Exploring Fuel Stacking And Clean Fuel Access In Rural Areas Of Pakistan: A Comprehensive Review

Nabeela Farah[1]*, Saira Siddiqui[2], Dilawaiz[3], Muhammad Touseef[4]

[1]*Visiting Assistant Professor, Department of Sociology, Government College University Faisalabad, Pakistan
[2]Lecturer, Department of Sociology, Government College University Faisalabad, Pakistan
[3]Lecturer, University of Veterinary and Animal Sciences (UVAS), Lahore, Pakistan
[4]BS Research Scholar, Department of Sociology, Government College University Faisalabad

***Corresponding Author:** donia.nabeela@yahoo.com

Abstract
Providing clean energy resources in developing countries is a challenge due to limited economic opportunities. This paper examines the challenges and implications of household fuel use in developing countries, with a focus on rural areas of Pakistan. The study explores the concept of fuel stacking, where households utilize multiple fuel sources, including traditional fuels, despite improvements in income. The research highlights the health effects associated with different fuel types and emphasizes the importance of transitioning to cleaner alternatives. The paper provides a comprehensive analysis of the topic by drawing insights from various studies conducted in different countries, including Guatemala, Turkey, Tanzania, India, Nepal, and Bangladesh. This study's main purpose is to evaluate this so-called energy mix as well as the health effects of households' experience with using various fuels. So, the present study was completely based on the fuel-stacking framework and examined why women's fuel-consuming attitudes remain the same even after household economic improvement and the effects of traditional fuel on their health. Fuel-stacking is a common practice and the dominant reason was cultural barriers of the families and traditional stoves usage. This paper contributes to the existing literature on household fuel use by providing a comprehensive review of theory, evidence, and interventions related to the topic. It underscores the need for improved exposure assessment, behavioral and nutritional interventions, and governance interventions to promote the use of cleaner and sustainable energy sources.

Keywords: cost, cooking, fuel, health, stacking, women

INTRODUCTION

More than three billion people worldwide, mostly in low and middle-income countries, rely on biomass as their primary source of fuel for cooking and heating in the form of charcoal, firewood, dung, and crop residues. Biomass fuels are often used in open flames or basic conventional stoves that do not provide ideal conditions for burning (WHO, 2019). In many developing countries, particularly in South Asia and Sub-Saharan Africa, a lack of affordable, clean, and reliable energy sources is the leading cause of excessive use of solid fuels (Rahut *et al.,* 2016; Rahut *et al.,* 2017; Behera *et al.,* 2015). Like many other developing countries to get clean, sufficient fuel for domestic use is the biggest challenge. Pakistan's high prices for modern fuels and shortages make this issue more acute (Abdo *et al.,* 2021) because wealth is one of the crucial parameters determining a household's choice of fuel (Mehash *et al.,* 2016; Hou *et al.,* 2017; Gregory and Stern, 2014). A household's choice of cooking fuel is influenced by characteristics such as money, taste, tradition, gender, education, and others (Farsi *et al.,* 2007; Rao and Reddy 2007). With a population of 197 million in 2017 and an annual GDP per capita of $1,547 (World Bank 2019), Pakistan's population is expected to be between 276 million and 344 million by 2050 (depending on the fertility rate assumed) (UN DESA, 2015). With this background, it is possible to comprehend the fuel selection behavior of families in Pakistan. Due to ignorance, cultural hurdles, and the high expense of fuel, rural women in Pakistan still practice outdated ways of cooking in their homes (Yadav *et al.,* 2021). Because they lack knowledge of modern methods for using fuel for household tasks and work, they use it like that of their predecessors. Also, rural women's unhealthy lifestyles, which are hurting their traditional values, generate problems with the quality of their cooking techniques (Waleed and Mirza, 2022). Moreover, jeopardizing and inhibiting developments are extreme risks regarding this particular aim of modern cooking (Pelz *et al.,* 2021). This study comes exclusively focused on the fuel stacking structure. It emphasizes the findings that women's behavior regarding fuel use has not changed despite the household's economic growth and stability (Nawaz and Iqbal, 2020) and also, examine the impacts of traditional fuel on women's health (Bharadwaj *et al.,* 2021; Hassam et al., 2021). The study explored that family attachments are the leading causes. Women's absolute dependence on conventional energy was found to have difficult effects on both their physical and emotional well-being (Shankar et al., 2020). This study argues that rather than households making efforts to buy modern fuels with which women have limited knowledge, the goal should be universally acknowledged to accomplish the success of modern fuels. Governments and developmental organizations in less developed nations like Pakistan prioritize worldwide access to affordable, clean, and cutting-edge energy sources (Rahut *et al.,* 2020). It should be emphasized that only a limited amount of modern fuels is used because they are more expensive and are in short supply in different parts of Pakistan (Nawaz and Iqbal, 2020). Taking into account the energy

mix is advantageous for protecting the environment, maintaining natural resources, and reducing reliance on conventional fuels (Mussida and Sciulli, 2022). The use of contemporary energy may cause women to go back to traditional fuels depending on their choices, finances, and requirements, even though multiple studies show that discontinuing the consumption of fuel across homes is not a change in direction for them (Schunder and Bagchi-Sen, 2019). Moreover, fuel stacking has been often seen in rural regions. The tasks of household modifications in fuel choices, among which cultural customs continue to be a prominent role, are fully explained by fuel stacking (Pratiti *et al.*, 2020). The implementation of modern fuel energy in families also encounters social, cultural, and environmental challenges (Abbas *et al.,* 2021). Even when switching fuels is difficult, financial and cultural obstacles are the main factors that influence fuel usage (Shyu *et al.,* 2021).

METHODS

The current review is aimed to focus on fuel-stacking behavior in concerns with the cultural barriers faced by women. The papers also observed the ailing health impacts due to fuel stacking behaviors. The current review included 50 papers that focused to observe the fuel stacking and fuel choices present for females while extending the discussion on health issues, SDG 7 as well as the availability of resources.

The studies shared some common insights about fuel stacking behavior. This includes

- Fuel stacking model and energy choices;
- Women and gender equity;
- Fuel choices and behaviors;
- Fuel usage and burden of diseases

DISCUSSION

Fuel Stacking

Fuel stacking refers to the use of different fuels or a combination of fuels. These fuels are used by households, based on their needs, financial matters, and preferences (Heltberg, 2004; Masera *et al.*, 2000). Energy choices in developing countries are currently studied under the fuel stacking model illustrates the use of fuels in combination due to several barriers (Choumert-Nkolo *et al.*, 2019). Many variables and interests influence government, corporate, and household decisions on energy provision and transition (Muller and Yan, 2018), but the most prominent are socio-economic and socio-environmental factors. Below there is the presentation of Fuel Stacking Model.

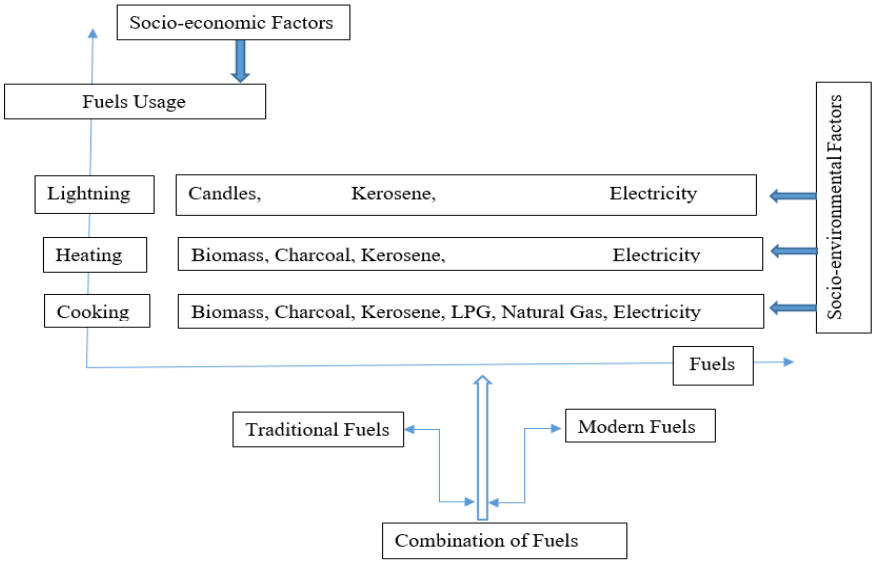

Figure 1. Fuel Stacking Model

According to this model (Fig:1) on fuel stacking, home energy transition does not follow a stair-step pattern; rather, rural families continue to rely on conventional fuels to fulfill the majority of their energy demands, with modern fuels augmenting demand if and when available. As a result, there is a practice in rural parts of so-called "emerging countries" of employing a portfolio of fuels.

Fuel Stacking Model and Energy Choices

Among the various studied elements, it is considered that switching between energy mediums and sources is also linked with cultural barriers (Alem *et al.*, 2016). Research scholars have studied that despite the energy fuel shift in domestic households, several families do not entirely discard the use of traditional fuels due to their lifelong familial practices, lack of awareness, and utilization of waste, fodder, and dung (Hou *et al.*, 2022). Thus, studying the cultural limitation to shift to modern ways is one of the major reasons that results in the practice of fuel stacking (Hassam *et al.*, 2021). The fuel stacking model was presented by Masera which identified the shortcomings of the energy ladder framework used

earlier. The model identified other factors than income that significantly impact the household's fuel choices (Batchelor and Brown, 2021). The study led by Masera debated that switching to modern fuels from tradition is never a unidirectional practice nor a complete shift observed among the households. Instead, the practice of energy mix has become common, involving both traditional and modern fuels (Ma *et al.*, 2022). Income is still a crucial factor that significantly impacts this shift of fuels to use different sources in rural areas. Due to limited income and access to resources, people commonly use animal waste, i.e., dung to agricultural waste and fodder alongside wood for cooking purposes (Shitsi *et al.*, 2020). However, fuel stacking behavior among the population is also prioritized due to their increased familiarity and easier access to traditional sources, i.e., charcoal and firewood (Price *et al.*, 2021). In addition, the literature cites that the rural household lifestyle has long been settled to specific practices continued from generation to generation (Pratiti *et al.*, 2020). Cultural and environmental practices have long been settled with their way of living and thus result in fuel stacking. In the wake of this, the price fluctuations to any inconvenience that may appear while using modern fuels thus make them more prone to practice the energy mix and include traditional fuels in their daily practice (Belmin *et al.*, 2022; Schunder and Bagchi-Sen, 2019). Batchelor and Brown, (2021) addressed the issue of fuel stacking, regarding it as a social and cultural problem among South-Asian households where the acceptance of modern fuels does not assure that traditional fuels are not completely discarded. Moreover, other than the cultural and social adaptation to income issues, fuel stacking is common because of the design deficiency to limited technical knowledge regarding the new cook stoves. The understanding of user-centered innovation brought by modern fuels remains limited (Osei *et al*., 2021). The fuel stacking behavior is not only associated with the domestic fuel choices linked with poverty. Lack of awareness and lack of choices provided to women also appear as part of cultural limitations (Shankar *et al*., 2020). World Bank, in their report on achieving SDG 7 (2020), argued that low-socioeconomic status is not only linked with the use of different fuels for domestic purposes but also shares a close association with the adverse impacts of these fuels on health.

Women and Gender Equity Theory

Gender plays a very significant role in energy source preferences. It's universal thought that females are mainly accountable for cooking (Baruah, 2017). Both men and women are stakeholders in benefiting from energy, but the same sources have different impacts on both men and women (Khamati, 2003). A division of labor based on gender, which is similar in most developing regions, means that the benefits of energy and capacities to access those benefits differ based on gender (Khamati, 2003). While both poor men and women suffer from energy poverty, women are extremely affected by unequal power relations (Kohlin *et al.*, 2011). In developing regions/areas women have poor health conditions, they usually go unpaid (if they are paid then incomes are low), their opportunities to improve labor productivity are down, out of the household their social and political interactions are restrained, their training for social and physical life are very limited and they are physically drained by the collection of biomass fuel (Danielsen, 2012; Khavari *et al*., 2022) compared to men (Alex *et al.*, 2018). The current study identifies that women are positively concerned with clean, effective modern energy resources, likewise natural gas and LPG (Falk and Hermle, 2018). Gender equity theory emphasizes equitable treatment for males and females in economic, power, social, nutrition, and health. The theoretical practices provide for providing both genders with reasonable and equal opportunities (Musango, 2022). However, due to power relations, gender equity is rarely practiced. Using power and energy resources for the greatest purpose and support continues to be a challenge for women. Their access to clean and energy-efficient alternatives is limited due to economic and cultural restrictions (Listo, 2018). About the research problem, the fuel stacking behavior is injurious is women's health; they suffer both psychologically and physiologically. While the world strives to implement sustainable practices following the United Nations' 17 Sustainable Development Goals (SDGs), there is a complex relationship shared by the two SDGs, namely gender equality (SDG-5) and access to affordable and clean energy (SDG-7) (Shupler *et al.*, 2021). There is long-standing inequality in homes, making it difficult for women to acquire inexpensive electricity, which has a negative influence on their health (Shyu, 2021). Findings revealed that resource availability in terms of fuel usage is performed through a bargaining way and is molded by social and cultural norms (Musango *et al.*, 2022; Shupler *et al.*, 2021). This is why fuel stacking remains an unhealthy and unsafe practice (Boudewijns *et al.*, 2022).

Fuel Choices and Behaviours

Currently, energy efficiency remains one of the critical drivers of economic development. However, several households and communities cannot access modern energy resources because of the power-poverty nexus (Mustafa *et al*., 2022). The literature raises serious environmental and health concerns over traditional fuels that result in increased carbon dioxide release, i.e., GHG emissions. According to the United Nations Statistics Division (2018), three billion people still use traditional fuel for cooking purposes. Women and children specifically are the two members that are particularly impacted within the community due to the indoor population (Jayaweera *et al.*, 2020). The inefficient cooking practices and fodder, wood, and animal waste are a considerable threat to health and the environment. The world is transforming towards eco-efficiency, so the demand for clean and modern energy has become popular (Celik and Oktay, 2019). Moreover, this practice also works against household carbon emission, which constitutes a huge proportion of the national and international sustainable development agenda.

Adopting modern fuels is essential for economic development and eco-friendliness and ensuring sustainability by providing increased access to modern energy options (Musango *et al.*, 2022). Extending the debate, energy mix or fuel

stacking appears as a combination of various fuels used by household users or women. However, it does not indicate the full use as well as the spending on each source (Alem *et al.*, 2016). A study conducted in Tanzania revealed that determining fuel stacking behavior is complex, whereas what influences the household to practice this act is also subjective. The government of Tanzania, in this case, even provided tax relief on LPG and called out a charcoal ban (Kapsalyamova, *et al.*, 2021). However, both efforts remained unsuccessful as the households did not wholly shift to modern fuels but continued to practice energy mix or fuel stacking (Khavari *et al.*, 2022). Likewise, another study by Mussida and Sciulli, (2022) claimed that wealth distribution in Pakistan's rural areas is poor. Majority of the population struggles to achieve their basic needs. In this scenario, fluctuating prices and economic uncertainty have an immediate effect on their choice fuels. Gould *et al.*, (2018) studied that literacy rate other than poverty is an essential factor that influences fuel stacking where households that were literate enough to understand the hazardous impact of pollution shifted to modern fuels rather than practicing fuel stacking (Falk and Hermle, 2018). However, in Pakistan, gender inequality and insufficient practices to improvise the energy rights status for women make fuel-stacking behavior more common (Abbas *et al.*, 2021). Household sizes are also strongly linked with fuel stacking, where households with more members used the energy mix practices due to its feasibility and more accessible access (Khavari *et al.*, 2022). The availability of substitutes, with most of them being traditional ones, and the shortfall of electricity and high prices of solar panels, cells, and batteries make it a resource unavailable to the general public in rural areas (Balmes, 2019; Ali *et al.*, 2019).

Fuels Usage and Burden of Diseases

Abdo *et al.*, (2021) observed that biomass used among rural families as a standard fuel for cooking is liked with several health issues and is divided into four different stages where in the first stage, only its collection results in bruises as well as insect bites. Following this, while biomass is stacked, many women and small children working alongside their mothers face severe rashes, allergies, and irritated hands (James *et al.*, 2020). The use of polluting fuels has been related to poor air quality and the transmission of multiple non communicable illnesses to household members. (Rahut *et al.*, 2020; Imran *et al.*, 2019; Drew *et al.*, 2022). Middle-income countries like Pakistan have an extensive burden of neonatal deaths and stillbirths. Several factors like lack of antenatal care, malnutrition, and indoor smoke adversely affect the mother's health as well as the unborn child (Fatmi *et al.*, 2010). Biomass fuel use increase stillbirths among those women who are using them during their pregnancy (Yakoob *et al.*, 2009). Low-weight births are directly associated with biomass fuel use. Much literature and previous studies revealed that the problems related to pregnancy, such as low birth weight, and stillbirth are linked with exposure to pollutants from biofuels (Boy *et al.*, 2002). Household air pollution due to biomass smoke is strongly associated with eye diseases (Sheila *et al.*, 2013) and becomes the reason for tears, trachoma, blindness, cataract, dry eye, and macular degeneration (Sheila *et al.*, 2013). In developing countries, household incomplete combustion products increase the rate of blindness among females (Gareeb *et al.*, 2001). Indoor air pollution contains different levels of particulate matter and carbon monoxide that are associated with meibomian gland dysfunction, which is a very common eye disease in developing regions (Malerbi *et al.*, 2012). On the other side wood smoke exposure is associated with ocular discomfort and the development of tear instability (Bourcier *et al.*, 2003; Lang *et al.*, 2008; Mirabelli *et al.*, 2009). Heart disease is a leading cause of death in developing countries (Murray *et al.*, 2012). In Asia and Africa where people use biomass fuel ultimately suffering heart diseases (Bonjour *et al.*, 2013). Combustion of biomass fuel generates concentrations of pollutants in kitchens, which are 100–200 times higher than the current ambient air standards (Clark *et al.*, 2013) and this increase is a serious risk factor for heart diseases. Poverty in rural areas is associated with tuberculosis and exposure to biomass fuel it's another possible mechanism (Mishra *et al.*, 1999). Socioeconomic characteristics may have a pathogenic role in the relationship between biomass fuel use and tuberculosis (Pérez-Padilla *et al.*, 2001). Chronic bronchitis is the production of sputum and the presence of cough for at least three months for repeatedly two years. There was found a well-established relationship between biomass smoke exposure and chronic bronchitis and their immediate effect on women of all ages (Albalak *et al.*, 1999). The situation in Pakistan is quite worse and the health effects of biomass fuel have received limited research attention (Akhtar *et al.*, 2007). In developing regions, biomass smoke exposure and its health effects are lacking key components (Perez-Padilla *et al.*, 2014). Furthermore, there is no criteria in Pakistan for assessing the effects of fossil fuel combustion as part of the cooking process. In most circumstances, the hazard limit is considerably above what is indicated internationally (Nawaz and Iqbal, 2020).

CONCLUSION

According to research, fuel stacking is a common practice in developing countries. Although many are trying to reach the stage to minimize fuel stacking, traditional approaches are well integrated into the culture. People find it hard to follow the new energy sources in different areas, but they find them complex. Primarily such practices of fuel stacking are observed in rural areas of Pakistan and residential solid-fuel use contributes largely to severe indoor air pollution and consequently high exposure and $PM_{2.5}$-related premature deaths. The utilization of affordable modern energy is an important aspect of sustainable development. It is vital to show real-world home energy features when analyzing the consequences of household energy and encouraging sustainable development.

Switching to clean modern domestic energy sources can have clear health and climatic benefits; nevertheless, the shift is often more than just a technical matter. Many non-technical factors affect the adoption and sustainable use of modern energy sources and the suspension of unclean solid fuels. The review of various studies concluded that these traditional

methods will remain part of the livelihood of the people living in rural Punjab. Various methods have been studied while examining the behaviors of fuel used for domestic purposes. The model shows that people belonging to lower-income households mostly use wood, dung, and charcoal to cover the energy demand. People in high-income areas use electricity, gas, coal, methanol, and others to fulfill their energy needs. Various factors are involved in managing fuel stacking like availability of fuels, fuel prices, number of people in households, the income of households, and cultural barriers. People prefer traditional fuels and fuel stacking due to the low prices and availability. The study investigated the relationship between fuel choice and gender biases. Things like the education of females in the household play an essential role in energy choices. As cooking is mainly associated with females, educated ones choose clean energy sources in Pakistan. But the decision power is in man's hands in the community, so it is important to educate both genders equally regarding these issues. The study discovered that many factors play a part in people using fuel stacking. These factors are households' income, lack of education and awareness, lack of infrastructure, price fluctuations of the clean sources, unavailability of clean sources, etc. These can only be reduced if all stakeholders provide these opportunities to the people in a reliable way. Fuel stacking is being done in many ways, such as using biofuels like wood, garbage, animal waste, plant residues, etc. These produce harmful environmental and human health effects: many people, especially women, encounter respiratory diseases like pneumonia, lung cancer, and tuberculosis. Solid fuels and energy sources emit many harmful substances such as ash and soot. Fine particles of these emissions can enter the human body and result in many dangerous, life-threatening diseases. Respiratory issues are widespread due to the continuous burning of biomass. Currently, the environment in Pakistan is below average. With the world facing global warming issues, these fuels are adding more harm. United Nations has provided sustainable development goals (SDG). These include the intended use of natural resources, promoting a healthy lifestyle, and reducing inequality. Problems like using biomass fuels and fuel stacking are causing harmful environmental reactions and going against sustainable development goals. There should be a process of end-to-end policy-making to plan and develop different strategies to cater to the problems faced by the people dwelling in rural areas. Local and National governments can be a part of making and implementing effective policies in energy utilization. So, the study suggests various methods such as policy interventions, cooperation of the responsible authorities, and strong energy governance are needed to integrate conventional methods. Such practices are also necessary to help achieve sustainable development goals through the responsible use of natural resources and decarburization. There is also a high demand for informing and educating people regarding these fuel sources. Many people in rural areas of Punjab cannot differentiate between clean and unclean energy sources. Due to low education levels, many are unable to understand the concept of pollution and the importance of reducing these components of pollution. There is a strong need for training for these citizens to not only facilitate them with clean energy sources but also help them learn the tips that can help achieve better results in terms of health and a cleaner environment. Government and other authorities can achieve these goals by making health centers for women, policy-making, and implementation in the assemblies.

SUGGESTED AREAS FOR FUTURE RESEARCHES

The following research areas have immense research potential. They include

1. Households' willingness to pay for improved fuels
2. Economic costs of indoor pollution resulting from biomass-dependent cooking
3. Modern fuels supplies
4. Standardizing cook stoves and
5. Secondary cook stoves within cleaner stacking strategies

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