures used on the surveys were insufficient for revealing them.

The impact that NaDEET has on students' general environmental attitudes, as assessed by the NEP, remains unanswered. Preliminary results from the six-month follow-up indicate that students who attended NaDEET do in fact have higher pro-environmental attitudes than they did shortly before arriving at NaDEET. But because immediately after camp, these students demonstrated no change, the mechanism for this is unclear. However, given that the control group shows no changes whatsoever across the three surveys, the gains may be attributed to NaDEET, at least in part.

It is also possible that students' have considerably higher, or lower, pro-environmental attitudes after attending NaDEET and that this instrument was simply inappropriate for detecting the change. While the NEP remains one of the most recommended instruments worldwide, criticisms are presented here for its use in this context with Namibian youth. For instance,

despite the age-appropriate language, some of the questions are unnecessarily nuanced. The prompt, *nature is strong enough to handle the bad effects of our modern lifestyle*, can reasonably be understood as a statement about *respecting* nature. While in the United States we would likely interpret this as a statement about human's plundering of natural resources, in Namibia, particularly in the Hardap where the usage of natural resources is minimal, this would not necessarily be the case. In fact, only 47% respondents disagreed with this statement, and this remained relatively unchanged across all three data points. Additionally, what may be considered a "modern lifestyle" in America (e.g., dependency on fossil fuels, consumerism, etc.), would not necessarily describe a modern lifestyle in the Hardap. The presence of an indoor tap or the ownership of a television may indicate "modern" to respondents with no such amenities.

It is also not true to imply that Namibian youth simply do not understand or are unaware of climate change or other environmental concerns. The majority of the participants in this study live in, or very near to, a desert, and Namibia is currently experiencing the harsh realities of a multi-year drought. When asked to what degree they agree or disagree with the statement *there is a water crisis in Namibia*, 82% of youth participants responded in the affirmative. Less than 5% of students disagreed with this statement at any time over the three surveys. When comparing this clear understanding of an environmental issue to the way students responded to the prompt described in the previous paragraph, it indicates a potential misunderstanding of the intended meaning. It is, therefore, not difficult to point to the ways that this instrument may be inherently biased toward Western culture.

Finally, it should be noted that NaDEET is internationally recognized for its exceptional ESD programming. The findings of this study are not meant to suggest that any ESD provider or program will yield the same results. In fact, NaDEET's approach is quite different from that of

other ESD providers in the country, as previously described. Many organizations offer one-day programs that are narrowly focused on a particular topic (e.g., human-wildlife conflicts between farmers and Namibia's big cats). While these organizations have a meaningful place within the landscape of all ESD opportunities in the country, their philosophy and work differs significantly from NaDEET, which holistically focuses on living a sustainable lifestyle. At NaDEET, students examine root causes of Namibia's environmental issues, and are challenged to think about how poverty exacerbates the issues and how the poor carry the brunt of the negative consequences. This is accomplished by direct, formal lessons in the Centre's classroom as well as in games that simulate the social and climate injustices of poverty. Some skills are explicitly taught (e.g., cooking with solar cookers, monitoring water and electricity usage) while others are taught implicitly through the residential nature of the program. For instance, in the bathrooms, there is no running water at each sink nor in the shower. Students must fill a cup with water at the single indoor tap in the bathroom in order to brush their teeth. For a hot shower, students must first go outside to the hot water tank, which is heated via solar energy, to fill a bucket. NaDEET's unique approach warrants further evaluation in an effort to more widely share its impact, and inspire others to adopt its methods and philosophies, and replicate its successes.

4.6 Specific Contributions

The findings of this study make contributions to the field of Education for Sustainability as well as to multidisciplinary cookstove research. Children are rarely considered stakeholders in cookstove research (Lindgren, 2020), yet this study unequivocally documents that in Namibia, children are already the users of cookstoves. This, by almost any definition in Stakeholder Theory, confirms children's status as stakeholders (Kaler, 2002; Miles, 2017). This study also demonstrates that energy-related education has positive effects on children's beliefs and attitudes

about sustainable energy. Both of these findings, taken together, point to the importance of the inclusion of youth in energy development efforts, particularly those that involve improved cooking technologies.

This study confirms what has been long known to be true about ESD, that it has the potential to transform individuals and communities. The improvement in attitudes and gains in knowledge documented in this study suggests that a change in public opinion, even for long-held beliefs and preferences, is possible. This may have long-term and positive implications for sustainability. If today's youth enter adulthood with a more pro-environmental worldview and an openness to alternative sources of energy, they will be poised to act. This study also highlights and confirms the mediating influence of poverty. Children from the poorest towns, as assessed by primary cooking fuel in the home and the cost per person spent for the experience at NaDEET (or for students in Windhoek, those from the government schools), have the lowest initial scores and responses on the energy and environment attitude questions and inventories. This highlights the importance of this type of education in reaching the populations who have the most to gain from it. This study, though not a comprehensive evaluation of NaDEET's impact, does point to the efficacy of NaDEET's approach, and will surely be of interest to ESD researchers and providers.

4.7 Limitations

The long-distance nature of much of this study adds to the limitations that exist by virtue of the methods employed. The reliance on a courier system to deliver surveys across the vast Namibian landscape was both more successful than, and as flawed as, expected. A number of schools did not receive the surveys in the intended time frame, or at all, which made acquiring three sets of data points from each student impossible. In addition to the schools mentioned in this study, an

additional private school from Windhoek, attended the NaDEET Centre. This school did not receive the surveys that were sent to them. And due to miscommunication and a staffing change, this was not discovered until it was too late to meaningfully include them in this study.

The environmental attitude instrument used in this survey was not found to be particularly useful. The NEP is one of the most well-used instruments in North American and European contexts, and while it has been used in non-Western contexts, the version with child appropriate language has had little use outside of the United States. Its appropriateness in its ability to communicate its intended meaning to Namibian youth is questioned. An instrument developed in a rural, southern African context, or even questions specifically designed for this study, may have allowed for more straightforward understanding, and therefore clearer results.

Further, on the third administration of this survey, there was an observed increase in scores on the NEP for students who had attended NaDEET, despite no immediate post-camp gain. Whether this effect is due to NaDEET's influence or some other on-going support or factor, it is unknown. The addition of more qualitative methods may have provided an explanation for this finding, and for others that are difficult to explain. For instance, after a significant increase in concern about plastic and rubbish in the environment as measured in the post-camp assessment, a large decrease in this same sentiment is noted in the six-month follow-up surveys. Without additional context, it is not possible to posit an explanation for this change (or for other findings such as students from households with past NaDEET experience not exhibiting higher initial scores on attitudinal scales). Qualitative methods may have helped uncover whether this change is because students learned behaviors at NaDEET that address recycling, composting, and other waste management issues and now feel empowered to act on this problem, or if they suddenly care less about this issue. The latter seems unlikely given the other documented gains

in positive attitudes, but without context cannot be known with certainty. As more six-month follow-up surveys are returned, a deeper analysis will be undertaken.

The scale of this study posed some additional challenges. By including each child who attended NaDEET Centre as an invited participant in this research study, context that could have potentially been provided by working closely with a smaller population was sacrificed. At the time of data collection, it was not possible to engage individual students in interviews, formal or informal, to ask clarifying questions or to probe their understanding. While a few open-ended responses were included in the survey, they addressed questions that were outside the scope of the research questions posed here. This is mentioned because it is assumed that these responses may provide additional context, some of which is lost when using questionnaires with pre-determined answer choices. These responses will be analyzed and published in future publications.

CHAPTER 5

Conclusion

The United Nations' Sustainable Development Goals (SDGs) explicitly mention youth as "critical agents of change" for their potential to act on a large scale and because they will be most impacted by a failure to realize the goals (United Nations, 2015a). The findings of the studies described in this dissertation indicate that placing hope in children, or at least in youth-oriented Education for Sustainable Development, is not misguided and has the potential to shift attitudes, generationally and at the community level. This chapter is devoted to examining the ways in which the findings from each study reinforce each other and support the use of Education for Sustainable Development as an effective communication tool in energy development work.

5.1 Summary and Interpretation of Findings

The work presented in this document, and carried out in Namibia in 2019, is motivated by historically low rates of sustained use of improved cooking devices and by the findings that youth are rarely purposefully engaged in cookstove dissemination programs. The research described within this document answers the call for more research in youth and international development work (von Braun, 2017) and seeks to broaden our understanding of how energy attitudes and behaviors are learned, and changed, within the home.

The community-based survey conducted in Stampriet and Gibeon, two rural towns in the Hardap, provide compelling evidence for the impact that youth-centric Education for Sustainable Development can have on individuals, households, and communities. Stampriet has sent at least one primary school group to NaDEET Centre for nine of the last ten years. Approximately a

third of the households sampled in Stampriet reported at least one family member who had attended a program at NaDEET in the past. These households were found to have significantly more positive attitudes regarding solar energy and solar cookers, and preferences for solar and other modern fuels. These preferences were more pronounced for families who primarily cooked with firewood, suggesting that fuel choice is a function of socioeconomic status.

By evaluating all cookstoves in the home using the same measure, it was found that in Stampriet, families who primarily cooked with firewood and also had NaDEET experience "adopted" their traditional cookstove less than other similar households in Stampriet without NaDEET experience. In fact, these NaDEET families were more similar in their preferences and attitudes to Gibeon, the slightly wealthier and more educated control town, where cooking with firewood is less common.

Households that had a family member who had attended NaDEET programming in the past were not similar in terms of socioeconomic status, education, location within the town, nor the type of dwelling that they lived in, suggesting that NaDEET experience is the common denominator. The majority (77%) of household NaDEET experience was had by children. In the absence of a variable that was not uncovered during the ten days spent in each community, these findings suggest that NaDEET's programming has a direct impact on its participants, and an indirect impact on the participants' households and communities.

This idea is further supported by the finding that households in Stampriet with children, but without NaDEET experience, were considerably more traditional in terms of their preferences for cooking energy, and attitudes toward electricity and other cleaner fuels. This suggests that children who attend NaDEET Centre are exerting some influence in the home over energy attitudes and behaviors.

To confirm that students' experiences and education from NaDEET were responsible for the measurable differences across Stampriet and between Gibeon, it was necessary to examine how students' knowledge and perceptions of energy- and environment-related topics change as a result of participation at NaDEET. As such, a study of nearly 1000 Namibian children was conducted. Of these students, approximately 600 attended a weeklong program at NaDEET Centre as part of a school group. The remaining participants were from the same schools as the NaDEET participants, one grade younger ensuring that they had not yet had the opportunity to experience NaDEET's programming themselves.

If it is true that youth education is advancing sustainable energy in terms of attitudes and behaviors, then it was expected that significant changes would be measured by comparing pre- and post-camp surveys. And indeed, these changes were detected. After a week's experience at NaDEET, students demonstrated significantly more positive attitudes regarding energy sources in the home, particularly for cooking. Preliminary results from the subset of students who have already returned their six-month follow-up surveys indicate that these gains hold. The control group exhibited no changes on the same measures across the three data points.

It can reasonably be suggested then that NaDEET, through its youth participants, has a positive impact on communities. And while this has implications for supporting development work committed to the realization of the SDGs, the findings described here may be particularly interesting to the cookstove research community. Differences in the adoption rates of traditional and electric cookstoves, particularly between houses with and without NaDEET experiences, appear to have occurred organically in the absence of a specific cookstove implementation program. Without advancing a particular improved cooking device or brand, NaDEET's ESD programming changed participants' opinions about improved and sustainable household energy.

While youth participants exhibited positive gains in attitudes and knowledge after just one week, it is not known how quickly these beliefs are transmitted through the household or broader community, though it is clear from the evidence presented in Chapter 3 that both do occur. It is accepted that children learn from their parents and elders. However, this study did not uncover evidence this translates to energy attitudes. Students from households with prior NaDEET experience, or from communities with a history of participation in NaDEET's programs, did not score higher than other students on initial inventories or individual attitude-type questions. This is significant for two reasons. First, that youth education can have a positive impact on household is not a new idea. However, little research has been done on the role that this education has in shaping families' energy beliefs and consumption patterns. At the time of writing, there is just one other study that examines this type of relationship. A study conducted in the Bay Area of California found that energy-focused education for Girl Scouts positively impacted parents' energy-saving behaviors. No similar study has been conducted in a resource-limited setting. Secondly, it is often assumed that environmental attitudes, of which energy is a part, is fixed by young adulthood. Yet the data from Stampriet and Gibeon suggest otherwise.

Central to both of the studies presented in this dissertation is the idea that children are energy stakeholders in the home and should be included in energy development work, including cookstove programs. To be clear, this should not be interpreted as a recommendation for engineers, innovators, development actors, or entrepreneurs to directly communicate about their product or service to children. Rather, this is a challenge, one that has been stated by others before, to do this work in multidisciplinary teams that are genuine collaborations with local organizations and individuals. While education and communication are central to the uptake and

sustained use of any new technology, this is best delivered by local educational partners to ensure that the message is contextually and age appropriate, as well as effective.

5.2 Future Research

These studies were just a small step toward understanding the role of youth in the advancement of sustainable energy. There is much more to be learned within the context of energy, and within the larger field of sustainable development. Further, new questions arise as a result of this research that can motivate several distinct, but related lines of inquiry in the fields of multidisciplinary cookstove research, Education for Sustainable Development, and Engineering Education. Each is discussed briefly.

Cookstove Research

The findings of these studies affirm the benefits of a multidisciplinary approach to cookstove implementation programs. Specifically, NaDEET was able to have an impact on energy attitudes at the community level in the absence of a specific cookstove study, indicating that youth education is an effective tool for communicating and affecting change. A logical next step would be to conduct a cookstove implementation program in collaboration with an organization such as NaDEET to ascertain the feasibility and efficacy of using ESD as an intentional piece of a behavior change communication framework.

This dissertation made use of the Adoption Index (Troncoso, 2013; Troncoso et al., 2013) to better understand participants commitment to both their traditional cookstove and any improved or other cooking device in the home. It may be possible that by treating all cooking devices equally, and by applying the same metrics to each, that we may better understand a new technology's potential to be taken up by a recipient community. That said, there are a number of

current issues with, and limitations of, the Adoption Index, and this idea needs further consideration. First and foremost, the metrics used to report the successes of cookstove implementation program varies widely with few areas of overlap (Jürisoo et al., 2018; Lindgren, 2020). The Adoption Index, commissioned by the Clean Cooking Alliance, is a step to address this issue. However, since its publication in 2013, few studies use or report this index. Further, there are issues with the index itself as a meaningful measure. As the cookstove community moves away from definitions and expectations of *exclusive use* toward *cleaner stacks* (Medina et al., 2019), this index, while a necessary first step, does not adequately encompass the nuanced ways that energy sources are prioritized within the home. Future research in this direction, including some guidance on universal metric reporting, particularly those that incorporate temporal and seasonal changes to cookstove stacking, would advance the field in terms of being able to distill and share best practices from a collection of disparate studies.

Education for Sustainable Development

The findings of NaDEET's impact inspires questions such as,

1. *If changes in adoption can occur without intentional, targeted messaging, as has been demonstrated in Stampriet due to youth-based ESD programming from NaDEET, would ESD improve initial uptake and sustained usage rates if it were part of an intentional behavior change communication framework*?
2. *If NaDEET's programming was used as part of a behavior change communication framework for a particular cooking technology, such as an improved cookstove or solar cooker, would uptake and sustained usage rates improve as compared to participants without exposure to this programming?*

3. *How would these uptake rates change if dyads of mothers and their children participated in NaDEET's programming together*?

These potential topics of future research are situated at the nexus of ESD and cookstove research, and a range of activities from community impact and evaluation studies, to the utility, efficacy, and appropriateness of ESD as a form of communication in development work, can be undertaken. Much needs to be learned about the development of relationships and partnerships between ESD providers, other educational organizations, and development actors, to support the inclusion of youth in energy development efforts.

NaDEET's holistic and authentic commitment to sustainability deserves additional attention. For instance, would the results presented in Chapter 3 occur if the youth-oriented ESD had been provided by an ESD organization other than NaDEET? The efficacy of NaDEET's approach is a ripe area for future research, not only to understand why NaDEET enjoys success where other institutions do not, but also in terms of the implications for scaling and the potential to reach broader audiences through replication, and the publication of case studies and evaluation results.

Engineering Education

The studies described in this dissertation are situated in cookstove implementation, after a stove has been designed and distributed. While subtle, the findings discussed in this dissertation have implications for the field of Engineering Education.

Innovation drives sustainable development. Products and services implemented in low- and middle-income countries are often designed in North America and in Europe by academics

and practitioners who share no common bond nor experience with their target market. The solutions are often technically sound, but can result in technologies that are ethnocentric and sexist. While ESD can be used to advance sustainability and innovation, how engineers come to develop their ideas, especially for communities that are not their own, must also be addressed. The studies conducted in Namibia highlight questions about how engineers learn to design solutions for communities that are not their own. This work supports the nascent study of contextual engineering (Witmer, 2018) and points once again to the importance of multidisciplinary international teams that are inclusive of local actors. Local and indigenous knowledge must be valued equal to the importance of the technology itself.

Two lines of questioning, central to cookstove and energy development work, can be pursued. First, *how can context be more authentically included to support engineers' professional development such that their designs are appropriate?* Relatedly, *how do engineers learn to design for multiple stakeholders?* And secondly, the ways in which engineers communicate about their designs is an important aspect of professional engineering, and should be a component of contemporary engineering education, especially if we expect engineers to be able to effectively communicate to, and design for, a diverse set of stakeholders which may include youth.

Improved cooking will likely continue to be a focus of the development community, and for good reason. With a presence in multiple Sustainable Development Goals, improved cooking has the potential to improve personal health and economy, and contribute to better earth stewardship. However, these benefits will only be realized if improved cooking technologies are acquired and used for the long-term. Broadening participation in these efforts, including local ESD providers,

multidisciplinary research teams, and an expanded definition of *stakeholder*, may inspire new avenues of research that advance both sustainable residential energy as well as our understanding of effective means of communicating to cookstove users.

References

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*, *25*(3), 273–291.

Adeola, F. O. (1996). Environmental contamination, public hygiene, and human health concerns in the Third World: The case of Nigerian environmentalism. *Environment and Behavior*. https://doi.org/10.1177/001391659602800503

Adkins, E., Tyler, E., Wang, J., Siriri, D., & Modi, V. (2010). Field testing and survey evaluation of household biomass cookstoves in rural sub-Saharan Africa. *Energy for Sustainable Development*, *14*(3), 172–185. https://doi.org/10.1016/j.esd.2010.07.003

Agarwal, B. (1983). Diffusion of rural innovations: Some analytical issues and the case of wood-burning stoves. *World Development*, *11*(4), 359–376. https://doi.org/10.1016/0305-750X(83)90047-5

Aipanjiguly, S., Jacobson, S. K., & Flamm, R. (2003). Conserving Manatees: Knowledge, Attitudes, and Intentions of Boaters in Tampa Bay, Florida. *Conservation Biology*. https://doi.org/10.1046/j.1523-1739.2003.01452.x

Ajiboye, J. O., & Silo, N. (2008). Enhancing Botswana Children ' s Environmental Knowledge , Attitudes and Practices through the School Civic Clubs. *International Journal of Environmental & Science Education*.

Alexander, D., Linnes, J. C., Bolton, S., & Larson, T. (2013). Ventilated cookstoves associated with improvements in respiratory health-related quality of life in rural Bolivia. *Journal of Public Health*, *36*(3), 460–466. https://academic.oup.com/jpubhealth/article-abstract/36/3/460/1520058

Alonso, M., Jahnke, K., Zhou, C., & Elliott-Litchfield, J. B. (2017). Performance Testing of a Portable Stored Solar Thermal Energy Cooking System: Household Energy Without Fuel, Fire, or Emissions. *6th Solar Cookers International World Conference*.

Arbuckle, J. G., Prokopy, L. S., Haigh, T., Hobbs, J., Knoot, T., Knutson, C., Loy, A., Mase, A. S., McGuire, J., Morton, L. W., Tyndall, J., & Widhalm, M. (2013). Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States. *Climatic Change*. https://doi.org/10.1007/s10584-013-0707-6

Arcury, T. A., & Christianson, E. H. (1990). Environmental worldview in response to environmental problems: Kentucky 1984 and 1988 Compared. *Environment and Behavior*. https://doi.org/10.1177/0013916590223004

Arnold, J., Köhlin, G., & Persson, R. (2006). Woodfuels, livelihoods, and policy interventions: changing perspectives. *World Development*, *34*(3), 596–611. https://www.sciencedirect.com/science/article/pii/S0305750X05002263

Arnold, M., Köhlin, G., Persson, R., & Shepherd, G. (2003). *CIFOR Occasional Paper No. 39 Fuelwood Revisited: What Has Changed in the Last Decade?* www.cifor.cgiar.org/publications/papers

Ashraf, N. (2009). Spousal control and intra-household decision making: An experimental study in the Philippines. *American Economic Review*. https://doi.org/10.1257/aer.99.4.1245

Aung, T. W., Jain, G., Sethuraman, K., Baumgartner, J., Reynolds, C., Grieshop, A. P., Marshall, J. D., & Brauer, M. (2016). Health and Climate-Relevant Pollutant Concentrations from a Carbon-Finance Approved Cookstove Intervention in Rural India. *Environmental Science and Technology*, *50*(13), 7228–7238. https://doi.org/10.1021/acs.est.5b06208

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change.

Psychological Review. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, A. (1986). Social Foundations of Thought and Action: A Social Cognitive Theory. In *The National Institute of Mental Health*. https://doi.org/10.4135/9781446221129.n6

Bandura, A. (1994). *Social Cognitive Theory and Exercise of Control over HIV Infection*. https://doi.org/10.1007/978-1-4899-1193-3_3

Barnes, B. R. (2014). Behavioural change, indoor air pollution and child respiratory health in developing countries: A review. *International Journal of Environmental Research and Public Health*, *11*(5), 4607–4618. https://doi.org/10.3390/ijerph110504607

Barnes, B., Rosenbaum, J., Mehta, S., Williams, K. N., Jagoe, K., & Graham, J. (2015). Behavior Change Communication: A Key Ingredient for Advancing Clean Cooking. *Journal of Health Communication*, *20*(sup1), 3–5. https://doi.org/10.1080/10810730.2014.996305

Barnes, D. F., Openshaw, K., Smith, K. R., & Van der Plas, R. (1994). What makes people cook with improved biomass stoves. In *World Bank Technical Paper*. https://doi.org/10.1016/0165-0572(87)90003-X

Battro, A. M., Lena, P., Sorondo, M. S., & von Braun, J. (Eds.). (2017). *Children and Sustainable Development: Ecological Education in a Globalized World*. Springer International Publishing AG.

Bauer, A., Hasan, R., Magsombol, R., & Wan, G. (2008). *The World Bank's New Poverty Data: Implications for the Asian Development Bank*.

Baumeister, R. F., & Newman, L. S. (1994). How Stories Make Sense of Personal Experiences: Motives that Shape Autobiographical Narratives. *Personality and Social Psychology Bulletin*. https://doi.org/10.1177/0146167294206006

Bautista, L. E., Correa, A., Baumgartner, J., Breysse, P., & Matanoski, G. M. (2009). Indoor

charcoal smoke and acute respiratory infections in young children in the Dominican Republic. *American Journal of Epidemiology*, *169*(5), 572–580. https://academic.oup.com/aje/article-abstract/169/5/572/142643

Bazilian, M., Cordes, L., Nussbaumer, P., & Yager, A. (2011). Partnerships for access to modern cooking fuels and technologies. *Current Opinion in Environmental Sustainability*, *3*(4), 254–259. https://doi.org/10.1016/J.COSUST.2011.05.004

BBC Media Action. (2013). *Climate Asia methodology series. Regional segment profiles*.

Beatty, S. E., & Talpade, S. (1994). Adolescent Influence in Family Decision Making: A Replication with Extension. *Journal of Consumer Research*. https://doi.org/10.1086/209401

Bechtel, R. B., Verdugo, V. C., & De Queiroz Pinheiro, J. (1999). Environmental belief systems United States, Brazil, and Mexico. *Journal of Cross-Cultural Psychology*. https://doi.org/10.1177/0022022199030001008

Belch, G. E., Belch, M. A., & Ceresino, G. (1985). Parental and teenage child influences in family decision making. *Journal of Business Research*. https://doi.org/10.1016/0148-2963(85)90038-4

Beltramo, T., Blalock, G., Levine, D. I., & Simons, A. M. (2015). Does peer use influence adoption of efficient cookstoves? Evidence from a randomized controlled trial in uganda. *Journal of Health Communication*, *20*(S1), 55–66. https://doi.org/10.1080/10810730.2014.994244

Beltramo, T., & Levine, D. I. (2013). The effect of solar ovens on fuel use, emissions and health: Results from a randomised controlled trial. *Journal of Development Effectiveness*, *5*(2), 178–207. https://doi.org/10.1080/19439342.2013.775177

Betsch, T., Haberstroh, S., Glöckner, A., Haar, T., & Fiedler, K. (2001). The Effects of Routine

Strength on Adaptation and Information Search in Recurrent Decision Making. *Organizational Behavior and Human Decision Processes*. https://doi.org/10.1006/obhd.2000.2916

Bhojvaid, V., Jeuland, M., Kar, A., Lewis, J. J., Pattanayak, S. K., Ramanathan, N., Ramanathan, V., & Rehman, I. H. (2014). How do People in Rural India Perceive Improved Stoves and Clean Fuel? Evidence from Uttar Pradesh and Uttarakhand. *Int. J. Environ. Res. Public Health*, *11*(2), 1341–1358. https://doi.org/10.3390/ijerph110201341

Bielecki, C., & Wingenbach, G. (2014). Rethinking improved cookstove diffusion programs: A case study of social perceptions and cooking choices in rural Guatemala. *Energy Policy*, *66*, 350–358. https://doi.org/10.1016/j.enpol.2013.10.082

Biran, A., Schmidt, W., Varadharajan, K., Rajaraman, D., Kumar, R., Greenland, K., Gopalan, B., Aunger, R., & Curtis, V. (2014). Biran, Adam, et al. "Effect of a behaviour-change intervention on handwashing with soap in India (SuperAmma): a cluster-randomised trial. *The Lancet Global Health*, *2*(3), 145–154.

Birol, F. (2006). World Energy Prospects and Challenges. *The Australian Economic Review*, *39*(2), 190–195. https://doi.org/10.1111/j.1467-8462.2006.00411.x

Bond, T. C., Doherty, S. J., Fahey, D. W., Forster, P. M., Berntsen, T., Deangelo, B. J., Flanner, M. G., Ghan, S., Kärcher, B., Koch, D., Kinne, S., Kondo, Y., Quinn, P. K., Sarofim, M. C., Schultz, M. G., Schulz, M., Venkataraman, C., Zhang, H., Zhang, S., … Zender, C. S. (2013). Bounding the role of black carbon in the climate system: A scientific assessment. *Journal of Geophysical Research Atmospheres*, *118*(11), 5380–5552. https://doi.org/10.1002/jgrd.50171

Bonjour, S., Adair-Rohani, H., … J. W.-E. health, 2013, U., Wolf, J., Bruce, N. G., Mehta, S.,

Prüss-Ustün, A., Lahiff, M., Rehfuess, E. A., Mishra, V., & Smith, K. R. (2013). Solid fuel use for household cooking: country and regional estimates for 1980–2010. *Environmental Health Perspectives*, *121*(7). https://doi.org/10.1289/ehp.1205987

Boudet, H., Ardoin, N. M., Flora, J., Armel, K. C., Desai, M., & Robinson, T. (2016). Effects of a behaviour change intervention for Girl Scouts on child and parent energy-saving behaviours. *Nature Energy*, *1*(8), 1–10. https://doi.org/10.1038/nenergy.2016.91

Bradley, J. C., Waliczek, T. M., & Zajicek, J. M. (1999). Relationship between environmental knowledge and environmental attitude of high school students. *Journal of Environmental Education*. https://doi.org/10.1080/00958969909601873

Bricker, J. B., Liu, J., Comstock, B. A., Peterson, A. V., Kealey, K. A., & Marek, P. M. (2010). Social Cognitive Mediators of Adolescent Smoking Cessation: Results From a Large Randomized Intervention Trial. *Psychology of Addictive Behaviors*. https://doi.org/10.1037/a0019800

Broom, C. (2017). Exploring the Relations between Childhood Experiences in Nature and Young Adults' Environmental Attitudes and Behaviours. *Australian Journal of Environmental Education*. https://doi.org/10.1017/aee.2017.1

Brown, L. D., & Ashman, D. (1996). Participation, social capital, and intersectoral problem solving: African and Asian cases. *World Development*. https://doi.org/10.1016/0305-750X(96)00053-8

Bruce, N., Pope, D., Rehfuess, E., Balakrishnan, K., Adair-Rohani, H., & Dora, C. (2015). WHO indoor air quality guidelines on household fuel combustion: Strategy implications of new evidence on interventions and exposure–risk functions. *Atmospheric Environment*, *106*, 451–457. https://doi.org/10.1016/J.ATMOSENV.2014.08.064

Bryant, C. K., & Hungerford, H. R. (1977). An Analysis of Strategies for Teaching Environmental Concepts and Values Clarification in Kindergarten. *The Journal of Environmental Education*, *9*(1), 44–49. https://doi.org/10.1080/00958964.1977.9942015

Burwen, J., & Levine, D. (2012). A rapid assessment randomized-controlled trial of improved cookstoves in rural Ghana. *Energy for Sustainable Development*, *16*(3), 328–338. https://doi.org/10.1016/j.esd.2012.04.001

Caldwell, L. (1976). Energy and the structure of social institutions. *Human Ecology*, *4*(1), 31–45.

Carmody, E., & Sarkar, A. (1997). Solar box cookers: towards a decentralized sustainable energy strategy for sub-Saharan Africa. *Renewable and Sustainable Energy Reviews*, *1*(4), 291–301.

CBD 2016 Fisk Factors Collaborators. (2017). Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-206: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*, *390*(10010), 1345–1422.

Cecelski, E. (2000). The role of women in sustainable energy development. *National Renewable Energy Laboratory (NREL)*, *June*, 1–37. https://doi.org/10.2172/758755

Chatti, D., Archer, M., Lennon, M., & Dove, M. (2017). Exploring the mundane: towards an ethnographic approach to bioenergy. *Energy Research & Social Science*, *30*, 28–34.

Chryst, B., Marlon, J., van der Linden, S., Leiserowitz, A., Maibach, E., & Roser-Renouf, C. (2018). Global Warming's "Six Americas Short Survey": Audience Segmentation of Climate Change Views Using a Four Question Instrument. *Environmental Communication*. https://doi.org/10.1080/17524032.2018.1508047

Cialdini, R., & Goldstein, N. (2004). Social influence: Compliance and conformity. *Annual*

Review of Psychology, *55*, 591–621.

City of Windhoek. (n.d.). *The History of Windhoek*.

Clancy, J., Winther, T., Matinga, M., & Oparaocha, S. (2012). Gender Equity in Access to and Benefits from Modern Energy and Improved Energy Technologies: World Development Report. *Gender and Energy WDR Background Paper*, 44.

Clark, M. L., Heiderscheidt, J. M., & Peel, J. L. (2015). Integrating behavior change theory and measures into health-based cookstove interventions: A proposed epidemiologic research agenda. *Journal of Health Communication*, *20*(S1), 94–97. https://doi.org/10.1080/10810730.2014.989346

Clark, M. L., Peel, J. L., Burch, J. B., Nelson, T. L., Robinson, M. M., Conway, S., Bachand, A. M., & Reynolds, S. J. (2009). Impact of improved cookstoves on indoor air pollution and adverse health effects among Honduran women. *International Journal of Environmental Health Research*, *19*(5), 357–368. https://doi.org/10.1080/09603120902842705

Cohen J. (1988). Statistical Power Analysis for the Behavioural Science (2nd Edition). In *Statistical Power Anaylsis for the Behavioral Sciences*.

Conley, T. G., & Udry, C. R. (2010). Learning about a new technology: Pineapple in Ghana. *American Economic Review*. https://doi.org/10.1257/aer.100.1.35

Cooper, I. D., & Johnson, T. P. (2016). How to use survey results. In *Journal of the Medical Library Association*. https://doi.org/10.3163/1536-5050.104.2.016

Cordes, L. (2011). Igniting change: a strategy for universal adoption of clean cookstoves and fuels. In *Global Alliance for Clean Cookstoves*. http://cleancookstoves.org/binary-data/RESOURCE/file/000/000/272-1.pdf

Cornelius, M., Armel, K. C., Hoffman, K., Allen, L., Bryson, S. W., Desai, M., & Robinson, T.

N. (2014). Increasing energy- and greenhouse gas-saving behaviors among adolescents: A school-based cluster-randomized controlled trial. *Energy Efficiency*, *7*(2), 217–242. https://doi.org/10.1007/s12053-013-9219-5

Corner, A., & Randall, A. (2011). Selling climate change? The limitations of social marketing as a strategy for climate change public engagement. *Global Environmental Change*. https://doi.org/10.1016/j.gloenvcha.2011.05.002

Correa, T. (2016). Acquiring a New Technology at Home: A Parent-Child Study About Youths' Influence on Digital Media Adoption in a Family. *Journal of Broadcasting and Electronic Media*, *60*(1), 123–139. https://doi.org/10.1080/08838151.2015.1127238

Correa, T., Straubhaar, J. D., Chen, W., & Spence, J. (2015). Brokering new technologies: The role of children in their parents' usage of the internet. *New Media and Society*, *17*(4), 483–500. https://doi.org/10.1177/1461444813506975

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*. https://doi.org/10.1007/BF02310555

Cundale, K., Thomas, R., Malava, J., Havens, D., Mortimer, K., & Conteh, L. (2017). A health intervention or a kitchen appliance? Household costs and benefits of a cleaner burning biomass-fuelled cookstove in Malawi. *Social Science and Medicine*, *183*, 1–10. https://www.sciencedirect.com/science/article/pii/S027795361730240X

D'Agostino, A., Sovacool, B., Trott, K., ERamos, C., Saleem, S., & Ong, Y. (2011). What's the state of energy studies research?: A content analysis of three leading journals from 1999 to 2008. *Energy*, *36*(1), 508-519.

Damerell, P., Howe, C., & Milner-Gulland, E. J. (2013). Child-orientated environmental education influences adult knowledge and household behaviour. *Environmental Research*

Letters, *8*(1). https://doi.org/10.1088/1748-9326/8/1/015016

Davis, J. (2009). Revealing the research 'hole' of early childhood education for sustainability: a preliminary survey of the literature. *Environmental Education Research*. https://doi.org/10.1080/13504620802710607

Ditto, P. H., & Lopez, D. F. (1992). Motivated skepticism: Use of differential decision criteria for preferred and nonpreferred conclusions. *Journal of Personality and Social Psychology*. https://doi.org/10.1037//0022-3514.63.4.568

Ditto, P. H., Munro, G. D., Apanovitch, A. M., Scepansky, J. A., & Lockhart, L. K. (2003). Spontaneous skepticism: The interplay of motivation and expectation in responses to favorable and unfavorable medical diagnoses. *Personality and Social Psychology Bulletin*. https://doi.org/10.1177/0146167203254536

Duflo, E., & Udry, C. (2003). Intrahousehold resource allocation in Cote d. Ivoire: Social norms, separate accounts and consumption choices'. *Yale University Economic Growth Center Discussion Paper*, 31.

Dugard, P., & Todman, J. (1995). Analysis of Pre-test-Post-test Control Group Designs in Educational Research. *Educational Psychology*. https://doi.org/10.1080/0144341950150207

Dunlap, R., Van Liere, K., Mertig, A., & Jones, R. (2000). New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale. *Journal of Social Issues*, *56*(3), 425–442.

Dutcher, D. D., Finley, J. C., Luloff, A. E., & Johnson, J. B. (2007). Connectivity with nature as a measure of environmental values. *Environment and Behavior*. https://doi.org/10.1177/0013916506298794

Duvall, J., & Zint, M. (2007). A review of research on the effectiveness of environmental

education in promoting Lntergenerational learning. *Journal of Environmental Education*. https://doi.org/10.3200/JOEE.38.4.14-24

Eccles, J. S., & Roeser, R. W. (2011). Schools as developmental contexts during adolescence. *Journal of Research on Adolescence*. https://doi.org/10.1111/j.1532-7795.2010.00725.x

Eckholm, E. (1975). The other energy crisis: firewood. In *Worldwatch paper 1*.

Edelstein, M., Pitchforth, E., Asres, G., Silverman, M., & Kulkarni, N. (2008). Awareness of health effects of cooking smoke among women in the Gondar Region of Ethiopia: A pilot survey. *BMC International Health and Human Rights*, *8*(1), 10. https://doi.org/10.1186/1472-698X-8-10

Evans, W., Johnson, M., Jagoe, K., Charron, D., Young, B., Rahman, A., & Ipe, J. (2018). Evaluation of Behavior Change Communication Campaigns to Promote Modern Cookstove Purchase and Use in Lower Middle Income Countries. *International Journal of Environmental Research and Public Health*, *15*(1), 11.

Ezzati, M., Bailis, R., Kammen, D. M., Holloway, T., Price, L., Cifuentes, L. A., Barnes, B., Chaurey, A., & Dhanapala, K. N. (2004). Energy Management and Global Health. *Annual Review of Environment and Resources*, *29*(1), 383–419. https://doi.org/10.1146/annurev.energy.29.062103.121246

Ferrant, G., Pesando, L., & Nowacka, K. (2014). *Unpaid Care Work: The missing link in the analysis of gender gaps in labour outcomes*.

Fisher, J. D., & Fisher, W. A. (1992). Changing AIDS-risk behavior. *Psychological Bulletin*. https://doi.org/10.1037/0033-2909.111.3.455

Flora, J. A., Saphir, M., Lappé, M., Roser-Renouf, C., Maibach, E. W., & Leiserowitz, A. A. (2014). Evaluation of a national high school entertainment education program: The Alliance

for Climate Education. *Climatic Change*. https://doi.org/10.1007/s10584-014-1274-1

Forouzanfar, M., Afshin, A., Alexander, L., Alexander, H., & ... Cohen, A. (2016). Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet*, *388*(10043), 1659–1724.

Foxman, E. R., Tansuhaj, P. S., & Ekstrom, K. M. (1989). Family Members' Perceptions of Adolescents' Influence in Family Decision Making. *Journal of Consumer Research*. https://doi.org/10.1086/209187

Frick, J., Kaiser, F. G., & Wilson, M. (2004). Environmental knowledge and conservation behavior: Exploring prevalence and structure in a representative sample. *Personality and Individual Differences*. https://doi.org/10.1016/j.paid.2004.02.015

García-Frapolli, E., Schilmann, A., Berrueta, V. M., Riojas-Rodríguez, H., Edwards, R. D., Johnson, M., Guevara-Sanginés, A., Armendariz, C., & Masera, O. (2010). Beyond fuelwood savings: Valuing the economic benefits of introducing improved biomass cookstoves in the Purépecha region of Mexico. *Ecological Economics*, *69*(12), 2598–2605. https://doi.org/10.1016/j.ecolecon.2010.08.004

Gebreegziabher, Z., van Kooten, G. C., & van Soest, D. P. (2017). Technological innovation and dispersion: Environmental benefits and the adoption of improved biomass cookstoves in Tigrai, northern Ethiopia. *Energy Economics*, *67*, 337–345. https://doi.org/10.1016/j.eneco.2017.08.030

Geiger, S., Dombois, C., & Funke, J. (2018). The role of environmental knowledge and attitude: Predictors for ecological behavior across cultures: An analysis of Argentinean and German students. *Umweltpsychologie*, *22*, 69–87.

Geiger, S. M., Geiger, M., & Wilhelm, O. (2019). Environment-specific vs. general knowledge and their role in pro-environmental behavior. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2019.00718

Geiger, S., Otto, S., & Diaz-Marin, J. (2014). A diagnostic Environmental Knowledge Scale for Latin America. *Psyecology*, *5*(1), 1–36.

Geller, E. (1983). The energy crisis and behavioral science: A conceptual framework for large scale intervention. In A. Childs & G. Melton (Eds.), *Rural Psychology*. Plenum Press.

Gill, J. (1987). Improved stoves in developing countries. A critique. *Energy Policy*. https://doi.org/10.1016/0301-4215(87)90121-2

Gladhart, P., & Roosa, M. (1982). Family Lifestyle and Energy Consumption: An Energy Adaption Model. *Journal of Consumer Studies & Home Economics*, *6*(3), 205–222. https://doi.org/10.1111/j.1470-6431.1982.tb00600.x

Glaser, B. G., & Strauss, A. L. (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research. In *Observations* (Vol. 1, Issue 4). https://doi.org/10.2307/2575405

Global Alliance for Clean Cookstoves. (2010). *Statistical Snapshot: Access to Improved Cookstoves and Fuels and its Impact on Women's Safety in Crises* (Issue May 2010). http://cleancookstoves.org/binary-data/RESOURCE/file/000/000/353-1.pdf

Global Alliance for Clean Cookstoves. (2017). *Country Profile: Namibia*. http://cleancookstoves.org/country-profiles/29-namibia.html

Goodwin, N. J., O'Farrell, S. E., Jagoe, K., Rouse, J., Roma, E., Biran, A., & Finkelstein, E. A. (2015). Use of behavior change techniques in clean cooking interventions: A review of the evidence and scorecard of effectiveness. *Journal of Health Communication*, *20*(S1), 43–54. https://doi.org/10.1080/10810730.2014.1002958

Gordon, J. K., Emmel, N. D., Manaseki, S., & Chambers, J. (2007). Perceptions of the health effects of stoves in Mongolia. *Journal of Health, Organisation and Management*, *21*(6), 580–587. https://doi.org/10.1108/14777260710834364

Government of the Republic of Namibia. (2017). *Government of the Republic of Namibia Ministry of Mines and Energy National Energy Policy Implementation Plan* (Issue January).

Green, M. (2001). Solar Cookers as a Mechanism for Women's Empowerment. *ISES World Solar Congress*.

Grundy, R. R., & Grundy, W. N. (1994). Diffusion of innovation: Solar oven use in Lesotho (Africa). *2nd International Conference on Solar Cooker Use and Technology*, 12–15.

Habermehl, H. (2008). Costs and benefits of efficient institutional cook stoves in Malawi. In *Eschborn*.

Hanna, R., Duflo, E., & Greenstone, M. (2016). Up in Smoke: The Influence of Household Behavior on the Long-Run Impact of Improved Cooking Stoves. *American Economic Journal: Economic Policy*, *8*(1), 80–114. https://doi.org/10.1257/pol.20140008

Hardap Regional Council. (n.d.). *About Us*. http://www.hardaprc.gov.na/about-us

Hart, C., & Smith, G. (2013). *Scaling adoption of clean cooking solutions through women's empowerment: A resource guide*.

Hazra, S., Lewis, J.J., Das, I., & Singha, A. (2014). *Adoption and use of improved stoves and biogas plants in rural India*.

Heider, F. (1944). Social perception and phenomenal causality. *Psychological Review*. https://doi.org/10.1037/h0055425

Heider, Fritz. (1946). Attitudes and Cognitive Organization. *Journal of Psychology: Interdisciplinary and Applied*. https://doi.org/10.1080/00223980.1946.9917275

Heimlich, J. E., & Ardoin, N. M. (2008). Understanding behavior to understand behavior change: a literature review. *Environmental Education Research*. https://doi.org/10.1080/13504620802148881

Hessen, J. O., Schei, M. A., & Pandey, M. R. (2001). Motivational Factors Related to Improving Indoor Air Quality in Rural Nepal. *Mountain Research and Development*, *21*(2), 148–153. https://doi.org/10.1659/0276-4741(2001)021[0148:mfrtii]2.0.co;2

Hines, J. M., Hungerford & Audrey, H. R., & Tomera, N. N. (1987). Analysis and Synthesis of Research on Responsible Environmental Behavior: A Meta-Analysis. *The Journal of Environmental Education*, *18*(2), 1–8. https://doi.org/10.1080/00958964.1987.9943482

Hollada, J., Williams, K. N., Miele, C. H., Danz, D., Harvey, S. A., & Checkley, W. (2017). Perceptions of improved biomass and liquefied petroleum gas stoves in Puno, Peru: Implications for promoting sustained and exclusive adoption of clean cooking technologies. *International Journal of Environmental Research and Public Health*, *14*(2), 182. https://doi.org/10.3390/ijerph14020182

Hopkins, C., & McKeown, R. (2002). Education for sustainable development: an international perspective. In *Education and sustainability: Responding to the global challenge, 13*.

Hutton, G., Rehfuess, E., & Tediosi, F. (2007). Evaluation of the costs and benefits of interventions to reduce indoor air pollution. *Energy for Sustainable Development*. https://doi.org/10.1016/S0973-0826(08)60408-1

Hutton, G., Rehfuess, E., Tediosi, F., & Weiss, S. (2006). *Evaluation of the costs and benefits of household energy and health interventions at global and regional levels*.

Iessa, L., De Vries, Y. A., Swinkels, C. E., Smits, M., & Butijn, C. A. A. (2017). What's cooking? Unverified assumptions, overlooking of local needs and pro-solution biases in the

solar cooking literature. *Energy Research and Social Science*, *28*(April), 98–108. https://doi.org/10.1016/j.erss.2017.04.007

International Dark-Sky Association. (n.d.). *International Dark Sky Reserves*. https://www.darksky.org/our-work/conservation/idsp/reserves/

International Energy Agency. (2018a). *Tracking SDG7: The Energy Progress Report 2018*.

International Energy Agency. (2018b). *World Energy Outlook 2018*.

Jackson, T. (2005). Motivating Sustainable Consumption. *A Review of Evidence on Consumer Behaviour and Behavioural Change In A Report to the Sustainable Development Research Network as Part of the ESRC Sustainable Technologies Programme Centre for Environmental Strategy University of Surrey Guildford*, *29*(1), 30–40. https://doi.org/10.1260/0958305043026573

Jagadish, A., & Dwivedi, P. (2018). In the hearth, on the mind: Cultural consensus on fuelwood and cookstoves in the middle Himalayas of India. *Energy Research and Social Science*. https://doi.org/10.1016/j.erss.2017.09.017

Jan, I., Ullah, S., Akram, W., Khan, N., Asim, S., Mahmood, Z., ..., & Ahmad, S. (2017). Adoption of improved cookstoves in Pakistan: A logit analysis. *Biomass and Bioenergy*, *103*, 55–62. https://doi.org/10.1016/j.biombioe.2017.05.014

Jaus, H. H. (1984). The development and retention of environmental attitudes in elementary school children. *Journal of Environmental Education*. https://doi.org/10.1080/00958964.1984.9942679

Jeuland, M. A., Bhojvaid, V., Kar, A., Lewis, J. J., Patange, O., Pattanayak, S. K., Ramanathan, N., Rehman, I. H., Tan Soo, J. S., Ramanathan, V., Soo, J. S. T., & Ramanathan, V. (2015). Preferences for improved cook stoves: Evidence from rural villages in north India. *Energy*

Economics, *52*, 287–298. https://doi.org/10.1016/j.eneco.2015.11.010

Jeuland, Marc A., & Pattanayak, S. K. (2012). Benefits and costs of improved cookstoves: Assessing the implications of variability in health, forest and climate impacts. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0030338

Johnson, M. A., & Chiang, R. A. (2015). Quantitative guidance for stove usage and performance to achieve health and environmental targets. *Environmental Health Perspectives*. https://doi.org/10.1289/ehp.1408681

Johnson, M., Edwards, R., Ghilardi, A., Berrueta, V., Gillen, D., Frenk, C. A., & Masera, O. (2009). Quantification of Carbon Savings from Improved Biomass Cookstove Projects. *Environmental Science & Technology*, *43*(7), 2456–2462. https://doi.org/10.1021/es801564u

Jürisoo, M., Lambe, F., & Osborne, M. (2018). Beyond buying: The application of service design methodology to understand adoption of clean cookstoves in Kenya and Zambia. *Energy Research & Social Science*, *39*, 164–176. https://doi.org/10.1016/j.erss.2017.11.023

Kaiser, F. G., & Frick, J. (2002). Development of an environmental knowledge measure: An application of the MRCML model. *Diagnostica*. https://doi.org/10.1026//0012-1924.48.4.181

Kaiser, F. G., Roczen, N., & Bogner, F. X. (2008). Competence Formation in Environmental Education : Advancing Ecology-Specific Rather Than General Abilities. *Umweltpsychologie*.

Kaler, J. (2002). Morality and strategy in stakeholder identification. *Journal of Business Ethics*. https://doi.org/10.1023/A:1016336118528

Kammen, D. M. (1995). Cookstoves for the developing world. *Scientific American*.

https://doi.org/10.1038/scientificamerican0795-72

Kandpal, T. C., & Broman, L. (2014). Renewable energy education: A global status review. In *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2014.02.039

Katz, V. S. (2010). How Children of Immigrants Use Media to Connect Their Families to the Community: The case of Latinos in South Los Angeles. *Journal of Children and Media*, *4*(3), 298–315. https://doi.org/10.1080/17482798.2010.486136

Kay, E. (2012). *Playing with fire: an MNC's inability to translate its market logic in a culturally complex exchange setting in rural India*. University of Oxford.

Keding, V. (2016). *Exploring NaDEET Centre's Community Environmental Education Programme: A Namibian Case Study of Sustainable Living and Solar Cooking*.

Kelly, C. (2018). *School absenteeism in Karonga district, northern Malawi: Trends, influences and the impact of cleaner burning biomass-fuelled cookstoves*. London School of Hygiene & Tropical Medicine.

Kempton, W., & Schipper, L. (1944). Expanding the human dimensions research agenda. *ACEE 1944 Summer Study on Energy Efficiency in Buildings*, 1–85.

Khamati-Njenga, B., & Clancy, J. (2005). *Concepts and issues in gender and energy*.

Khan, A., Khan, M. N., & Adil, M. (2012). Exploring the New Ecological Paradigm (NEP) Scale in India: Item Analysis, Factor Structure and Refinement. *Asia-Pacific Journal of Management Research and Innovation*. https://doi.org/10.1177/2319510x13477966

Khandelwal, M., Hill, M. E., Greenough, P., Anthony, J., Quill, M., Linderman, M., & Udaykumar, H. S. (2017). Why Have Improved Cook-Stove Initiatives in India Failed? *World Development*, *92*, 13–27. https://doi.org/10.1016/j.worlddev.2016.11.006

Kiesler, S., Zdaniuk, B., Lundmark, V., & Kraut, R. (2000). Troubles with the Internet: The

dynamics of help at home. *Human-Computer Interaction*. https://doi.org/10.1207/S15327051HCI1504_2

Kioko, J., & Kiringe, J. (2010). Youth's knowledge, attitudes and practices in wildlife and environmental conservation in Maasailand, Kenya. *Southern African Journal of Environmental Education*, *27*.

Klasen, E., Miranda, J. J., Khatry, S., Menya, D., Gilman, R. H., Tielsch, J. M., Kennedy, C., Dreibelbis, R., Naithani, N., Kimaiyo, S., Chiang, M., Carter, E. J., Sherman, C. B., Breysse, P. N., Checkley, W., Huaman, A., Levano, M., Haustein, D., Rhodes, E., … Baliddawa, J. (2013). Feasibility intervention trial of two types of improved cookstoves in three resource-limited settings: Study protocol for a randomized controlled trial. *Trials*. https://doi.org/10.1186/1745-6215-14-327

Kleinschafer, J., & Morrison, M. (2014). Household norms and their role in reducing household electricity consumption. *International Journal of Consumer Studies*. https://doi.org/10.1111/ijcs.12066

Knafo, A., & Galansky, N. (2008). The Influence of Children on Their Parents' Values. *Social and Personality Psychology Compass*. https://doi.org/10.1111/j.1751-9004.2008.00097.x

Kreuter, M. W., Christopher De Rosa, M., Howze, E. H., & Grant Baldwin, C. T. (2004). Understanding Wicked Problems: A Key to Advancing Environmental Health Promotion. *Health Education & Behavior*, *31*(4), 441–454. https://doi.org/10.1177/1090198104265597

Kruglanski, A. W., & Webster, D. M. (1996). Motivated Closing of the Mind: "Seizing" and "Freezing." *Psychological Review*. https://doi.org/10.1037/0033-295X.103.2.263

Kumar, R., & Best, M. L. (2007). Social Impact and Diffusion of Telecenter Use: A Study from the sustainable Access in Rural India Project. *Educomm Asia*.

Lane, J. F., Floress, K., & Rickert, M. (2014). Development of school energy policy and energy education plans: A comparative case study in three wisconsin school communities. *Energy Policy*. https://doi.org/10.1016/j.enpol.2013.10.006

Leeming, F. C., Dwyer, W. O., & Bracken, B. A. (1995). Children's environmental attitude and knowledge scale construction and validation. *Journal of Environmental Education*, *26*(3), 22–31. https://doi.org/10.1080/00958964.1995.9941442

Legault, L., & Pelletier, L. G. (2000). Impact of an environmental education program on students' and parents' attitudes, motivation, and behaviours. *Canadian Journal of Behavioural Science*. https://doi.org/10.1037/h0087121

Leiserowitz, A., Maibach, E., Roser-Renouf, C., Feinberg, G., & Rosenthal, S. (2014). Climate change in the American mind: April, 2014. In *Yale Project on Climate Change Communication*.

Leung, C., & Rice, J. (2002). Comparison of Chinese-Australian and Anglo-Australian environmental attitudes and behavior. *Social Behavior and Personality*. https://doi.org/10.2224/sbp.2002.30.3.251

Levison, D., Degraff, D. S., & Dungumaro, E. W. (2018). Implications of environmental chores for schooling: Children's time fetching water and firewood in Tanzania. *European Journal of Development Research*, *30*(2), 217–234. https://doi.org/10.1057/s41287-017-0079-2

Lewis, J. J., Bhojvaid, V., Brooks, N., Das, I., Jeuland, M. A., Patange, O., & Pattanayak, S. K. (2015). Piloting improved cookstoves in India. *Journal of Health Communication*, *20*(S1), 28–42. https://doi.org/10.1080/10810730.2014.994243

Lewis, J. J., Hollingsworth, J. W., Chartier, R. T., Cooper, E. M., Foster, W. M., Gomes, G. L., & Rodes, C. E. (2016). Biogas stoves reduce firewood use, household air pollution, and

hospital visits in Odisha, India. *Environmental Science & Technology*, *51*(1), 560–569.

Lewis, J. J., & Pattanayak, S. K. (2012). Who adopts improved fuels and cookstoves? A systematic review. *Environmental Health Perspectives*, *120*(5), 637–645. https://doi.org/10.1289/ehp.1104194

Lim, S., Vos, T., Flaxman, A., Danaei, G., Shibuha, K., Adair-Rohani, H., & Aryee, M. (2012). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study. *The Lancet*, *380*(9859), 2224–2260.

Lindgren, S. (2020). Clean cooking for all? A critical review of behavior, stakeholder engagement, and adoption for the global diffusion of improved cookstoves. *Energy Research & Social Science*.

Listo, R. (2018). Gender myths in energy poverty literature: A critical discourse analysis. *Energy Research and Social Science*. https://doi.org/10.1016/j.erss.2018.01.010

Loewenstein, G. F., Hsee, C. K., Weber, E. U., & Welch, N. (2001). Risk as Feelings. *Psychological Bulletin*. https://doi.org/10.1037/0033-2909.127.2.267

Lohr, S. (1999). *Sampling: design and analysis*. Nelson Education.

Lopez, L. M., Tolley, E. E., Grimes, D. A., & Chen-Mok, M. (2009). Theory-based interventions for contraception. *Cochrane Database of Systematic Reviews*, *1*. https://doi.org/10.1002/14651858.CD007249.pub2

Lutzenhiser, L. (1992). A cultural model of household energy consumption. *Energy*, *17*(1), 47–60. https://doi.org/10.1016/0360-5442(92)90032-U

Lutzenhiser, L., & Shove, E. (1999). Contracting knowledge: The organizational limits to interdisciplinary energy efficiency research and development in the US and the UK. *Energy*

Policy. https://doi.org/10.1016/S0301-4215(99)00012-9

Macrotrends. (2020). *Windhoek, Namibia Metro Area Population 1950-2020*.

Madajewicz, M., Pfaff, A., van Geen, A., Graziano, J., Hussein, I., Momotaj, H., Sylvi, R., & Ahsan, H. (2007). Can information alone change behavior? Response to arsenic contamination of groundwater in Bangladesh. *Journal of Development Economics*. https://doi.org/10.1016/j.jdeveco.2006.12.002

Maio, G. R., Verplanken, B., Manstead, A. S. R., Stroebe, W., Abraham, C., Sheeran, P., & Conner, M. (2007). Social Psychological Factors in Lifestyle Change and Their Relevance to Policy. *Social Issues and Policy Review*, *1*(1), 99–137. https://doi.org/10.1111/j.1751-2409.2007.00005.x

Malla, S., & Timilsina, G. (2014). *Household cooking fuel choice and adoption of improved cookstoves in developing countries: a review*.

Manibog, F. R. (1984). IMPROVED COOKING STOVES IN DEVELOPING COUNTRIES: PROBLEMS AND OPPORTUNITIES. *Annual Review of Energy*. https://doi.org/10.1146/annurev.eg.09.110184.001215

Manoli, C. C., Johnson, B., & Dunlap, R. E. (2007). Assessing children's environmental worldviews: Modifying and validating the New Ecological Paradigm Scale for use with children. *Journal of Environmental Education*, *38*(4), 3–13. https://doi.org/10.3200/JOEE.38.4.3-13

Maruyama, E., Torero, M., & Viceisza, A. (2013). *he Toy Effect: Children's Influence on Parental Behavior. Experimental Evidence from Perú*.

Masera, O., Edwards, R., Arnez, C., Berrueta, V., Johnson, M., Bracho, L., Riojas-Rodriguez, H., & Smith, K. (2007). Impact of Patsari improved cookstoves on indoor air quality in

Michoacán, Mexico. *Energy for Sustainable Development*, *11*(2), 45–56. https://www.sciencedirect.com/science/article/pii/S0973082608603993

Masera, O. R., Díaz, R., & Berrueta, V. (2005). From cookstoves to cooking systems: the integrated program on sustainable household energy use in Mexico. *Energy for Sustainable Development*, *9*(1), 25–36. https://www.sciencedirect.com/science/article/pii/S0973082608604809

Masera, O. R., Saatkamp, B. D., & Kammen, D. M. (2000). From linear fuel switching to multiple cooking strategies: A critique and alternative to the energy ladder model. *World Development*. https://doi.org/10.1016/S0305-750X(00)00076-0

Matinga, M. N., Annegarn, H. J., & Clancy, J. S. (2013). Healthcare provider views on the health effects of biomass fuel collection and use in rural Eastern Cape, South Africa: An ethnographic study. *Social Science and Medicine*, *97*, 192–200. https://doi.org/10.1016/j.socscimed.2013.08.015

Mayer, F. S., & Frantz, C. M. P. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*. https://doi.org/10.1016/j.jenvp.2004.10.001

McBeth, W., & Volk, T. (2009). The national environmental literacy project: A baseline study of middle grade students in the United States. *Journal of Environmental Education*. https://doi.org/10.1080/00958960903210031

McCracken, J. P., Smith, K. R., Díaz, A., Mittleman, M. A., & Schwartz, J. (2007). Chimney stove intervention to reduce long-term wood smoke exposure lowers blood pressure among Guatemalan women. In *Environmental Health Perspectives*. https://doi.org/10.1289/ehp.9888

McKenzie-Mohr, D. (2002). The next revolution: Sustainability. In *Psychology of sustainable development* (pp. 19–36). Springer.

McKenzie-Mohr, Doug. (2000). New Ways to Promote Proenvironmental Behavior: Promoting Sustainable Behavior: An Introduction to Community-Based Social Marketing. *Journal of Social Issues*. https://doi.org/10.1111/0022-4537.00183

Medina, P., Berrueta, V., Cinco, L., Ruiz-García, V., Edwards, R., Olaya, B., Schilmann, A., & Masera, O. (2019). Understanding Household Energy Transitions: From Evaluating Single Cookstoves to "Clean Stacking" Alternatives. *Atmosphere*, *10*(11), 693. https://doi.org/10.3390/atmos10110693

Mehta, S., & Shahpar, C. (2004). The health benefits of interventions to reduce indoor air pollution from solid fuel use: a cost-effectiveness analysis. *Energy for Sustainable Development*, *8*(3), 53–59. https://doi.org/10.1016/S0973-0826(08)60466-4

Meinhold, J. L., & Malkus, A. J. (2005). Adolescent environmental behaviors: Can knowledge, attitudes and self-efficacy make a difference? *Environment and Behavior*. https://doi.org/10.1177/0013916504269665

Melber, H. (2015). *Understanding Namibia: The trials of independence*. Oxford University Press.

Mercy, A., Asinobi, C., & Yemi, I. (2008). ttitudes of Rural and Urban Women in Bamako District and Koulikoro Region of Mali to the Use of a Solar Cooker. *24th Annual Meeting of the Association for International Agricultural and Extension Education*, 15–27.

Meredith, J., Robinson, J., Walker, S., & Wydick, B. (2013). Keeping the doctor away: Experimental evidence on investment in preventative health products. *Journal of Development Economics*. https://doi.org/10.1016/j.jdeveco.2013.08.003

Michie, S., Richardson, M. S., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M. P., Cane, J., & Wood, C. E. (2013). The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions. *Annals of Behavioral Medicine*, *46*(1), 81–95. https://doi.org/10.1007/s12160-013-9486-6

Miles, S. (2017). Stakeholder Theory Classification: A Theoretical and Empirical Evaluation of Definitions. *Journal of Business Ethics*. https://doi.org/10.1007/s10551-015-2741-y

Miller, G., & Mushfiq Mobarak, A. (2015). Learning about new technologies through social networks: Experimental evidence on nontraditional stoves in Bangladesh. *Marketing Science*. https://doi.org/10.1287/mksc.2014.0845

Ministry of Education. (2014). *Press Release on the 2014 Results of Grade 10 and Grade 12 Namibia Senior Secondary Certificate Higher Level.*

Minsch, J., Goldblatt, D., Flüeler, T., & Spreng, D. (2012). The indispensable role of social science in energy research. In *Tackling Long-Term Global Energy Problems* (pp. 23–43). Springer.

Mitcham, C., & Rolston, J. S. (2013). Energy Constraints. *Science and Engineering Ethics*, *19*(2), 313–319. https://doi.org/10.1007/s11948-013-9446-3

Mobarak, A. A. M., Dwivedi, P., Bailis, R., Hildemann, L., & Miller, G. (2012). Low demand for nontraditional cookstove technologies. *Proceedings of the National Academy of Sciences*, *109*(27), 10815–10820. https://doi.org/10.1073/pnas.1115571109

Modi, S., & Firestone, R. (2014). *Social marketing evidence base: Methodology and findings*. Population Services International.

Mohapatra, S., & Simon, L. (2017). Intra-household bargaining over household technology

adoption. *Review of Economics of the Household*, *15*(4), 1263–1290. https://doi.org/10.1007/s11150-015-9318-5

Molnar, T. I. (2017). *Variation in Cookstove Demand: Age and Education Effects in Northern Ghana*. University of Colorado.

Mortimer, K., Ndamala, C. B., Naunje, A. W., Malava, J., Katundu, C., Weston, W., Havens, D., Pope, D., Bruce, N. G., Nyirenda, M., Wang, D., Crampin, A., Grigg, J., Balmes, J., & Gordon, S. B. (2017). A cleaner burning biomass-fuelled cookstove intervention to prevent pneumonia in children under 5 years old in rural Malawi (the Cooking and Pneumonia Study): a cluster randomised controlled trial. *The Lancet*, *389*(10065). https://doi.org/10.1016/S0140-6736(16)32507-7

Moses, N., & MacCarty, N. (2018). *Cookstove Usability Testing Protocol*.

Muchiri, L. (2008). Gender and Equity in Bioenergy Access and Delivery in Kenya. In *Practical Action Eastern Africa*.

Mukhopadhyay, R., Sambandam, S., Pillarisetti, A., Jack, D., Mukhopadhyay, K., Balakrishnan, K., Vaswani, M., Bates, M. N., Kinney, P. L., Arora, N., & Smith, K. R. (2012). Cooking practices, air quality, and the acceptability of advanced cookstoves in Haryana, India: an exploratory study to inform large-scale interventions. *Global Health Action*. https://doi.org/10.3402/gha.v5i0.19016

Muneer, S. (2003). Adoption of biomass improved cookstoves in a patriarchal society: an example from Sudan. *Science of the Total Environment*, *307*(1–3), 259–266.

Muraven, M., & Baumeister, R. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin*, *126*(2), 247.

Namibia Statistics Agency. (2011). *Namibia 2011 Population and Housing Census Main Report*.

http://www.nsa.org.na/files/downloads/Namibia 2011 Population and Housing Census Main Report.pdf

NamibRand Nature Reserve. (n.d.). *NamibRand Nature Reserve*. Retrieved January 24, 2020, from http://www.namibrand.com/about-us.html

Nederhof, A. J. (1985). Methods of coping with social desirability bias: A review. *European Journal of Social Psychology*. https://doi.org/10.1002/ejsp.2420150303

Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2011). Happiness is in our Nature: Exploring Nature Relatedness as a Contributor to Subjective Well-Being. *Journal of Happiness Studies*. https://doi.org/10.1007/s10902-010-9197-7

Norris, C., Goldberg, M. S., Marshall, J. D., Valois, M. F., Pradeep, T., Narayanswamy, M., Jain, G., Sethuraman, K., & Baumgartner, J. (2016). A panel study of the acute effects of personal exposure to household air pollution on ambulatory blood pressure in rural Indian women. *Environmental Research*. https://doi.org/10.1016/j.envres.2016.02.024

Ntona, E., Arabatzis, G., & Kyriakopoulos, G. L. (2015). Energy saving: Views and attitudes of students in secondary education. In *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2015.02.033

Ogunbode, C. (2013). The NEP scale: measuring ecological attitudes/worldviews in an African context. *Environment, Development and Sustainability*, *15*(6), 1477–1494.

Ogunlela, Y., & Mukhtar, A. (2009). Gender issues in agriculture and rural development in Nigeria: The role of women. *Humanity & Social Sciences Journal*, *4*(1), 19–30.

Okyere, C. Y., Pangaribowo, E. H., Asante, F. A., & von Braun, J. (2017). The Impacts of Household Water Quality Testing and Information on Safe Water Behaviors: Evidence from a Randomized Experiment in Ghana. *SSRN Electronic Journal*.

https://doi.org/10.2139/ssrn.2955038

Opar, A., Pfaff, A., Seddique, A. A., Ahmed, K. M., Graziano, J. H., & van Geen, A. (2007). Responses of 6500 households to arsenic mitigation in Araihazar, Bangladesh. *Health and Place*. https://doi.org/10.1016/j.healthplace.2005.11.004

Otte, P. P. (2013). Solar cookers in developing countries-What is their key to success? *Energy Policy*. https://doi.org/10.1016/j.enpol.2013.08.075

Palmer, C., & MacGregor, J. (2009). Fuelwood Scarcity, Energy Substitution and Rural Livelihoods in Namibia. *Environment and Development Economics*, *14*(6), 693–715.

Pandey, S., & Yadama, G. N. (1992). Community Development Programs in Nepal: A Test of Diffusion of Innovation Theory. *Social Service Review*, *66*(4), 582–597. https://doi.org/10.1086/603949

Pattanayak, S. K., & Pfaff, A. (2009). Behavior, Environment, and Health in Developing Countries: Evaluation and Valuation. *Annual Review of Resource Economics*. https://doi.org/10.1146/annurev.resource.050708.144053

Pieterse, J. N. (2010). *Development Theory: Deconstructions/Reconstructions*.

Pine, K., Edwards, R., Masera, O., Schilmann, A., Marrón-Mares, A., & Riojas-Rodríguez, H. (2011). Adoption and use of improved biomass stoves in Rural Mexico. *Energy for Sustainable Development*, *15*(2), 176–183. https://www.sciencedirect.com/science/article/pii/S0973082611000238

Pope, D., Bruce, N., Dherani, M., … K. J.-E., & 2017, U. (2017). Real-life effectiveness of 'improved'stoves and clean fuels in reducing PM2. 5 and CO: systematic review and meta-analysis. *Environment International*, *101*, 7–18.

Prozesky, D. R. (2000). Communication and effective teaching. In *Journal of Community Eye*

Health.

Puttick, G., Kies, K., Garibay, C., & Bernstein, D. (2015). Learning and behavior change in a Girl Scout program focused on energy conservation: Saving energy to "save the planet." *Journal of Sustainability Education*.

Puzzolo, E., Stanistree, D., Pope, D., Bruce, N., & Rehfuess, E. (2013). *Factors influencing the largescale uptake by households of cleaner and more efficient household energy technologies*.

Quansah, R., Semple, S., Ochieng, C., Juvekar, S., Armah, F., Luginaah, I., & Emina, J. (2017). Effectiveness of interventions to reduce household air pollution and/or improve health in homes using solid fuel in low-and-middle income countries: A systematic review and meta-analysis. *Environment International*, *103*, 73–90.

Ramanathan, V., Han, H., & Matlock, T. (2017). Educating Children to Bend the Curve: For a Stable Climate, Sustainable Nature and Sustainable Humanity. In *Children and Sustainable Development*. https://doi.org/10.1007/978-3-319-47130-3_1

Ramirez, S., Dwivedi, P., Ghilardi, A., & Bailis, R. (2014). Diffusion of non-traditional cookstoves across western Honduras: A social network analysis. *Energy Policy*. https://doi.org/10.1016/j.enpol.2013.11.008

Ramsey, C., & Rickson, R. (1976). Environmental knowledge and attitudes. *The Journal of Environmental Education*, *8*(1), 10–18.

Rauwald, K. S., & Moore, C. F. (2002). Environmental attitudes as predictors of policy support across three countries. *Environment and Behavior*. https://doi.org/10.1177/001391602237243

Rehfuess, E. A., Puzzolo, E., Stanistreet, D., Pope, D., & Bruce, N. G. (2014). Enablers and

barriers to large-scale uptake of improved solid fuel stoves: A systematic review. *Environmental Health Perspectives*, *122*(2), 120–130. https://doi.org/10.1289/ehp.1306639

Republic of Namibia. (1990). *Namibian Constitution*. https://laws.parliament.na/cms_documents/namibian-constitution-e77d13246a.pdf.

Republic of Namibia. (2011). *National Policy on Climate Change for Namibia*. http://www.met.gov.na/files/files/National Policy on %0D%0AClimate Change for Namibia 2011(1).pdf%0D%0A

Reyes, R., Schueftan, A., Ruiz, C., & González, A. (2019). Controlling air pollution in a context of high energy poverty levels in southern Chile: Clean air but colder houses? *Energy Policy*, *124*, 301–311.

Rhodes, E. L., Dreibelbis, R., Klasen, E., Naithani, N., Baliddawa, J., Menya, D., Khatry, S., Levy, S., Tielsch, J. M., Miranda, J. J., Kennedy, C., Checkley, W., Jaime Miranda, J., Kennedy, C., Checkley, W., & Jaime Miranda, J. (2014). Behavioral attitudes and preferences in cooking practices with traditional open-fire stoves in Peru, Nepal, and Kenya: implications for improved cookstove interventions. *International Journal of Environmental Research and Public Health*, *11*(10), 10310–10326. https://doi.org/10.3390/ijerph111010310

Rimal, R. N., & Flora, J. A. (1998). Bidirectional familial influences in dietary behavior: Test of a model of campaign influences. *Human Communication Research*. https://doi.org/10.1111/j.1468-2958.1998.tb00433.x

Robinson, T. N., & Borzekowski, D. L. G. (2006). Effects of the SMART classroom curriculum to reduce child and family screen time. *Journal of Communication*. https://doi.org/10.1111/j.1460-2466.2006.00001.x

Rogers, E. (1985). *Diffusion of Innovations 4th Edition*. Simon and Schuster.

Rogers, E., & Kincaid, D. (1981). *Communication networks: Toward a new paradigm for research*. Free Press.

Rogers, E., & Shoemaker, F. (1971). *Communication of Innovations; A Cross-Cultural Approach*.

Romieu, I., Riojas-Rodríguez, H., Marrón-Mares, A. T., Schilmann, A., Perez-Padilla, R., & Masera, O. (2009). Improved Biomass Stove Intervention in Rural Mexico: Impact on the respiratory health of women. *American Journal of Respiratory and Critical Care Medicine*, *180*(7), 649–656. https://doi.org/10.1164/rccm.200810-1556OC

Rosa, G., Majorin, F., Boisson, S., Barstow, C., Johnson, M., Kirby, M., Ngabo, F., Thomas, E., & Clasen, T. (2014). Assessing the impact of water filters and improved cook stoves on drinking water quality and household air pollution: A randomised controlled trial in Rwanda. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0091011

Rosenthal, J. P., & Borrazzo, J. (2015). Saving lives by building bridges between user needs and clean cooking technology. In *Journal of health communication*. https://doi.org/10.1080/10810730.2014.996304

Ruiz-Mercado, I., & Masera, O. (2015). Patterns of Stove Use in the Context of Fuel–Device Stacking: Rationale and Implications. *EcoHealth*, *12*(1), 42–56. https://doi.org/10.1007/s10393-015-1009-4

Ruiz-Mercado, I., Masera, O., Zamora, H., & Smith, K. R. K. (2011). Adoption and sustained use of improved cookstoves. *Energy Policy*, *39*(12), 7557–7566. https://doi.org/10.1016/j.enpol.2011.03.028

Samuel, O., Baba, M., & Thlimabari, A. (2018). The Ecological, Economical and Social Impact

of Adoption Solar Cooking in Mubi Metropolis Adamawa State, Nigeria. *Journal of Scientific Research and Reports*, 1–6.

Schultz, P. W. (2000). New Environmental Theories: Empathizing With Nature: The Effects ofPerspective Taking on Concern for... *Journal of Social Issues*. https://doi.org/10.1111/0022-4537.00174

Schwela, D. (1997). Cooking smoke: a silent killer. *People and the Planet*, *6*(3), 24–25. https://www.popline.org/node/269365

Shankar, A., Johnson, M., Kay, E., Pannu, R., Beltramo, T., Derby, E., Harrell, S., Davis, C., & Petach, H. (2014). Maximizing the benefits of improved cookstoves: Moving from acquisition to correct and consistent use. In *Global Health Science and Practice* (Vol. 2, Issue 3, pp. 268–274). Johns Hopkins University Press. https://doi.org/10.9745/GHSP-D-14-00060

Shankar, A., Sundar, S., & Smith, G. (2019). Agency-Based Empowerment Interventions: Efforts to Enhance Decision-Making and Action in Health and Development. *Journal of Behavioral Health Services and Research*. https://doi.org/10.1007/s11414-018-9592-0

Shankar, A. V., Onyura, M., & Alderman, J. (2015). Agency-based empowerment training enhances sales capacity of female energy entrepreneurs in Kenya. *Journal of Health Communication*, *20*(S1), 67–75. https://doi.org/10.1080/10810730.2014.1002959

Shell Foundation. (2013). *Social marketing in India: Lessons learned from efforts to foster demand for cleaner cookstoves*.

Shen, G., Lin, W., Chen, Y., Yue, D., Liu, Z., & Yang, C. (2015). Factors influencing the adoption and sustainable use of clean fuels and cookstoves in China-a Chinese literature review. *Renewable and Sustainable Energy Reviews*, *51*, 741–750.

Smith-Sivertsen, T., Díaz, E., Bruce, N., Diaz, A., Khalakdina, A., Schei, M., McCracken, J., Arana, B., Klein, R., Thompson, L., & Smith, K. (2004). Reducing indoor air pollution with a randomised intervention design–. *Norsk Epidemiologi*, *14*(2), 137–143. https://www.researchgate.net/profile/Tone_Smith-Sivertsen/publication/284472960_Reducing_indoor_air_pollution_with_a_randomised_intervention_design_-_A_presentation_of_the_Stove_Intervention_Study_in_the_Guatemalan_Highlands/links/582c910c08ae004f74b93d4a

Smith, K.R., McCracken, J., Weber, M., Hubbard, A., Jenny, A., Thompson, L., & Bruce, N. (2011). Effect of reduction in household air pollution on childhood pneumonia in Guatemala (RESPIRE): a randomised controlled trial. *The Lancet*, *378*(9804), 1717–1726.

Smith, K. R., Bruce, N., Balakrishnan, K., Adair-Rohani, H., Balmes, J., Chafe, Z., Dherani, M., Hosgood, H. D., Mehta, S., Pope, D., & Rehfuess, E. (2014). Millions Dead: How Do We Know and What Does It Mean? Methods Used in the Comparative Risk Assessment of Household Air Pollution. *Annual Review of Public Health*, *35*(1), 185–206. https://doi.org/10.1146/annurev-publhealth-032013-182356

Smith, K.R., Samet, J., Romieu, I., & Bruce, N. (2000). Indoor air pollution in developing countries and acute lower respiratory infections in children. *Thorax*, *55*(6), 518–532.

Snyder, L. B., Hamilton, M. A., Mitchell, E. W., Kiwanuka-Tondo, J., Fleming-Milici, F., & Proctor, D. (2004). A meta-analysis of the effect of mediated health communication campaigns on behavior change in the United States. *Journal of Health Communication*. https://doi.org/10.1080/10810730490271548

Sovacool, B. K. (2014). What are we doing here? Analyzing fifteen years of energy scholarship

and proposing a social science research agenda. *Energy Research and Social Science*, *1*, 1–29. https://doi.org/10.1016/j.erss.2014.02.003

Sovacool, B. K., Sidortsov, R. V., & Jones, B. R. (2013). *Energy security, equality and justice*. Routledge.

Staff Reporter. (2019, July 16). Charcoal industry now employs some 10000 workers. *New Era Live*. https://neweralive.na/posts/charcoal-industry-now-employs-some-10-000-workers

Stanistreet, D., Hyseni, L., Bashin, M., Sadumah, I., Pope, D., Sage, M., & Bruce, N. (2015). The role of mixed methods in improved cookstove research. *Journal of Health Communication*, *20*(S1), 84–93. https://doi.org/10.1080/10810730.2014.999896

Steg, L. (2008). Promoting household energy conservation. *Energy Policy*. https://doi.org/10.1016/j.enpol.2008.09.027

Stern, P. C. (1992). What psychology knows about energy conservation. *American Psychologist*, *47*(10). https://doi.org/10.1037/0003-066X.47.10.1224

Stern, P. C. (1993). A second environmental science: Human-environment interactions. In *Science*. https://doi.org/10.1126/science.260.5116.1897

Stern, P. C. (2000). New Environmental Theories: Toward a Coherent Theory of Environmentally Significant Behavior. *Journal of Social Issues*. https://doi.org/10.1111/0022-4537.00175

Stern, P. C. (2014). Individual and household interactions with energy systems: Toward integrated understanding. *Energy Research and Social Science*. https://doi.org/10.1016/j.erss.2014.03.003

Stirling, A. (2014). Transforming power: Social science and the politics of energy choices. *Energy Research and Social Science*. https://doi.org/10.1016/j.erss.2014.02.001

Sudman, S. (1976). *Applied Sampling*. Academic Press, Inc.

Symons, M. (2003). *A history of cooks and cooking*. University of Illinois Press.

Takama, T., Tsephel, S., & Johnson, F. X. (2012). Evaluating the relative strength of product-specific factors in fuel switching and stove choice decisions in Ethiopia. A discrete choice model of household preferences for clean cooking alternatives. *Energy Economics*. https://doi.org/10.1016/j.eneco.2012.07.001

Thacker, K., Barger, M., & Mattson, C. (2014). A global review of end user needs: Establishing the need for adaptable cookstoves. *IEEE Global Humanitarian Technology Conference*, 649–658.

Thomas, D. (1990). Intra-Household Resource Allocation: An Inferential Approach. *The Journal of Human Resources*. https://doi.org/10.2307/145670

Tigabu, A. (2017). Factors associated with sustained use of improved solid fuel cookstoves: A case study from Kenya. *Energy for Sustainable Development*, *41*, 81–87. https://doi.org/10.1016/j.esd.2017.08.008

Tindall, L., & Shaw, D. (2016, August). New short video on NamibRand Nature Reserve. *The Barking Gecko: Newsletter of the NamibRand Nature Reserve*.

Trewhella, W. J., Rodriguez-Clark, K. M., Corp, N., Entwistle, A., Garrett, S. R. T., Granek, E., Lengel, K. L., Raboude, M. J., Reason, P. F., & Sewall, B. J. (2005). Environmental education as a component of multidisciplinary conservation programs: Lessons from conservation initiatives for critically endangered fruit bats in the western Indian Ocean. In *Conservation Biology*. https://doi.org/10.1111/j.1523-1739.2005.00548.x

Troncoso, K. (2013). *A Recipe for Developing Adoption & Impact Indices*.

Troncoso, K., Armendáriz, C., & Alatorre, S. (2013). Improved cook stove adoption and impact

assessment: A proposed methodology. *Energy Policy*, *62*, 637–645. https://doi.org/10.1016/j.enpol.2013.07.074

Troncoso, K., Castillo, A., Masera, O., & Merino, L. (2007). Social perceptions about a technological innovation for fuelwood cooking: Case study in rural Mexico. *Energy Policy*, *35*(5), 2799–2810. https://doi.org/10.1016/j.enpol.2006.12.011

Tucker, M. (1999). Can solar cooking save the forests? *Ecological Economics*. https://doi.org/10.1016/S0921-8009(99)00038-5

Ueyama, M. (2007). *Income Growth and Gender Bias in Childhood Mortality in Developing Countries*. International Food Policy Research Institute (IFPRI), Food Consumption and Nutrition Division. No. 00739.

UNESCO. (2005). Decade of Education for Sustainable Development (2005-2014). *United Nations Educational, Scientific and Cultural Organization*. https://doi.org/ED/2005/PEQ/ESD/3

UNESCO Principal Regional Office for Asia and the Pacific. (1998). *Educational innovation for sustainable development; report of the Third UNESCO-ACEID International Conference*.

United Nations. (2015a). Transforming Our World: The 2030 Agenda for Sustainable Development. In *A New Era in Global Health*. https://doi.org/10.1891/9780826190123.ap02

United Nations. (2015b). World population prospects: The 2015 Revision, Key Findings and Advance Tables. In *United Nations*. https://doi.org/10.1017/CBO9781107415324.004

United Nations Educational Scientific and Cultural Organization. (2008). *Decade of Education for Sustainable Development*. http://unesdoc.unesco.org/images/0014/001486/148654e.pdf

Valente, T. W., & Pumpuang, P. (2007). Identifying opinion leaders to promote behavior change.

Health Education and Behavior. https://doi.org/10.1177/1090198106297855

Vanschoenwinkel, J., Lizin, S., Swinnen, G., Azadi, H., & Van Passel, S. (2014). Solar cooking in Senegalese villages: An application of best-worst scaling. *Energy Policy*. https://doi.org/10.1016/j.enpol.2013.12.038

Vaughan, C., Gack, J., Solorazano, H., & Ray, R. (2003). The Effect of environmental education on schoolchildren, their parents, and community members: A study of intergenerational and intercommunity learning. *Journal of Environmental Education*. https://doi.org/10.1080/00958960309603489

Verplanken, B., & Aarts, H. (1999). Habit, Attitude, and Planned Behaviour: Is Habit an Empty Construct or an Interesting Case of Goal-directed Automaticity? *European Review of Social Psychology*. https://doi.org/10.1080/14792779943000035

Verplanken, B., Aarts, H., & Van Knippenberg, A. (1997). Habit, information acquisition, and the process of making travel mode choices. *European Journal of Social Psychology*. https://doi.org/10.1002/(sici)1099-0992(199709/10)27:5<539::aid-ejsp831>3.3.co;2-1

Verplanken, B., & Wood, W. (2006). Interventions to break and create consumer habits. In *Journal of Public Policy and Marketing*. https://doi.org/10.1509/jppm.25.1.90

von Braun, J. (2017). Children as Agents of Change for Sustainable Development. In A. Battro, P. Lena, M. Sorondo, & J. von Braun (Eds.), *Children and Sustainable Development* (pp. 17–30). Springer International Publishing AG.

Von Schirnding, Y., Bruce, N., Smith, K., Ballard-Tremeer, G., Ezzati, M., & Lvovsky, K. (2002). *Addressing the Impact of Household Energy and Indoor Air Pollution on the Health of the Poor: Implications for Policy Action and Intervention Measures Paper Prepared for the Commission on Macroeconomics and Health World Health Organization*.

http://www.who.int/entity/mediacentre/events/H&SD_Plaq_no9.pdf

Vulturius, G., & Wanjiru, H. (2017). *The role of social relations in the adoption of improved cookstoves*. Stockholm Environment Institute.

Wallace, M. (2014). *History of Namibia: From the Beginning to 1990*. Oxford University Press. https://books.google.com/books?hl=en&lr=&id=8kK1DwAAQBAJ&oi=fnd&pg=PP1&dq=History+of+Namibia:+From+the+Beginning+to+1990&ots=43ssSa3GTH&sig=umEWN3FZlyr8DFto6nqCNL1j0ZE

Wallenborn, G., & Wilhite, H. (2014). Rethinking embodied knowledge and household consumption. *Energy Research and Social Science*. https://doi.org/10.1016/j.erss.2014.03.009

Wang, Y., & Bailis, R. (2015). The revolution from the kitchen: Social processes of the removal of traditional cookstoves in Himachal Pradesh, India. *Energy for Sustainable Development*. https://doi.org/10.1016/j.esd.2015.05.001

Webb, T. L., & Sheeran, P. (2006). Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychological Bulletin*. https://doi.org/10.1037/0033-2909.132.2.249

Weiss, R. S. (1994). Learning From Strangers. Qual Interviews.Pdf. In *Learning from strangers The art and method of qualitative interview studies*. Simon and Schuster.

Wesley Schultz, P., & Zelezny, L. (1999). Values as predictors of environmental attitudes: Evidence for consistency across 14 countries. *Journal of Environmental Psychology*. https://doi.org/10.1006/jevp.1999.0129

Wilson, M., & Green, J. (2000). The feasibility of introducing solar ovens to rural women in Maphephethe. *Journal of Family Ecology and Consumer Sciences /Tydskrif Vir*

Gesinsekologie En Verbruikerswetenskappe, *28*(1), 54–61. https://doi.org/10.4314/jfecs.v28i1.52793

Witmer, A. (2018). Contextual Engineering To Address Preservation Of Rural Societies. *Journal of Academic Perspectives*, *3*(1).

Wolf, J., Mäusezahl, D., Verastegui, H., & Hartinger, S. M. (2017). Adoption of clean cookstoves after improved solid fuel stove programme exposure: A cross-sectional study in three peruvian andean regions. *International Journal of Environmental Research and Public Health*, *14*(7). https://doi.org/10.3390/ijerph14070745

Women's Refugee Commission, & World Food Programme. (2010). *Cooking fuel needs in Haiti: A rapid assessment*.

Wood, W., Quinn, J. M., & Kashy, D. A. (2002). Habits in everyday life: Thought, emotion, and action. *Journal of Personality and Social Psychology*. https://doi.org/10.1037/0022-3514.83.6.1281

Wood, W., Tam, L., & Witt, M. G. (2005). Changing circumstances, disrupting habits. *Journal of Personality and Social Psychology*. https://doi.org/10.1037/0022-3514.88.6.918

World Bank. (2011). *Household cookstoves, environment, health, and climate change: a new look at an old problem.*

World Bank. (2018). *Poverty and shared prosperity*. https://doi.org/10.1596/978-1-4648-0958-3

World Bank. (2019). *Country and Lending Groups*. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

World Health Organization. (2016). World Health Statistics: monitoring health for the SDGs, sustainable development goals. Geneva, Switzerland. In *World Health Statistics: monitoring*

health for the SDGs, sustainable development goals. Geneva, Switzerland.

Wrangham, R. (2009). *Catching fire: How cooking made us human*. Basic Books.

Yadama, G. (2013). *Fires, fuel, and the fate of 3 billion: the state of the energy impoverished*. Oxford University Press.

Zelezny, L. C. (1999). Educational interventions that improve environmental behaviors: A meta-analysis. *Journal of Environmental Education*. https://doi.org/10.1080/00958969909598627

Zukin, C., Keeter, S., Andolina, M., Jenkins, K., & Carpini, M. (2006). *A new engagement?: Political participation, civic life, and the changing American citizen*. Oxford University Press.

Appendix A: IRB Approval

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Office of the Vice Chancellor for Research

Office for the Protection of Research Subjects
528 East Green Street
Suite 203
Champaign, IL 61820

July 27, 2016

J Bruce Elliot-Litchfield
Agricultural & Biological Engr
206 Engineering Hall
1308 West Green Street
Urbana, IL 61801

RE: *Cooking with Stored Solar Energy*
IRB Protocol Number: 17037

Dear Dr. Elliot-Litchfield:

This letter authorizes the use of human subjects in your project entitled *Cooking with Stored Solar Energy*. The University of Illinois at Urbana-Champaign Institutional Review Board (IRB) approved, by expedited review, the protocol as described in your IRB application. The expiration date for this protocol, IRB number 17037, is 07/26/2017. The risk designation applied to your project is *no more than minimal risk*.

Copies of the attached date-stamped consent form(s) must be used in obtaining informed consent. If there is a need to revise or alter the consent form(s), please submit the revised form(s) for IRB review, approval, and date-stamping prior to use.

Under applicable regulations, no changes to procedures involving human subjects may be made without prior IRB review and approval. The regulations also require that you promptly notify the IRB of any problems involving human subjects, including unanticipated side effects, adverse reactions, and any injuries or complications that arise during the project.

If you have any questions about the IRB process, or if you need assistance at any time, please feel free to contact me at the OPRS office, or visit our website at https://www.oprs.research.illinois.edu.

Sincerely,

LeaAnn Carson

LeaAnn Carson, MS

OPRS Specialist

Attachment(s)

c: Keilin Jahnke
Samantha Lindgren

UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Office of the Vice Chancellor for Research
Office for the Protection of Research Subjects
805 West Pennsylvania Ave
Urbana, IL 61801

June 26, 2017

J Bruce Elliott-Litchfield
Agricultural & Biological Engr
345 Coordinated Science Lab
1308 West Main St
Urbana, IL 61801

RE: *Cooking with Stored Solar Energy in Educational Settings*
IRB Protocol Number: 17844

Dear Dr. Elliott-Litchfield:

This letter authorizes the use of human subjects in your project entitled *Cooking with Stored Solar Energy in Educational Settings.* The University of Illinois at Urbana-Champaign Institutional Review Board (IRB) approved, by expedited review, the protocol as described in your IRB application. The expiration date for this protocol, IRB number 17844, is 06/25/2020. The risk designation applied to your project is *no more than minimal risk.*

Copies of the attached date-stamped consent form(s) must be used in obtaining informed consent. If there is a need to revise or alter the consent form(s), please submit the revised form(s) for IRB review, approval, and date-stamping prior to use.

Under applicable regulations, no changes to procedures involving human subjects may be made without prior IRB review and approval. The regulations also require that you promptly notify the IRB of any problems involving human subjects, including unanticipated side effects, adverse reactions, and any injuries or complications that arise during the project.

You were granted a three-year approval. If there are any changes to the protocol that result in your study becoming ineligible for the extended approval period, the RPI is responsible for immediately notifying the IRB via an amendment. The protocol will be issued a modified expiration date accordingly.

If you have any questions about the IRB process, or if you need assistance at any time, please feel free to contact me at the OPRS office, or visit our website at https://www.oprs.research.illinois.edu.

Sincerely,

Michelle Lore

Michelle Lore, MS
Human Subjects Research Specialist, Office for the Protection of Research Subjects

Attachment(s): 1 Research Team Attachment, 4 Consent Forms

c: Keilin Jahnke
Samantha Lindgren

Appendix B: Study Permissions from the Republic of Namibia

REPUBLIC OF NAMIBIA

MINISTRY OF EDUCATION, ARTS AND CULTURE

Tel: (061) 2933276
Fax: (061) 2933922
Enquiries: Loide Kapenda
Email: Loide.Kapenda@moe.gov.na

Luther Street, Govt. Office Park
P/Bag 13186
WINDHOEK

TO: Ms Victoria Keding
Director
NaDEET

Dear Ms Keding

SUBJECT: PERMISSION TO CONDUCT RESEARCH IN HARDAP AND ERONGO REGIONS

Your letter with the above subject was received and your request to conduct research and interview at schools in Erongo and Hardap region has a blessing of our office. The Ministry of Education, Arts and Culture would need to be informed in the form of the report submission after the completion of this research.

The Directors of the regions where this activity will take place are informed by copy of this letter. Your team should report to the offices of the Directors before the commencement of the research.

The Ministry wish you well in your endeavor to complete this activity.

Yours Sincerely,

Sanet L. Steenkamp
EXECUTIVE DIRECTOR

Ministry of Education, Arts and Culture
Office of the Executive Director
2019 -05- 15
Tel: 061-2933923/4
Fax: 061-253671
Private Bag 13186, Windhoek, Namibia

CC: 1. Director of Education Arts and Culture: Erongo Region
2. Director of Education, Arts and Culture: Hardap Region

All official correspondences should be addressed to the Executive Director

FORM RST/4

NATIONAL COMMISSION ON RESEARCH, SCIENCE AND TECHNOLOGY

RESEARCH, SCIENCE AND TECHNOLOGY ACT, 2004

RESEARCH PERMIT FOR NON-NAMIBIAN-BASED RESEARCH INSTITUTE/PERSON

(Section 21 and Regulation 22)

Permit Number
RPIV00452018

Name of Non-Namibian-based Research Institute/Person: Samantha Anne Lindgren	**Physical Address:** 810 West White Street, Champaign, IL 61820, USA		
Issue Date: 12 November 2018	**Commence Date:** January 15, 2019		
Termination Date: 30 June 2019	**Sample Taking Authorised:**	YES ☐	NO ☑
Type of Research Authorised The Role of Youth in the Advancement of Sustainable Energy Non Commercial research and the use of the resources be limited to what is specified in the research proposal.			
Type and Size of Sample Taking Authorised N/A			
Locations Authorised for Research and /or Sample Taking NamibRand Nature Reserve			
Intended Use of Samples N/A			
Responsible Person: Samantha Anne Lindgren	**Contact No:** +12175509689		

Signed on behalf of the National Commission on Research, Science & Technology

Official Stamp of the National Commission on Research, Science & Technology

National Commission on Research, Science & Technology
12 DEC 2018
P/Bag 13253
Windhoek, Namibia

Appendix C: Community Consent Document

ILLINOIS

COLLEGE OF EDUCATION

Responsible Principal Investigator: Dr. Bruce Elliott-Litchfield

Other Investigator(s): Samantha Lindgren, Viktoria Keding, Geovanna Iipinge, Kevin Booysen

Purpose of the Study: The purpose of this study is to gather information about your thoughts regarding the environment and energy use.

Procedures to be followed: Researchers will be visiting your home as part of this research study. You will be given a short survey in which a member of the research team will ask you questions about your household, including the ages, education of each person in your household. The researcher will ask you about your current cooking habits including how often you cook, the types of food you cook, and the fuel and utensils you use to cook. Your name will not be used on the survey.

Discomforts and Risks: Some people feel discomfort when talking aloud about their household, family and personal background. The answers we are seeking are simply your opinions and so you should not feel anxious if you do not have an answer for a survey or interview question. However, if the interview causes you stress, you always have the option to stop the activity.

Benefits: Participants often find sharing their opinions enjoyable. We expect that you will enjoy participating in this research project, which seeks to better understand environmental topics of importance in your community.

Statement of Confidentiality: Your name will not be associated with any of the data that we collect in this study. However, we would like to audio record the interviews and surveys, as well as to take photographs of your stove(s). Faculty, students and staff who may see your information will maintain confidentiality to the extent of laws and university policies. Personal identifiers will not be published or presented.

Whom to contact: Samantha Lindgren at salindgr@illinois.edu or call +1 217 550 9689. Please contact Ms. Lindgren with any questions or concerns about the research. If you have any questions about your rights as a participant in this study or any concerns or complaints, please contact the University of Illinois Institutional Review Board at +1 217 333 2670 (collect calls will be accepted if you identify yourself as a research participant) or via email at irb@illinois.edu.

Voluntariness: Participation in this study is voluntary and you may discontinue at any time without any penalty.

University of Illinois at Urbana-Champaign
Institutional Review Board
Approved: 6-20-2017
Expires: 6-19-2020
IRB #: 17037

Appendix D: Community Household Survey

Household Questionnaire[5]

A. Participant Identification		
A1	Date [dd-mm-yy]	
A2	Time of visit [hh:mm] 24-hr time	
A3	Household ID [Town Letter, Segment #, House #]	
A4	GPS coordinates of house	
A5	Town	
A6	First name of main cook	
A7	Language of Interview	

A.1 Consent	
Consent Received	☐ Yes ☐ No
Audio Consent Received	☐ Yes ☐ No

A.2 Child Questionnaire	
Child Questionnaire(s)	☐ Yes ☐ No
Parent/Adult Consent Received	☐ Yes ☐ No
Child Assent Received	☐ Yes ☐ No
Child Questionnaire(s) Numbers	

A.3 Photos		
Dwelling Exterior	☐ Yes ☐ No	Image #s:
Kitchen Area(s)	☐ Yes ☐ No	Image #s:
Traditional Stove(s)	☐ Yes ☐ No	Image #s:
Efficient Stove(s)	☐ Yes ☐ No	Image #s:

[5] This document, as well those that follow in subsequent appendices, were formatted to be printed on A4 paper which is the default size in Namibia. Tables are split across pages in this document to accommodate the smaller US letter paper size.

Solar Oven/Stove(s)	□ Yes □ No	Image #s:

B.1 Primary Cook					
ID	**Relationship to Head of Household** 1: Head of House 2: Wife 3: Co-wife 4: Mother-in-law 5: Daughter/in-law 6: Sister/-in-law 7: Son/in-law 8. Niece/Nephew 99: Other (describe)	**Sex** 1: M 2: F	**Age** Years	**Highest Level of Education** 0: None 1: Primary [grade:] 2: Secondary [grade:] 3: College 4: Graduate School 99: Other (describe)	**Attended a session at NaDEET?** 1: Yes 2: No [Record Date/Year if known]

B.2 Other Household Residents					
ID	**Relationship to Head of Household** 1: Head of House 2: Wife 3: Co-wife 4: Mother-in-law 5: Daughter/in-law 6: Sister/-in-law 7: Son/in-law 8. Niece/Nephew 99: Other (describe)	**Sex** 1: M 2: F	**Age** Years	**Highest Level of Education** 0: None 1: Primary [grade:] 2: Secondary [grade:] 3: College 4: Graduate School 99: Other (describe)	**Attended a session at NaDEET?** 1: Yes 2: No [Record Date/Year if known]
B2.1					
B2.2					
B2.3					
B2.4					
B2.5					
B2.6					
B2.7					
B2.8					
B2.9					
B2.10					
B2.11					
B2.12					

B.3 NaDEET [only if a household member(s) has been to NaDEET]		
B.3	What do you remember about what you (or your family member) learned at NaDEET?	

C. Household Background Information			
C.1	Who is the primary income earner in the household?	Use row number from B.2 above:	
C.2	What type of work provides the **main source of income** in the household at this time of year?	No one in this house works	1
		Self-employed in agriculture	2
		Self-employed in non-agriculture	3
		Paid wages in agriculture	4
		Paid wages in non-agriculture	5
C.3	If **main source of income** is not agriculture, please state what type of work is carried out.		
C.4	Do you grow any of your own food?	Yes	1
		No	2

C.5	What do you do with your rubbish?	It gets collected weekly/regularly	1
		We burn it	2
		We have a rubbish pile	3
		We take it to the dump	4
		Other (describe):	99
C.6	What do you do with food scraps?	Put with rubbish	1
		Feed to animals	2
		Compost	3
		Other (describe):	99
C.7	From where do you get your water?	Inside tap	1
		Private outside tap/well on property	2
		Community tap/well/tank	3
		Community well	4
		Other (describe):	99
C.8	Do you conserve or save water? How?		

C.9	What are the sources of energy that you use for **lighting** your home?		**Primary Energy Source**	**2nd Energy Source**	**Days per week used**	**Hours per day used**
		Wood	1	1		
		Candles	2	2		
		Kerosene lamps	3	3		
		Solar (lantern or other)	4	4		
		Wind up torch/lamp	5	5		
		Chargeable torch/lamp	6	6		
		Electricity (connection to grid)	7	7		
		Electricity (generator)	8	8		
		No secondary source		88		
		Other (Describe)	99	99		

C.10	Does this house have access to electricity?	Yes	1
		No (go to section D)	2
C.11	What is the **main** source of electricity?	Grid (pre-pay box)	1
		Grid (post-pay)	2
		Own Generator	3
		Solar Panel	4
		Other (describe):	99

C.12	If you purchase electricity, how much do you typically pay at this time of the year?	Cost	Per (Circle one)			
			Day	Week	Month	Year

C.13	Do you own any of the following electrical appliances? How often?	**Own?** 1 = Yes 2 = No	**Times Used**	**How often?**			
	Electrical fan			Day	Week	Month	Year
	Mobile phone charger			Day	Week	Month	Year
	Electric heater			Day	Week	Month	Year
	Refrigerator			Day	Week	Month	Year
	Television			Day	Week	Month	Year
	Radio			Day	Week	Month	Year
	Torch charger			Day	Week	Month	Year
	Computer			Day	Week	Month	Year
	Other: (describe)			Day	Week	Month	Year

D. Cooking Fuel Information				
D.1	What type of fuel do you use ***the most*** to cook?		**Primary Cooking Fuel**	**Other Fuels Used**

			(circle one)	(circle all)
		Wood	1	1
		Propane/LPG	2	2
		Charcoal	3	3
		Dung	4	4
		Electricity	5	5
		Other:	99	99
D.2	Why do you use this type of fuel **the most**?			
D.3	Do you collect or purchase your cooking fuel?	Collect (e.g. firewood)		1
		Purchase (Go to D.7)		2
D.4	Who collects the fuel?	[use row numbers from B.2]		
D.5	How do you feel about time spent collecting fuel?	It is a serious burden		1
		It is a nuisance		2
		Neutral		3
		Enjoys a little		4
		Enjoys a lot		5
D.6	How much time do you or someone who lives in our home spend collecting or buying fuel, (per day or per week)?			
D.7	Is fuel collected with other people from other households? Who (e.g. female family/friends, children, etc.)?			
D.8	How enjoyable is spending time collecting or buying fuel with other people?	Not at all		1
		Not very		2
		Neutral		3
		Somewhat		4
		Very		5
		Doesn't do this with other people		0
D.9	In your opinion, what is the best fuel for cooking?	Wood		1
		Gas/LPG		2
		Charcoal		3
		Dung		4
		Electricity		5
		Other (describe):		99
D.10	Have you ever used recycled firebricks (fireballs) for fuel?	Yes		1
		No (Skip to D.14)		2
D.11	Where did you get the recycled firebricks?	She/family member made them at home		1
		Bought them		2
		Child made them at school		3
		She/family member made at NaDEET		4
		Other (describe):		99
D.12	Where did you first hear about firebricks?	Adult family member		1
		Child		2
		Workshop or Training Program		3
		NaDEET		4
		Other (describe):		99
D.13	Have you ever made a firebrick? If yes, What material do you use to make firebricks?	Yes		1
		No		2
		Material Used:		
D.14	What kind of fuel do you use to **heat** your home?		**Primary Source**	**2nd Source**
		Wood	1	1
		Propane/LPG	2	2
		Charcoal	3	3
		Dung	4	4
		Electricity	5	5
		Other (describe):	99	99

E. Cooking Preferences			
E.1	Where do you do most of your cooking?	Separate building (separate from main house)	1

		Separate kitchen attached to main house	2
		Indoors in separate room for cooking, enclosed with walls/door	3
		Inside main living area of house	4
		Outside under a porch attached to house	5
		Outside in an uncovered area/yard/courtyard	6
		Other (describe):	99
E.2	Do you cook with an open fire/traditional stove?	Yes	1
		No	2
E.3	How much do you like cooking on a traditional stove or open fire?	She does not like it	1
		She does not like it but thinks it is convenient for some tasks	2
		She is indifferent (she does not like or dislike it)	3
		She likes it but acknowledges some problems	4
		She likes it very much	5
E.4	Where is your open fire/traditional stove?	She does not use a traditional stove	1
		Outdoors	2
		Outside under a roof with 1 or 2 walls	3
		Indoors	4
E.5	Has your open fire/traditional stove always been located here?	Yes	1
		No [ask why stove moved]	2
		Reason stove moved:	

E.6	How often do you cook with an open fire/traditional stove?	**Times (#)**	**Frequency (circle one)**			
			Per Day		Per Week	Per Month
E.7	What other kinds of stove(s) do you use? **Satisfaction:** 1: none 2: low 3: satisfaction 4: good 5: very good	**Stove Type**	**Own? 1: Yes 2: No**	**How many days/wk?**	**Satisfaction**	**Would you purchase it again?**
		Efficient Cookstove				
		Solar Oven (Box)				
		Solar (Parabolic)				
		LPG Stove				
		Electric Cooker				
		Other:				

E.8	Where can you purchase an efficient stove?	Local store	1
		Market	2
		Store in nearby town/city (name):	3
		Other (describe):	99
E.10	If you were interested in purchasing a new stove, who would you discuss it with? [Use row numbers from B.2]		
E.9	[Ask if children in household]:Would you discuss it with the children in the household?	Yes	1
		No	2
		Maybe	3
E.11	Who would make the decision about whether to purchase an efficient stove?	Self	1
		Head of Household	2
		Jointly with Head of Household	3
		Other (describe):	99

For Interviewer:

1) *Ask to see the traditional stove/kitchen and take photo of stove(s) in-situ.*
2) *Where is the traditional stove located? [Circle one]*

By window	*By door to outside*	*In hearth*	*In hearth, with chimney*	*Other:*

F. Ask only if they own an Efficient Cookstove		
F.1	What do you cook on your efficient cookstove? [If she uses more than one, ask her which she uses the	

	most often and make a note of which one it is].		
F.2	Can you cook your entire meal on this cookstove?	Yes	1
		No	2
F.3	Have you noticed any changes in your family's health since you started using the efficient stove? [If she uses more than one, ask about the one used **most often**]	Yes	1
		Maybe	2
		No	3
F.4	Does the efficient cookstove save fuel? [If she uses more than one, ask about the one used **most often**]	No fuel savings	1
		A little fuel savings	2
		Some savings	3
		Impressed with fuel savings	4
		Very impressed with fuel savings	5
F.5	Is smoke in the cooking area an important concern to you?	Very unimportant	1
		Unimportant	2
		Somewhat important	3
		Very important	4
F.6	Did your efficient stove come with an instruction manual?	Yes	1
		No	2
F.7	From where did you get your efficient cookstove?		
F.8	Were you trained on how to use your efficient cookstove? By whom?	Yes	1
		No	2
F.9	Why did you decide to get/buy an efficient stove?		

For Interviewer:

1) *Ask to see the efficient cookstove/kitchen and take photo of stove(s) in-situ.*
2) *What is the condition of the clean cookstove(s)? [Circle one based on your observation]*
3) *Where is it located?*

Destroyed or in disuse	*With modification that impair its performance*	*With modifications that do not impair its performance*	*Working with low maintenance*	*Perfect with good maintenance*

G. Ask only if they own a Solar Cooker			
G.1	What do you cook with your solar cooker?		
G.2	Can you cook your entire meal with this solar cooker?	Yes	1
		No	2
G.3	Have you noticed any changes in your family's health since you started using the solar cooker? [If she uses more than one, ask about the one used most often]	Yes	1
		Maybe	2
		No	3
G.4	Does the solar cooker save fuel? [If she uses more than one, ask about the one used most often]	No fuel savings	1
		A little fuel savings	2
		Some savings	3
		Impressed with fuel savings	4
		Very impressed with fuel savings	5
G.5	Is smoke in the cooking area an important concern to you?	Very unimportant	1
		Unimportant	2
		Somewhat important	3
		Very important	4
G.6	Did your solar cooker come with an instruction manual?	Yes	1
		No	2
G.7	From where did you get your solar cooker?		
G.8	Were you trained on how to use your solar cooker? By whom?	Yes	1
		No	2

For Interviewer:

1) *Ask to see the solar cooker and kitchen and take photo of cooker(s) in-situ.*
2) *What is the condition of the solar cooker(s)? [Circle one based on your observation]*
3) *Where is it located?*

Destroyed or in disuse	*With modification that impair its performance*	*With modifications that do not impair its performance*	*Working with low maintenance*	*Perfect with good maintenance*

H. Environment Questions						
I am now going to ask you how much you agree or disagree with some statements. There is no correct answer. Please tell me if you strongly agree, agree, feel neutral, disagree, strongly disagree. [Circle **one** answer that most closely aligns to response. Answer any clarifying questions]						
		Strongly Disagree	**Disagree**	**Unsure/ Neutral**	**Agree**	**Strongly Agree**
H.1	We are approaching the limit of the number of people the Earth can support	1	2	3	4	5
H.2	Humans have the right to modify the natural environment to suit their needs.	1	2	3	4	5
H.3	When humans interfere with nature it often produces disastrous consequences.	1	2	3	4	5
H.4	Human ingenuity/cleverness will insure that we do NOT make the earth unlivable	1	2	3	4	5
H.5	Humans are severely abusing the environment	1	2	3	4	5
H.6	The earth has plenty of natural resources if we just learn how to develop them	1	2	3	4	5
H.7	Plants and animals have as much right as humans to exist	1	2	3	4	5
H.8	The balance of nature is strong enough to cope with the impacts of modern industrial nations	1	2	3	4	5
H.9	Despite our special abilities, human are still subject to the laws of nature	1	2	3	4	5
H.10	The so-called "ecological crisis" facing humankind has been greatly exaggerated	1	2	3	4	5
H.11	The earth is like a spaceship with very limited room and resources	1	2	3	4	5
H.12	Humans were meant to rule over the rest of nature	1	2	3	4	5
H.13	The balance of nature is very delicate and easily upset	1	2	3	4	5
H.14	Humans will eventually learn enough about how nature works to be able to control it	1	2	3	4	5
H.15	If things continue on their present course, we will soon experience a major ecological catastrophe	1	2	3	4	5

I. Solar Cooking Questions						
I am now going to ask you how much you agree or disagree with some statements. There is no correct answer. [Answer any clarifying questions]						
		Strongly Disagree	**Disagree**	**Unsure**	**Agree**	**Strongly Agree**
I.1	Solar cooker usage can solve energy problems	1	2	3	4	5
I.2	Solar cooker usage can reduce time spent on cooking	1	2	3	4	5
I.3	Solar cooking is more economical than all other types of energy in Namibia	1	2	3	4	5
I.4	Solar cookers can cook all types of food	1	2	3	4	5
I.5	Solar cookers are durable	1	2	3	4	5
I.6	Solar cookers are accepted in my culture	1	2	3	4	5
I.7	Solar cookers are easily available	1	2	3	4	5
I.8	Solar cookers do not burn food	1	2	3	4	5
I.9	Solar cookers are affordable	1	2	3	4	5
I.10	Energy from the sun can be used for cooking	1	2	3	4	5

J. Global Warming Questions **[Read answer choices for each question]**					
J.1	How much do you think global warming will harm future generations of people?	Not at all	Only a little	A moderate amount	A great deal

J.2	How important is the issue of global warming to you personally?	Not too important	Somewhat important	Very important	Extremely important
J.3	How worried are you about global warming?	Not very	Somewhat	Very worried	
J.4	How much do you think global warming will harm you personally?	Not at all	Only a little	A moderate amount	A great deal

K. Closing

1) Is there anything else that you would like to tell us about your family and how you cook, use energy or water?
2) Are there any children who would like to answer a couple of questions, it will take 3-5 minutes?
3) Any questions? Thank you for your time!

Appendix E: Youth Study Consent Documents

Dear Teacher,

Re: Instructions for EE/ESD Surveys

We are from the Namib Desert Environmental Education Trust (NaDEET) and the University of Illinois and we are writing to you because your learners will soon be attending a session at NaDEET Centre. We are conducting on how children's attitudes and beliefs about the environment and sustainability change as a result of their time at NaDEET Centre. Your principal/director has already been informed about this research via letter.

Overview of Research:
Learners will take a brief survey, three times:

- 1-2 weeks *before* their week at NaDEET Centre,
- *after* their week at NaDEET Centre,
- and *six months later*

Participating Learners:

- The entire class of learners scheduled to attend NaDEET Centre (even those who are unable to attend)
- One class of children in the grade below
    - For example, if Grade 6 attends NaDEET Centre, the survey should be given to Grade 5 and Grade 6 learners

This study has been approved by the Ministry of Education, Arts and Culture and the University of Illinois Institutional Review Board. A research permit for this study has been obtained from the National Commission on Research Science and Technology.

Thank you for helping us evaluate the impact of EE/ESD!
We look forward to seeing you at NaDEET Centre!

Sincerely,

Viktoria Keding, MsC
Director, NaDEET
vkeding@nadeet.org

Samantha Lindgren, M.Ed.
University of Illinois, Urbana-Champaign, USA
salindgr@illinois.edu

This package contains materials for two classes of learners: the learners who will be attending NaDEET Centre and the learners in the grade below. (For instance, if Grade 6 will attend NaDEET, then both Grade 5 *and* Grade 6 learners must complete the surveys). Please review the contents of this package and ensure that you received all of the materials.

Package Contents:

- Survey Instructions for Teachers (x2)
- Teacher Consent Forms (x2)
- 3-page Pre-Survey (enough for both grades)
- 3-page Post-Survey (enough for grade attending NaDEET Centre)
- 2-page Post-Survey (enough for grade below)
- Pre-Paid Nampost Courier Easy Pack

Teacher Instructions:

One Week (or More) Before NaDEET Visit

- ☐ Give each learner a copy of the 3-page Pre-Survey
- ☐ Read Instructions to learners (next page)
- ☐ Learners complete Pre-Survey
- ☐ Collect Pre-Surveys, checking to ensure learners answered all questions
- ☐ Teacher records each learner's name on the Teacher Consent Form
- ☐ Store Pre-Surveys in a secure location

The Week After NaDEET Visit

For the Grade that Attended NaDEET:

- ☐ Give each learner a copy of the 3-page Post-Survey
    - If a learner missed the NaDEET Centre trip, he/she does not need to complete the last page of this survey
- ☐ Read the introduction statement to the learners (next page)
- ☐ Learners complete Post-Survey
- ☐ Collect Post-Surveys, checking to ensure learners answered all questions

For the Grade Below:

- ☐ Give each learner a copy of the 2-page Post-Survey
- ☐ Read introduction statement to learners (next page)
- ☐ Learners complete Post-Survey
- ☐ Collect Post-Surveys, checking to ensure learners answered all questions

Return Surveys via Nampost Courier

- ☐ Place all Materials in the pre-paid Easy Pack:
    - Pre- and Post-Surveys for both grades
      (It is helpful if the surveys are sorted by learner, but not necessary)
    - Any unused surveys
    - Teacher Consent Forms for both grades
- ☐ Drop off or schedule a Nampost Courier Collection

In Six Months:

The Follow-Up Surveys will be sent to you via Nampost Courier in six months, following this same process.

Survey Instructions

1. **Teachers**: Please read the following out loud to your learners before giving them a copy of the survey. You may read this in English and/or in your learners' primary language/mother tongue.

"You are invited to participate in a research study being conducted by the Namib Desert Environmental Education Trust (NaDEET) and the University of Illinois Urbana- Champaign in the United States. This study will take approximately 10 minutes of your time. You will be asked to complete a survey about your thoughts about the environment.

Your decision to participate in this study is completely voluntary and you have the right to stop participating at any time without penalty. You may skip any questions you do not wish to answer. If you want do not wish to complete this survey, do not write on it. If there is a word or a question that you do not understand, you can ask your teacher what it means. There are no right or wrong answers.

Although your participation in this research may not benefit you personally, it will help us understand how youth, like yourself, feel about environmental topics. There are no risks for participating in this survey. Your decision to participate, decline, or withdraw from participation will have no effect on your current status or future relationship with NaDEET, the University of Illinois, or your teachers and school.

We will keep your answers private. Once we have collected your surveys, your name will be removed, and will not be used in any report.

If you feel that you have been not treated well by this research you may call the Office for the Protection of Research Subjects (OPRS) at +1 217 333 2670 or e-mail OPRS at irb@illinois.edu

If you have questions about this research, please contact Samantha Lindgren at +1 217 244 6477 or by e-mail at salindgr@illinois.edu"

2. **Teachers:** Please give each learner a copy of the survey. Allow learners time to complete the survey, 10-15 minutes.

   You may read the questions out loud to the learners, if you wish, in English and/or their primary language/mother tongue. If the learners have a question about a word or phrase on the survey, you may explain it to the child, but please do not tell them which answer choice to select. There are no correct or incorrect answers.

   Children should not talk to each other while completing the survey.

3. Please collect and safely store all surveys. Once surveys are collected, the learners **may not** see them again nor make changes to them.

4. **Return *both* the Pre- and the Post-Surveys for both grades *after* the NaDEET Centre visit, in the same Easy Pack envelope. Please return any unused surveys.**

ILLINOIS

COLLEGE OF EDUCATION

I give permission for my learners to participate in this research project.
Names of learners participating:

1. ……
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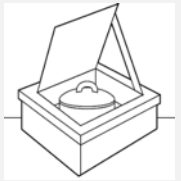
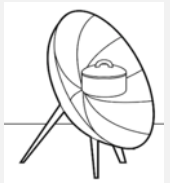
…… ……..…… ……
Teacher's name (print) Teacher's signature Date

Appendix F: Youth Pre-Camp Questionnaire

First Name: Surname: Teacher Surname:

Please mark one answer choice for each question.		
1	Grade	☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11
2	Age	☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17 ☐ 18
3	Gender	☐ Male ☐ Female
4	How many children (including you) live in your house?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ More than 6
5	How many adults live in your house?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ More than 6
6	Have you ever been to NaDEET Centre before?	☐ Yes ☐ No
7	When have you been to NaDEET Centre before?	☐ Grade 3 ☐ Grade 4 ☐ Grade 5 ☐ Grade 6 ☐ Grade 7 ☐ Grade 8 ☐ Grade 9 ☐ Never
8	Has anyone in your family been to NaDEET Centre before?	☐ Yes ☐ No
	If yes, who?	☐ Parent ☐ Brother ☐ Sister ☐ Uncle/Aunt ☐ Other
9	Does your family grow any of its own food?	☐ Yes ☐ No
10	What does your home do with rubbish? Check all that apply.	☐ It gets collected every week ☐ We have our own rubbish pile outdoors ☐ We burn our rubbish outdoors ☐ We burn our rubbish for cooking fuel ☐ We take our rubbish to the dump ☐ Other:
11	What does your family do with food scraps?	☐ It is rubbish ☐ Feed to our animals ☐ Compost ☐Other:
12	Does your home have electricity?	☐ Yes ☐ No
13	Does your home have a water tap indoors?	☐ Yes ☐ No

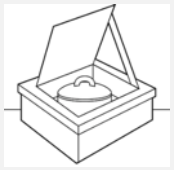
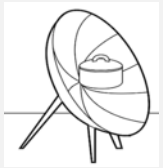
14	How worried are you about plastic and other rubbish?	☐ A lot ☐ A little ☐ Not at all
15	What do you do at home to save water?	
16	Is there recycling at your school?	☐ Yes ☐ No ☐ Unsure

Please mark one answer choice for each question.		
1	Who does most of the cooking at your home?	☐ Mother ☐ Father ☐ Grandmother ☐ Grandfather ☐ Sister ☐ Brother ☐ Someone Else ☐ Myself
2	How often do you help cook meals at home?	☐ Every day ☐ Several times a week ☐ Several times a month ☐ Rarely ☐ Never
3	How enjoyable do you find cooking meals? Circle one.	
4	Circle all of the stoves that you have at your house.	 Open Fire  Fuel-Efficient Stove  Electric Stove  Gas Stove  Solar Oven  Parabolic Solar
5	Which type of stove does your family use the **most**?	☐ Open Fire ☐ Fuel-Efficient Stove ☐ Solar Oven ☐ Electric Stove ☐ Gas Stove ☐ Solar Parabolic
6	Do you collect firewood for your family?	☐ Yes ☐ No
7	How often do you collect firewood?	☐ Every day ☐ Several times a week ☐ Several times a month ☐ Rarely ☐ Never
8	Do other people in your family collect firewood? If yes, who?	☐ Yes ☐ No ☐ Parent ☐ Brother ☐ Sister ☐ Uncle/Aunt ☐ Other

9	How enjoyable do you find collecting firewood? Circle one.	
10	Have you ever used a solar cooker before?	☐ Yes ☐ No
	If yes, where?	☐ Home ☐ School ☐ Friend/family member's home ☐ Other
11	Have you ever used a recycled firebrick or fireball?	☐ Yes ☐ No
12	In your opinion what is the best cooking fuel?	☐ Wood ☐ LPG/Gas ☐ Charcoal ☐ Animal dung ☐ Electricity ☐ Solar ☐ Recycled material ☐Other:

For each statement below, mark one box to state how you much you agree with the statement. There are no right or wrong answers.						
		 **Strongly Agree**	 **Agree**	 **Neither Agree nor Disagree**	 **Disagree**	 **Strongly Disagree**
1	Plants and animals have as much right as people to live.	☐	☐	☐	☐	☐
2	There are too many (or almost too many) people on earth.	☐	☐	☐	☐	☐
3	People are clever enough to keep from ruining the earth.	☐	☐	☐	☐	☐
4	People must still obey the laws of nature.	☐	☐	☐	☐	☐
5	When people mess with nature it has bad results.	☐	☐	☐	☐	☐
6	Nature is strong enough to handle the bad effects of our modern lifestyle.	☐	☐	☐	☐	☐
7	People are supposed to rule over the rest of nature.	☐	☐	☐	☐	☐
8	People are treating nature badly.	☐	☐	☐	☐	☐
9	People will someday know enough about how nature works to be able to control it.	☐	☐	☐	☐	☐
10	If things don't change, we will have a big disaster in the environment soon.	☐	☐	☐	☐	☐
11	Using a solar cooker can solve energy problems.	☐	☐	☐	☐	☐
12	Using a solar cooker can reduce time spent on cooking.	☐	☐	☐	☐	☐
13	Solar cooking costs less money than all other types of energy in Namibia.	☐	☐	☐	☐	☐
14	Solar cookers can cook all types of food.	☐	☐	☐	☐	☐
15	Solar cookers are durable.	☐	☐	☐	☐	☐
16	Solar cookers are accepted in my culture.	☐	☐	☐	☐	☐
17	Solar cookers do not burn food.	☐	☐	☐	☐	☐
18	Energy from the sun can be used for cooking.	☐	☐	☐	☐	☐
19	There is a water crisis in Namibia.	☐	☐	☐	☐	☐
20	Having the opportunity to go to NaDEET Centre is important to me.	☐	☐	☐	☐	☐

Appendix G: Youth Post-Camp Questionnaire

Please mark one answer choice for each question.		
1	What does your home do with rubbish? Check all that apply.	☐ It gets collected every week ☐ We have our own rubbish pile outdoors ☐ We burn our rubbish outdoors ☐ We burn our rubbish for cooking fuel ☐ We take our rubbish to the dump ☐ Other:
2	How worried are you about plastic and other rubbish?	☐ A lot ☐ A little ☐ Not at all
3	What do you do at home to save water?	
4	What does your family do with food scraps?	☐ It is rubbish ☐ Feed to our animals ☐ Compost ☐Other:
5	How often do you help cook meals at home?	☐ Every day ☐ Several times a week ☐ Several times a month ☐ Rarely ☐ Never
6	How enjoyable do you find cooking meals? Circle one.	
7	Circle all of the stoves that you have at your house.	 Open Fire  Fuel-Efficient Stove  Electric Stove  Gas Stove  Solar Oven  Parabolic Solar

8	Which type of stove does your family use the **most**?	☐ Open Fire ☐ Fuel-Efficient Stove ☐ Solar Oven ☐ Electric Stove ☐ Gas Stove ☐ Solar Parabolic
9	Do you collect firewood for your family?	☐ Yes ☐ No
10	How often do you collect firewood?	☐ Every day ☐ Several times a week ☐ Several times a month ☐ Rarely ☐ Never
11	Do other people in your family collect firewood?	☐ Yes ☐ No
	If yes, who?	☐ Parent ☐ Brother ☐ Sister ☐ Uncle/Aunt ☐ Other
12	How enjoyable do you find collecting firewood? Circle one.	
13	In your opinion what is the best cooking fuel?	☐ Wood ☐ LPG/Gas ☐ Charcoal ☐ Animal dung ☐ Electricity ☐ Solar ☐ Recycled material ☐ Other:

For each statement below, mark one box to state how you much you agree with the statement. There are no right or wrong answers.						
		 Strongly Agree	 Agree	 Neither Agree nor Disagree	 Disagree	 Strongly Disagree
1	Plants and animals have as much right as people to live.	☐	☐	☐	☐	☐
2	There are too many (or almost too many) people on earth.	☐	☐	☐	☐	☐
3	People are clever enough to keep from ruining the earth.	☐	☐	☐	☐	☐
4	People must still obey the laws of nature.	☐	☐	☐	☐	☐
5	When people mess with nature it has bad results.	☐	☐	☐	☐	☐
6	Nature is strong enough to handle the bad effects of our modern lifestyle.	☐	☐	☐	☐	☐
7	People are supposed to rule over the rest of nature.	☐	☐	☐	☐	☐
8	People are treating nature badly.	☐	☐	☐	☐	☐
9	People will someday know enough about how nature works to be able to control it.	☐	☐	☐	☐	☐
10	If things don't change, we will have a big disaster in the environment soon.	☐	☐	☐	☐	☐
11	Using a solar cooker can solve energy problems.	☐	☐	☐	☐	☐
12	Using a solar cooker can reduce time spent on cooking.	☐	☐	☐	☐	☐
13	Solar cooking costs less money than all other types of energy in Namibia.	☐	☐	☐	☐	☐
14	Solar cookers can cook all types of food.	☐	☐	☐	☐	☐
15	Solar cookers are durable.	☐	☐	☐	☐	☐
16	Solar cookers are accepted in my culture.	☐	☐	☐	☐	☐
17	Solar cookers do not burn food.	☐	☐	☐	☐	☐
18	Energy from the sun can be used for cooking.	☐	☐	☐	☐	☐
19	There is a water crisis in Namibia.	☐	☐	☐	☐	☐
20	Having the opportunity to go to NaDEET Centre is important to me.	☐	☐	☐	☐	☐

Please tell us a bit about your experience at NaDEET Centre.
List 3 things that you learned at NaDEET Centre.
What did you learn at NaDEET that you are now doing at home?
If you could visit NaDEET Centre in the future, what would you like to do again? What wouldn't you want to do again?
How would you explain NaDEET Centre to someone who has never been there?

Appendix H: NaDEET Programme Schedules

NaDEET SCHOOL Programmes: 2020

"We practice what we teach!"

Using hands-on practical learning, our school programmes challenge learners to think and live in a more sustainable way. The setting at NaDEET Centre gives learners the opportunity to practice daily what they learn in the classroom.

PARTICIPANTS

We welcome both primary and secondary school learners from grades 6-12. The recommended group size is approximately 30-40 learners with 2-3 accompanying adults.

PROGRAMME DURATION

To make the learning worthwhile we recommend a 4-day programme. It begins at 2 pm on Monday and ends at 9 am on Friday. We are open from early February to 1 December, including school holidays.

PRIMARY SCHOOL PROGRAMME

Our well established primary school programme engages young learners with the natural environment. It gives them practical experience in living a sustainable lifestyle while promoting teamwork.

SAMPLE ACTIVITIES

- Family-style solar cooking
- Water saving: Using Bucket Showers
- Recycling: The 3 Rs Game
- Measuring our Enviro Footprint
- Exploring the Namib Desert in a Dune Walk and Catch and Release Trapping

WHY BRING LEARNERS TO NaDEET?

- ◊ Do you and your learners know how to live sustainably?
- ◊ Do your learners know what their impact is on the environment?
- ◊ Do you want your learners to be able to put into practice what they learn in your classroom?

"Thanks to NaDEET I enjoyed possibly the most meaningful week of my life. To "sustain" is a word that did not come up in my vocabulary. This experience however will change a lot of wrong doings. Our kids learnt a lot and practised what we taught them throughout the grade 6 and 7 syllabi. By doing it, they will remember it." -
Teacher from Rehoboth

SECONDARY SCHOOL PROGRAMME

Our secondary school programme promotes critical and creative thinking skills in young adults regarding the environment and their personal impact on it. Through teamwork and leadership, learners gain knowledge and skills in sustainable living.

SAMPLE ACTIVITIES

- Environmental Challenge Game
- Shop Til You Drop
- Marketing Apprentice
- Biodiversity Exploration
- Family-style solar cooking

OUTPUTS

The school programmes focus on four major areas:

- Energy
- Water
- Waste
- Biodiversity

For each, learners can expect to have a better understanding of the topic and how it relates to their lives and communities. A key output of the NaDEET programme is to build skills in addressing environmental problems through improved teamwork, cooperation and leadership.

All NaDEET activities are linked to the Namibian school curriculum. This includes most subjects such as English, Maths, Sciences and Life Skills. We encourage teachers to use the NaDEET Centre programme as a continuous assessment opportunity.

COST

The cost is N$245/person/day. A four-day programme therefore costs N$980 and includes:

- **Programme**
- **Food**
- **Accommodation**

Co-sponsorship is available to learners and schools in need of financial support. The recommended lowest co-sponsorship amount is N$75/person/day.

Please contact us for more information.

Please add on t-shirts (N$110), buffs (N$90), caps (N$90) and beanies (N$90) if you are interested in getting these for each participant.

For more information or to make a reservation, please contact:
NaDEET, P.O. Box 8702 Swakopmund, Namibia
Mobile:081 367 5310 **Email:** admin@nadeet.org **Fax-to-Email:**0886552669
Website: www.nadeet.org

Primary School Sample

Winter

TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Theme	*Arrival Day*	*Our Resources: Food,*	*Our Surrounding*	*Taking Action, Improving*	*Departure Day*
6:00		Breakfast preparation	Breakfast preparation	Breakfast preparation	Breakfast preparation Pack & Load Luggage
6:15					
6:30					
BREAKFAST @ 6:45					
6:45		Breakfast	Breakfast	Breakfast	Breakfast
7:00					
7:15		Breakfast clean-up	Breakfast clean-up Weather Report	Breakfast clean-up Weather Report	Clean Centre (Group photo)
7:30					
7:45		Weather Report	Biodiversity Dune Walk	Introduction to Adaptations	
8:00					
8:15		What is the Environment?		Nocturnal Trapping: check traps (Clean traps)	Depart for Bus
8:30					
8:45		Environmental Crisis Game (Assign drama topics)			
9:00					
9:15		Family Style Solar Cooking: LUNCH		Family Style Solar Cooking: LUNCH	
9:30					
9:45		Cooking Clean Up & House Team Solar Cooking: DINNER		Cooking Clean Up & House Team Solar Cooking: DINNER	
10:00					
10:15		Snack Break		Snack Break	
10:30			Break		
10:45		Exploring Sustainable Energy		Water Is Life Part 2	
11:00			Family Style Solar Cooking: DINNER		
11:15				Super Adapted Desert Creatures	
11:30			Cooking Clean Up & House Team Solar Cooking: LUNCH		
11:45					
12:00			Water Is Life: Part 1		
12:15				Sustainable NaDEET Game	
12:30		Investigating Lightbulbs: Which ones to choose?			
12:45			Lunch		
13:00		Lunch			
13:15			Lunch clean-up	Lunch	
13:30		Lunch clean-up			
13:45			Break	Lunch clean-up	
14:00	Arrive & Walk to Centre	Break			
14:15				Break	
14:30	Intro to Accommodation		Staff & Supervisors Drama prep.		
14:45	Living Teams & Move in	Measuring our Enviro Footprint- Day 1	Measuring our Enviro Footprint- Day 2		
15:00				Recycle Rubbish from Houses	
15:15	Personal introductions, Class Teams, Attendance, SL Journals, NaDEET Presentation, Rules, Menu, Intro to Recycling & Kitchen (Assign Dune Walk groups)	Recycling @ NaDEET: Waste Management 3 R's Game	Teacher & Staff Enviro Drama	Measuring our Enviro Footprint- Day 3	
15:30					
15:45			Practicing Dramas		
16:00				Your Enviro Handprint (Dune boarding instructions)	
16:15		Fuel Efficient Stoves & Recycled Fire Balls			
16:30				Break	
16:45			Break	Dune Boarding	
17:00	Staff & Supervisors Mtg				
17:15	Break (soak paper)		Nocturnal Trapping: Set traps		
17:30		Break			
17:45					
DINNER GROUP PREPARATION STARTS @ 18:00					
18:00	Dinner group preparation	Dinner group preparation	Dinner group preparation	Dinner group preparation	
18:15	Dinner	Dinner	Dinner	Dinner	
18:30					
18:45	Dinner clean-up	Dinner clean-up (pack backpacks for Dune Walk)	Dinner clean-up	Dinner clean-up	
19:00					
19:15	Environmental Film Night: "NamibRand" and "Fire & Water" video	Africa's First International Dark Sky Reserve	Environmental Drama & The Global Goals for Sustainable Development - Introduced by Kolo Touré	Tell us what you think! Assign Cleaning Duties Collect Pouches	
19:30					
19:45					
20:00				Environmental Quiz	
20:15					
20:30					
20:45	Programme Ends				
21:00		Programme Ends	Programme Ends	Programme Ends	

Secondary School Sample

Winter

TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Theme	*Arrival Day*	*Our Changing Environment*	*Exploring Biodiversity*	*Taking Action, Improving our Environment*	*Departure Day*
5:45		Breakfast preparation	Breakfast preparation	Breakfast preparation	Breakfast preparation Pack & Load Luggage
6:00					
6:15					
		BREAKFAST STARTS @ 6:30			
6:30		Breakfast	Breakfast	Breakfast	Breakfast
6:45					
7:00		Breakfast clean-up	Breakfast clean-up	Breakfast clean-up	Clean Centre (Group photo)
7:15					
7:30		Sustainable Energy for All Access, Efficiency, Solar Park + Solar Deck	Biodiversity Dune Walk	Biodiversity Exploration: Part 2	
7:45					
8:00					Walk to & load bus
8:15					
8:30					Depart
8:45					
9:00					
9:15				Family Style Solar Cooking: LUNCH	
9:30		Snack Break			
9:45				Cooking Clean Up & House Team Solar Cooking: DINNER	
10:00		Family Style Solar Cooking: LUNCH			
10:15				Snack Break (extra snacks)	
10:30		Cooking Clean Up & House Team Solar Cooking: DINNER			
10:45			Break	NaDEET Environmental Challenge Game	
11:00		Exploring Environmental Problems and Solutions: The Environmental Problem Tree	Family Style Solar Cooking: DINNER		
11:15					
11:30			Cooking Clean Up & House Team Solar Cooking: LUNCH		
11:45					
12:00			Lunch		
12:15					
12:30			Lunch clean-up		
12:45					
13:00		Lunch	Break		
13:15					
13:30		Lunch clean-up		Lunch	
13:45					
14:00		Break		Lunch clean-up	
14:15	Arrive & Walk to Centre		Measuring our Enviro Footprint Day 2		
14:30				Break	
14:45	Welcome & Living Teams	Measuring our Enviro Footprint Day 1	Weather + Climate		
15:00	Intro to Accomodation & Move in				
15:15				Measuring our Enviro Footprint Day 3 (Dune boarding instructions)	
15:30	Consumer survey	Break	Break		
15:45	Personal introductions, Class Teams, Attendance, SL Journals, NaDEET Presentation, Rules, Menu, Intro to Recycling & Kitchen (Assign Dune Walk groups)	The Fuel Race	Biodiversity Exploration: Part 1	Break	
16:00				Dune Boarding	
16:15		3Rs: Recycled Fire Balls			
16:30					
16:45					
17:00					
17:15		Break		Break	
17:30	Staff & Supervisor Mtg		Break		
17:45	Break (Soak Paper for Fire Balls)	Dinner group preparation	Dinner group preparation	Dinner group preparation	
18:00		Dinner	Dinner	Dinner	
18:15	NRNR Film				
18:30	Dinner group preparation	Dinner Clean-up (prepare backpacks for Dune Walk)	Dinner Clean-up	Dinner Clean-up	
18:45	Dinner				
19:00		Break		Global Goals- "Tell Everyone" video + Your Eco Handprint	
19:15	Dinner Clean-up	Africa's First International Dark Sky Reserve	The Global Goals & Giraffe: Africa's Gentle Giants		
19:30				Tell us what you think! Assign Cleaning Duties Collect Pouches	
19:45	Break				
20:00	Shop Til You Drop			Enviro Quiz	
20:15					
20:30					
20:45		Programme Ends	Programme Ends		
21:00					
21:15				Programme Ends	
21:30	Programme Ends				