Household energy transition in developing countries: Two alternative frameworks for analysis


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Introduction

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  - University of East Anglia, Norwich [UK]
    - Bachelor of Science (Honours) in Environmental Sciences, Major: Sustainable and Environmental Economics & Politics
  - Norwegian University of Life Sciences, Ås [Norway]
    - Master of Sciences in International Environmental Studies, Major: Sustainable & Environmental Development
  - Collège des Ingénieurs, Paris [France]
    - Master of Business Administration

- Norwegian University of Life Sciences (UMB)
  - Department of International Environment and Development Studies, Noragric

- Gesellschaft für Internationale Zusammenarbeit (GIZ)
  - Private Sector Development in Agriculture (PSDA), Nairobi [Kenya]
  - Energising Development (EnDev) Programme
Research background

- Dependency on traditional biomass in many developing countries is still very high

- Health and environmental implications are significant

- Energy transition to more modern, cleaner, and efficient sources will affect vast numbers of people and the environment

- Understanding households’ consumption patterns and adoption behaviour is crucial

- Literature does not give a consistent answer
  - Why households diversify their stove and fuel use
  - Why households choose or dismiss a particular stove or fuel
Literature review

Energy ladder

- The positive relationship between socio-economic level and modern fuel uptake
- Inherently ranked fuel preferences ordered by physical characteristics as well as fuel costs
- Assumption of complete substitution of one fuel for another

Multiple fuel use approach

- Lower level fuels are kept and used simultaneously or as supplement
- Reliable energy supply as reason
- Specific fuels for a specific task
Literature review

- Increasing dependency between fuel and stove along the energy transition
- Leads to the question of technology adoption theory

- Subjective perception and personal behaviour play an important role in the technology adoption

- Main criteria for adopting a technology:
  - Observability
  - Triability
  - Relative advantage
  - Compatibility
  - Complexity

- “Perceived ease of use” & “Perceived usefulness”
  - Affected by individual’s characteristics (e.g. experience, age, gender)
  - Personality traits
Literature review

- Income is not the sole factor for technology adoption and energy transition
- Fuel & stove diversification is a frequent phenomenon
- Existing explanations are implemented into the energy ladder model
- The dominant energy transition theory has focused much critic
- But no alternative framework is proposed for interpreting such behaviour
Methodology

- Sept. 2011 - May 2012
- 3 GIZ Cluster
- 6 locations randomly chosen
- 12 villages surveyed
- 320 questionnaires
  - 163 rural
  - 157 rural
- 15 households interviews
- 4 institutional interviews
- 6 location profiles
- Observations

Kenya map with detailed view on GIZ Clusters (data retrieved from GIZ & WRI)
Methodology
Results

Percentage of household using a particular fuel as energy source sorted by income category
Results

Diversification of stoves & fuels used in households by rurban and rural areas and income
## Results

<table>
<thead>
<tr>
<th>Reason - Multiple Stove</th>
<th>N</th>
<th>%</th>
<th>Reason - Multiple Fuel</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simultaneous cooking</td>
<td>105</td>
<td>51.0</td>
<td>Food/stove /task</td>
<td>184</td>
<td>57.5</td>
</tr>
<tr>
<td>Food type &amp; quantity</td>
<td>118</td>
<td>57.2</td>
<td>Fuel availability</td>
<td>198</td>
<td>61.9</td>
</tr>
<tr>
<td>Fuel availability</td>
<td>77</td>
<td>37.4</td>
<td>Seasonal fuel availability</td>
<td>47</td>
<td>14.7</td>
</tr>
<tr>
<td>Seasonal fuel availability</td>
<td>11</td>
<td>5.3</td>
<td>Backup fuels</td>
<td>104</td>
<td>32.5</td>
</tr>
<tr>
<td>Fuel affordability</td>
<td>25</td>
<td>12.1</td>
<td>Fuel affordability</td>
<td>48</td>
<td>15.0</td>
</tr>
<tr>
<td>Wanted new/better stove</td>
<td>57</td>
<td>27.1</td>
<td>Fuel is free</td>
<td>26</td>
<td>8.1</td>
</tr>
<tr>
<td>Other reason</td>
<td>68</td>
<td>33.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results

Histograms of the number of fuels used in households for the main tasks

a) # of Cooking fuels

b) # of Warming Up fuels
c) # of Water Boiling fuels

d) # of Lighting fuels
e) # of Communication & Entertainment fuels

f) Mean = 2.33
Std. Dev. = 0.997
N = 320

Mean = 3.08
Std. Dev. = 1.133
N = 319
Results

Main task fuel from households with more than one fuel option per task in rurban and rural areas
## Results

<table>
<thead>
<tr>
<th>Reason</th>
<th>Main Cooking fuel</th>
<th>Main Lighting fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Affordability</td>
<td>18</td>
<td>5.6</td>
</tr>
<tr>
<td>Availability</td>
<td>114</td>
<td>35.6</td>
</tr>
<tr>
<td>Affordability &amp; availability</td>
<td>120</td>
<td>37.5</td>
</tr>
<tr>
<td>Efficiency &amp; cost-effectiveness</td>
<td>43</td>
<td>13.5</td>
</tr>
<tr>
<td>Flexibility</td>
<td>9</td>
<td>2.8</td>
</tr>
<tr>
<td>Smoke reduction &amp; cleanliness</td>
<td>5</td>
<td>1.6</td>
</tr>
<tr>
<td>Development</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>3.4</td>
</tr>
</tbody>
</table>
## Results

<table>
<thead>
<tr>
<th>Reason</th>
<th>Main Cooking Stove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency &amp; cost-effectiveness</td>
<td>123</td>
</tr>
<tr>
<td></td>
<td>38.4 %</td>
</tr>
<tr>
<td>Fuel affordability</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>23.8 %</td>
</tr>
<tr>
<td>Stove affordability</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>5.9 %</td>
</tr>
<tr>
<td>Tradition &amp; familiarity</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>6.6 %</td>
</tr>
<tr>
<td>Lack of knowledge</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1.6 %</td>
</tr>
<tr>
<td>Smoke reduction &amp; cleanliness</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>0.9 %</td>
</tr>
<tr>
<td>Other</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>10.3 %</td>
</tr>
</tbody>
</table>
Results

Fuel and stove preferences other than main device for specific types of food
Results

- No significant relationship found between fuel & stove choice and ...
  - Age of household’s head and main person cooking
  - Education level of household’s head and main person cooking
  - Occupation of household’s head and main person cooking
  - Household size
Alternative framework

- Task’s nature determines stove and fuel choice
  - Efficiency
  - Cost-effectiveness

- Final selection is influenced by
  - Income
  - Culture
  - Individual

- Increasing dependency between fuel & stove
- Weak effect of stove & fuel ownership in task demand

- Multifaceted demands = Major driver for fuel & stove diversification
Alternative framework

- Qualitative framework for technology adoption
- Out of a contingent of possibilities the individual forces refine the final choice

Allocation of the forces is chosen to support the argument but is acknowledged to be interchangeable

Further quantitative research would be necessary to determine the influence of the individual forces in the adoption process
Conclusion

- Income was indicated to play an important role in energy & technology adoption
- However, the effect of availability and access can outweigh it
- Energy security as one of the main drivers for fuel and stove diversification
- But, technologies were used according their efficiency and cost-effectiveness for a particular task
- Multifaceted demands = Major driver for fuel & stove diversification
- Social, cultural, and individual preferences determine the choice
- The two proposed frameworks allow
  - For a more comprehensive interpretation of energy consumption patterns & transition
  - For the application in general technology adoption theory
Thank you for your attention!

Any questions?

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Appendix - Locations

Overview of the surveyed locations and sub-locations

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Location</th>
<th>Rurban/rural</th>
<th>Sub-location</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western</td>
<td>Khayega</td>
<td>Rurban</td>
<td>Shidodo</td>
<td>51</td>
<td>15.9</td>
</tr>
<tr>
<td></td>
<td>Shibuye</td>
<td>Rural</td>
<td>Shiasava</td>
<td>50</td>
<td>15.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td></td>
<td>101</td>
<td>31.5</td>
</tr>
<tr>
<td>Central</td>
<td>Gatuya</td>
<td>Rurban</td>
<td>Gatuya</td>
<td>52</td>
<td>16.3</td>
</tr>
<tr>
<td></td>
<td>Maragua Ridge</td>
<td>Rural</td>
<td>Kamuiru</td>
<td>55</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td></td>
<td>107</td>
<td>33.5</td>
</tr>
<tr>
<td>Transmara</td>
<td>Kiogoro</td>
<td>Rurban</td>
<td>Boronyi</td>
<td>52</td>
<td>16.2</td>
</tr>
<tr>
<td></td>
<td>Ndanai</td>
<td>Rural</td>
<td>Kipsingei</td>
<td>60</td>
<td>18.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td></td>
<td>112</td>
<td>35</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>320</td>
<td>100</td>
</tr>
</tbody>
</table>
Appendix - Sampling

- All potential GIZ locations in a Cluster were categorized into rural, rurban, urban
- 1 rurban & rural location randomly chosen
- 1 sub-location in each location
- 2 villages randomly picked in each sub-location

- Random-walk sampling principle starting at one of the four corners which was randomly chosen
- Equal chance to be surveyed by picking every \( n_{vil}^{\text{th}} \) household
- Where \( n_{vil} = \frac{N_{vil}}{X} \)

- \( N_{vil} \) being the total number of households in the particular village and \( X \) the amount of planned questionnaires in that village

- \( X = \frac{n_{tot}}{V} \)
- \( V = 12 \), the total number of surveyed villages
Appendix - Sampling

- Total survey sample size calculated using sample size calculator by Raosoft, Inc.
  \[ n_{tot} = \frac{N_{tot}x}{\left(\frac{N_{tot}}{N_{tot} - 1}E^2 + x\right)} \]

- With a total population \( N_{tot} = 38,610,097 \) (KNBS 2010) and the variable \( x \) given by
  \[ x = Z\left(\frac{c}{100}\right)^2r(100 - r) \]

- Where \( Z\left(\frac{c}{100}\right) \) is the critical value for the confidence level \( c = 95\% \) and \( r = 50\% \), the fraction of responses interested in which values were suggested by the literature

- Margin of error \( E = \sqrt{\left(\frac{(N_{tot}-n_{tot})x}{n_{tot}(N_{tot}-1)}\right)} \)

- Accounting for 5% recording error and some household non-responses the final sample size was increased to a minimum of \( n_{tot} = 312 \) and thus \( E = 5.55\% \)

- Interview at least a quarter of participants in each location \( [N_{int} \geq 13] \) and the total number being decided by saturation