Chapter 15
Redesigning Walker for Elderly

Nilanjana Bairagi and Prathmesh Mahajani

Abstract The present paper aims to redesign a walking aid for the elderly through a user-centric design research approach. The study involved 12 elderly volunteers. During the research, detailed observation has been carried out in the area of the daily activities of the elderly, in their real environment with assistive devices and interaction with other objects using ethnographic research method. Users' problems and preferences toward assistive devices were also studied. It was found from the pilot study that the existing walkers make the elderly feel psychologically dependent and disabled. Many elderly persons found it shaky while using. This leads to non-use or abandonment of the walker, though medically advised. Therefore, this study focused on redesigning of walker to address the above issues. The designing criteria were derived from the observations and interviews with stakeholders, concepts were developed, prototypes were made and user tested, before arriving at the final design. During prototyping and material exploration, indigenous natural material like rattan cane was used to design the walker with additional features like bottle holder, newspaper holder, and mobile phone holder. User trials indicated the advantages of the rattan walker-like easier handling, faster gait speed due to 16% lighter in weight, and aesthetically pleasing appearance. There was an increase in the gait speed of the users using rattan cane walker as compared to the conventional walking frame. The psychological effect of feeling disabled was significantly reduced with the new design as observed during the study. The study shows the possibility of designing a user-centric walker using a rattan cane walker for the elderly in India.

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15.1 Introduction

Aging is the process of becoming older, wherein the person's cells and tissues start to change which leads to greater risk of being diseased or dead [1]. As defined in a research [2], the elderly is the chronological age of 65 years. Mass of the lower limb muscles reduces at an older age. This phenomenon is called sarcopenia [3]. This results in imbalance and falls among the elderly. When the center of mass (COM) exceeds the bounds of the base of support (BOS), falls are likely to occur. The elderly walk slowly and tire more quickly due to loss of strength and mass in leg muscles due to aging. More than 70% of the falls among people aged more than 65 take place at home and 20% of them need hospitalization [4]. The most common consequences of falls are hip fractures, restricted activities, psychological impacts like reduced self-esteem, and reduced quality of life [5]. The majority of falls lead to hip fractures, which lead to either long-term hospitalization or death [6]. To prevent this, assistive devices like walkers are used. Walkers increase the base of support of the elderly, thereby improving their balance and stability [7].

Although the likelihood of disability increases with aging, it is not just associated with a particular age of population but may affect at any age. Some common reasons for disability are chronic diseases like cardiovascular disorders, musculoskeletal disorders and mental health conditions like dementia and depression. Other reasons are injuries due to accidents or mishaps and malnutrition [8].

Assistive devices like canes, crutches, walkers and wheelchairs are advised to meet mobility challenges among the elderly. Different novel solutions have been proposed through a user-centric design approach to meet the mobility challenges of the elderly. For instance, Khan et al. [9] have designed a novel sit-to-stand walking aid that incorporates a pantograph mechanism to aid sit-stand transfer, coupled with a walking frame to assist walking. Another lift-assist walker has been proposed by Bulea and Triolo [10] for individuals suffering from spinal cord injury, which uses gas springs to create powerless lift assist. Integration of ergonomics in product design is found to be relevant and useful in designing products for differently-abled users. This has been shown by Das and Seid in their work with the self-transfer assistive devices for wheelchair users [11].

Fundamentally, a walker is a four-legged frame used by people who need support in balance and mobility. It is also used by older adults to prevent falls. During the pilot study, it was observed that out of the different types of walkers like rollators (wheeled walkers), weight-bearing type (with wheels on rear legs of the walker), and non-weight bearing type of walker (with all four legs of walker without wheels), the most commonly used was the non-weight bearing type. As a part of the pilot study, during interviews with doctors and physiotherapists, it was learned that there is a design opportunity in the area of the walker in the Indian context as many patients are not comfortable with the existing commercially available models. As there is limited research in the Indian context, using a user-centric approach in the designing of an assistive device for the elderly, the aim of this research was to redesign a walker for the elderly. This would help towards the improvement of physical rehabilitation.

15.2 Research Methodology

A user-centered design approach was undertaken for this research as presented in Fig. 15.1. User-centered design is an iterative design process in which the designers focus on the users and their needs in each phase of design [12]. The first step in user-centered designing is to understand the user needs and requirements. This is done through an ethnographic research approach where the users were studied in a real environment in their home setting or home-cum-rehabilitation center. During the ethnographic observations, the activities, environment, interaction, objects and users (AEIOU) principles of design thinking were used. The detailed observation was carried out in the area of their daily activities, their living environment, the interactions in their real environment with the assistive devices and other objects and user preferences were studied. Users were also interviewed to study the ease of using a walker and performing daily tasks. Empathy mapping was carried out to understand these needs from the perspective of the potential users.

A case study approach has been used. Out of a total population of 28 patients from an old age home-cum-rehabilitation center, Kadji Care, Vadodara, Gujarat, interviews of 12 senior citizens using walkers, who volunteered to be a part of the

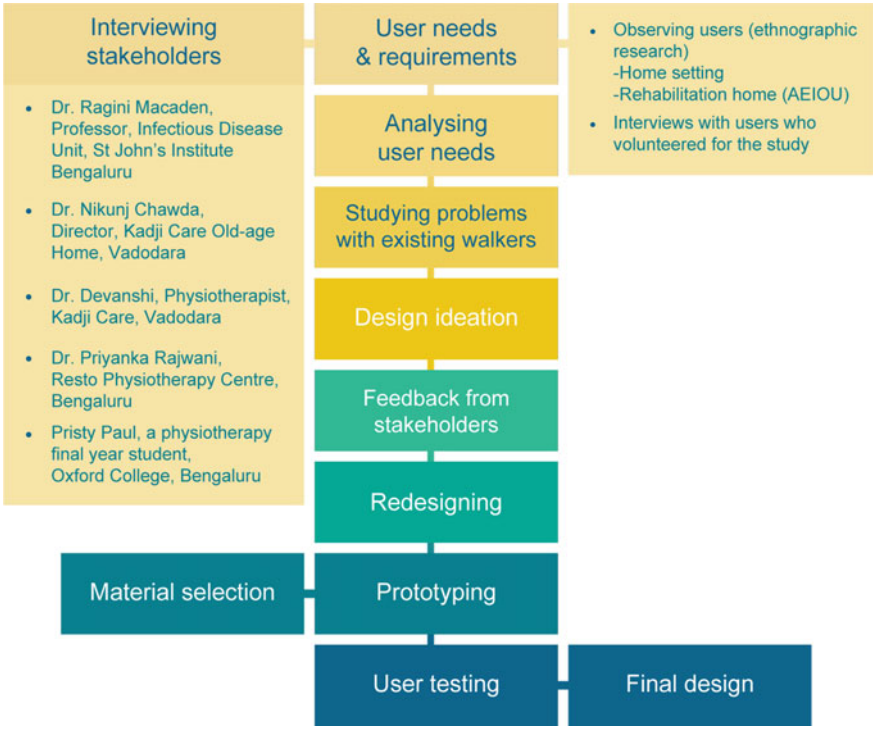

Fig. 15.1 Research methodology

study, were carried out. Informed consent was obtained from all the participants. Contextual interview questions were asked during the ethnographic research like: 1. Have you ever experienced a fall? Where? How? How frequently? 2. What kind of assistive device do you have? How do you find it? How easy it is to use this device? How useful do you think it will be to move around this living environment with this assistive device? How comfortable do you feel when using this device in front of other people? 3. Do you think the device can be improved? How? Answers to these questions have been collected and were noted in the form of insights.

To understand the perspective of healthcare professionals—physiotherapists, orthopedic doctors, and neurologists have been interviewed using convenience sampling. A comparative analysis of the most frequently bought walkers was done with help of 10 surgical shops in Bengaluru, India.

User needs have been assessed at home settings and at rehabilitation center during the research. The main requirements in a walker were identified during the observation and interaction with the users. The emotional feeling associated with the use of a walker was also investigated through care-givers. The activities of the users are observed like—using the walker to stand up, navigate in the home spaces, including accessing the washrooms, sitting on a chair, using mobile phones, carrying small objects like a bottle of water or newspaper, their stability, and convenience of using the walker were also observed.

Designs were conceptualized based on the initial research. User feedback was taken to improve the design and during the material selection process. Prototypes were developed and feedback was taken from the stakeholders. User testing was carried out with two elderly volunteers, with informed consent. To understand the difference in their gait speed, elderly volunteers are asked to travel a 12 m distance using the conventional walker as well as the redesigned walker. A stop timer is used to note the time taken to travel the distance and their average speed was calculated. Based on the feedback and observations, the prototype was modified and redesigned before the development of the final design.

15.3 Research Findings

During the study, it was observed that the main needs of the users are durability and stability of walkers. The conventional walker gets shaky and wobbly over a short period of use. The grip of the walker is too short for the hands of the Indian elderly. Due to smaller base of the walker, the walker's legs are often placed on the user's footwear, which at times leads to falling. The users expressed the need for a pocket to keep utility things like—a bottle of water or essentials like newspaper or spectacles. A foldable seat was also expressed as one of the requirements. The users have to look behind to avoid fall while performing standing-to-sitting with the walker (Fig. 15.2c) while using conventional walkers. Once the user sits with the walker, he gets locked and someone needs to move the walker away (Fig. 15.2b). It was also found that the common reason to prefer a non-weight bearing walker is its stability and sense

a. b. c.

Fig. 15.2 **a** User navigating inside home using walker, **b** user seated and locked around by walker in front side of body, **c** user performing sit-to-stand and stand-to-sit

of confidence from falls. Also, it has fewer number of moving parts and needs less maintenance. The wheeled walkers were not preferred by most of the users as it is less stable and the users need to walk faster than their comfortable pace. It was also expressed by the users that the walkers make them feel psychologically dependent and weak.

Therefore, the design criteria that were derived from the user studies are:

- To design a more stable and durable walker
- Absence of pinch points and sharp edges.
- To be able to withstand everyday use for 2–3 years
- To be able to fit in 18 × 22 × 31-inch space for transportation [7]
- Must be psychologically and aesthetically pleasing to the user.

15.4 Development of Concept Sketches

Based on the research findings, initial sketches focused on designing the frame that would meet the criteria of better stability as shown in Fig. 15.3. The ergonomics of using a walker were considered while concept generation based on the observations. Figure 15.4 shows the study of grip, sizing, or dimensions and shape for the appropriate handling of walker [13]. Accessories like alarm/ horn, torch, seat and bag were also conceptualized from users' interviews and feedback.

15.5 Prototyping

To meet the basic requirements of stability and durability, different materials were explored like steel, plastic, and organic materials as shown in Fig. 15.5. In terms of

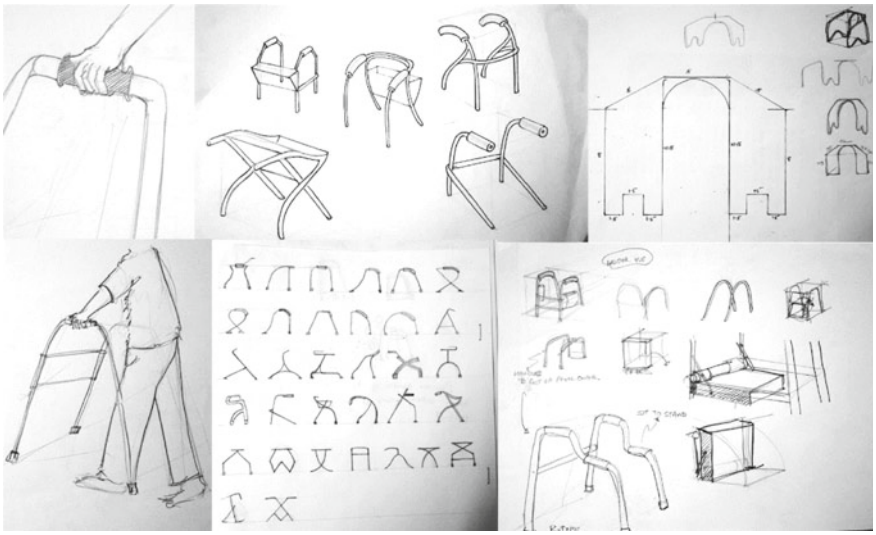

Fig. 15.3 Sketches of concepts of grip design and walker's frame design

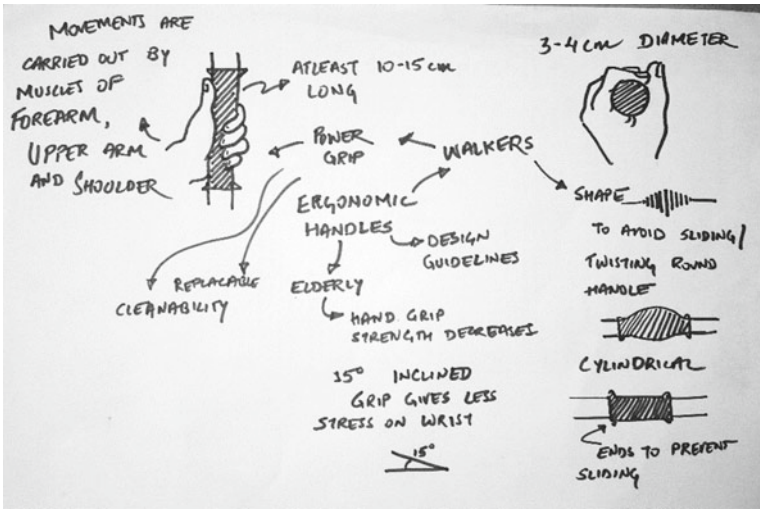

Fig. 15.4 Conceptualization of grips for walker design

steel, low-scale frugal prototypes are made using locally sourced galvanized wire (GI) wire and parts of the Mechanix tool kit. To reduce the weight of the walker, lightweight polyvinyl chloride (PVC) pipes were also explored. It was observed that lightweight PVC structures are prone to bending and twisting.

Walker designs were further developed using natural material rattan cane as presented in Fig. 15.6. The prototype was developed to check the feasibility of

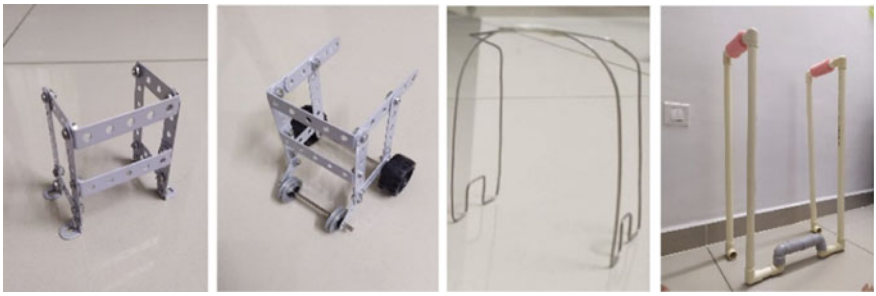

Fig. 15.5 Initial prototyping of walkers using Mechanix tool kit, GI wire and PVC pipes

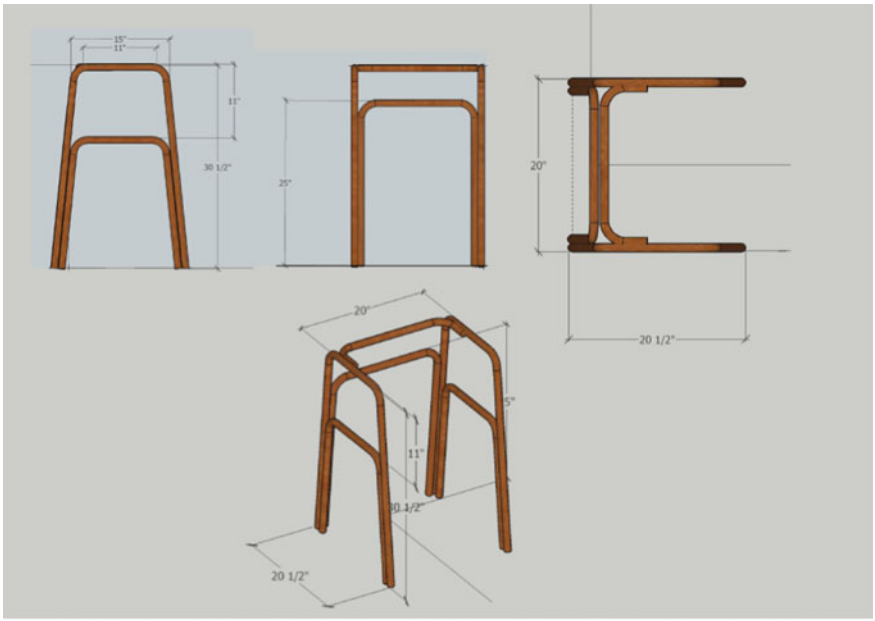

Fig. 15.6 Conceptual design of a walker made out of rattan cane

bending the material, the stability of the structure, and weight assessment as presented in Fig. 15.7. The dimensions of the rattan cane walker were 20 (width) × 20 (depth) × 30 (height) inches.

15.6 User Testing

User testing of the rattan cane walker was carried out in real set up as shown in Fig. 15.8. It was found that the prototype met the required criteria of stability and

Fig. 15.7 Process of walker design using rattan cane

Fig. 15.8 Users trying out the rattan cane walker in home setting

was easy to use. From the user's feedback, it is found that the legs of the walker may be prone to wearing off, thereby leading to instability of the walker. To overcome this problem, rubber stubs for walker's legs were designed. Additionally, gait speed was calculated using the rattan cane walker.

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To study the difference in their gait speed, two elderly volunteers are asked to travel 12 m distance using conventional walker v/s rattan cane walker. A stop timer is used to note the time taken to travel the distance and speed was calculated. The results are presented in Tables 15.1 and 15.2. The results of the user testing indicate that the average gait speed of the two elderly users using a rattan cane walker is more

Table 15.1 Gait parameters using aluminum walking frame

	Stride length (cm)	Distance (m)	Time taken (s)	Speed (m/s)
Elderly 1	32	12	222	0.054
Elderly 2	50	12	152	0.078

Table 15.2 Gait parameters using rattan cane walker

	Stride length (cm)	Distance (m)	Time taken (s)	Speed (m/s)
Elderly 1	30	12	120	0.1
Elderly 2	50	12	75	0.16

as compared to the average gait speed while traveling the same distance using a commercially available metallic walking frame. The comparison has been presented in Table 15.3. This may be attributed to the ease of using the rattan cane walker as it is 16% lighter in weight than the metallic frame walker as presented in Table 15.3.

The rattan cane walker was perceived to be more user-friendly and light in weight. The prototype was also viewed to be aesthetically pleasing to the users, thereby reducing the psychological barrier that they have toward the commercially available walkers.

15.7 Conclusion

During the pilot study, it was learned that there is an opportunity in the area of redesigning a walker in the Indian context as many users are not comfortable with the existing commercially available walkers. Additionally, there is limited research in the Indian context; using a user-centric approach in the designing of an assistive device for the elderly. Therefore, the objective of this paper was to redesign a walker for the elderly that would help in physical rehabilitation.

The methodology used was user-centered research, using ethnographic research, where the users were studied in a real environment in their home setting or home-cum-rehabilitation center. 12 senior citizens volunteered for the study. Detailed observation in the area of their daily activities in their actual living environment, the interactions with the assistive devices and other objects were carried out. During the research, various designs are conceptualized, prototypes were developed and natural material-like rattan cane was also explored. The main design needs were the stability of the walker, ease of use while doing the daily activities. Indigenous material like rattan cane was used to design the walker with a larger base area and additional features like bottle holder, newspaper holder, and mobile phone holders. The redesigned walker was preferred by the elderly in the study. The results of the user testing indicated that the average gait speed of the elderly users using a rattan cane walker is more as compared to the average gait speed while traveling the same distance using a commercially available metallic walking frame. This was attributed to the ease of using the rattan cane walker as it is 16% lighter in weight than the metallic frame walker. The psychological effect of feeling disabled was also less among the users with the rattan cane walker. Therefore, rattan cane can be used as an alternative natural material for designing of custom-made walkers for the elderly in the Indian context.

Table 15.3 Parameters and challenges addressed by the redesigned walker

Parameters	Challenges with commercially available metal frame walkers	Design proposed	Features of the developed rattan cane walker
Stability	Walker is wobbly	Need for a more table design/structure	Walker is stable as the weight gets well distributed along the legs of walker
Illumination	Difficulty in seeing obstacles on the ground under poor illumination	Torchlight can be attached to the walker	An attachment may be incorporated
Mobility	Difficulty in sitting-to-standing	For sitting-to-standing, counterweights can be added to the front end of the walker	Weight of walker is naturally more toward the front two legs, making it firm
Ergonomics	Walker's leg might fall on the foot of the user by mistake	Need for bigger base of support	Wide legs give a good base for support and mobility
Ergonomics	Need to adjust the height of the walker for different users	Custom made walkers can be used	The walker may be custom made in the range of 75–95 mm, for a particular height of the user
	This is difficult for the elderly as the studs are not easy to push in the slots for height adjustment		
	Short grip	A longer grip can be used	Grip is long and firm
Maintenance	This also makes the walker noisy and shaky which needs maintenance		Less maintenance, as there are no nuts and bolts
Accessories	No pocket/space to carry essentials like spectacles, newspapers, books	A pocket can be added, even a bottle stand can be added to the walker	Rattan cane basket can be easily attached to the walker
Weight	Around 3 kg weight, heavy	Lightweight material may be used	Rattan cane walker weighs less, 2.5 kg
Temperature	Aluminum gets cold in winter and hot in summer depending upon ambient conditions	Material with poor thermal conductivity may be used	Rattan cane is a poor conductor of heat so the temperature variation in the product is less

(continued)

Table 15.3 (continued)

Parameters	Challenges with commercially available metal frame walkers	Design proposed	Features of the developed rattan cane walker
Bending modulus	68.9 GPa for aluminum [14]	Should meet the requirements	2.6 GPa for rattan cane treated with methyl methacrylate [15]
Compressive strength	30 MPa for aluminum [14]		36.96 MPa for rattan cane treated with methyl methacrylate [15]
Average gait speed to cover distance of 12 m (6 m forward and return to starting point)	Average gait speed for elderly using aluminum walker was 0.066 m/s		Average gait speed for elderly using rattan cane walker is 0.13 m/s
Average cost of walker	INR 1100/-		INR 3000/- (for prototyping as a custom made product)

References

1. Tosato, M., Zamboni, V., Ferrini A., Cesari, M.: The aging process and potential interventions to extend life expectancy (2007)
2. Orimo, H., Ito, H., Suzuki, T., Hosoi, T., Sawabe, M.: Reviewing the definition of elderly. Geriatrics Gerontol. Int. **6** (2006)
3. Spirdus, W.W., Francis, K.L., MacRae, P.G.: Physical dimensions of aging (2005)
4. Berg, R.L., Cassells, J.S.: The Second Fifty Years: Promoting Health and Preventing Disability. National Academy Press, Washington D.C. (1992)
5. Luz, C., Bush, T., Shen, X.: Do Canes or Walkers Make Any Difference? NonUse and Fall Injuries
6. Parkkari, J., Kannus, P., Palvanen, M., Natri, A., Vainio, J., Aho, H., Vuori, I., Jarvinen, M.: Majority of hip fractures occur as a result of a fall and impact on the greater Trochanter of the Femur: a prospective controlled hip fracture study with 206 consecutive patients. Calcif. Tissue Int. **65**, 183–187 (1999)
7. Foley, M., Johnson, K., Kalbach Jr, J.E., McNally, B.: Improved Walker Design: A Major Qualifying Project Report. WORCESTER POLYTECHNIC INSTITUTE (2010)
8. Sarkar, S., Das, A.K.: Design Modularity in the Assistive Devices for the Elderly People. Springer Nature Singapore Pte Ltd., Guwahati (2017)
9. Khan, M.R., Patnaik, B., Patel, S.: Design and Development of a Novel Sit-to-Stand and Mobility Assistive Device for Ambulation and Elderly. Springer Nature Singapore Pte Ltd (2017)
10. Bulea, T.J., Triolo, R.J.: Design and Experimental Evaluation of a Vertical Lift Walker for Sit-to-Stand Transition Assistance. Cleveland, USA (2012)
11. Seid, K., Das, A.K.: Conceptual Design and Evaluation of a Novel Self-transfer-Assistive Device. Springer Nature Singapore Pte Ltd, Guwahati (2019)
12. Abras, C., Maloney-Krichmar, D., Preece, J.: User-centered design. In: Encyclopedia of Human-Computer Interaction (2004)

13. Patkin, M.: A Check-List for Handle Design. Ergonomics Australia On-Line, South Australia (2001)
14. AZoM.: Aluminum—Advantages and Properties of Aluminum, 4 June 2002 [Online], Available: https://www.azom.com/article.aspx?ArticleID=1446.
15. Liu, X., Yang, S., Shang, L., Ma, J.: Properties of Rattan cane and its comprehensive utilization technology. In: International Seminar on Rattan Sustainable Management and Utilization in South-East Asia.