Fuelwood scarcity and its adaptation measures: an assessment of coping strategies applied by small-scale farmers in Dodoma region, Tanzania

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Abstract

In Tanzania, the majority of the rural population still relies on fuelwood as their major source of cooking energy. The adaptation measures of small-scale farmers in response to increasing fuelwood scarcity play a key role in altering the course of nutrition insecurity, environmental degradation, and economic instability. This study delivers a classification of coping strategies that does not exist in the literature. Furthermore, it analyses the adaptation measures applied by small-scale farmers in the semi-arid region of Dodoma district in response to fuelwood scarcity. A comparison between two case study sites provides information on the choice of adaptation measures by households. Overall, 28 coping strategies from 24 studies are identified, then differentiated into preventive and acute measures that are arranged into eight clusters. The classification is then used as a codebook to identify applied coping strategies at two case study sites. In total, 23 adaptation measures, including two strategies not cited in the literature, were identified through 39 household interviews. This suggests that the majority of coping strategies applied are independently from regional and social conditions. The majority of the strategies applied at the case study sites and described in the literature are acute measures that do not tackle the underlying problem triggering forest degradation. It is observed that the adaptation measures across the case study sites are widely congruent, thus showing that acute strategies are not replaced by preventive strategies but rather co-exist.

Introduction

Globally, around 2.7 billion people rely on solid biomass as primary cooking fuel (IEA 2016). In order to supply this demand, nearly half of globally harvested wood is used for energy production (Bruinsma 2003). In sum, traditional bioenergy represents approximately 15% of total global energy use (Creutzig et al 2015) and is responsible for 1.9%–2.3% of global CO2 emissions annually (Bailis et al 2015). It is predicted that, through the next decade, the number of people dependent on it will remain unchanged at approximately 2.3 billion people (IEA 2017), with the population of Sub-Saharan Africa (SSA) remaining reliant on woodfuels also for the coming decades (Iiyama et al 2014). Around 78% of the population in SSA still relies on solid biomass—especially fuelwood4 and charcoal—for cooking (IEA 2017). Nearly three-quarters of those dependent on fuelwood for cooking live in rural areas (IEA 2014), while those in urban areas are more likely to use charcoal (Arnold and Persson 2003).

With a population of more than 50 million, only 2% of the Tanzanian population has access to clean cooking energy, while in rural areas, fuelwood dependency is 89% (NBS2014, GTF2017). At the same time, mainland Tanzania is affected by deforestation, losing approximately 4 Wood in the rough (such as chips, sawdust and pellets) used for energy generation. It can also be termed as firewood (FAO 2008).
370 000 ha per year (FAO 2015), with a forest cover of roughly 48 million ha (NAFORMA 2015). The country is among the top ten countries reporting the greatest annual loss of forest area between 2010 and 2015 (FAO 2015). Fuelwood utilization covering domestic fuelwood demand for cooking could be a major driver of forest degradation, depending on the geographic context (Bailis et al. 2015, Creutzig et al. 2015, Masera et al. 2015, IEA 2017). In this paper, we understand fuelwood scarcity as something that can be observed when behavioral changes, such as coping strategies, become necessary.

In particular, due to continued fuelwood scarcity, rural households are developing strategies to cope with the added stress, such as increasing labor for fuelwood collection, collecting fuelwood from non-forest areas, or using crop residues (Brouwer et al. 1997, Jagger and Shively 2014). In this context, women in SSA generally carry the majority of this burden, as they are traditionally responsible for collecting fuelwood and for developing strategies to respond to its increasing scarcity (Köhlin et al. 2011). There are a wide variety of coping strategies applied on the ground. In this research paper, coping strategies are defined as adaptation measures applied by rural households due to a fuelwood shortage occurring. Studies show that these coping strategies negatively affect the nutritional and environmental situations of the people (Heltberg et al. 2000), such as omitting or substituting dishes with high nutritious value (e.g. dry beans) (Makungwa et al. 2015). According to Heltberg et al. (2000), fuelwood collection and forest degradation are closely related. An increase in fuelwood collection can lead to the degradation of forests and forested areas while, in turn, this degradation can lead to physical fuelwood scarcity. Brouwer et al. (1997, p 256) attributes a ‘chronic character’ to this self-reinforcing process, which worsens over time, while Matsika et al. (2013) refers to the energy poverty cycle that links high usage of fuelwood to localized environmental degradation. Although coping strategies seek to alter or manage the cause of the problem, often it is beyond the reach of households to address the root of the problem (Brouwer et al. 1989, p 352). From a more theoretical viewpoint, Foeken and Hoorweg (1988) suggest differentiating coping strategies between preventive responses and those reflecting an acute scarcity. For example: planting trees or using alternative cooking technologies with higher efficiency can be understood as preventive responses because they hold the capacity to alter the cause of the problem. The latter includes different technologies, such as using improved cooking stoves (ICS). As an alternative to the traditional fuelwood based three-stone-fire stoves (TSF), ICS reduces fuelwood consumption through its higher thermal efficiency rates (Zein-Elabdin 1997, Ochieng et al. 2013). However, acute strategies are more common: these are short-term adjustments that do not affect the underlying cause of the problem. Specifically in the context of fuelwood scarcity and food security, several authors highlight that energy-demanding dishes with high nutritional value, such as dry beans, are omitted or substituted (FAO 1990, Brouwer et al. 1996b, Makungwa et al. 2013). To mitigate fuelwood scarcity, Akther et al. (2010) identifies several substitutes for fuelwood, including leaves, twigs, cow dung, and crop residues.

As coping strategies play an intermediary role between scarcity, societal impact, and environmental conservation, they must be considered as a leverage point that can alter the course of nutrition insecurity, environmental degradation, and economic instability. However, there is neither a review of coping strategies from different thematic areas nor a suitable classification scheme available. Particularly important are coping strategies with regard to fuelwood scarcity in regions that are classified as semi-arid. In Tanzania, these areas are in the center of the country, with Dodoma region being one of them. This region is also characterized by unimodal precipitation (WFP 2013). Although fuelwood scarcity in Dodoma can be observed, the role and the potential of coping strategies are not yet evaluated. Scientific data for the interplay between preventive and acute strategies is missing.

In order to close these research gaps and to provide more detailed insights into general strategies from the literature and strategies applied on the ground, this research paper provides: (1) a literature review of coping strategies and their classification; (2) an assessment of coping strategies at two case study sites (CSS); and (3) a quantitative comparison of the coping strategies applied by households at the two CSS.

Methods

Review of coping strategies from literature

In a first step, we identify coping strategies that households in rural areas apply to cope with fuelwood scarcity in the literature. The review articles by Brouwer et al. (1989) and Sola et al. (2016) on energy access, food security, and nutritional impacts provide the baseline for this review. Additional literature is identified using the bibliographic databases Web of Science, ScienceDirect and Google Scholar. In addition, relevant reports were searched for on websites of the FAO, the WFP, and the World Bank. The following broad search terms and their synonyms were used: (i) fuelwood and nutrition security; (ii) fuelwood and food security; (iii) fuelwood and alternative energy; and (iv) fuelwood and environment. Original and review articles were both included in the review process.

In total, we found 46 articles that were preselected based on their title and abstract. Subsequently, the articles were screened on the eligibility criteria, ‘coping strategies due to fuelwood scarcity’. Out of this, 24 articles were identified as eligible for a full review process (table 1).

In a second step, we classify the identified coping strategies from the literature. In particular, we differentiate...
between preventive and acute measures (Foeken and Hoorweg 1988). The former potentially reduces deforestation, while acute measures are used ad hoc in order to cope with immediate fuelwood scarcity.

**Study area**

The study was conducted at the two case study sites—Idifu and Mzula—both located in the Chamwino district of Dodoma region, Tanzania (figure 1). Dodoma region is semi-arid, consisting mainly of savannas and grasslands (Mutabazi 2016) and is part of the unimodal zone with one long rainy season that lasts from December to April (WFP 2013). There is a growing perception by the farmers of a decrease in rainfall that is leading to drought. At the same time, farms steadily move into new areas, accelerating the clearing of forest land (Goulden et al. 2009), leading to dilapidated forest and woodland areas (Mutabazi 2016). Idifu has approximately 1200 households (Hafer 2016), while Mzula has around 750 households (Mutabazi 2016). Most of the households are subsistence farmers. Fuelwood is the main energy source for cooking and boiling water in both villages. At the case study sites, two different cooking technologies are used. In Idifu, ICS have been introduced and adopted by several households, replacing TSF. Mzula households rely solely on TSF.

**Assessment of coping strategies in the Dodoma region**

Within our assessment, 39 household interviews were conducted in the two villages of Mzula ($n = 20$) and Idifu ($n = 19$). The interviews included a mix of unstructured and semi-structured questions in order to identify a full range of coping strategies. In the first part, households were asked about their livelihood, routines, responsibilities, and changes in their daily routine. In the structured part, direct questions about fuelwood availability and applied coping strategies were asked.

In Idifu, we only interviewed households using ICS, while in Mzula only households using TSF were sampled in order to assess differences in the choice of coping strategies. In Idifu, households were purposive sampled; in Mzula households were randomly sampled. In both villages, we only interviewed women, because women are mainly responsible for fuelwood collection and food preparation (Lim et al. 2012, Kahimba et al. 2015). The interview questions were professionally translated from English to Kiswahili.

The interviews were transcribed and analyzed using structured qualitative content analysis, based on the procedure described by (Mayring 2016, p 115). Three measures were taken to indicate and rank the coping strategies that households apply in Mzula and Idifu villages. First, the classification of the coping strategies from the literature was used as the codebook. In the second step, the codebook was used to systemize the applied coping strategies and to identify additional strategies that are not yet cited within the existing literature. Multiple coping strategy responses per household were possible. In a third step, the extracted strategies underwent a quantified ranking. The ranking is based on how often the strategies are mentioned by the households.

In order to identify differences in the choices of coping strategies by the households if preventive measures are applied, a quantitative comparison of the identified

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Table 1. 24 articles identified for the full review process on coping strategies applied due to fuelwood scarcity.

| Author (Date) | Topic |
|---------------|-------|
| Howes (1985)  | Rural energy |
| Shanahan (1986) | Woodfuel and rural households |
| Cecelski (1987) | Energy and women |
| Brouwer et al (1989) | Fuelwood shortage and nutritional impacts in developing countries |
| Dewees (1989) | Woodfuel crisis |
| FAO (1990) | Fuelwood scarcity and its impacts |
| Bradley and Kenya Woodfuel Development Programme (1991) | Woodfuel, women and woodlots |
| Brouwer et al (1996b) | Fuelwood and food security |
| Brouwer et al (1996a) | Wood quality and food security |
| Brouwer et al (1997) | Fuelwood availability and its impacts |
| Madubansi and Shackleton (2006) | Energy profiles and consumption |
| van’t Veld et al (2006) | Firewood crisis in India |
| Akther et al (2010) | Fuelwood scarcity and adaptation measures |
| World Bank (2010) | Household cookstoves |
| Bandypadhyay et al (2011) | Forest, biomass use and poverty |
| Kohlin et al (2011) | Energy, gender and development |
| Cardoso et al (2012) | Use of fuelwood in a semi-arid region |
| Damte et al (2012) | Fuelwood scarcity and adaptation measures |
| WFP (2012) | Firewood and alternative energy |
| FAO (2013) | Firewood and alternative energy |
| Makungwa et al (2013) | Fuelwood and food security |
| Guta (2014) | Fuelwood scarcity and socio-economic factors |
| Boafo et al (2016) | Ecosystem service-sharing |
| Baudron et al (2017) | Forests and dietary diversity |
strategies between the CSS was completed. Therefore, both the strategies and the number of applied strategies are compared.

Results

Classification of coping strategies based on existing literature

In total, the 24 studies identify 28 coping strategies that address the problem of fuelwood scarcity. Three preventive strategies in two clusters and 25 acute strategies in six clusters are identified (table 2).

Household responses to fuelwood scarcity and comparison between the CSS

The analysis of data collected in Mzula and Idifu show that a total of 23 strategies are applied in the villages, 21 of which are already identified in the codebook. We find two strategies used to cope with existing fuelwood scarcity that are not cited in literature:

- Use of improved collection means

Farmers use transportation means, such as wheelbarrows, oxcarts, or bicycles, to carry the collected wood. This facilitates the transportation of larger amounts of wood.
Table 2. Classification of coping strategies from existing literature including the respective sources.

| Clusters                          | Coping strategies                                                                 | Authors                                                                 |
|-----------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Preventive strategies             | On-farm tree planting                                                             | Dewees (1989), Köhlin et al (2011)                                      |
|                                   | Improved forest management                                                       | Köhlin et al (2011)                                                     |
| Decreased fuelwood provision      | Use of improved cooking technologies                                             | World Bank (2010)                                                      |
| Acute strategies                  | Use of private trees instead of trees from communal land                          | van’t Veld et al (2006)                                                |
|                                   | Cut down a tree as a fuelwood source                                             | Shanahan (1986)                                                        |
|                                   | Shift to lesser quality of fuelwood                                              | Brouwer et al (1989, 1997)                                            |
|                                   | Use of trees that produce food and fodder (fruit, spice or foliage trees)        | Shanahan (1986)                                                        |
|                                   | Decrease of stock building in fuelwood                                           | Bradley and Kenya Woodfuel Development Programme (1991)               |
| Increased use of substitutes for fuelwood | Use of crop residues instead of fuelwood (rice husks and straw, maize cobs, etc) | Brouwer et al (1989), Akther et al (2010)                                |
|                                   | Use of animal dung instead of fuelwood                                           | Akther et al (2010), Köhlin et al (2011), Cardoso et al (2012),          |
|                                   | Use of twigs and leaves instead of fuelwood                                      | Damte et al (2012), Baudron et al (2017)                                |
| Increased input of time and effort | Increase in walking distance to collect fuelwood                                 | Howes (1985), Brouwer et al (1989, 1997), Akther et al (2010)           |
|                                   | Increase in frequency of fuelwood collection                                     | Howes (1985), Brouwer et al (1989, 1997), FAO (1990), Guta (2014)      |
|                                   | Increase in time spent to collect fuelwood                                        | Howes (1985), Brouwer et al (1989, 1997), FAO (1990), Guta (2014)      |
|                                   | Change in weight of bundle collected                                             | Cecelski (1987)                                                        |
| Market-based measures             | Sell or barter food to procure fuelwood                                          | Brouwer et al (1996b, 1997), WFP (2012), FAO (2013)                     |
|                                   | Purchase fuelwood                                                                 | Brouwer et al (1997), Madubansi and Shackleton (2006)                   |
|                                   | Decrease in sales and exchange of fuelwood                                        | Brouwer et al (1997)                                                   |
| Utilization of human resources and social relationships | Change in who collects (children, older people, men)                          | Howes (1985), FAO (1990), Köhlin et al (2011)                           |
|                                   | Borrowing fuelwood from friends                                                  | Brouwer et al (1996a), Boafo et al (2016), FAO (2013)                   |
| Decreased food and health         | Switch to food of lower nutritional value                                         | Brouwer et al (1989, 1996b), WFP (2012), FAO (2013)                     |
|                                   | Undercook food to save fuelwood                                                  | FAO (1990, 2013), WFP (2012)                                           |
|                                   | Eat fewer meals                                                                  | FAO (1990, 2013), Brouwer et al (1996a), WFP (2012)                     |
|                                   | Replacement of long-time cooking dishes with high nutritional value (esp. beans) | FAO (1990), Brouwer et al (1996b), Makungwa et al (2013)               |
|                                   | Omit snacks (maize kernels or scones)                                            | Brouwer et al (1996a)                                                  |
|                                   | Reduced food for vulnerable people (infants, toddlers and sick people)            | FAO (1990)                                                             |
|                                   | Boiling water insufficiently or not at all to save fuelwood                      | Brouwer et al (1989), WFP (2012)                                       |
Differences in coping strategies if preventive measures, on two different sampling methods in order to identify the context-independence of coping strategies. This includes the identification of classification schemes based on the literature, own data, and the revision of previously developed categories is a common process for empirical-qualitative research (Barton and Lazarsfeld 1979). Additionally, Mayring (2016, p 115) describes structured qualitative content analysis, which seeks to identify specific aspects in interview material based on classification criteria that were developed beforehand. Both analytical approaches provide the stringent methodological framework applied in this study.

Classification of coping strategies

The systematic literature review of 24 articles and the identification of 28 coping strategies provide a comprehensive overview of adaptation measures to fuelwood scarcity. Nevertheless, a full systematic review would enhance our understanding of how farmers make their choices. Overall, we differentiate between preventive and acute measures in order to outline the different characteristics of applied strategies. Measures are grouped into two and six clusters, respectively, offering a holistic classification of coping strategies across the thematic areas. However, other authors use different clusters. Köhlin et al (2011), Damte et al (2012), and Schuenemann et al (2018) mainly differentiate between supply side and demand side strategies, while Egeru et al (2014) distinguishes between short-term and long-term coping mechanisms. Brouwer et al (1997) divides coping strategies into fuel collection, type of fuel used, and fuel use. In contrast, our approach offers practitioners direct strategic pathways to select appropriate strategies, depending on the cluster from which a strategy is needed.

Applied coping strategies at the CSS

Context-dependency of coping strategies

Literature reveals a wide variety of coping strategies when fuelwood is scarce. The fact that more than 90% of the identified strategies at the CSS are similar to those mentioned in the literature underlines the context-independence of coping strategies. This means they are applied autonomously from regional and social conditions. However, exceptions must be carefully considered. For example, the use of animal...
Table 3. Coping strategies derived from the household interviews of both CSS including a quantified ranking. The ranking is based on how frequently they were mentioned by the households. Multiple responses are possible.

| Clusters                              | Coping strategies                              | Coping strategies applied in Mzula (N = 20) | Coping strategies applied in Idifu (N = 19) |
|---------------------------------------|------------------------------------------------|------------------------------------------|------------------------------------------|
| Preventive strategies                 | Increased fuelwood provision                   | 15 %                                     | 58 %                                     |
|                                       | On-farm tree planting                          |                                          |                                          |
|                                       | Decreased fuelwood demand                      | 0 %                                      | 100 %                                    |
|                                       | Use of improved cooking stoves (prerequisite)   |                                          |                                          |
| Acute strategies                      | Alternative fuelwood consumption               | 75 %                                     | 0 %                                      |
|                                       | Cut wet fuelwood instead of collecting dry fuelwood |                                          |                                          |
|                                       | Cut down a tree as a fuelwood source           | 5%                                       | 5%                                       |
|                                       | Use of private trees instead of trees from communal land | 5%                                       | 5%                                       |
|                                       | Use of wet fuelwood instead of dry fuelwood     | 0%                                       | 3%                                       |
|                                       | Use of fuelwood with less quality              | 0%                                       | 5%                                       |
|                                       | Decreased fuelwood demand                      |                                          |                                          |
|                                       | Use of improved cooking stoves (prerequisite)   | 0%                                       | 100%                                     |
| Increased use of substitutes for fuelwood | Use of twigs instead of fuelwood               | 60%                                      | 47%                                      |
|                                       | Use of crop residues instead of fuelwood (esp. maize residues) | 15%                                      | 21%                                      |
|                                       | Use of cow dung instead of fuelwood            | 0%                                       | 11%                                      |
| Increased input of time and effort    | Increase in walking distance to collect fuelwood| 70%                                      | 79%                                      |
|                                       | Increase in frequency of fuelwood collection    | 25%                                      | 32%                                      |
|                                       | Increase in time spent to collect fuelwood      | 10%                                      | 0%                                       |
|                                       | Change in weight of bundle collected           | 5%                                       | 0%                                       |
| Market-based measures                 | Use of improved collection means (wheelbarrow, oxcart, bicycle) | 0%                                       | 37%                                      |
|                                       | Purchase fuelwood                              | 5%                                       | 11%                                      |
|                                       | Purchase charcoal                              | 5%                                       | 0%                                       |
|                                       | Hire someone to collect fuelwood               | 5%                                       | 0%                                       |
| Utilization of human resources and social relationships | Ask a neighbor for fuelwood                     | 85%                                      | 53%                                      |
|                                       | Involve children in fuelwood collection        | 10%                                      | 0%                                       |
|                                       | Gathering remains of charcoal production¹      | 10%                                      | 0%                                       |
|                                       | Ask relatives for fuelwood                     | 0%                                       | 5%                                       |
| Decreased food and health             | Eat fewer meals                                 | 55%                                      | 37%                                      |

¹ Newly identified coping strategies.
dung as a source of fuel for cooking is described and evaluated by several authors (Akther et al 2010, Köhlin et al 2011, Damte et al 2012). Its use has strong cultural and taste connotations (Köhlin et al 2011), but can only be applied if livestock farming is practiced. The two newly identified strategies, use of improved collection means and gathering remains of charcoal production, can also be considered as context-dependent strategies, since they are not yet mentioned in the literature.

Identification process of applied coping strategies
In total, 23 coping strategies are identified at the CSS. One major difficulty in identifying coping strategies is the fact that farmers themselves do not necessarily define their adaptation measures as coping strategies. Therefore, the methodology of structured interviews and questionnaires are not suitable for directly identifying coping strategies from different thematic areas. For example, the strategy increase in walking distances to collect fuelwood, described by several authors (Howes 1985, Brouwer et al 1989, Köhlin et al 2011, WFP 2012) and applied by more than 70% of the farmers at the CSS, is a strategy that is not considered as an adaptation measure by farmers but rather as a necessity due to the situation. This corresponds with the findings of Schindler et al (2016, p 42) that farmers consider indirect linkages taking their complex livelihoods into account while scientists rather focus on direct casual impact chains. On the other hand, not every adaptation measure described in the scientific literature can be identified as such on the ground. Damte et al (2012) proves that Ethiopian households use dung and crop residues as a source of energy for cooking, however these are not considered as substitutes for fuelwood. Hence, an open and participatory process is needed to identify and understand the adaptation measures applied by the farmers when fuelwood is scarce.

Using coping strategies from the scientific literature as a codebook to identify similar strategies on the ground in a specific social and cultural context is an approach that must be implemented carefully. Some authors use generic terms to describe strategies, whilst others describe specific and context-dependent strategies. In their articles, Brouwer et al (1989, 1997) describe the generic strategy shift to lesser quality of fuelwood. Typically, twigs, leaves, crop residues, and animal dung are considered to be inferior energy forms. Our study identifies that the strategy to cut and use wet fuelwood instead of dry fuelwood can also be considered as using inferior energy forms. However, to cut branches off intact trees or shrubs as well as the use of wet fuelwood as a change in fuelwood supply is not mentioned in the reviewed literature. One reason could be that in many cultures the cutting and drying of wet fuelwood is a common process. However, households at the CSS define collecting fuelwood as a process of collecting dry wood from the ground or cutting off dead branches without any drying procedure. Cutting and drying wet fuelwood instead of collecting dry fuelwood was described as a very recent development due to the degradation of the forests. Hence, it is important to assess and clearly define coping strategies within their contextual dependencies.

Preventive versus acute strategies
The findings of this research show the multidimensional impact of fuelwood availability on rural livelihoods. The scarcity of fuelwood negatively affects food and nutrition security, soil fertility, and labor availability (Sola et al 2016). Only 9% of the identified coping strategies at the CSS can be considered as preventive. The same holds true for the literature review with preventive measures making up around 10% of the options. Our findings show that the statement by Brouwer et al (1989, p 352), ‘in most cases, because of lack of access to resources such as land, labor and cash, it is beyond the reach of households to alter the cause of the problem,’ is still valid. Identified coping strategies due to a fuelwood shortage are mainly short to mid-term adjustments that do not offer a sustainable solution for a positive feedback loop of fuelwood collection, degradation of forests and forested areas, and physical fuelwood scarcity. Although strategies such as improved collection means (e.g. wheelbarrows) (Idifu 37%) might have a short-term impact on reduced workload and time to collect fuelwood, these do not solve the situation of an imminent fuelwood scarcity. We base our results solely on the perception of local farmers due to the fact, that no historical data for the region is available.

Comparison of coping strategies between the CSS
Our assessment shows that preventive and acute measures to cope with fuelwood scarcity are applied at the CSS. In both villages, households use an average of about four strategies to cope with fuelwood scarcity (excluding ICS). Although ICS were introduced in Idifu village in 2015, the average number of coping strategies was only slightly lower than in Mzula, where TSF are used. This indicates that the number of applied adaptation measures was not at all, or only insignificantly, reduced due to ICS usage in Idifu. Hafner et al (2018) show that the fuelwood savings of ICS in Idifu is between 15.6% and 37.1% compared to TSF. Hence, we would expect that the overall number of coping strategies in Idifu to be lower than in Mzula due to the reduced demand for fuelwood in Idifu. The findings suggest that the reduction of fuelwood demand for cooking purposes does not automatically lead to a reduction in the number of applied coping strategies.

Around 43% of the applied coping strategies between the two CSS are congruent, even if preventive measures are applied in Idifu. This shows that small-scale farmers do not cope with fuelwood scarcity by simply replacing acute strategies with preventive strategies. Preventive strategies are applied as an additional strategy by
households in order to manage and adapt to the scarcity situation. Preventive strategies, such as planting on-farm trees or using ICS, might have a greater potential to reduce fuelwood scarcity than acute measures. The usage of ICS and local tree plantations might improve the fuelwood situation in deforested areas of Mzula and Idifu in the mid- to long-term. However, measures such as tree plantations need several years before fuelwood is produced; thus deforestation is not reduced in the short term (Egeru et al. 2014). Uckert et al. (2017) indicate that limited financial capacities and a lack of awareness are bottlenecks for adopting energy-efficient fuelwood consumption solutions. Our findings, regarding the comparison of coping strategies between the CSS, suggest that if the aim is to reduce forest degradation, then decreasing fuelwood demand alone may not be effective. This corresponds with the findings of Damte et al. (2012) that supply side strategies alone may not be effective at addressing the problem of forest degradation. Further research analyzing the interplay of preventive and acute measures is needed in order to understand the choice behavior of households with regards to coping strategies.

Identifying and disseminating additional local strategies to cope with fuelwood scarcity is not enough to solve the problems of degraded and deforested areas in Tanzania. Likewise, leap-frogging from fuelwood based forms of cooking toward non-fuelwood based energy forms cannot be expected in the near future (Grimsby et al. 2016). In this context, Maes and Verbist (2012) suggest focusing on enhancing the efficiency of traditional energy systems instead.

Conclusion

The adaptation measures of small-scale farmers to fuelwood scarcity play a key role in altering the course of nutrition insecurity, environmental degradation, and economic instability. In this study, a classification of coping strategies in line with existing literature was completed. A total of 28 coping strategies from 24 studies are identified, differentiated into preventive and acute measures, and then grouped into eight clusters. This classification scheme is then used as a codebook to identify applied coping strategies in Mzula and Idifu villages, Dodoma region, Tanzania. During this process, we identify 23 strategies, including two measures not cited in the literature. This suggests that the majority of coping strategies have a context-independent character. Both the majority of the applied strategies in the CSS as well as those described in the literature are acute measures that do not tackle the underlying problem of deforestation and forest degradation. We observed that the type, as well as the number, of coping strategies between the CSS are widely congruent, suggesting that acute measures are not replaced with preventive strategies, but rather these co-exist. Therefore, decreasing fuelwood demand alone may not effectively address the problem of forest degradation.

In order to enhance the understanding of the choice behavior of households with regards to coping strategies, not only does further research need to analyze the interplay between preventive and acute measures, but it must provide a full systematic literature review for different thematic and regional areas.

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