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Domestic Firewood Consumption Pattern and Degradation of Forest Cover: A Case Study of Mokokchung Town, Nagaland

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Abstract: ***In the developing counties of the world, domestic cooking energy meets mostly by firewood. However, in India the majority of urban households are switching from firewood to modern clean cooking energy due to smoke hazard and cooking space limitation. Domestic firewood demand and consumption pattern in the Mokokchung town area was studied interviewing 137 households. The study reveals that cooking by firewood is a regular practice among town dwellers even though other alternative clean energy sources were available for use. Demand for firewood and forest degradation status of the state was analysed. It was found that the availability and quality of firewood have degraded in recent years. The study shows firewood consumption rate in the area is 610±42 kg capita^{-1} year^{-1}. Estimating from AGB of the state, every year the town population alone consumes about 15 sq km area of forest cover as firewood which may be collected from up to 40 km distance. The study may help planners for better forest and environmental management.***

Keywords: Community forest, Cooking energy, Eastern Himalaya, Food habit, Fire wood

1. Introduction

Energy is a basic necessity in the daily activities of a household. Wood is society's oldest source of energy. Its use for cooking and heating remains vital to the daily energy needs of over 2 billion people in developing countries (FAO, 2010). Woodfuel is defined as all types of fuels originating directly or indirectly from woody biomass. Firewood or fuelwood is woodfuel in which the original composition of the wood is preserved. Charcoal is also woodfuel where the solid residue derived from the carbonization, distillation, pyrolysis and torrefaction of wood (FAO, 2004). Woodfuels currently account for a greater share of global energy consumption than all other forms of "renewable" energy combined. Fuelwood consumption is considered unsustainable due to the low efficiency and often poor quality of associated resource management, but it can be considered as a "new" energy source in the sense that modern and efficient applications for wood energy are increasingly being used, especially in member countries of the OECD, to produce cost-effective, high-quality energy services at various scales (FAO, 2010).

In recent time, global warming and climate change phenomenon is mounting pressure on mankind to reduce 'greenhouse gas' (GHG) emissions. Vegetation is nature's inherent solution to curb global warming by sequestering carbon from the atmosphere. Unsustainable deforestation is a serious problem globally in general and locally in particular. In urban areas of developing countries, population pressure on forest resource is more intense and rapid than nature can recuperate its forest cover sustainably.

Naga people are traditionally inseparably dependent on the forest for firewood and other bio-resource needs. Nagaland is predominantly a hilly state with rich natural resource base and associated biodiversity due to its unique geographical location and climatic conditions. Nagaland is part of Indo-Burma biodiversity hotspot located in eastern Himalaya and endowed with a rich diversity of flora and fauna. Urbanisation and population growth causing more resource demands from its environment. However, forest resource lays the foundation for sustainable livelihood prospect and economic security for the state (Pant et al., 2016).

The study would help to understand the cause for preferring firewood as a primary source of cooking energy in most urban households despite alternative energy sources are available to them. This investigation is aimed to evaluate per capita demand of firewood in an urban setup. Through this study, we estimated ecological footprint exerted on forest resource by the town population from the use of firewood.

2. Study Area, Data Base and Methodology

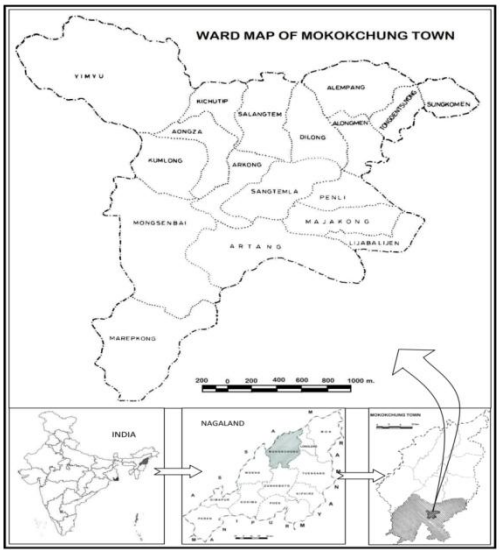


Figure 1

The study was conducted in the Mokokchung town of Nagaland situated in hilltop location (Figure-1). It is situated at 26˚18'08" to 26˚20'20" N latitude and 94˚29'42" to 94˚32' E longitude. It is also the headquarter of Mokokchung district situated at an altitude of about 1,325 m. and relative relief of the town is about 450 metre. Few streams are originating from this town and flowing out radially. The town municipal area formed merging of three Ao Naga villages viz. Mokokchung village, Ungma village and Khensa village covering 4.5 km^2. The population of the town is 35,913 persons as per 2011 census estimating the population density of about 8,000 person/km^2. It is connected by road transport with commercial town Mariani and Amguri in Assam for essential commodities. Also, it connects state capital Kohima and district headquarters Tuensang and Zunheboto of Nagaland. Original hilltop settlement is spreading out towards downhill in recent time and also expanding along the highways owing to topographic limitation and rapid urbanization.

Firewood collection and consumption is an unorganised sector of energy and the proper account is difficult to get without direct inquiry from the users. Therefore primary data was collected from households by random sampling survey from different wards of the town with a structured questionnaire. Apart from filling the questionnaire, elderly people of the town were consulted to understand the ground situation of the problem and interview was conducted with firewood retail sellers of the town. The interview was based on semi-structured questionnaires that focused on the type of energy used in a household. Basic household data such as regular family members, income, livelihood, house type etc. was collected along with energy consumption pattern of the household.

3. Analysis of the study

As most people expressed their firewood consumption in approximate volume only, household firewood consumption weight was calculated based on Table-1. The table was compiled by a discussion with firewood retail sellers of the town which is a rough estimation only. Because the equal volume of firewood may differ its weight significantly due to species variation and variation in moisture content and also girth of the stem. Calculation of basic statistics and generation of chart/ graph was performed using Microsoft Excel software.

Table 1: Firewood weight by its volume

Local nomenclature	Volume*	Weight* (quintal)	Remark
1 Thak (standard stack)	3′X3′X6′=54 cft	6	Weight may differ considerably depending on hardness and dryness of wood
1 Bolero Pickup or 1 Tata DI	2 Thak= 108 cft	12	
1 Mini Tata or 407	4 Thak / 2 Pickup	24	
1 Tata	8 Thak/ 2 Mini Tata/ 4 Pickup	48 (40-50 quintal)	

Source: Field Survey 2014-18

District Census Handbook (DCHB) of Mokokchung, 2011 were analysed to know firewood consumption pattern in both rural and urban area of Mokokchung. Compilation of temporal forest cover density change was done from India State of Forest Report (ISFR). Forest Survey of India's biennial publication ISFR adopted three categories of canopy density classification since 2003. Hence, forest cover density of the state was compiled from 2003 to 2017 in Figure-3. According to ISFR classification forest cover includes only those areas with more than 10% canopy density and minimum map able area of 1 ha (Table-2). Distributions of district wise forest cover density also shown in Figure-4.

Table 2: Forest Cover Within and Outside GWA (area in sq km)

Forest Cover within Green Wash area	Canopy density	Area (km^2)	Geog. area (%)
a) Very Dense Forest	> 70%	1,185	7.15
b) Moderately Dense Forest	40%–70%	3,323	20.04
c) Open Forest	10%–40%	4,269	25.75
Total		**8,777**	**52.94**
Forest Cover outside Green Wash area	**Canopy density**	**Area (km^2)**	**Geog. area (%)**
a) Very Dense Forest	> 70%	94	0.57
b) Moderately Dense Forest	40%–70%	1,264	7.62
c) Open Forest	10%–40%	2,354	14.20
Total		**3,712**	**22.39**
Grand total		**12,489**	**75.33**

Source ISFR 2017

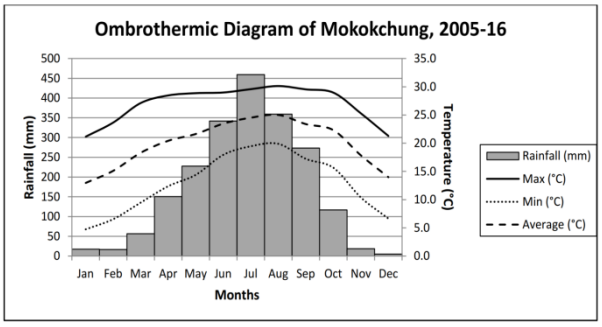
Table 3: Distribution of Recorded Forest Area (RFA) 2013-14

	Legal Status of forest Ownership	Forest Area (sq km)	Forested Area (%)	Geog. Area (%)
A	**Government Owned**	**1008.23**	**11.68**	**6.08**
	Reserved Forest	62.26	0.72	0.38
	Purchased Forest	192.47	2.23	1.16
	Protected Forest	516.79	5.99	3.12
	Wild Life Sanctuary	34.69	0.40	0.21
	National Park	202.02	2.34	1.22
B	**Village Owned** (Private/ Clan/ Community)	**7621.07**	**88.32**	**45.97**
	Virgin Forest	4778.27	55.37	28.82
	Degraded Forest	2842.80	32.94	17.15
	Total (A+B)	8629.**30**	**100.00**	**52.05**

Table 4: Forest Cover Change in Nagaland

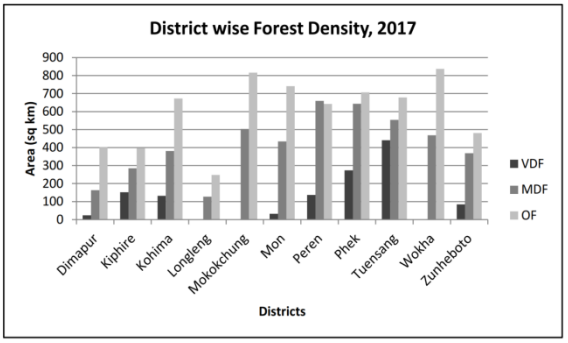
Year	VDF	MDF	OF	Total	Geog. Area	Change	Data acquisition period
2003	57	5,650	7,902	13,609	82.09%	264	Oct 2002 to Dec 2002
2005	236	5,602	7,881	13,719	82.75%	110	Oct 2004 to Feb 2005
2009	1,274	4,897	7,293	13,464	81.21%	-255	Oct 2006 to Mar 2007
2011	1,293	4,931	7,094	13,318	80.33%	-146	Oct 2008 to Mar 2009
2013	1,298	4,736	7,010	13,044	78.68%	-274	Oct 2010 to Jan 2012
2015	1,296	4,695	6,975	12,966	78.21%	-78	Oct 2013 to Feb 2014
2017	1,279	4,587	6,623	12,489	75.33%	-477	Oct 2015 to Feb 2016

Compiled from ISFR Reports



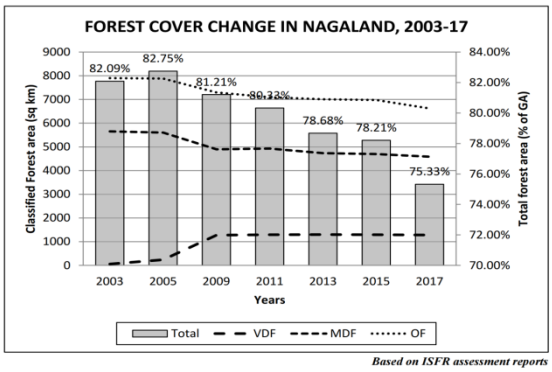
Source: Directorate of Soil & Water Conservation, Kohima

Figure -2



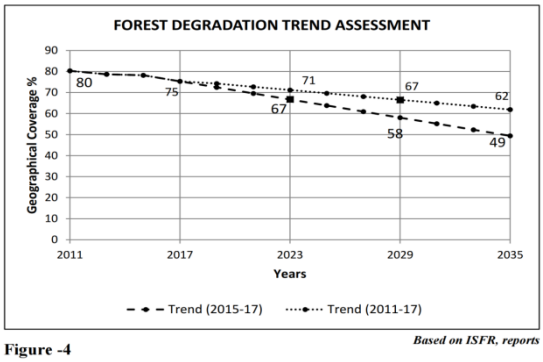
Based on ISFR, 2017

Figure -4



Based on ISFR assessment reports

Figure -3



Based on ISFR, reports

Figure -4

Different categories of land classified by the state Government was compiled from Statistical Handbook of Nagaland (SHBN) showing the various category of the area under forest as Recorded Forest Area (RFA) (Table-3).

We also estimated the forest area needed to meet the domestic firewood demand of the Mokokchung town. This was calculated from standard tabulated data of Carbon

stock in India's forest published by ISFR considering firewood as above ground biomass (AGB).

It was found that most of the household uses multiple types of energy for cooking, such as firewood, LPG and electricity in the surveyed household. They also use Kerosene in small amount only to ignite firewood, instead of burning in Kerosene stove. Households use cooking energy by a combination of choice but not as total dependency on a single fuel type. This type of energy use may be described by "energy stake" model contrary to "energy ladder" model ('The energy ladder: Theoretical myth or empirical truth?', n.d.).

A comparative study from other countries reveals that the Firewood consumption in our study area was higher than some other countries like South Africa (1,454 kg household^{-1} year^{-1}), Mozambique (5.47±1.00 kg household^{-1} day^{-1}) and Myanmar estimated at 217 ± 38.9 kg capita^{-1} year^{-1} (Win et al., 2018). While it is lower than the northern Brazilian Atlantic Forest estimated as 686 ± 644 kg person^{-1} year^{-1} (Specht, Pinto, Albuquerque, Tabarelli, & Melo, 2015).

Traditional Naga kitchen cum fireplace is built separately from their bedroom to evade smoke. Fireplace (locally known as Chouka) is made rectangular in shape which can surround for space heating making bigger kitchen size. The Chouka may either be located in the middle or towards wall with a chimney. These open type Chouka's build by laying two or more horizontal iron bars over two stone pillars separated at about 24 to 30 inches to enable placing two or three cooking pots over iron bars. Though not fuel efficient these traditional Chouka is still popular among Naga household, where big sized firewood can be used for cooking as well as space heating surrounding to it. Moreover, hanging racks placed over these Chouka for drying firewood and smoking foodstuffs. No household was found using typical 'three-stone stove' in their kitchen due to poor space heating function. It may be said that a typical Naga fireplace is not fuel efficient and consumes more firewood.

Rice is a staple food for Naga people mostly combined with non-vegetarian food habit. According to Naga folks, food prepared in firewood is more delicious and healthy. They believe that processes like smoking, roasting, grilling, drying and boiling of food items done by firewood gives an enhanced taste and flavour than done by any other modern energy sources of cooking. Execution of these processes takes relatively longer duration and become cost-effective by firewood only than any other energy sources like LPG etc. In most household drinking water sterilization by boiling and hot water for bathing is done in firewood only. Preparation of domesticated animal feed also may demand more firewood in a household.

According to India State Forest Report (ISFR) overall forest cover of Nagaland is 75.33% of the state's geographical area covering 12,489 sq km (ISFR, 2017). This percentage of Forest Cover is in compliance with the National Forest Policy 1988 for the hilly and mountainous region (NFP, 1988). Forest canopy density changes were compiled from biennial ISFR from 2003 to 2017. Graphical representation (Figure-3) clearly shows that forest cover is gradually declining in the state after every assessment period. However, a sharp decline is seen in recent time between 2015 to 2017, which is the second highest forest cover loss in the country with an area of 477 sq km. The loss is highest in the category of Open Forest (OF) and Moderately Dense Forest (MDF) than Very Dense Forest (VDF) canopy cover (Table-4). Thus overall forests cover loss from 2003 to 2017 is 1,120 sq km amounting nearly 6.76% of the state's geographical area. According to ISFR report, this forest cover loss is attributed to shifting cultivation and some developmental activities of the state. But some recent study shows that except some interior area of the state, Jhum cycle is improving in the developed areas. Thus this loss should be looked at seriously by concerned stakeholders.

It is also assessed forest degradation trend based on two recent assessment periods from 2011 to 2017 and 2015 to 2017 and graphically presented in Figure-4. The trend lines indicate that, if degradation continues at the same pace then within 2023 to 2029 forest cover may reduce to below norm set by National Forest Policy, 1988 causing serious environmental consequences. There are two categories of ownership within Reported Forest Area (RFA) of Nagaland State Government (Table-3) out of which major 88.32% share is under Village forest category which is owned by Individual, Clan or Community and only 11.68% share is under State Government control (SHBN, 2014, 2017). within Village forest category there is Virgin forest and degraded forest. Within the government-controlled area also there are classifications such as Reserved Forest (RF), Protected Forest (PF), Wildlife Sanctuary, National Park and Purchased Forest land but canopy density can't be verified within these categories due to lack of digital boundary while preparing ISFR. However, ISFR calculates Green Wash Area (GWA) as a proxy to RFA (ISFR, 2017 p-255) in the absence of digitized boundaries of the RFA. Canopy density separating within and outside GWA is shown in Table-2. Nevertheless, ISFR 2017 (p-6) reports a reduction of forest in RFA by 599 sq km since 2015. This has reflected that within RFA forest has degraded considerably.

Since the pre-independent period, Nagas have enjoyed a distinct form of Village-State governance and after independence also the Nagas could retain their traditional form of local-governance structures through Article 371(A) of the Indian Constitution. This provision gives supremacy of the Naga customary laws and procedure, including the ownership of land and its resources, over the national statutes.

After the enactment of the Nagaland Village and Area Council Act 1978 by the Nagaland Government, Village Council (VC) and its development wing the Village Development Board (VDB) were established in every village of Nagaland as an attempt to codify and bring up uniform law in the administration of the village. Accordingly, villages own and govern its own resources, plans its developmental activities, maintains law and order,

delivers justice and secures defence. As ownership of land is by individuals or clans, the control of forests is predominantly by the community. Community Forest Management (CFM) is largely practised across the state in compliance with the respective customary law of various tribes of the state. The decision of the VC is final and anyone failing to abide by the Council's decision entails serious fines and penalty. Such measures are taken keeping in mind the fertility of the soil in a rotational practice of cultivation and to protect the forest for future use. Villagers are not allowed to cultivate any land apart from the land allotted by the Council. This customary practice protects the random cutting of forest in the village and also reduce pressure on land (George & Yhome, 2008). Thus, the onus of forest management to sustain, increase, enhance and strengthen forest area largely lies with the communities (Pant et al., 2016). So the state government has to play a limited role in decision making accordingly in support of the respective VC's.

To evaluate the impact of firewood consumption on forest we have to look for the preference of the tree species as firewood and its size while collecting from the forest. Also, it is important to know locality and distance from the residence to the collection area. Moreover fellow period of the wood before consumption as green or dead wood may be indicative of deficit or surplus of firewood respectively.

After the analysis of the data, it is found that people use firewood (610±42 kg capita^{-1} year^{-1}) with diameter more than 4 cm. mostly transporting from the outskirt of town due to limited space for homestead tree within the core area of the town. However, in the peripheral area of the town household have found using some amount of homestead grown firewood also. As stated above there are few common tree species preferred as firewood which yields less smoke and produces lasting heat. According to respondents, it is becoming scarce due to high demand and less availability in recent time. However, few households were found choosy for only quality firewood and were willing to pay a higher rate of transportation charge. Majority respondent brings firewood (dead wood felled in the previous year) from their respective village lands bearing transportation and labour cost. However, firewood retail stall generally brings green wood without an option for selection in its quality. Thus assuming from the surveyed data we can estimate that the Mokokchung town has its footprint in surrounding forest area up to about 40 km distance. Moreover, Figure- 4 shows that adjacent districts like Wokha, Longleng including Mokokchung has a very low amount of VDF, which may be linked to aggressive use of forest resource.

As reported by the households, LPG dealers don't provide home delivery service causing inconvenience to the customer. LPG cylinder can be obtained through porters by paying some extra fee if not fetched from a dealer. Without an LPG connection, also some household buy from some broker paying the almost the double price. Smokeless cooking and easy ignition make LPG an alternative choice for cooking energy next to firewood.

Generally, charcoal is preferred over fuelwood in urban areas because it is easier to transport, and fuelwood is used mostly in rural areas. (Dam, 2017). In the present study area, charcoal consumption was not significant. There are reportedly few charcoal sellers in the town, who sells charcoal in gunny bags during winter season only. Though charcoal is a cleaner source than firewood the habit of using charcoal as cooking energy is not yet developed among town dwellers. Thus the demand for charcoal is not growing yet except for space heating.

An electric Rice cooker is getting popularity in recent time due to 'auto off' and 'keep warm' functions. Moreover, some people use rice cooker for boiling water also. But the electric stove is not a popular choice due to load shedding in the town.

4. Findings and Conclusion

4.1. Household characteristics in the study area:

About 84% of surveyed households composed of 6 or less family members within which the majority household was with 4 members. Though household income amount is difficult to ask directly to respondents, this was indirectly assessed by the researcher. It was estimated that the average household income is about Rs. 41,000/- month. The main livelihood activities of the households were government employee, agricultural work, business, government pensioner, or self-employed. It was difficult to find percentage value out of these activities because members of a family may engage in a mixture of different activities. Most people of the town have multi-storeyed buildings with congested dwelling. For slope stability, most buildings are built cutting within 'vadose zone' of the slope. Due to small land holding within the core area of town, their buildings occupy almost the entire campus area, and space for plantation is limited. Also, space crunch is seen for storing essential commodities like water and firewood for daily activities. The electrified household was found 100% with average monthly power bill ranging from Rs. 400 to 700.

4.2. Source, Type, Size and Species of Firewood:

No household reported collecting firewood by head load due to long distance and difficult topography from the forest. It was found that the majority of house owner and their tenant originated from the Mokokchung district only. The present study reveals that firewood was mostly collected form Longkhum village (about 20 km towards Wokha). Not only those families originating from Longkhum village brings firewood from their own forest land but also some Longkhum villager sells firewood to town dwellers directly charging labour and transportation cost. Moreover. most firewood stall also purchases from this village or along Wokha approach road. To curb logging intensity in recent time, Longkhum Village Council has imposed prohibition to use elephant for logging. Some people reported buying from about 40 km far Tuensang approach road, where good quality firewood is available and transportation cost is high due to long distance and bad road condition.

Fresh cut green firewood generally not fetched due to inferior burning and heavier load than seasoned firewood. If a log is found unsuitable for timber due to some structural defect or inferior species, it may be considered as firewood grade and cut into sizable length for transportation. Generally, less than 4 cm diameter leafy branch is not collected as firewood. Thus stem diameter of firewood may vary from 4 cm to 18 cm. From Jhum field also partially burned wood is collected as firewood.

Some common local wood species are Schima wallichii (Makrisal), Terminalia myriocarpa (Hollock), Alnus nepalensis (Alder), Tectona grandis (Teak), Ficus benghalensis (Banyan), Michelia champaca (Tita Sopa), Quercus serrata (Oak), Prunus serrulata (Cherry) etc. Though these species are used for furniture also but waste part is preferred as firewood which produces less smoke and gives lasting heat.

4.3. Firewood consumption rates in the study area:

Analysing the household data, we found that average (± standard error) consumption of firewood was 610±42 kg capita^{-1} year^{-1}, while average household consumption of firewood was estimated as 2,460±140 kg year^{-1} and daily consumption estimated as 6.74±0.38 kg household^{-1}. However, there will be high seasonal variation in consumption rate but the variation could not be stated by the respondents. Thus average firewood consumption rate should be roughly one Thak person^{-1}Year^{-1}.

4.4. Cooking energy use in the study area:

Mokokchung town census data (DCHB, 2011) belonging to Ongpangkong Sub-District were studied. It shows that firewood share in rural setup was 90.61% while in urban area 52.73%. Again for LPG, the urban setup share was 45.23% and the rural area was 8.45%. It clearly shows that both in rural and urban area principal fuel for cooking is firewood followed by LPG. Moreover, some household stated to use Electricity, Kerosene, Charcoal and Crop residue though it is insignificant. The census data reflect total dependency on each type of fuel by a household, while in reality, a household may use 'fuel-mix' rather than sole dependency on a certain type of fuel.

On the other hand, the present study also reveals that about 96.3% of family found to use firewood. But respondent was unable to tell the exact amount of firewood they consume in terms of weight because generally, they buy in bulk amount. Rather, respondents commonly expressed the amount in terms of Thak (Stack of firewood) or load volume by typical firewood carrying vehicle in the locality as rough consumption per household per year (Table -1). However, the retail value of ordinary firewood was Rs. 350/- per quintal at the time of the survey. According to firewood retail seller of the town, Thak volume may not be fixed, as stem may cut into shorter length at source than the standard 3 feet.

Correlation between family members and the requirement of firewood was calculated as 0.33. This shows a positive relation indicating, when a family member increases than firewood consumption also increase. But this consumption is not proportionate, because, with inflating family size, the requirement of firewood for cooking and space heating does not increase proportionately. The household firewood consumption increases as increase in family size, however, the per capita firewood consumption decrease as increase in family size (Luitel, n.d.).

The electric rice cooker was found to use by 83.8% household in the study area, which is a common and popular cooking device introduced since more than 15 years. Though regular periodic load shedding experienced in the town, people's cooking activity in a rice cooker is planned accordingly.

Out of surveyed households, 97.8% found using LPG for cooking. But none of the households reported home delivery service from the dealer. Survey reveals that 17.6% of household uses only single cylinder while 69% of household uses double cylinders. Even three and four cylinders also used by 8% and 3% household respectively within surveyed households.

Though no respondent found to use Kerosene stove, about three-fourths (75.7%) respondent found using it for igniting firewood or charcoal. Even some household used it for other non-burning utilities. So, Kerosene can't be said as an important cooking and lighting fuel in the town though it is supplied through the public distribution system (PDS).

Though charcoal can be used in cooking, out of all surveyed houses we found only one house to use it. So, charcoal is not used for cooking purpose. Rather it is needed for space-heating during winter. Moreover, some household may prepare the required amount from firewood at their fireplace. Thus charcoal seller is limited in the town and they mostly sell in gunny bag during the winter season.

4.5. Estimating forest area needed to meet firewood demand:

From the household consumption rate per year, the entire town consumption was estimated. Considering one Tata vehicle load as 48 quintals (approx), it will need about 4,320 Tata loads in a year with the higher end of standard error. Carbon stock in the forest of Nagaland in Above Ground Biomass (AGB) is estimated as 12.93 ton ha^{-1} (ISFR, 2017 p-130). Thus to meet the demand of firewood in the Mokokchung town forest area needed is of about 15 sq km. However such forest area presently located in between 20 km to 40 km from the town.

It was observed that, even though almost all household has the alternative option of cooking energy such as LPG and electric cooking devices, firewood still preferred as primary cooking energy among the town population. Energy using choice of the town shows 'energy stake' model rather than 'energy ladder' model. Being a habitual user of firewood with rural background, most people don't want to depend on another type of energy. Following the legacy of the traditional system, town dwellers need

firewood for space heating simultaneously while cooking and prepare their ethnic food items in the fireplace, which can't be performed by modern energy. We estimated that to meet the demand of firewood in the Mokokchung town there is need of about 15 sq km forest area. In other words, it can roughly be stated that the town consumes firewood from more than 3 times larger area of its size.

Management of forests and natural resource by the traditional village institutions is still the norm in the State. It is therefore imperative that these institutions are enlightened on the impact of resource management and are strengthened so that their discretion relating to sharing and use of natural resources can be channelized towards conservation and sustainable management practices (Pant et al., 2016).

Forest is the prime source of income and livelihood for Naga people. However, it can be further enhanced through mobilizing value chain to generate employment opportunity. Due to population growth and subsequent urbanization in recent years, the pressure on forest is increasing in Nagaland.

Thus, the area needs urgent attention as to how this growing pressure on the environment can be mitigated scientifically and save the fragile mountain ecosystem and its biodiversity of eastern Himalaya for the benefit of mankind. It is therefore important to find stages of targeted interventions for a viable solution, which fits best to the traditional ethnic lifestyle and meet energy services sustainably.

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