Species Richness of Yapen Island for Sustainable Living Benefit in Papua, Indonesia

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ABSTRACT

The objective of this study was to precisely identify the types of forest resources utilization in two local communities. All forest plants used were identified and classified based on their types and classes during data collection. Semi-structural interviews through questionnaires were undertaken to obtain daily information. The results showed that there were a total of 64 forest plant life forms and categories extracted for various reasons. Most of the subject forest plants were found in the surrounding lowland tropical forest, the dominant categories were monocotyledons followed by dicotyledons, pteridophytes, and thallophytes. A strong positive correlation was determined between the frequency of species use and the benefit value that was gained (0.6453), while a strong negative correlation was observed between the value of plant's benefit and the difficulty of access to those plants (-0.2646). Frequency of use and the future prospect of forest plant availability (-0.1405) also showed a negative correlation.

Keywords: species richness, tropical forest, local communities, forest plant, edible plant

INTRODUCTION

Papua Island is the largest land mass in the Indonesian archipelago with a total area of 416,129 km² that constitutes millions of living organisms. Several natural resources are still in pristine condition and these lands are abundantly covered by thousands of plant types. The island where one of the oldest tropical forests in Asia and the Pacific is preserved, has the potential to support all living activities (Takeuchi et al., 2003; Lekitoo et al., 2017). The fact that native people and tribes have benefited from the forest and environment over many generations is the key element on how the forest's support for living is tangible (Klute, 2008). More than 200 tribes and traditional communities live in Papua, and most of them continue to depend on the forest. This is in the portrait of current living in interdependency with forests (Cabuy et al., 2012).

The support of the forest for relentless use of plant sources is fundamentally important, not only for balancing the natural ecosystem, but more importantly, it has been sustainably providing multi-benefit incomes in the social aspects of people's lives. The people who live and frequently interact with the forest have mostly benefited during their lifetime (Ros-Tonen et al., 2003). Multiple commodities were provided from the surrounding forest: staple foods, complementary foods and beverages, medicine, housing construction materials, clothes, and other daily components of the local lifestyle. This phenomenon occurred due to a legacy of traditional belief in which forests and the whole set of natural components are a fundamental heritage from ancestors and should be

preserved as well as managed in appropriate and sustainable ways (Wollenberg and Ingles, 1998; Morsello et al., 2012). However, the extraction of forest commodities in Papua is varied and depends on a tribe's background, living area, geographical status, etc. Such different circumstances lead to different forest utilization patterns among tribes and forest communities, as well as their future perspectives towards the long-term benefits of forests in Papua.

Therefore, the objective of this study was to identify the forest plants intended for main and complementary components of living in Natabui and Papuma villages of Yapen Island in Indonesian New Guinea. For clarity, the term *forest plant* used in this study describes all plant species belonging to vascular and non-vascular plants, plant life forms and plant categories which were found during the field study. The study result will eventually provide a better understanding of forest plant distribution and how those plants contributed to living in traditional communities in Indonesian New Guinea. Although the data used were quite old, the significant impact of these data and the information on the use of forest vegetation in both areas will be very valuable at present since no study or research have been done so far in terms of identifying the forest benefits to the community. In addition, the data and analysis results from this study will be a fundamental contribution for governments and related stakeholders to design a better management for the forest resources and manage a sustainable living benefit as a solution for the communities in the area. This research outcome will provide a real solution from government to design forest and agro-based diversification program such as agroforestry to support food availability as well as keep the forest ecosystem in the good shape. Moreover, related stakeholders such as NGO's will be able to determine specific food diversification practices for locals to be more sustainable with their edible natural forest resources.

In addition, the contribution of the study will promote high diversity of tropical plant species and its distribution based on the geographical area across the world. Therefore, it will reveal the tropical forest contribution towards traditional living benefit in Indonesian New Guinea which is fundamental to set up a long-term program and policy toward the existence and benefit in both forest vegetation and communities. Hence, even though the study was done in 2011, this study

information, due to its pivotal contribution, is considerably important to disseminate through an academic publication.

MATERIALS AND METHODS

Study area

The study area was situated in the low land tropical forest of Yapen Island in Indonesia New Guinea which lies between -2°2,4'8,424" and -1°23,4'19,548" South latitude, and between 134°56'21,708" and 137°4,2'20,592" East longitude (Center of Statistics Agency, 2018). Two villages, namely Papuma and Natabui were chosen to conduct this study with a duration of 2 months during the summer of 2011. In general, both preferred study locations are in the same island of Yapen and close in terms of distance. Both locations had the same annual rainfall (1500 mm/year), temperature range (27–34 °C), relative humidity (75–87%). In terms of geographical landscape, Natabui village is higher and relatively far from the coastal area, while Papuma is dominant in the lower area and close to the coastal area. Besides, both areas are still considered to be forested with the forest cover of more than 70%. The condition then effected the forest vegetation which is almost alike in both villages.

METHODS

Sample methods

The descriptive method involving deep-interview and discussion was used in this study. Both deep-interview and discussion are based on semi-structural questionnaires. In detail, there were four key questions: 1) How often do local communities interact with the surrounding forests and plant resources? 2) What is the benefit of the plant resources from the forest? 3) How difficult is it to harvest the plant resource? and 4) What is the future prospect of the availability of plant resources, based on traditional perspectives in both villages? These questions were modified and designed based on the previous study by Aronggear (2010) that were carried out in the both communities regarding non-timber forest products as well as other numerous semi-formal discussions that related to the use of forest resources for fulfilling daily needs across several forest communities

in Papua. These questions were determined based on the most daily activities in the community and pre-discussion responses that were carried out before the study was undertaken. From the all data collected during the interviews and discussions were used to generate a trend of interaction in both villages.

Respondent preference

In order to obtain the questionnaire data, respondents were selected based on the frequency of interaction with the surrounding forest and their socio-cultural role in the community. The authors decided to choose 20% from the total population of both villages. Sampling is quite effective when dealing with a large ethnobotany study (Tongco, 2007). Therefore, a total of 70 people (n = 70) (20% of the total population) were chosen to be respondents from both villages. These participants were then classified as village's leaders (10), religious leaders (4), or as zestfully active and inactive gardeners (56) who have experience with the plant resources.

Data collection

All the data were recorded and converted to a quantitative system through a scoring from 0 to 10 based on the study by Sandelowski et al. (2009). Some modifications to the scoring system were made in this study for a better representation of the data (Whitehead and Schneider, 2012). For the frequent use aspect, 0 represented lesser use and 10 represented the highest consumption of forest plants; for the aspect of benefit contribution of various plant sources, 0 indicated lesser benefit and 10 indicated the greatest benefit; for the aspect of difficulty of access, 0 was the most difficult and 10 was the easiest collection of plant sources; for the future prediction scenario of plant source availability, 0 indicated the highest threat and 10 indicated the least threatened of forest plants.

Data analysis

In order to quantify the distribution of forest plant life forms based on the growing habitat, a simple histogram was prepared. For the frequent plant uses based on plant life forms and plant categories in distributions, the Kruskal Wallis test was applied using dplyr and ggpubr packages. In addition to understanding the correlation among

frequency, benefit, access, and sustainability of use of forest plants in both villages, a correlation analysis was calculated and performed using corrplot package. These data were calculated using R statistical program (R Development Core Team, 2018).

RESULTS

Local people in both villages extracted 64 types of forest plants from 33 families. In terms of plant life form, these consisted of 8 palm species, 14 perennial herb species, 4 climbing herb species, 2 liana species, 17 tree species, 4 bamboo species, 4 fern species, 3 shrub species, and 8 mushroom species. In addition to the plant category, these were classified as 36 monocotyledon species, 16 dicotyledon species, 4 pteridophyte species, and 8 thallophyte species (Figure 3). Most of these plants were consumed daily as food whereas some were used for traditional medicine, housing construction, and as food complements.

It was obvious that the monocotyledon species were preferable to the dicotyledon species for both villagers. In the Natabui village, there were a total of 36 species from 17 families that came from the monocotyledon class. Next, dicotyledon use totaled 16 species from 13 families, and thallophytes and pteridophytes were the least consumed with only 12 species from 6 families.

In terms of geographical plant distribution and preference, most consumed plants were taken from the low land forest areas (<400 masl). For the preference of plant life form consumed, trees became were the most numerous consumed plants with a total of 17 species. The consumption of tree materials was followed by perennial herbs finally, lianas with only two species (Figure 1). For the plant category, monocotyledon was the dominant form of consumable (36 species) compared to dicotyledons (16 species), pteridophytes (4 species), and thallophytes (8 species) (Figure 2). From a total of 64 species of consumed plants, the leaf parts were preferred with 28 species. The second most frequently consumed plant portion was the fruit with about 19 species and the third was sprout emanating from five species, and other minor portions were seeds and piths.

In order to understand the broader scope of intent, benefits gained from various forest species, difficulty of access, and prospects for the future availability, a Spearman correlation among these variables was generated based on scoring
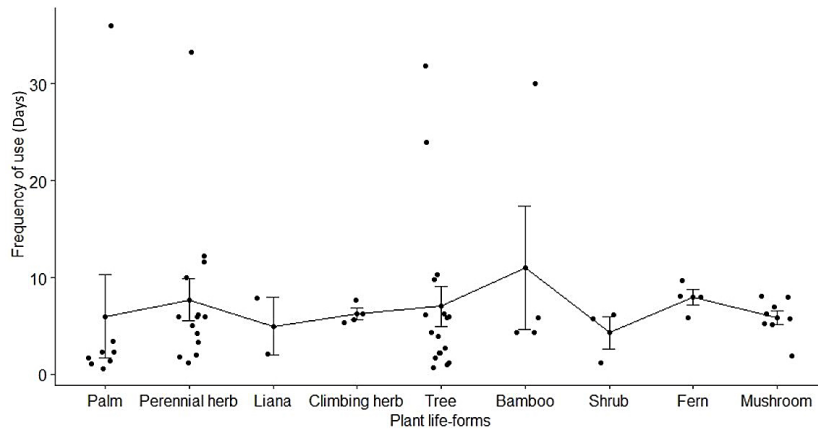
Figure 1. The relationship between plant life form distributions and frequency of use from all plant species consumed in the Papuma and Natabui villages. Kruskal Wallis test noted that there is no significant difference in use between plant life forms and use which is indicated by p-value of 0.219 (> 0.05 of significance level)

data set obtained from community respondents. A strong positive correlation (0.6453) was indicated between frequency of use and benefit value gained for most respondents in both villages, while a strong negative correlation was observed between the benefit value and accessibility of certain species (-0.2646). In addition, a strong negative correlation was noticed between frequency of use and the future prospect of forest species availability (-0.1405) (Figure 4).

DISCUSSION

Plant resources represent substantial benefits and play a pivotal role in the existence of local communities in both the Papuma and Natabui villages in Yapen Island. In terms of landscape

preference for harvesting, it was obvious that the local communities were more likely to yield various plant resources in the lowland forest (<600 masl) which generally tends to be a relatively even landscape with a slope lesser than 20°. Ecologically more dominant plant life forms and categories, in particular palm, perennial herb, climbing herb, grass, and several other monocotyledon were spread below 700 masl (Whitmore, 1998; Huang et al., 2003). Keppel et al. (2005) found as many as 560 indigenous species of vascular plants (52% endemic) in the low land tropical rain forest of Viti Levu, Fiji. In addition, a high number of soil nutrients in the lowland forest of Yapen Island was observed, with a high amount of substrate also abundantly found in the two lowland forest areas, presumably indicating a potential regeneration of plant growth compared
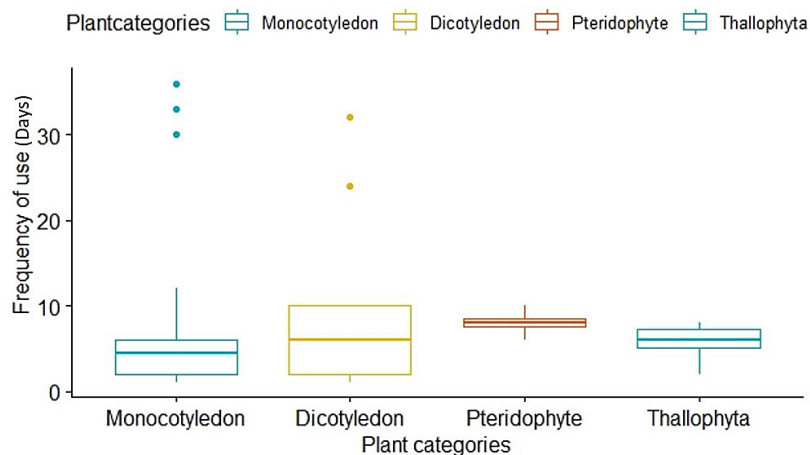
Figure 2. Relationship between the plant categories (monocotyledon, dicotyledon, pteridophyte, and thallophyte) and frequency of use intended for consumption in Papuma and Natabui villages. Kruskal Wallis test designated no significant difference as indicated by p-value of 0.208 (> 0.05 of significance level)
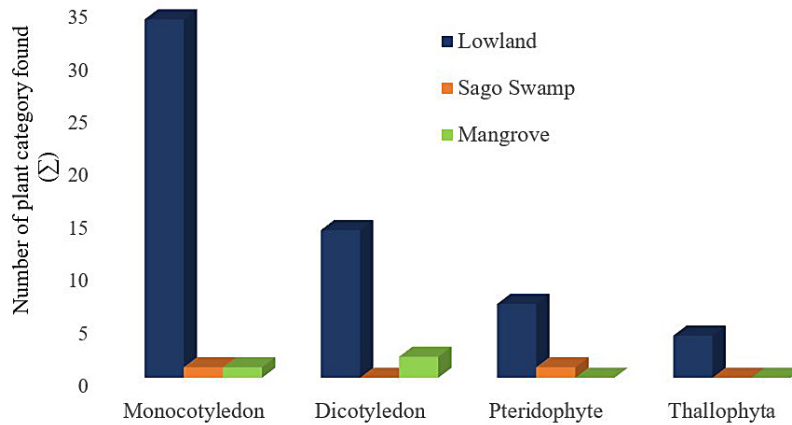
Figure 3. Histogram highlighting the distribution of plant sources based on categories and growing habitat in Papuma and Natabui villages of the Yapen Island

to that in the higher land (Ostertag et al., 2014). Sago palm as the most preferred staple food for locals was growing along the river, low-land swamp forest and peat land. These areas have been rich in soil nutrients and substrate which contributed toward the sago starch productivity (Lina et al., 2010; Novero, 2012; Ehara et al., 2018). Sim and Ahmed (1991) noticed a stunning production of sago starch in Sarawak, Malaysia ranging between 88 kg and 179 kg found in the peat soil and mineral soils. Several edible palms were growing along the riverside and lowland areas in both villages as these areas were characterized by an ideal temperature (Eiserhardt et al., 2011; Elias et al., 2019).

The tendency to choose monocotyledons was driven by their wider distribution and growth dominance in the lowland forest and landscape. Bognounou et al. (2011) highlighted that monocotyledons were more diverse and higher in density than dicotyledons in both primary and secondary forests of Corcovado National Park in Costa Rica. Apart from these, several plants have been pivotal for daily consumption and function as staple food and essential vegetables. Meanwhile, dicotyledons have been prioritized solely

Figure 4. Multiple correlations indicating the relationships among frequency of use, benefit value, access, and sustainability of forest resources in both villages based on scoring list data ranging from 1 to 10 gathered from respondents. Dark blue color (top bar scale) indicated very positive significant correlation, whereas the dark red color (bottom bar scale) indicated very negative significant correlation from variables

for wood consumption and housing construction. However, a small portion was preferred as food. Thallophytes and pteridophytes contribute as additional nutrients and improve daily diets. Rasingam and Parthasarathy (2008) revealed that herbs, shrubs, and grasses have been the dominant species growing densely in the lowland forest in Little Andaman Island, India. However, the dominance of monocotyledon species can be a glaring indication of ecological degradation in the ecosystem (Granville, 1984).

The basic rationale for the local inhabitants in both villages to prefer tree was that a whole tree could provide multiple benefits ranging from timber for construction and, fire, shoes/clothing, home furnishing, and daily diet for local inhabitants (Michon, 2005; Powell et al., 2014; Marwa et al., 2019). Hlaing et al. (2017) defined timber as the most frequently gathered material (96%) from the forest compared to other sources among rural forest communities in the Katha district of Myanmar. Perennial herbs possess multiple benefits, such as food for carbohydrate and vitamin sources and the use of stem, leaves and barks for medicinal purpose, which the locals take advantage of (Sunderland and Ndoye, 2004; Tölgyesi et al., 2018). A primary component from palm (sago) is starch as a carbohydrate source, while its bark and leaves can be converted to housing components such as flooring and roofing. Mushrooms can be consumed on a daily basis as a vitamin source and a medicinal component for healing several common diseases occurring in those villages (Wasser, 2002). Leaves render multiple uses being sources of vitamins in the form of vegetables, sources of medicine, as well as use in housing and various home accessories. Sunderland et al. (2002) specified the contribution of edible leaves at approximately 23.3% and for housing thatch at approximately of 0.7% towards the cash income for local communities around Takamanda Forest Reserve of Cameroon. Kamga et al. (2013) noted a high intensity of leaves consumed on the household scale which was more than once a week in Yaounde, southern Cameroon. Concerning the consumption pattern, 13 species (20.4%) of forest plants could be directly consumed and 51 species (79.6%) were processed through cooking methods. The predominance of indirect uses means local communities prefer variation towards final products of edible plants. By cooking, the taste, shape and nutrient components will be different. Most of indirect edible products were produced

using the leaves and starch (FAO, 2011; Nowak, 2017). Frequent directly consumed parts of forest plants were sprouts growing from several palms, perennial herbs, trees species, and young leaves (Márton et al., 2010; Maroyi, 2014).

It has been a fact that more interactions with the forest will render more foods and other complementary goods (Sonbait et al., 2018). Colfer et al. (2006) found that a good diet requires food availability and can often be a result of interaction with the forest. In terms of the economic income, the use of basic forest plants can be a source of money, which can be spent toward the improvement of local households' life (Neumann and Hirsch, 2000; Eastin et al., 2011). Vinceti et al. (2013) indicated the importance of edible forest foods obtained overtime because they consistently fulfilled the locals' necessities, rather than solely in a particular period. On the contrary, high frequency of forest access and plant consumption eventually will attenuate the overall potency of forest biodiversity and edible resources in both villages (-0.1405). Therefore, a potential alternative of better forest resource management such as community forest will increase the future prospect of forest sustainability (Dhakal et al., 2016). Mitchell et al. (2003) pointed out the negative effect on the ecological landscape and natural regeneration of flowering when the nut and fruits were extracted overtime with the high frequency.

CONCLUSION

The distribution of forest plants that are consumed was assessed by evaluating the species contribution toward local living benefit in two villages, Papuma and Natabui. Semi-structural interviews were carried out to determine how intense the collection was, what the value of the benefits from the plant resources was, the accessibility of the plants, and the prospects for the future sustainability of the surrounding forest plants for inhabitants in both villages. The results indicate that various life forms and categories of forest plants have significant contributions particularly to the daily food supply for diet. Spearman correlation indicated a strong positive correlation between the frequency of interaction and value of the benefit gained from surrounding forest, where a strong negative correlation was shown regarding the correlation between the accessibility of forest plants and value of the benefit gained.

Acknowledgements

REFERENCES

1. Aronggear A. 2010. Non timber forest products identification in Papuma and Natabui villages of Kepulauan Yapen District. [Mini-Thesis]. Faculty of Forestry, State University of Papua, Manokwari.

2. Bognounou F., Morton R., Ayangma S., Jonkers L., Bjorkman C., Bylund H., Vega A., Oden P.C. 2011. Stand structure of monocotyledons and dicotyledons in different successional stages in Corcovado National Park, Costa Rica. Bois Et Forets Des Tropique 307, 33–40.

3. Cabuy R.L., Marwa J., Manusawai J., Rahawarin Y.Y. 2012. Non-woody plant species of Papuan Island forests, A sustainable source of food for the local communities. Indian Journal of Traditional Knowledge, 11, 586–292.

4. Center of Statistics Agency. 2018. Kepulauan Yapen in figure. Centre of Statistics Agency of Kepulauan Yapen.

5. Colfer C.J.P., Sheil D., Kishi M. 2006. Forest and human health. Assessing the evidence. Occasional Paper No. 45. Center for International Forest Research, Bogor, Indonesia.

6. Dhakal P., Paudel D.R., Baral D.R. 2016. Inventory of non-timber forest products in western Nepal and strategies for sustainable management. International Journal of Environment, 5, 87–103.

7. Eastin I., Garcia C.M.C., Cortiguerre E.M. 2001. Some considerations for the more effective production and marketing of non-timber forest products in the Philippines. Final Marketing Report, FPRDI-ITTO Project PD 15/96 Rev.2 (M,I).

8. Ehara H., Toyoda Y., Johnson D.V. 2018. Sago palm. Multiple contributions to food security and sustainable livelihoods. Springer.

9. Eiserhardt W.L., Svenning J.C., Kissling W.D., Balslev. 2011. Geographical ecology of the palms (Arecaceae): determinants of diversity and distributions across spatial scales. Annals of Botany, 108, 1391–1416.

10. Elias G.A., Giehl E.L., De Gasper A.L., Lima J.M.T., Dos Santos R. 2019. Low temperature extremes influence both the presence of palms and palm species richness in the Atlantic Forest, Southern Brazil. Ecología Austral, 29, 041–049.

11. FAO. 2011. Forests for improved nutrition and food security. Food and Agriculture Organization, Rome.

12. Granville J-J. 1984. Monocotyledons and pteridophytes indicators of environmental constraints in the tropical vegetation. Conservatoire Et Jardin Botaniques De Geneva, 39, 265–269.

13. Hlaing Z.C., Kamiyama C., Saito O. 2017. Interaction between rural people's basic needs and forest products: A case study of the Katha District of Myanmar. International Journal of Forest Research, Article ID 2105012, 18 pages, https://doi.org/10.1155/2017/2105012.

14. Huang W., Pohjonen V., Johansson S., Nashanda M., Katigula M.I., Luukkanen O. 2003. Species diversity, forest structure and species composition in Tanzanian tropical forest. Forest Ecology and Management, 173, 11–24.

15. Kamga R., Kouamé C., Akyeampong E. 2013. Vegetable consumption patterns in Yaounde, Cameroon. African J. of Food, Agriculture, Nutrition and Development, 13, 7399–7414.

16. Keppel G., Navuso F.C., Naikatini A., Thomas N.T., Rounds I.A., Osborne T.A., Batinamu N., Senivasa E. 2005. Botanical diversity at Savura, a lowland rain forest site along the PABITRA Gateway transect, Viti Levu, Fiji. Pacific Science, 59, 175–191.

17. Klute M. 2008. Forest in Papua: Data and fact. Contribution to the forest conference of the West Papua network in Witten on 26th January 20108. https://www.biofuelwatch.org.uk/docs/papua_article.pdf.

18. Lekitoo K., Peday H.F.Z., Panambe N., Cabuy R.L. 2017. Ecological and ethnobotanical facet of 'Kelapa Hutan' (*Pandanus* spp.) and perspectives towards its existence and benefit. International Journal of Botany, 13, 103–114.

19. Lina S.B., Okazaki M., Kimura S.D., Quevedo M.A., Loretoz A.B., Mariscal A.M. 2010. Nitrogen uptake and growth response of sago palm (*Metroxylon sagu* Rottb.) to two types of urea fertilizer application. Sago Palm, 18, 73–83.

20. Maroyi A. 2014. Not just minor wild edible forest products: consumption of pteridophytes in sub-Saharan Africa. Journal of Ethnobotany and Ethnomedicine, 10, 1–9.

21. Márton M., Mándoki Zs., Kiss-Csapó Zs., Csapó L. 2010. The role of sprouts in human nutrition. Acta Univ. Sapientiae Alimentaria, 3, 81–117.

22. Marwa J., Sardjono M.A., Ruchaemi A., Devung S., Cabuy R.L. 2019. Benefit sharing schema from the forest: Identifying potential distributions to customary communities in Teluk Bintuni District, Indonesia. Acta Universitatis Agriculturae Et Silviculturae Mendelianae Brunenses, 67(4), 963-972.

23. Michon G. 2005. Domesticating forests. How farmers manage forest resources. Center for International Forest Reseach and The World Agroforestry Centre.

24. Mitchell C.P., Corbridge S.E., Jewitt S.L., Mahapatra A.K., Kumar S. 2003. Non timber forest products: Availability, production, consumption, management and marketing in Eastern India. https://assets.publishing.service.gov.uk/media/57a08ce8ed915d3cfd0016d4/R6916FTR.pdf

25. Morsello C., Ruiz-Mallén I., Diaz M.D.M., Reyes-García V. 2012. The Effects of processing non-timber forest products and trade partnerships on people's well-being and forest conservation in amazonian societies. PLoS ONE, 7, e43055. https://doi.org/10.1371/journal.pone.0043055.

26. Neumann R.P., Hirsch E. 2000. Commercialisation of non-timber forest products: Review and analysis of research. Center for International Forest Research with support from Food and Agriculture Organisation of the United Nations, Rome.

27. Novero A.U. 2012. Recent advances in sago palm (*Metroxylon sagu* Rottb.) micropropagation. Frontier on Recent Developments in Plant Science, 1, 60–66.

28. Nowak D.J. 2017. Assessing the benefits and economic values of trees. In: Ferrini, Francesco; van den Bosch, Cecil CK; Fini, Alessio, eds. Routledge handbook of urban forestry. New York, NY: Routledge: 152–163. Chapter II.

29. Ostertag R., Narahari I.F., Cordell S., Giardina C.P., Sack L. 2014. Forest structure in low-land tropical forests: A study of Hawaiian wet and dry forests. PLoS ONE, 9 (8), 1-8, e103268. doi:10.1371/journal.pone.0103268.

30. Powell B., Ickowitz A., McMullin S., Jamnadass R., Padoch C., Pinedo-Vasquez M., Sunderland T. 2013. The role of forests, trees and wild biodiversity for nutritionsensitive food systems and landscapea. ICN2 Second Internaitonal Conference on Nutrition. Better Nutrition Better Lives.

31. Rasingam L., Parthasarathy N. 2008. Diversity of understory plants in undisturbed and disturbed tropical lowland forests of Little Adaman Island. Biodivers Conservs, 18, 1045–1065.

32. R Development Core Team. 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, URL http://www.R-project.org.

33. Ros-Tonen M.A.F., Wiersum K.F. 2003. The importance of non-timber forest products for forest-based rural livelihoods: an evolving research agenda. Paper presented at The International Coference on Rural Livelihoods, Forest and Biodiversity 19–21 May 2003, Bonn, Germany.

34. Sandelowski M., Voils C.I., Knafi G. 2009. On quantitizing. Journal of mixed methods research, 3, 208–222.

35. Sim E.S., Ahmed M.I. 1991. Leaf nutrient variations in sago palms. In Proceedings of the Fourth International Sago Symposium. In Ng T. T., Tie Y. L., Kueh H. S. (Eds). Lee Ming Press Kuching, Sarawak, Malaysia, pp. 102–110.

36. Sonbait L.Y., Warmetan H., Manik H., Cabuy R.L. 2018. Inter-dependency of forest diversity and service towards the potency of ecotourism development in Pegunungan Arfak nature reserve. Ecology, Environment and Conservation Journal, 24, 1952–1957.

37. Sunderland T., Besong S., Ayeni J.S.O. 2002. Distribution, utilisation and sustainability of the non-timber forest products of the Takamanda Forest Reserve, Cameroon. A consultancy report for the project: Protection of the Forests Around Akwaya (PROFA).

38. Sunderland T., Ndoye O. 2004. Forest products, livelihoods and conservation. Case studies of non-timber forest product systems. Vol 2 – Africa. Center for International Forest Research. Bogor, Indonesia.

39. Takeuchi W., Maturbongs R., Sambas E., Allison A., Kurniati H., Menzies J., Murwanto A., Novotny V., Auga J., Amir M., Cholik E., Taylor G., Renyaan S., van Balen B., Kilmaskossu A. 2003. Flora and fauna survey of the Tangguh LNG site Papua Province, Indonesia. Exclusive summary. British Petroleum.

40. Tölgyesi C., Valkó O., Deák B., Kelemen A., Bragina T.M., Gallé R., Erdoz L., Bátori Z. 2018. Tree-herb co-existence and community assembly in natural forest-steppe transitions. Plant Ecology and Diversity DOI: 10.1080/17550874.2018.1544674.

41. Tongco D.C. 2007. Purposive sampling as a tool for informant selection. Ethnobotany Research and Application, 5, 147–158.

42. Vinceti B., Ickowitz A., Powell B., Kehlenbeck K., Termote C., Cogill B., Hunter D. 2013. The contribution of forests to sustainable diets. International Conference of Forests for Food Security and Nutrition. FAO, Roma.

43. Wasser S. 2002. Medicinal mushrooms as a source of antitumor and immunomodulating polysaccharides. Applied Microbiology and Biotechnology, 60, 258–274.

44. Whitehead D., Schneider Z. 2012. Mixed-methods research. Ch. 14. Book: Nursing and midwifery research. 4th edition, 432 pp.

45. Whitmore T.C. 1998. An Introduction to Tropical Rain Forests, 2nd Edition. Oxford University Press, New York.

46. Wollenberg E., Ingles A. 1998. Incomes from the forest. Methods for the development and conservation of forest products for local communities. Center for International Forest Research (CIFOR), 227 pp.