

Urbanisation and domestic energy trends: Analysis of household energy consumption patterns in relation to land-use change in peri-urban Accra, Ghana

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ABSTRACT

Urban living has become a dominant lifestyle in the 21st century. The period also comes with far-reaching changes in knowledge-gathering, which has become more compartmentalised, fragmented and specialised. This is reflected in the ways of working of both academic and government institutions, and has led to incomplete knowledge and understanding of human ecology, and the formulation of unwise, strongly sectoral policies, not least in respect to the understanding, planning and managing the dynamics of energy use and land-use change in an era of global climate change. This study contributes to addressing the perceived shortcoming by comparing patterns of energy consumption in two research locations in peri-urban Accra: representing a more urbanised, and a cluster of rural communities, respectively. The study applied an inter-disciplinary approach combining expert interviews, a literature review, and an in-depth change analysis based on remote sensing/geo-information systems. The paper establishes a relationship between land-use change and wood-fuel and LPG usage mediated by geographical and socioeconomic discrepancies. We conclude that different peri-urban patterns are driven by geographic, historical, cultural and economic disparities. Therefore, if energy policies and strategies for sustainable development are to be successfully constructed, there is the need to accommodate and enforce land-use policies by adopting a comprehensive approach to governance¹.

1. Introduction

Urbanisation and climate change are two essential features in the 21st century. More than half of the world's population lives in urban areas (Satterwhite, 2020). Due to the ongoing urbanisation and growth of the world's population, it is estimated that about 2.5 billion more people will be added to the urban population by 2050, mainly in Africa and Asia. The world's urban areas are highly varied. Nevertheless, many cities and towns are facing similar problems such as lack of jobs, homelessness and expanding squatter settlements, inadequate infrastructure, poor health and educational services and high levels of pollution (Gyasi et al., 2014). The increasing demand for built infrastructure results in increasing urban sprawl. The negative effects of sprawl are particularly visible and crucial in developing countries like Ghana, where unplanned land-use change does not only obstruct but indeed, is one of the critical drivers of unsustainable development

(Cobbinah and Niminga-Beka, 2017). This has generated several environmental and socio-cultural concerns, including the conversion of open spaces and agricultural lands to residential areas (Ablo et al., 2020; Cobbinah et al., 2017; Mensah, 2014). In Ghana, the situation is accentuated by its legal pluralism – the co-existence of different land tenure regimes, including family, stool/skin, individual and state ownership (Boamah, 2014).

In most cases, the conversion of open and agricultural lands into residential facilities leads to a situation where peri-urban communities become encircled with newer urban dwellings. However, changes in energy consumption for domestic purposes have not kept pace with the rather rapid expansion of cities to their frontiers. Traditionally, most Sub-Saharan Africans use biomass (i.e. firewood, charcoal, millet stocks, cow dung, etc.) as sources of energy for cooking. Of all these, wood constitutes about 85 percent of the energy (see Mwampamba, 2007). In Ghana, woodfuel has been the primary source of energy for cooking and

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heating. Analyses of the national energy balance data showed that the most significant energy use is in the residential sector since domestic needs are mostly met from heavy dependence on woodfuel (Kemausuor et al., 2011). The biomass consumption for cooking was about 78 percent in 2017 with electricity consumption at only 16 percent (GEC, 2018). The observed low consumption of electricity may be attributable to the high tariffs (GEC, 2018).

Many studies contend that land-use change often leads to a reduction in open spaces, agricultural and forest lands (e.g., Bhatta, 2010; Cobbinah et al., 2015; Gyasi et al., 2014; Mensah, 2014; Nixon and Newman, 2016; Sulemana and Yiran, 2018; Wolch et al., 2014). While these studies highlight the complex outcomes of land-use changes, several vital questions still require further interrogation. In the first place, how does urbanisation and the resultant urban sprawl affect household energy consumption patterns in peri-urban Accra? Secondly, how can urban policies be enforced to change the course of urbanisation so that increasing energy demand is constrained and promote sustainable development? This current paper seeks to answer these two important questions. This research is particularly important because the government's policy intervention to encourage the use of Liquefied Petroleum Gas (LPG) and reduce the dependency on biomass has yielded limited results, as the use of woodfuel for cooking still constitutes about 80 percent energy mix for domestic use (Kemausuor et al., 2011).

2. Energy transition and sustainability in peri-urban contexts

As urbanisation proceeds, there is a transition from dirty energy to clean energy (Barnes et al., 2010). Energy transition refers to the total change from one energy system to another (Bridge et al., 2013; Israel-Akinbo and Fraser, 2018; Ma et al., 2019). Thus, in the literature, the urban energy transition is frequently described as the progressive evolution from firewood, to charcoal and kerosene, and finally to Liquefied Petroleum Gas (LPG) and electricity consumption (Barnes et al., 2010). These energy forms also have different technologies (e.g. stoves) for cooking and these help in the transition. Thus, this study envisages a change from firewood and charcoal to LPG, as the woodfuels (firewood and charcoal) get scarce in the peri-urban areas due to urbanisation and government's policy to discourage woodfuel use and encourage the use

of LPG. This policy aims to control deforestation resulting from the consumption of woodfuels. The energy sustainability theory, which focuses on the sustainability of affordable clean energy, also guided the study. Emphasis is on the ability of people to access secure and affordable clean energy while meeting the environmental, social and economic needs within the overall development context of that society, and with equitable distribution (Davidson, 2002; ICSU, 2007 cited in Mainali et al., 2014). Thus, for peri-urban dwellers who are experiencing the transition from one energy form to another, the energy needs at any point must meet the environmental, social and economic pillars of sustainability. Therefore, the two theories reinforce each other for the study of energy consumption, especially in peri-urban areas where lifestyles are evolving due to the changing culture, incomes, health and land use patterns. Fig. 1 draws on the energy transition and sustainability theories to develop a conceptual framework for exploring land-use change and fuelwood consumption patterns in peri-urban Accra. As shown in Fig. 1, sustainable development of a city cannot be achieved if urbanisation does not occur without compromising the environmental integrity and the social and economic wellbeing of the people. Urban land use primarily for residential development as it is the case is in Accra results in the fundamental transformation of the environment and affects the traditional source of woodfuel, that is, a reduction in tree and shrub cover as well as agricultural residue within the peri-urban areas for domestic use. Clearing the land to build at the initial stages may make more wood available for use as woodfuel (Barnes et al., 2010). However, with time, as more land is converted, the forest within the local area becomes scarce, and for households to secure energy for cooking, they will have to diversify or import from other regions. Diversification leading to consumers making different energy choices depends on both availability and affordability and in some cases, the technologies (see Fig. 1) of the various energy forms.

The initial cost of the technology (stoves) as well as user-friendliness, also influences the choice of fuel for cooking. Woodfuel obtained from the local environment is cheaper than those imported, but as urbanisation expands, this local woodfuel becomes limited. Urbanisation also brings about changing lifestyle and incomes (Adaku, 2014; Amoateng et al., 2013; Oppong and Yeboah, 2013). A similar study in China reveals that the increase in income of rural households increases their

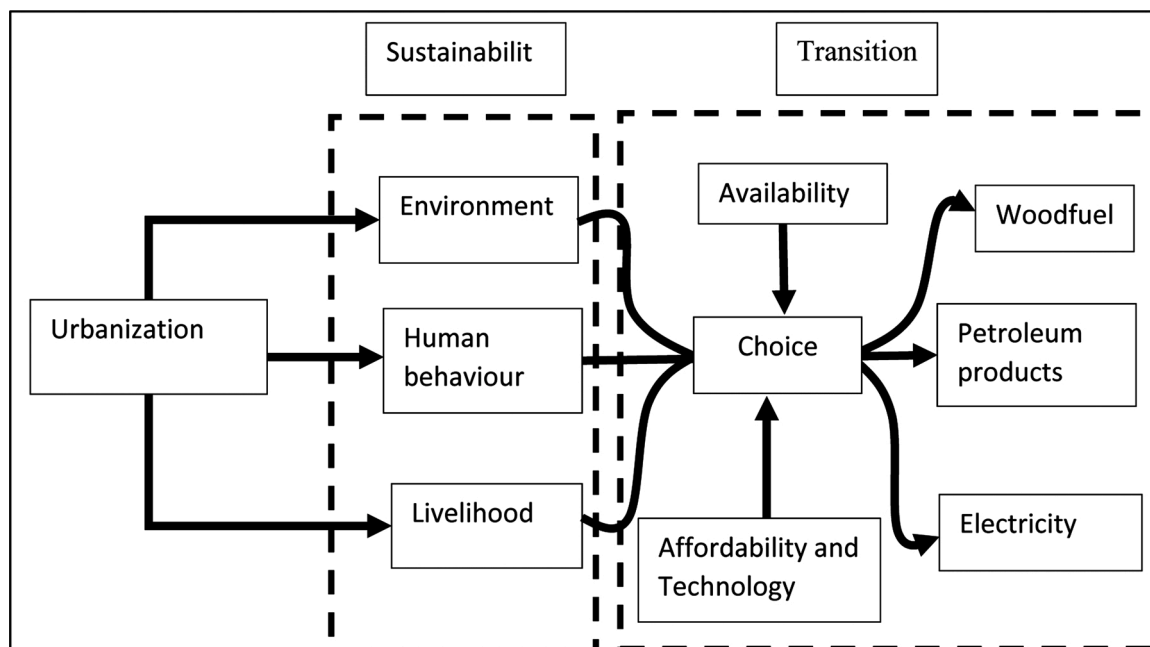


Fig. 1. The sustainability and transition of household energy. Source: Authors' construct.

preference (a lifestyle or human behaviour) for clean cooking energy (Hou et al., 2018). Although income, as shown above, influences lifestyle, it is considered a livelihood in this study. Another livelihood factor is health; various cooking fuels have corresponding health and safety risks. For example, smoke affects the eyes and nose and may cause respiratory problems after prolonged exposure. Additionally, women and children are also among those who suffer burns as they bear the significant responsibility, for instance, for woodfuel harvesting (see GEC, 2018; Hou et al., 2018; Israel-Akinbo and Fraser, 2018).

Although the woodfuel from the local environment is getting scarce, people have a higher income to buy woodfuel imported from distant places or pay for alternative cooking fuels such as LPG and electricity. However, the extent to which the residents in peri-urban areas can harness their cooking fuels depends on how affordable the fuels are. Some structures such as government policies have been introduced to make alternative fuels (e.g. LPG) accessible and to ensure the access to energy-saving cooking stoves (e.g. Kemausuor et al., 2011; Mainali et al., 2014). This consequently, informs peoples' behaviour and choice of cooking fuels. A household's choice of cooking energy, therefore, depends on complex and interrelated factors, which change from time to time. The next section discusses the study area and methods used to collect and analyse the data for this study.

3. Study area and methods

3.1. Choice of the study area

The study was conducted in two peri-urban areas of the Greater Accra Metropolitan Area (GAMA). These areas are Papase in the Ga West Municipality, and Abokobi in the Ga East Municipality and a cluster of three small rural communities (Abonya, Djormaa and Sota) in the Shai Osudoku District as shown in Fig. 2, which are experiencing urban sprawl. Due to the political and economic role of Accra, the region receives the highest number of migrants in the country (GSS, 2012) with increasing housing needs that are currently unmet.

The sprawling of Accra is occurring northward with Ga West, Ga East and Shai Osudoku assemblies at the forefront of this expansion. These assemblies were selected because they are among the fastest-growing

areas in GAMA and is inhabited by many rural communities that are experiencing rapid transformation. These districts and the whole of the Greater Accra Region fall in the coastal savannah agroecological zone of Ghana. The coastal savannah comprises of scattered trees, shrubs and grass. Some few decades ago, these districts were rural fringes with largely agricultural patches and bushes (trees, shrubs and grass). The inhabitants could source energy for cooking from their immediate environment. However, the fast-growing nature of the city of Accra has transformed these hitherto rural districts to peri-urban or urban areas, with a transformed landscape from agricultural settlements to built-up areas. However, over 77 % of residential energy consumed is from woodfuel (GEC, 2018). Data from the GEC (2018) show a steady increase in woodfuel consumption for residential purposes since 2008, and most of the consumption is within the urban centres. Thus, studying communities with varying physical/human characteristics will provide a more balanced information on the residential energy supply/demand nexus and offer direction for policy for sustainable energy achievement.

3.2. Methods

The mixed-method approach comprising of the use of both quantitative and qualitative methods was employed in collecting data for the study. Triangulation of the two approaches was necessary because of their complementary roles in understanding social research problems (Clark and Creswell, 2010; Teye, 2012). Both quantitative and qualitative data were collected by administering questionnaires to household heads/representatives and conducting focus group discussions and in-depth interviews with key informants.

The sampling procedure was multi-stage sampling. First, the study locations in the peri-urban area of GAMA were selected through a restricted random sampling method (Yiran et al., 2017). This was done by dividing the area into three zones (more urbanised, less urbanised and rural) based on the state of development obtained from our 2017 image classification (inset on Fig. 2). All towns/villages within this zone were then written on a piece of paper, and one was randomly selected for the study. Thus, Abokobi, Papase, and Djormaa (see Fig. 2) were selected. However, upon entering Djormaa and interacting with the chief and some elders, it was realised that the entire community was

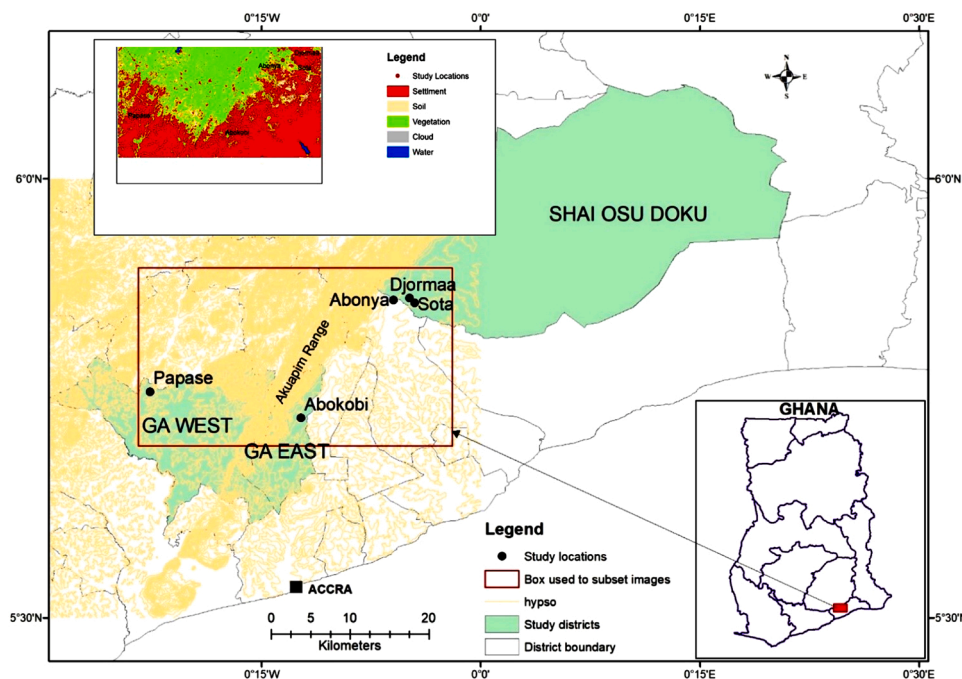


Fig. 2. Map of the Study Area.
Source: Authors' Construct.

about 200 people and so, two nearby communities Sota and Abonya (small) were added to obtain the desired sample size. These communities are hereafter referred to as a cluster.

According to a table published by Reisman (2000), with a population more than 5000 and at 5% sample error, a minimum sample size of 357 can be used (cited in Baker and Bruner, 2010). Based on this, a total of 600 household heads or representatives were involved in the questionnaire. The sample was distributed equally across the three study locations. At each study location, 200 respondents were sampled due to the lack of statistics on the population of some of the communities to constitute the sample frame. This is because some of the villages are aggregated with other communities in the population data, and it is, therefore, difficult to get exact population data for some communities. Other researchers (e.g. Yiran and Stringer, 2016) encountered similar challenges of the lack of precise statistics on the population and the equal distribution of samples in study sites did not affect the outcome of their studies. Using this study as a precedence, we assume that ours too will not be biased.

We employed the systematic sampling method in selecting the houses in each community and where a chosen house contained more than one household, a simple random selection (lottery method) was used to select the household head or representative for the survey. In conducting systematic sampling, we started from the chief's palace or community leader's house in each community. From the chief's palace, we walked along the roads, and every fifth household was selected. The selection interval (i.e. 5) was also determined arbitrarily since we did not have information on the exact number of households within the communities and considering that some of the communities; especially the rural communities were small. We chose systematic sampling because it is easy to use and it is again accurate. As the communities did not follow a well-layout plan and that the layouts in the communities were not radial, some branches of roads that did not originate from the chief's palace were also included. We went around the community with members of the community appointed by the chief. The assistance of these community members helped to ensure that all people interviewed were members of the communities. The community assistants were not involved in data collection and, therefore, had no influence on which house to select or respondents. They only ensured that we did not stray outside the community borders since there were no physical boundaries between communities. Additionally, the presence of community members as we walked through the communities also made it easier for the people to accept to talk to us.

The questionnaire contained both closed and open-ended questions. The open-ended questions were meant to allow respondents to express their views on some of the issues under investigation. Three women (one above 60, one in her 40 s and the other in her 20 s), as well as one fuelwood seller and one charcoal seller in each of the study locations, were selected for in-depth interviews. Thus, a total of 15 women were involved, and this number is good enough for this as it is within the numbers recommended for qualitative studies (see Boddy, 2016; Vasileiou et al., 2018). Only women were considered for the in-depth interviews because within the culture of the study area, cooking-related activities and for that matter, fetching of woodfuel is the preserve of women. Therefore, they have a deeper understanding of the dynamics in woodfuel energy. The in-depth interviews discussed issues on trends of residential cooking energy, types, sources, cause of changes, supply and demand. The data collection took place between August and September 2017 unpublished documents by the Energy Commission from its website and other scholarly materials served as secondary data for the study.

The quantitative data collected were analysed using the Statistical Software Package (SPSS version 22.0). The analysis was done using descriptive statistics, mainly frequency and cross-tabulations to describe trends and patterns of fuelwood consumption over the past 30 years. This period coincided with the period after Ghana adopted the structural adjustment programme, which ensured the liberalisation of many sectors, including the housing sector (Fuseini et al., 2017). Recorded

interviews were transcribed into English and analysed. Thematic content analysis was done to identify the key issues that emerged from the discussions with the women. In some cases, verbatim quotations of some critical statements made by the women were used to explain or give emphasis to the trends or patterns that emerged. Satellite image classification was done to show pictorially, the trends in changes in vegetative cover over time. The images used were Landsat images of 30 m resolution on path 194 and row 056 captured on December 26, 2002, February 2 2008 and February 10, 2017. These years were used because the images had less than 10 % cloud cover. The images were geometrically and radiometrically corrected and classified using supervised classification. We classified the images into four classes, namely, water (lakes, lagoons, sea, and reservoirs), settlement (built-up), vegetation (woodland, grassland, farms, shrubs, etc.) and soil (bare land, sand winning sites, farms, etc.). A combination of unsupervised classification and Google Earth was used to derive the training samples for the classification. The information generated from the classification was used to verify or back assertions from respondents. The other secondary data mainly from the Energy Commission of Ghana were used to support the analysis.

4. Findings

This section focuses on the presentation and discussion of the results. We first discuss the trends to identify any energy transitions, analyse the reasons for the use of energy and the link between household energy choice and land-use change. While varied issues emerged on energy use, the study focused primarily on household energy for cooking/heating purposes only.

4.1. Trends

Majority of Ghanaians especially those in the low-income bracket eat at least one meal prepared by themselves, making energy for cooking an essential commodity for households (Mills et al., 2017). Thus from Fig. 3, woodfuel (charcoal and firewood) has been and still constitutes the dominant energy type used in homes in the study communities.

About 44 % of households interviewed indicated that they use woodfuel alone, while 36 % use multiple types, including woodfuel. Multiple users for charcoal and firewood use them interchangeably, while those for LPG and charcoal use them for cooking different dishes or switch to charcoal when the LPG is finished. A multiple-user indicated that 'sometimes I am in the middle of cooking and the gas finishes, so I have to switch to charcoal to continue and go for a refill later because I have to travel far to refill and it might even finish in the night'. Many middle-income earners are involved in LPG/charcoal multiple uses. Multiple uses help to explain why 80 % of the energy used for cooking is woodfuel (Kemausuor et al., 2011). Many studies have made similar findings that use of woodfuel makes up the bulk of energy for cooking in the peri-urban areas with similar consumption patterns, especially among low-income households in urban areas (Kimemia, 2015; Ma et al., 2019;

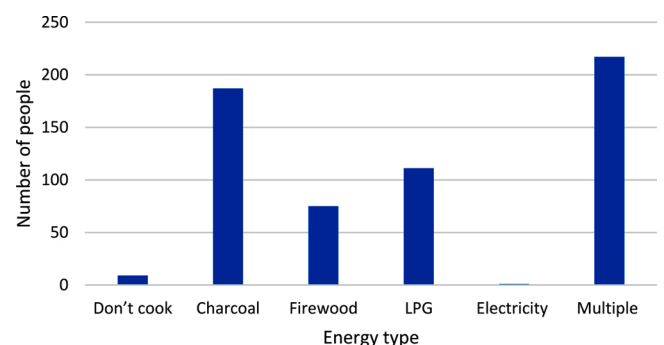


Fig. 3. Types of energy for cooking and heating. Source: Fieldwork, 2018.

Paudel et al., 2018). Multiple-use is very popular in many developing countries, often known as fuel stacking (Choumert-Nkolo et al., 2019; Gould et al., 2018). This implies that woodfuel will continue to be a significant source of fuel for cooking for low-income households, at least, into the near future.

However, the use of these energy types varied spatially (Fig. 4) in the study communities. As shown in Fig. 4, the use of firewood (grey colour in the pie chart) can be related to land-use change.

In Abokobi, the land is almost built-up very few people use fuelwood. In Papase where the built-up intensity is less than Abokobi, more people use firewood whereas in the rural areas (cluster) where the built-up is far less intense has the highest use. On the other hand, LPG increases from the cluster to Abokobi. Thus, as the built-up intensity increases, the use of firewood decreases. This means that land-use change from vegetal cover to built-up reduces the use of firewood. Although researchers such as Israel-Akinbo and Fraser (2018) found that geographic location (urban, peri-urban and rural) influences the choice of energy, the link with land-use change intensity makes this finding unique. The increase in built-up causes a depletion of the green environment (Fig. 5) where the locals harvested wood freely. As can be seen in Fig. 5, this piece of land in 2011 was occupied with trees and shrubs where the locals could harvest firewood freely by had almost been fully built-up by 2018.

This high rate of consumption of open spaces and farmlands have many negative ramifications on locals and poor household in the peri-urban areas because it depletes their source of woodfuel for cooking (Simon and Peterson, 2019). In the in-depth interviews, scarcity of firewood in the immediate surroundings was highlighted. The clearing of shrubs and trees for construction, increased the time and distance spent in the search for firewood in the peri-urban areas. A woman in Djormaa (a village in the cluster) where the shrubs and trees are still dominant, stated that *'most of us [women] pick [cut wood/crop residue] from our immediate environment for cooking. Those who are not able to go to the bush buy from the market, but those women are not many'*. Her statement suggests that those who do not have time to go to the bush to fetch firewood due to their work schedules may have to shift to another available source; charcoal or LPG. The satellite image analyses of the area (Fig. 6) reveal that over three decades, the woody savanna and grasslands close/within the peri-urban settlements have reduced and shifted inland, thereby reducing access to freely available firewood.

This finding confirms the perception of the respondents that the source of firewood dwindles as built-up intensifies. Jagger and Shively (2014) reported similar findings of limited access to freely available woodfuel because of the land-use change, which influences household energy choices.

A trend analyses (Fig. 7) of respondents' energy use in the three localities over the three decades further affirms the reduction in firewood use due to scarcity. Firewood was the most widely used energy source in all the locations; but has reduced over time with charcoal taking over while LPG usage is rising. The indication from Fig. 7 is that woodfuel, mainly charcoal, will remain irrespective of the level of land-use change intensification. One of the reasons for the high choice of charcoal is the introduction and promotion of efficient charcoal stoves (GEC, 2006; Kemausuor et al., 2014). Many households use the Gyapa, which is an improved cooking stove due to vigorous marketing campaigns (cited in Kemausuor et al., 2014).

What can be deduced from Figs. 6 and 7 is that built-up intensification contributes to a reduction in firewood. However, as firewood use decreases, charcoal usage increases. This is because charcoal has always been imported into the Greater Accra Region from other regions, especially the Volta and Northern parts of the country. According to Dam (2017), charcoal demand will continue to rise in Africa. This calls for exploration of sustainable approaches to charcoal production that will minimise greenhouse gas emission while ensuring reliable energy supply to low-income communities in peri-urban Africa. On the part of LPG, it was found that LPG is not readily available in the communities and people have to travel long distances to refill. For example, the nearest

LPG to even the more urbanised settlement (Abokobi) is more than 3 km away, and this means people must travel for a quite a distance to purchase LPG. It is therefore apparent from these findings clearing of the woody/savanna grassland to make way for buildings is affecting woodfuel use with more effect firewood than charcoal.

4.2. Other factors accounting for the use of woodfuel

Besides the scarcity of freely available woodfuels, several other factors account for the pattern of woodfuel use observed in the study sites. Each respondent was asked to choose the factors he/she believes trigger the change from one energy source to another and further provide an explanation for his/her choice. As shown in Table 1, the major factors accounting for the decrease in the use of firewood are housing structure, changing lifestyle and financial reasons. The housing structure is the leading factor in the near completely built-up areas as it got the highest responses among all the elements. The reasons given for this in Papase and Abokobi is that most of the shared-tenancy houses do not have kitchens and those that have kitchens, they are not designed for firewood.

About 77 % of these respondents² explained that firewood stoves are made with stones or mud on the floor, but, the modern kitchens in the self-contained and some shared-tenancy houses are tiled and not conducive for mounting stones for firewood use. Additionally, 67 % reasoned that firewood produces copious amounts of smoke, which stains the walls, and ceilings of kitchens, and this has been problematic for more 70 % shared-tenancy households. Thus, the housing form and ownership structures of the house are also driving factors that influence the choice of fuel which supports the finding of Adeyemi and Adereleye (2016). In the rural areas, kitchens are not entirely enclosed, and some are in the open, allowing the smoke to escape freely during cooking. Concerning Fig. 1, the housing structure can be classified as both behavioural and environmental factors as they are the most available dwelling units as well as tenants' preference for them for reasons of privacy and security.

Another behavioural factor, which is changing lifestyle (see Table 1), especially among the more urbanised respondents such as the desire of modern-day woman/man to be multitasking, also featured prominently. According to over 80 % of multiuser respondents, in addition to reasons for multiple uses stated above, people these days want to do many things at the same time: cooking while bathing children, watching TV, or ironing. Such people will therefore, find the use of firewood inconvenient since it requires one to be by the fire almost throughout the cooking period to either push the firewood in or fan it. Charcoal, on the other hand, requires far less time than wood, whereas LPG requires minimal attention during cooking. Multiple users (Table 1) have cookers with various burners and coal pots. Respondents also note that cooking with LPG is faster than the woodfuels, which also accounts for the increasing use of LPG especially by middle-income households who leave home early and return late in the night. Thus, for those in the urban/peri-urban areas, efficiency was crucial and LPG comes in handy. The use of different stoves and their efficiencies explains how technology shapes the choice of fuel (see Fig. 2).

In the cluster communities, finance was the primary driver of energy type used for cooking (Table 1) compared to the urban/peri-urban settlements. The respondents stated that charcoal is cheap and with as little as GHC 1.00 (about US\$ 0.18), they can buy charcoal. In Papase also, finance was a problem mainly for those switching to LPG, as the initial cost in terms of purchase of a gas cylinder and gas cooker, and the weekly/monthly refill was costly. This is in line with the proposal of GEC (2006) that the initial setup cost of using LPG is problematic for many

² Note that this was an open-ended question and most respondents gave more than one reason and was recoded into something like a multiple choice question, therefore total is not relevant

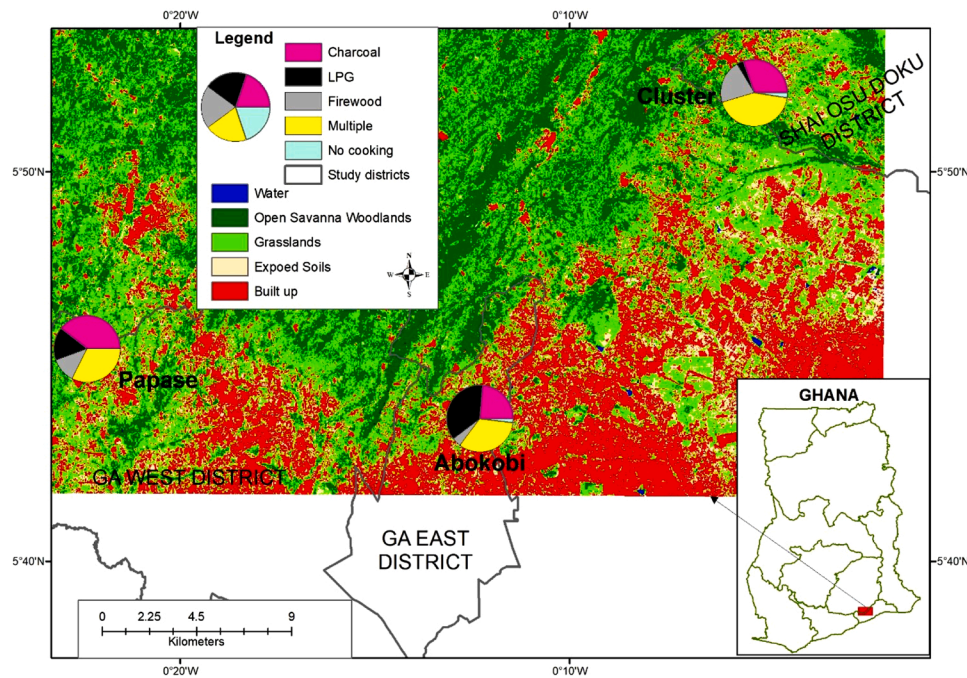


Fig. 4. Types of Energy by locality.
Source: Fieldwork, 2018.

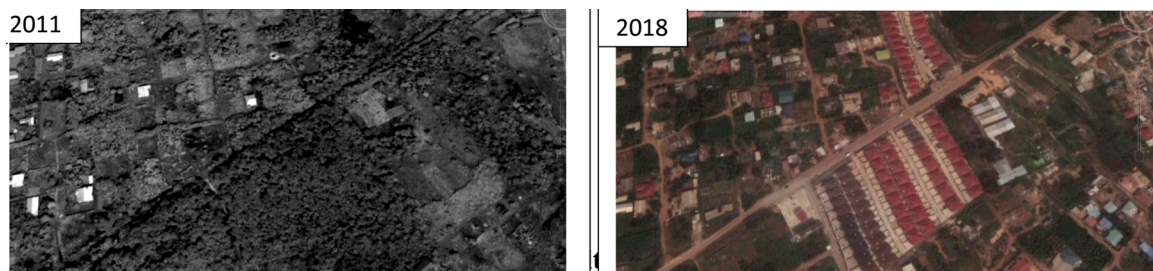


Fig. 5. Land conversion from vegetation to built-up in Abokobi.
Source: Retrieved from Google Earth on May 30, 2020.

households when switching to LPG. In the urbanised Abokobi, LPG was cheaper than the most desirable alternative option of electricity. Only one respondent was found using electricity for cooking. This is reinforced by a woman in Abokobi who claimed that ‘when I moved in here, I started cooking with electricity, and I was paying more than GHC 250.00 [about US\$46] a month, but when I switched to LPG, my electricity bill came down to about GHC 100.00 [about US\$18.6], and I spend about GHC 70.00 [about US\$13] a month on LPG’. Statistics from the Energy Commission (Table 2) indicate that electricity tariffs are high and has been increasing over the years. Although the 0–50 tariff category is set low to benefit the low-income residents, many of them live in compound houses with several households connected to a single electricity meter hence their total consumption exceeds the threshold for low-income households. They, therefore, end up paying high tariff, which is a disincentive for the use of electricity for cooking. In addition, just coming out of the severe power outages between 2012 and 2016, electricity supply was not guaranteed in their minds.

However, the price of charcoal, although rising every year (Fig. 8) is still far cheaper than electricity or LPG. According to the traders in woodfuel, the cause of the annual rise in the price of charcoal is the rising cost of transportation.

However, the amount spent on each type of fuel a month depends on the cooking/heating habit (frequency of cooking) of the individual/household and quantity of food cooked as well as other sources of

cooking energy. Therefore, cost/affordability plays a role in the transition, and this transition is very apparent in Fig. 7, which implies a switch from firewood to charcoal in the cluster.

Nevertheless, the charcoal users stated that even though charcoal is cheaper, they are still shifting to LPG due to some of the reasons explained earlier and health. The health issues mentioned included heat, coughing, sight problems and running nose for firewood/charcoal. Comparatively, the effects of charcoal were said to be much less than firewood. The health conditions and other harmful effects of indoor air pollution to human health due to the use of biomass energy is well documented in earlier studies (e.g. GEC, 2006; Ma et al., 2019; Ravindra et al., 2019). These health effects have had some socioeconomic influences on families, especially the financial demands for the treatment of eye and respiratory diseases.

On the other hand, the health effects of LPG stated by all respondents who use it included injuries (burns) and loss of lives. This was obvious because burns and deaths are the most frequent occurrence resulting from fire outbreaks caused by LPG. According to the respondents in the in-depth interview, although they have not personally experienced fire outbreak resulting from LPG, they have heard or seen the damage it has caused in other areas. One respondent noted that a relative died at Tema due to burns sustained from LPG accident. Another respondent also used a televised documentary from the burns centre at Korle Bu Teaching Hospital about injuries on people resulting from domestic gas explosions

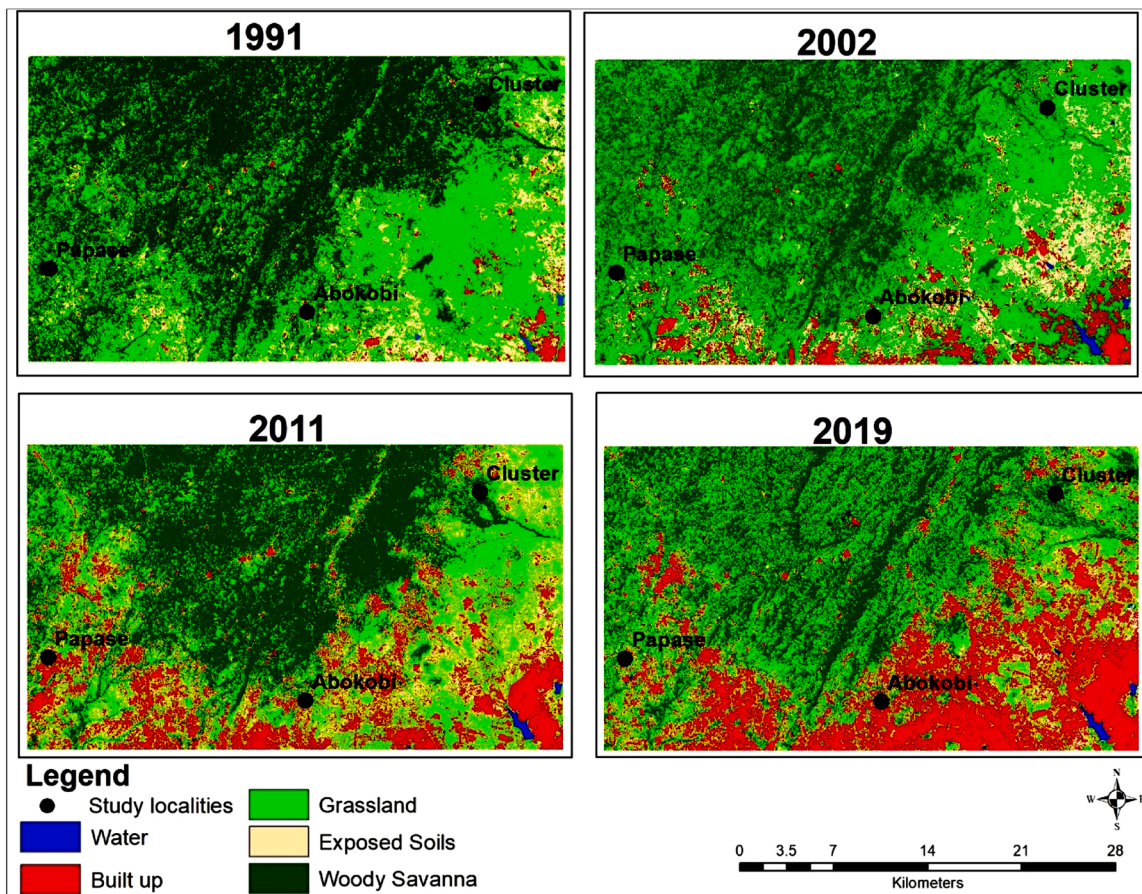


Fig. 6. Classified images from 1991 to 2019. Source: Authors' construct.

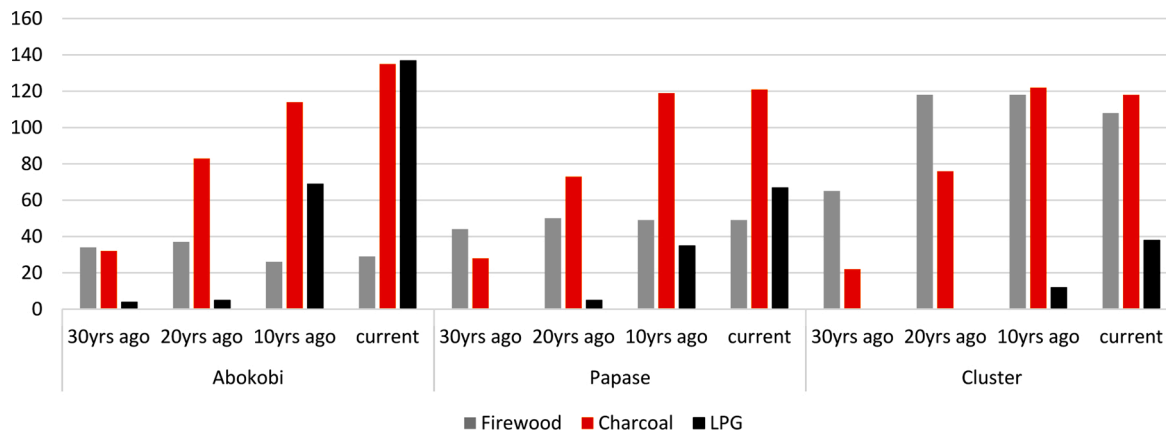


Fig. 7. A trend analysis of significant energy forms across the study communities⁴. Source: Fieldwork, 2018.

as her evidence of the health effects of LPG related health effects. Due to the risk of fire and its associated damages to property and life, some respondents expressed fear for using LPG. Though those who expressed fear, from our data, is less than 10 % of respondents, it is a critical factor limiting the use of LPG as we observed that LPG related fire incidents are on the ascendency. However, the Ghana Fire Service and the National Petroleum Authority (NPA) in the media address safety concerns about LPG explosions and injuries/deaths through public sensitisation programs.

Another factor identified by respondents relating to energy choice is

the scarcity of the cooking fuel type in terms of availability and regularity of supply. All respondents who use LPG indicated they have to travel more than 3 km to refill their cylinders because there was no LPG filling station within the study communities. The need for consumers to go a distance to have access to LPG is a limiting factor to LPG use. LPG supply has generally become regular after Ghana started extracting oil and gas in commercial quantities offshore its western coast (Ablo and Asamoah, 2018). As a respondent observed, 'for the past three years, there has scarcely been a shortage of LPG lasting up to a week'. Thus, the only problem here is the distance we have to travel to access the LPG. Another

Table 1
Factors accounting for the change to dominant fuel used for cooking.

Name of community	Factors							Total
	Housing structure	Financial	Scarcity	Health	Changing lifestyle	Other ^a	No change	
Abokobi	86	9	4	17	75	5	4	200
Papase	95	41	15	9	38	1	1	200
Cluster	27	83	47	11	27	5	0	200
Total	208	133	66	37	140	11	5	600

Source: Fieldwork, 2018.

^a The 'Other' represents those who do not cook or use electricity or other fuels such as kerosene, farm residue etc.

Table 2
Electricity tariffs for residential consumers.

Tariff Category (Residential)	Effective Date								
	Dec, 2011	Oct, 2013	Jan, 2014	Jul, 2014	Oct, 2014	Apr, 2015	Jul, 2015	Dec, 2015	Mar, 2018
0 - 50 (Exclusive)	9.5	15.7	17.2	19.3	20.5	21.1	21.1	33.6	27.7
51 - 300 (GHp/kWh)	17.6	31.4	34.5	38.7	41.2	42.3	42.3	67.3	55.5
301 - 600 (GHp/kWh)	22.8	40.8	44.9	50.2	53.5	54.9	54.9	87.4	72.1
600+ (GHp/kWh)	25.3	45.3	49.8	55.8	59.4	61.0	61.0	97.1	80.1
Service Charge (GHp/month)	165.3	295.7	324.5	363.8	387.5	397.7	397.7	633.2	397.7

Source (GEC, 2018).

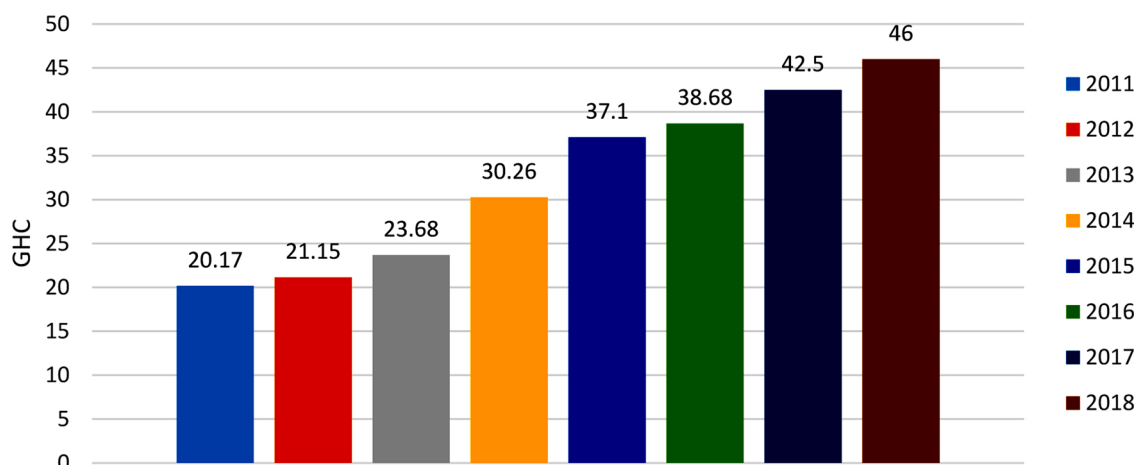


Fig. 8. Average price of Maxibag⁵ of charcoal in the Greater Accra Region.
Source (GEC, 2019)

problem associated with LPG was the frequent price hikes as can be seen from the 2018 critical energy statistics report (Fig. 9). The price of LPG is rising rapidly and is very expensive for low-income earners. For charcoal, respondents note that charcoal has never been out of supply. They nevertheless stated that firewood that they could get free from their environment is now scarce in the urbanised study locations. Another factor that was also given by interviewees in the relatively urbanised communities as a trigger of the fast rate of transition from firewood to other energy forms is the bulkiness of firewood. A synthesis of statements from the open-ended questions and in-depth interviews indicated that wood is bulky and requires space to store, which is virtually unavailable for tenants in rented and shared properties. Here, it is obvious the bulkiness of firewood coupled with the changing housing structure driven by urbanisation has influenced household energy choice.

The dynamics of household energy use is aptly summarised by an interviewee in Papase who contends that,

I am using this rented open space to store and sell the fuelwood products, but my customers do not have enough space to store and therefore cannot buy in large quantities. It is also inconvenient for them to keep coming here daily to buy firewood as many people get home late from work. Even in homes that do have spaces, sometimes women fight as they accuse each other of stealing

wood. As a result, the wood is primarily patronised by food vendors while households buy charcoal because it can be stored on the veranda/porch. My charcoal moves faster than firewood.

Other interviewees across the study areas shared the viewpoint above on the fact that storage space has a substantial influence on the transition from firewood to other energy forms. We also observed that most of the wood is placed in the open thus, exposing them to rain, which is one of the reasons interviewees allude to as a factor accounting for the decrease in the use of wood. According to them, they might not be able to cook if they rely on firewood because it might rain on them, making them wet and difficult to burn, especially when they are away from home. However, bulkiness or storage space was not a problem in the cluster villages as they are still in the rural setting with ample open space that they use to store their wood. They also have kitchens designed to allow cooking with firewood.

As shown in Fig. 1, income is one of the drivers of the energy transition. To determine the relationship between income and choice of fuel, we used two proxies, level of education and occupation, as we could not measure income directly. This was borne out of our experience with difficulty in measuring income, especially in the informal sector in Ghana. We found that the level of education of respondents also

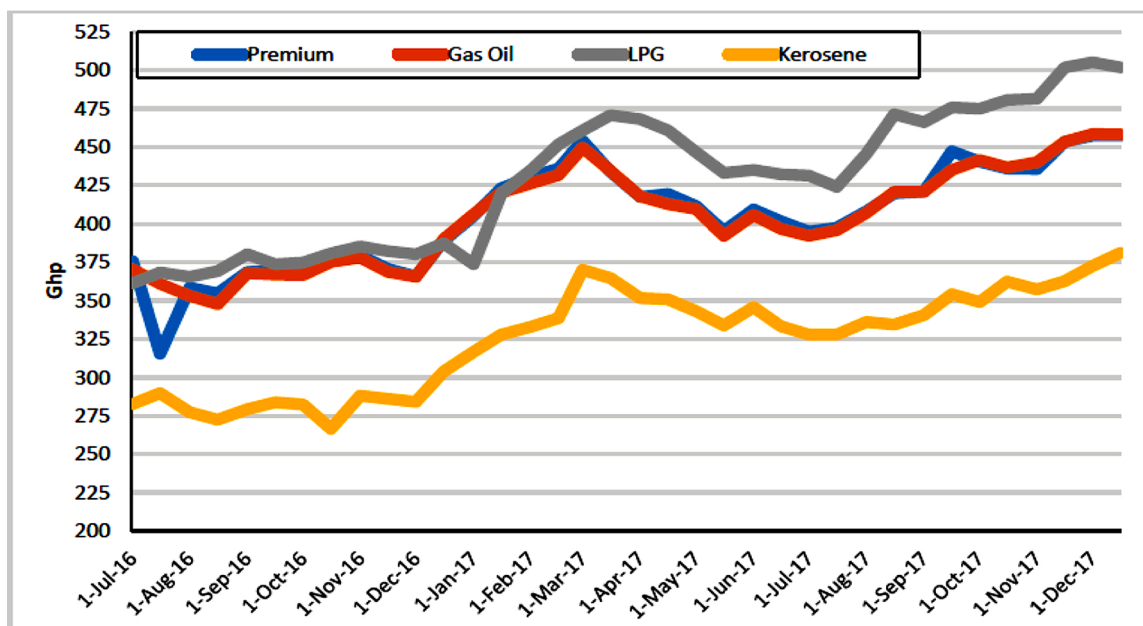


Fig. 9. Prices of petroleum products⁶.
Source (GEC, 2018).

influenced their choice of fuel for cooking (Table 3). Although the majority (76 %) of the respondents had no or only basic education (primary/JHS/Middle), a critical analysis of Table 3 reveals that, the level of education had a role to play in the transition process. Thus, as people moved up the educational ladder, there was a corresponding decrease in the numbers using charcoal and firewood. Education gives people diversified and better opportunities as well as increasing their awareness of health problems associated with their choice of cooking fuels. In addition, few (6.5 %) respondents had tertiary education, but the majority (44 %) of them used LPG, while 41 % used multiple, mainly LPG and charcoal.

This finding supports Paudel et al. (2018) and Sakanko, David, and Yakubu (2018), who established that education influenced peoples' choice of energy for cooking. Closely linked to education, and income of the people is the job types as specific jobs pay higher than others, and this shapes choice of energy for cooking (Ma et al., 2019; Paudel et al., 2018; Sakanko et al., 2018). The study reveals that those in high-income-earning jobs use clean energy (LPG) more than those with low-income jobs (Table 4).

As shown in Table 4, high-paying jobs such as accounting, construction, engineering, health work and proprietor/entrepreneur correlate with the use of LPG more than any other fuels for cooking. In contrast, unemployed and low paying jobs such as traders, teachers³, driver, and security, among others, use charcoal and firewood more than LPG. The findings show that urbanisation influences the choice of energy. In the next section, we discuss the implication of land use policy and global change or development.

³ Most of the teachers here are uncertified Senior High School leavers who earn very low incomes and most of the traders are engaged in petty trading.

⁴ Results are based on recollection from respondents, age of respondent or length of stay in the area and might sum up to the total and that could probably be the reason for the low values for 30 years ago.

⁵ The weight of a maxibag is between 45 – 50 kg

⁶ One Ghana pesewas is 1/100 of one Ghana cedi (i.e. 0.0018USD). The prices of the other products are Ghp/litre

4.3. Implications of the findings

Based on the findings, it is evident that there is a transition from firewood to charcoal and LPG. One factor responsible for this transition is the reduction in vegetation cover from the local environment, the source of woodfuel, due to a change in the use of the land from natural vegetation to built-up. Thus, peri-urban development takes place without control, resulting in almost every undeveloped land being converted to residential use. This has resulted in the almost total clearing of trees and shrubs (see Fig. 5) in the peri-urban areas, the source of woodfuel, especially firewood. According to Månsson et al. (2014), clearing of the environment for residential use affects the availability of local woodfuel and hence energy security. This is because it results in an increase in the prices of household woodfuel. Therefore, energy will become unaffordable to the peri-urban poor, and this will impede the achievement of the Sustainable Development Goals (SDGs), which seek to ensure access to affordable, reliable, sustainable and modern energy for all (McCollum et al., 2017).

For energy balance, woodfuel (both charcoal and firewood) is being imported from other parts of the country. Data from the Energy Commission showed that wood supplied to the Greater Accra Region for both firewood and charcoal rose from about 3 million in 2008 to about 4 million kilotonnes of oil equivalent (ktoe) in 2017 (GEC, 2018). This may lead to deforestation in the source regions, and if the trend continues, it may result in desertification. The devegetation (i.e. clearing of vegetation) stemming from urban sprawl contributes to local and global climate changes (Kalnay and Cai, 2003) as carbon sequestration is greatly affected.

However, since woodfuel consumption will continue to rise, there is the need for sustainable production of woodfuel. This can be achieved on the one hand by controlling urbanisation or land-use change and on the other hand, planting more trees to replace the felled ones and reducing dependency on wood. One of the major causes of the rapid land-use change occurring in the peri-urban areas is the construction of informal housing which, in many cities, constitutes about 80 % of the housing needs (Sheppard, 2010). This is very problematic due to the land tenure systems in these cities, particularly in peri-urban Accra where the land is owned mainly by individuals, families and chiefs (Boamah, 2014), who allocate the land without recourse to land use

Table 3
Level of education against the choice of fuel.

Education	Type of energy used for cooking/heating					Total	
	Charcoal	Firewood	LPG	Multiple	Other		
No education	70	38	17	63	0	4	192
Basic	90	28	40	104	0	3	265
Second cycle	24	4	39	34	1	2	104
Tertiary	3	3	17	16	0	0	39
Total	187	73	113	217	1	9	600

Source: Fieldwork, 2018.

Table 4
The influence of occupation on the choice of energy.

Occupation	Charcoal	firewood	LPG	Multiple	Don't cook	Total
Accounting	0	0	4	1	0	5
Food	3	0	2	1	0	6
Contractor/ Factory hand	1	2	3	2	0	8
Farmer	19	17	1	29	0	66
Hairdresser/ Barber	5	3	7	10	1	26
Herdsmen	0	1	0	1	0	2
Engineer	0	0	2	1	0	3
Office Clerk/ labourer/ Laundry	3	2	0	3	0	8
Health Worker	1	0	4	1	0	6
Artisan	15	4	13	17	1	50
Proprietress/ Entrepreneur/ Self employed	0	0	3	3	0	6
Repairer	0	0	3	1	0	4
Retiree	2	1	4	3	0	10
Security	3	0	2	1	0	6
Fashion	9	3	6	15	1	34
Teacher	2	4	1	8	0	15
Driver	6	4	4	9	0	23
Store Keeper	3	0	4	2	0	9
Unemployed	30	13	17	36	0	96
Trader	82	20	30	68	6	206
Other	3	1	1	6	0	11
Total	187	75	111	218	9	600

Source: Fieldwork, 2018.

plans (Mireku et al., 2016). The chiefs, families and individuals who own the land in peri-urban areas seek to maximise monetary benefits by converting green belts, open spaces, playgrounds, and school lands into building plots (Ubink and Quan, 2008) and sell to prospective developers. This is the result of the increase in built-up intensification and expansion witnessed in these peri-urban areas captured in Fig. 5. This development in many third world cities often occurs as a result of lack of urban planning and nonadherence to land use regulations (Awuah and Hammond, 2014; Awuah et al., 2014). Land use plans as tools to control the delivery of land and buildings have been absent in peri-urban areas in many developing countries (Bhatta, 2010; Cobbinah and Aboagye, 2017). Land use planning schemes ascribe uses to the various areas and demarcate the boundaries of the individual plots (Ubink, 2008). Proper engagement of the custodians of the land is needed to produce 'community-based land-use plans' which will significantly contribute to controlling rapid land-use change and consequently maintain some vegetal cover which can serve as a source of woodfuel. This kind of engagement will yield the integrated/all-inclusive plans proposed by other researchers such as (Cobbinah and Darkwah, 2017; Yigitcanlar and Teriman, 2015).

On the other hand, planting more trees, especially in areas where trees are felled in large quantities for firewood and charcoal according to the strategic national energy plan is a possible option to meet future demand (GEC, 2006). This will create many jobs for not only those

engaged in tree plantation and woodfuel production but also artisanal workers who will participate in the manufacturing of improved stoves. This will also contribute to the realisation of SDGs 1 (no hunger), 3 (good health and wellbeing), and 7 (affordable and clean energy). Successful implementation of the plantation programme will help combat land degradation/desertification (Yiran et al., 2012) as well as reduce the harsh microclimatic conditions and global warming through carbon sequestration.

The strategic energy plan also recognised the switch to energy substitutes, especially LPG. However, the deregulation of petroleum products is likely to affect this. The liberalisation has made LPG very expensive rising at a fast rate while woodfuel is relatively cheaper and relatively stable. The rising cost of LPG and electricity implies that people, particularly those in the lower-income bracket will fall back on woodfuel, thereby increasing demand. This may lead to energy insecurity for many people in the future and derail the achievements of the SDGs if the sustainable source of woodfuel is not guaranteed. The implication is that it is not possible in the near future to have a complete shift from one energy form to another, and charcoal will remain an essential source of fuel for many households. Several factors underlie the argument above, including the cost of LPG, the types of food cooked, the cooking stove used and above all the availability of the energy.

5. Conclusion

The study showed that transition from the various woodfuel, especially from firewood to LPG and charcoal because of urbanisation is influenced by environmental (storage space and the presence of the energy), behavioural (housing structure and lifestyle) and livelihoods (financial, education/skills, occupation and health) factors. The environmental factors are essential for the availability of the energy form while the human behaviour and livelihood factors influence the affordability of the energy. When the factors are combined, they determine the choice of the energy to use for cooking that is, using woodfuel, LPG or both. Electricity for cooking has been unpopular in the study area due to its high cost compared to other energy sources. A key finding is that the transition is more towards mixed-use of energy, especially LPG and charcoal. Government efforts must therefore, be geared towards controlling urbanisation through the formulation of an inclusive land use policy, which will lead to the design of community-based land-use plans. These land-use plans must be implemented, and lands allocated for green spaces must be acquired by the government and used for cultivating woodlots/afforestation. In addition, efforts at increasing accessibility and affordability of LPG as a more sustainable option for household energy should be prioritised. Further, there is the need for research into sustainable charcoal production, especially in the savannah belt and investments in safer and improved kiln/stove technologies to reduce the environmental and health impacts of charcoal as its consumption continues to increase. Finally, afforestation programs must be promoted to compensate for vegetation harvested for woodfuel.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.landusepol.2020.105047>.

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