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Community and Industry Attitude Towardsusing Invasive *Prosopisjuliflora*as a Dry Matter Energy Sourcefor Small Scale Industries: A Case Study in Hambantota, Sri Lanka

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Abstract

Bundala is Sri Lanka's first RAMSAR wetland declared under Ramsar Convention, and it has been declared as a national park in 1993 under Fauna and Flora Protection ordinance.At present, wide spread of *P.juliflora* in the Bundala National Park area has become a threat to diverse ecosystems, and the park management is removing substantial biomass of *P. juliflora* each year in an attempt to control this invasive species. As such, investigating the potential to utilize the removed biomass of *P.juliflora* has become important. This study was conducted with the objective of evaluating community and industry attitude and awareness of using *P.juliflora* as a dry matter energy source in Hambantota District. Two different questionnaires were used for two groups after pre testing in Ambalantota, Hambantota and Tissamaharama Divisional Secretariat Divisions. According to study findings, subsistence energy needs of community are basically fulfilled by common fuel wood species in the area such as *Manilkarahexandra* and *Drypetessepiara*. Community in the area is aware about the fast spread of *P. juliflora* over native species. Approximately 45% of study respondents represent brick industry and they often use rice husk ovens due to lack of firewood to be found in the area and the high availability of rice husk. Since industry and community prefer *P.juliflora* as a fuel, responsible agencies should make appropriate arrangements to harvest, process and make available the biomass to partially fulfill the thermal energy requirement in the area.

Key words: Prosopisjuliflora, small scale industries, Bundala National Park, dry matter energy source

1. Introduction

Mesquite, *Prosopisjuliflora* (Fabaceae) which is native to Central and Northern South America, was first introduced to Sri Lanka by the Royal Botanic Gardens, Peradeniya in 1880. Later in early 1950s, it was introduced to Hambanthota District in Southern Province of Sri Lanka to improve saline soils, and to address soil erosion in the coastal region (Algama and Seneviratne, 2000, Kotagama et al., 2009).Since then, *P. juliflora* has become a very aggressive invasive plant threatening wide ranges of agricultural lands and natural habitats including Bundala National Park (BNP) in Hambanthota District. Bundala was designated a National Park in 1993 andis the island's first RAMSAR wetland. Seven terrestrial vegetation/habitat types, namely dry thorny scrubland, arid zone forests, sand dune vegetation, gentle sea shore vegetation, arid zone maritime grasslands/pastures, riverine forest, Mesquite scrublands have been identified from Bundala national park (Bambaradeniya et al., 2002, MENR, 2005).Die back of *Manilkarahexandra* that forms a single species dominant canopy in tropical semi deciduous forests in BNPhas been observed after the invasion of *P. juliflora* (Perera, 2012, Gunarathne and Perera, 2016).

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The seeds of *P. juliflora*are dispersed by animals, specifically by cattle and elephants that eat pods (Rathnayake, 2014).Wide spread of *P. juliflora* along with other invasive plants such as *Opuntiaficus* has affected the survival of elephants and migratory birds by changing their habitats in the BNP (Bambaradeniya et al., 2002). The shade provided by *P. juliflora*creates a more favourable environment for *O. ficus* that also has negative impact on wild animals. With deep penetrating roots, *P. juliflora* can draw water from deeper soil layers and hence affects the ground water table. Before this invasion of *P. juliflora* in Bundala National Park, over 75% of the beach in Hambantota District was covered with *Spinifexlittoreus* together with other native species.

The thorny shrub forests in the area are naturally covered entirely with native species such as *Dichostachyscinerea, Flueggealeucopyrus, Cassia auriculata, Salvadorapersica*and *Ziziphus* spp. Aggressive growth of *P. juliflora*a has resulted in reduction in population density of these native floral species. *P.juliflora* has invaded the beach near Hambantota town and it is spreading towards the Bundala National Park (Algama and Seneviratne, 2000). *P.juliflora* thrives in almost all types of soils under widely varying climatic conditions and set seeds from the second year (Silva, no date; Mendes, no date).Apart from this, a study revealed that presence of fast growing *P. juliflora* might be the reason for dying back of *M. hexandra* which is a native and common species to Bundala due to efficient drawing of ground water through its extended root systemand creates water scarce situation during dry periods.

Power generation from vegetation biomass is considered one of the best alternatives to the growing energy demand. Recent fluctuations in energy costs and growing attention to greenhouse gas emissions have made vegetation biomass a potentially stable green fuel source that can help displace the demand for fossil fuels and purchased electricity (Perera et al., 2010). Conversion of vegetation biomass into energy is carbon dioxide neutral. Past studies have shown that *P.juliflora* grown in Sri Lanka has a high energy potential as it contains high calorific value, high wood density, low moisture content and low ash content comparative to, *Gliricideasepium*, *Acacia auriculiformis*, *Leucenaleucocephala* and *Eucalyptus grandis*; the commonly used fuel wood species in the country (Bandara and Ranasinghe, 2016).It is being utilized in industrial sectors for their thermal energy requirements in Africa and Asia. Since *P.juliflora* has a fast growth rate and an ability to grow in variety of soil conditions, coppicing ability and rapid re-sprouting following harsh and repeated cutting, devoid of showing any harmful effects on plant health this plant can be considered as a favorable fuel wood species (Pasieczniketal.,2011).

At present, salt industry in Hambantota District produces 60% of the total salt production of the country (Hambantota District Chamber of Commerce, 2017). There are over 3,000 familiesin operation engaged in textile weaving, sewing, and tile and brickwork while over 55% of the total population depends on agriculture, especially paddy milling is a major industry in the region(Hambantota District Chamber of Commerce, 2017). Further citronella, cinnamon, pepper, fruits such as mango, melon, papaya, citrus, wood apple, pineapple and banana grow well here alongside low country vegetables like beans, tomato, gourd, and pumpkin.Coconut and coconut by-products as copra-mills, coconut oil, coir mills, and distilleriescan be identified as another major source of income. Fisheries is a leading industry and also Hambantota is reputed for buffalo milk and curd, which also contributes significantly to the regional economy. Livestock farming and animal husbandry in cattle, poultry and goats are among other income generating sectors of the community (Hambantota District Chamber of Commerce, 2017). Out of 156,476 families live in Hambantota district, 93% families rely on fuel wood to fulfill their energy requirement while 0.1% from Kerosene, 6.4% LPG, 0.01% from electricity, 0.007 from saw dust/paddy husk and 0.21 from other sources (Department of Census and statistics, 2017).

Though *P. juliflora*is rapidly expanding its range in the BNP affecting biodiversity no attempt has been yet taken either to eradicate or control its range expansion. Therefore, this study was

conducted with the primary objective of evaluating community and industry attitude and awareness of using *P. juliflora* as a dry matter energy source in Hambantota district.

2. Methodology

Two different questionnaires were designed to survey the attitudes of the community and industryin using*P. juliflora*as a dry matter energy source Questionnaires consist of five sections to cover the; community and industry knowledge on different uses of *P.juliflora*, current energy sources of community and industry, community and industry preference on *P.juliflora* over other available energy sources and the advantages of using this species as an energy source. Questionnaires were designed with structured, scale and open ended questions and they were pre tested with randomly selected 10 university students and 10 academics in the University of Kelaniya. Questionnaires wereedited to incorporate comments before collection of data. The survey was carried out in Thissamaharamaya, Ambalantota and Hambantota divisional secretariat divisions in Hambantotadistrict. Thesethree divisional secretariatslie in the boundary of Bundala National Park (Figure 1).

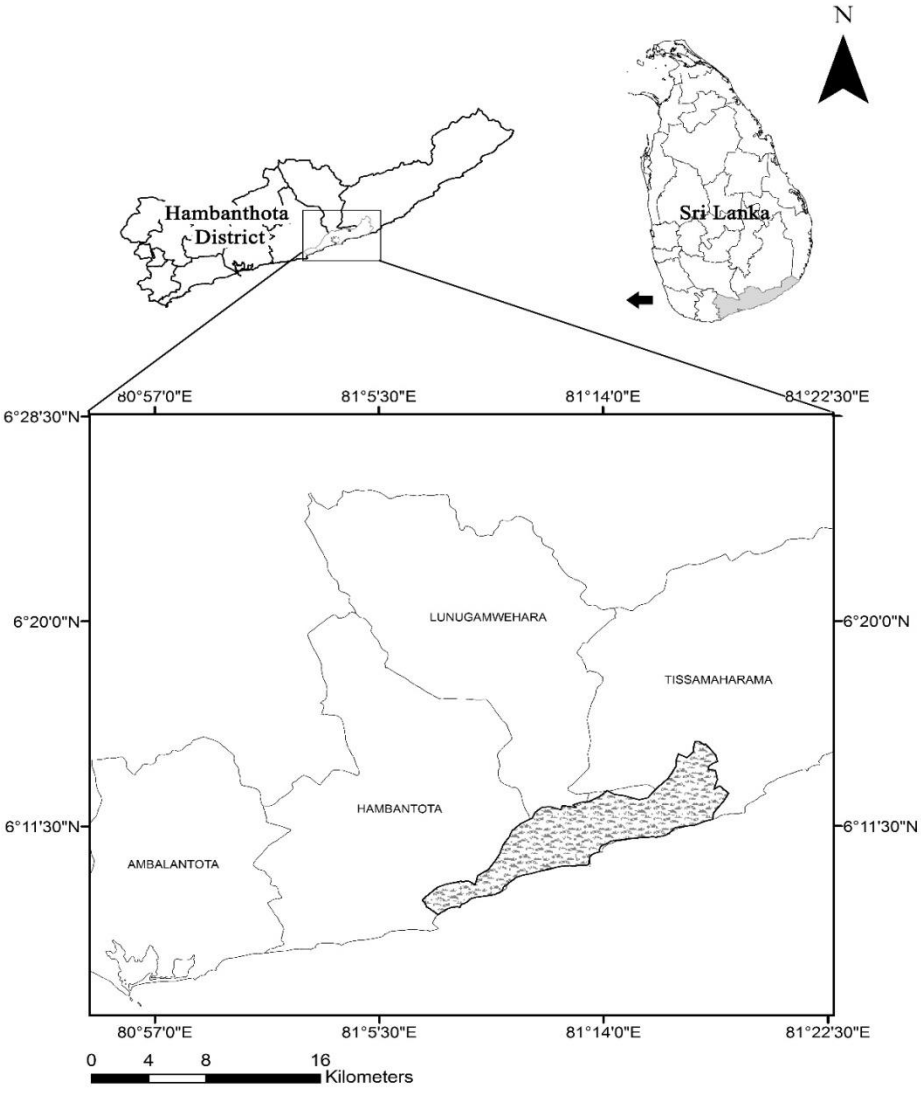

Figure 1: Map of the Ambalantota, Hambantota, Lunugamwehera and Tissamaharama Divisional Secretariat of Hambantota District where community and Industrial survey was carried out.Shaded area represents Bundala National Park.

For the questionnaire survey, a total of 55 industries and 30 households were randomly selected representing three divisional secretariats in the Hambanthota district. Face to face interviews

were carried outusing pre designed and tested questionnaire with the selected respondents.Data collected from two different questionnaires were analysed using SPSS software. Descriptive statistics were used to identify frequencies, mean values and respondents' profile. Cluster analysis was performed to identify clusters of respondents to identify the market segment where *P.juliflora* is readily accepted as a dry matter energy source.

3. Results

3.1 Respondents profile

Response rate for both surveys were 100% as respondentswere interviewed face to face by an interviewer.When considering the composition of industries, majority aremediumscale industries (SSI) comprised ofbrick, curd, bakery, salt and a few small scale industries (SSI) such as sweet manufacturing industry in Ambalantota, Hambantota and Thissamaharamaya divisional secretariats. Brick, curd and bakery industries were common to all the selected areas while salt and sweet production was confined to Hambantota divisional secretariat (Figure 2).

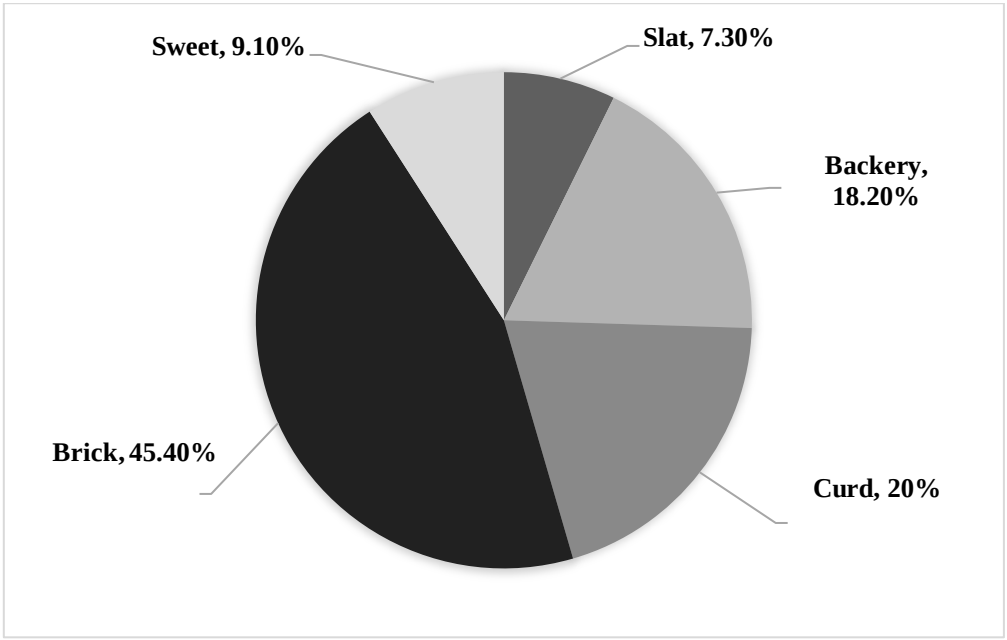

Figure 2: Composition of industries participated for the survey in Hambantota district.

All the respondents from three divisional secretariat prefer *M. hexandra* (100%) followed by *Drypetessepiara* (80%) as a dry matter energy source to produce thermal energyin their relevant industries.Most of the industries in Hambanthota (78.7%) and Ambalanthota (75%) used*M. hexandra* as their main fuel wood while the industries in Thissamaharamaya preferred other types of fuel wood species (75%) such as *Limoniaacidissima*, *Chloroxylonswietenia*, *Azadirachataindica, Leucaenaglauca*.

Respondents of industries in all the three divisional secretariatscould identify*P.juliflora*. More than 50% of respondents of industries have an understanding on usage of*P.juliflora*asas a fuel wood. However, the highest industrial usage of *P.juliflora* as an energy source was recorded fo rHambantota (57.89%) followed by Ambalantota (38.46%) and Thissamaharama(26.08%). most of the industries such as curd and sweet could be seen in Hambantota Divisional secretariat while the industry composition of other two study areas is primarily consist of brick industry with ovens mostly fed by rice husks.Respondents of industries had comparatively lower understanding on important energy properties of *P. juliflora* as a dry matter energy source; high heat capacity, high production of charcoal and ease of ignition.

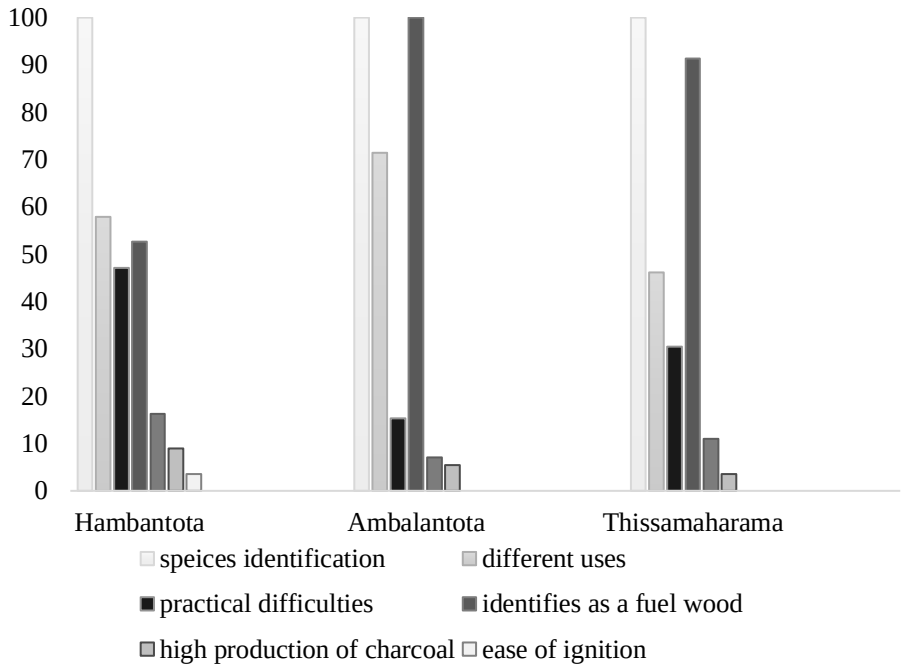

Figure 3: Percentage of respondents from each divisional secretariat about their level of understanding of fuel wood attributes of *P. juliflora*.

Apart from the Forest Act No.1908 of Sri Lanka which prohibits extraction of trees from a national park, This study revealed that the practical difficulties experienced by majority of industries in all the three areas of using of *P.julifloras*as a fuel wood are thorny stems, difficulties in fellingdue tostrong hard core, difficulties in transportation and lack of on time availabilityto meet the existing demand. However, community preference of using *P.juliflora* species show higher values in all three areas.

According to the results, large scale industries in the three selected divisional secretariats, salt and bakery industries, use electricity as their main energy source while small and medium scale industries such as curd, sweet and brick industries use firewood as their main energy source. Bakery and curd industries show 100% usage of fire wood in Thissamaharama and Ambalantota area. Therefore, supply of *P.juliflora* as a fuel wood will be more beneficial for curd and bakery industries which are located in Thissamaharama and the Ambalantota area.

Subsequently, of salt industries which use only *P.juliflora* could be observed in Hambanthota area. They use this species in salt drying process and an elevated temperatures could be experienced within the salt drying yardAccording to study 75% respondentsfrom salt processing industries believe that *P.juliflora* is a superior energy source with its high generating heat capacity and they are very willing to use *P.juliflora* in their industries as a dry matter energy source if available.

Majority of sweet(78%) and curd (81%) industries use *P.julifloras*due to its high heat capacity. Both of these industries use *P.julifloras*along with *M. hexandra* and *D. sepiara* which are abundant in the area. According to the cluster analysis carried out, three industry clusters could be derived based on their primary energy source.

Table 1: Identified three clusters of respondent industries based on current primary energy source.

	Cluster1	Cluster 2	Cluster 3
	μ=0.03	μ=0.89	μ=0.07
Energy source	Electricity	Fuel wood	Rice husk
% of respondents	0.54%	50.9%	43.6%
Scale	Large scale	Small scale	Small scale
Typeof industries	salt, bakery	curd, bakery, sweet, salt	brick
Willingness to use *P. Juliflora* as an energy source	0%	100%	70.9% (if fuel wood ovens are provided)
Currently use *P. Juliflora* as an energy source	0%	38.1%	0%

3.2 Use ofP. juliflora as a *household energy source*

Majority of respondents occupied in agriculture related activities.All the respondents use fuel wood as their main energy source for their daily subsistence consumption. About 17% ofrespondents use electricity while 7% use LP gas to fulfill their energy requirements. According to observations villagers can fulfill their fuel wood requirementfrom their own home gardens. Hundred percent of respondents use *Manilkarahexandra* ,followed by *Drypetessepiaria* (80.00%), *Leucaenaglauca* (33.3%), *Gliricidiasepium*(16.4%) and other types of trees (43.3%) such as *Azadirachtaindica*, *Limoniaacidissima* and *Prosopisjuliflora* as fuel wood sources for their stoves.

Majority of respondents (90%) could easily identify *P.juliflora* species and 93% of respondentswereaware of the usefulness of *P.julifloraas*as timber and fodder. Interestingly, 90% of respondents prefer to use *P.julifloraas*as an energy source to fulfill their subsistence need (Figure 4).

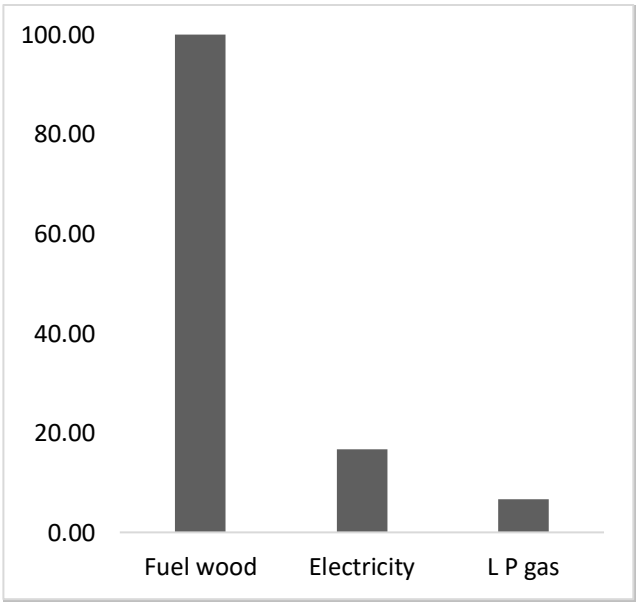

Figure 4: Percentage usage of source of energy by the community in Hambantota district.

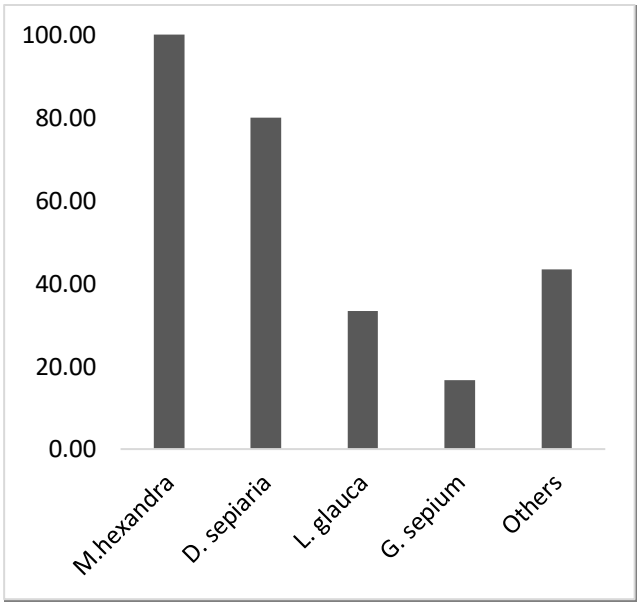

Figure 5: Percentage of different types of fuel wood species used by the community in Hambantota district.

People in study area use *P.juliflora* for co-combustion with other commonly use fuel wood species. However, 60% of respondents in the community were aware about the advantages of using

P.juliflora as an energy source compared to the other common fuel wood species in the area. Sixty three percent of respondents had an understanding on high calorific value produced by 1 kg of fuel wood relative to the other common fuel wood species and its ability of continuous burning after ignition. About 61% of respondents believe that about low moisture content of *P.juliflora* fuel wood increases the efficiency and decreases the time taken for ignition. However, only 13% of respondents were aware of that *P.juliflora*fuel wood produces less amount of ash which is paramount for a good biomass energy source. Study revealed that some percentage of the community use *P.juliflora*by knowing its advantages as a fuel wood source and some percentage use *P.juliflora*without knowing its advantages as a fuel wood source. Out of all the respondents 60% of respondents know that the fuel wood is hard and heavy in weight comparative to the other fuel wood speciesthough they cannot recognize that property as the wood density.

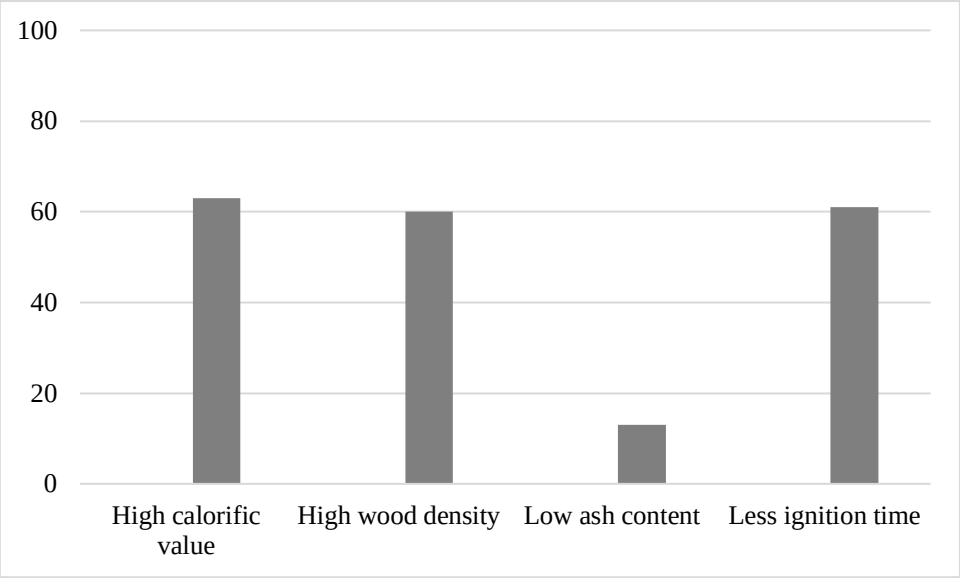

Figure6: Community awareness on certain fuel wood characteristics of *P.juliflora.*

People use to make fences from this plant since the stem is hard and thorny. However, majority of respondents (90%) preferred to use *P.juliflora* if there is adequate supply. But, community in the surveyed area do not have access right to this species because of the rules and regulations executed by the department of wildlife to avoid entering to the BNP where *P. juliflora*is highly abundant. Further, community has found it difficultto mechanically harvest the tree due to its hard, and thorny multi stems.

4. Discussion

With growing demand for timber and fuel wood, utilization of alternative timber species have been emphasized in recent research (Hoogwijk et al., 2003; Mohan et al., 2006; Perera et al., 2012; Jayawardhane et al., 2016). Especially, the possibility of utilizing the biomass of invasive plants such as *P. juliflora* has been explored in literature (Field et al., 2008; Oduor and Githiomi, 2013). The results of the study reveals the willingness of community in Hambathota District to use *P. juliflora*as an energy source for domestic and industrial purposes. *P. juliflora* as a dry matter energy source was highly preferred byindustries in Ambalantota followed by Tissamaharama and Hambantota D.S. Divisions. Brick and Bakery industries were mostly found in Ambalantota and Tissamaharama D.S. Divisions and they prefer to use *P.juliflora*as a primary energy source in their industries. Respondents who use chaff or rice husks ovens were also preferred touse *P.juliflora* as a fuel source if they are provided with fuel wood ovens for brick manufacturing. According to the brick stove owners, there are certain advantages of having fuel wood ovens over rice husk ovens in brick manufacturing. Bricks from fuel wood ovens are higher in mechanical properties including water resistance capacity,

durabilityand production time than rice husk ovens. Lack of continuous supply and relatively high cost of fuel wood are the main reasons for using rice husk ovens.

Small scale industries in the study area utilize 750-1500 kg of fuel wood per weekon average. If this species is given to the small scale industries with a proper management system, it would be an economically and environmentally feasible option for industries in Hambantota district. It is recommended to carry out a feasibility study to supply *P.juliflora* as a dry matter energy source for small scale industries in Ambalantota, Tissamaharama and Hambantota areas. At the same time fast spread of invasive P.*juliflora* can be controlled in a sustainable manner.

5. Conclusion

Prosopisjuliflora is a fast growing tree species that can be seen in Hambantota district, Sri Lanka and it has invadedinto important ecosystems in the area including Bundala National Park. Periphery of the Bundala national park is already dominated by *P.juliflora* along with cactus and this spread inhibits the growth of other plant species native to the area. Community in the area is aware about the fast spread of *P. juliflora* over native species even though they are not aware of the scientific means of invasion.According to study findings, subsistence energy needs of the community is basically fulfilled by different fuel wood species, *Manilkarahexandra* and *Drypetessepiara*, which are available in the area but legally restricted in felling. Utilization of *Ipilipil*, *Gliricideasepium* and other fuel wood species common to the country are significantly low.

Brick industry in Hambantota District often use rice husk ovens instead of fuel wood ovens and the main reason for that is the lack of adequate and continuous supply of firewood in the area and the abundant of rice husk as main livelihood of the people is agriculture. Community and the small scale industry in the region are willing to use *P. juliflora* as a dry matter energy source to fulfill their energy needs if the fuel wood is readily available for them.

Recommendation

Since industry and community are very much interested in using *P.juliflora* as a fuel wood species responsible agencies should make proper arrangements to harvest, process and make available the species as a dry matter energy source to partially fulfill the energy requirement in the region.For this, collaboration of responsible agencies, the Wildlife Department, Timber Cooperation, Sustainable Energy Authority and Ministry of Mahaweli Development and Environment is needed. Similarly cutting down of native plant species for fuel wood such as *Manilkarahexandra* and *Drypetessepiaria* can be minimized if this species is promoted as an alternative fuel wood.

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