CHAPTER 1

INTRODUCTION

Coconut is one of the most important crops in Kerala, since it has many uses in the day today life of the people and it is also an important agricultural produce in trade and marketing. Kerala is actually named after the coconut tree with “Kera” meaning coconut tree and the “alam” meaning land thus meaning “land of coconut trees”. It is mainly grown in tropical and coastal areas of lands. India is the leading producer of coconut in the world. Coconut provides principal sources of agricultural income to the population in Kerala through coir industry and edible oil industry. The net area under coconut cultivation in Kerala during the year 2017-2018 was 1.90 million ha, which occupies 48.96 per cent of total area in the state. Considering the area under the cultivation, the coconut occupies first place among different cash and non- cash crops in Kerala. The coconut brings much more economic gains to the people of Kerala through diversified uses in different sectors.

Coming on the social values of the coconut, it has got much importance influence in the cultural and religious beliefs of the people in Kerala. It is used as an important ingredient and oil in most of the dishes prepared in Kerala homes. Coconut and its products are used as a raw material for producing many value added products at present. The coconut is used for coconut oil production and it is a base oil many industrial products. Another by product is the oil oil extraction is the cake is used as cattle feed. The endosperm is used for making coconut cookies and other bakery items. The neera and toddy is extracted from coconut tree inflorescence is used natural drinks and used for making other products. The coconut tree leaves are used for thatching houses and feed for animals like elephants. Coconut harvesting and cleaning and applying nutrients in the crown are main problems faced by the home steads and farms in Kerala since expert climbers are not available for these tasks since climbing tall trees are risky and a sudden fall leads to permanent disability or death.

The coconut tree climbing in Kerala experienced severe palm climber shortage due to lack of trained workers, peak season demand, high cost of wages and other social problems lead to the development of palm climbing aids. Since 2010, many research works are going on to develop a simple, safe and easy to use coconut palm climbing aid. Many universities in India including

Kerala Agricultural University have developed many models of coconut climbing aids. The Kerala Government through Coconut Development Board, Kochi have successfully trained thousands of persons and climbing aids were gifted free to sustain this vocation in rural areas of Kerala with reasonable wages.

As of now, the climbers have become popular and users have started expressing their needs in the existing climbing aids technology and design to make simple, safe and light in weight with utilities for easy mounting and un-mounting from trees, securing the aid in top of the tree etc. Many research studies are in vogue to further modernize the climbing aids further to meet climber requirements. Many universities and institutions are trying to develop the climbing aid lighter, safer and efficient in operation and climbing aid with lighter materials, improving safety features, clamping and locking device for easy mounting and un-mounting the aid and for reducing the climber drudgery to tap maximum share in the climbing aid market. So today, the technological innovations are sought in the design and manufacturing climbing since climber safety is the utmost concern. The climbing aid should be designed ergonomically to suit climber and tree features otherwise palm climbing will be risky task for minor design mistake will results in death. However, the remote controlled machine concept is to be developed in future to suit coconut harvesting to replace humans from these kinds of tasks.

Coconut climbing aids have become inevitable since traditional climbers are very few and avoid using traditional aids for the climbing tasks since it is too risky. Now interested persons are trained in palm climbing tasks using climbing aids only. People are attracted to palm climbing jobs' due to the higher wages they get compared to other agricultural tasks in a short time period of work. The climbing aid market is critical and market depends on the fulfilment climber (customer) needs like portability of aid, ease of mounting and un-mounting aid, ease lifting and climbing with aid, ergonomical factors of climbing aid fitting the user, safety of aid, locking of aid in the top of the tree etc. Other factors like free training and climbing aid and safety mechanism are important factors in the decision making for selecting climbing aids use by the new entrants in this field.

The palm climber using aids are suffering from many problems mainly due to the improper anthropometrical design problems which cause musculoskeletal pains. An ideal climbing aid satisfying the customer requirements is yet to reach the market giving prime importance to the safety of climber. Though many climbers like KAU model and its modified model, TNAU model and its modified model, CPCRI model, Chemberi model etc., are available in the market. However, the principles of climbing aids working are different for each type and make. All models works on the principle of the posture adopted by the operator to climb the tree with climbing aid either in standing or sitting posture. Depending upon the coconut tree height and ease and speedy working, the Chemberi Model and Chachoos model climber aids are the most popular ones. Persons trained and using one particular type of climbing aid is not at all willing to use another type of climbing aid with few exceptions. So the preference of using one type of climbing aid varies with person to person and according to their comfort and easiness of climbing the trees. So an ergonomically designed climbing aid should ensure overall performance efficiency and climber design should fit the majority of the climbers' population.

In this case of climbing aids study, we are mainly concerned with the needs or requirements of the climber or customers according to their needs and technical experts are giving the suggestions for design modifications of existing climbing aids or for a new climber. But unfortunately the cimbers choices and needs vary and a correct decision making is practically impossible due to various limitations. So in this study we are going to introduce and apply a novel technique that can be used for making decision in such a way that a pair wise comparison of the customer requirements and their relative weightage with respect to the design specifications are analysed and improvement can be made. The technique of analytical hierarchical process for determining the weightage of customer requirements and integrating with quality functional deployment can applied to improve the design requirements of climbing aids and select most suited climbing aid in the market.

Palm climbing aids have different constraints in harvesting coconuts from palm trees using climbing aids due to the height and variations diameter of coconut palm trees which is to be analysed for the selecting the performance of the climbing aids. So considering all the factors discussed, the climbing aids present in the market have to evaluated according the customers' needs based on the regulation such that climbing aid can be based on climbing performance from operators from health and safety point of view.

At present we have many models of climbing devices available in the market. In this study, we are evaluating the different types of climbing aids from their working principle, efficiency, safety and ergonomical performance. Considering these facts in view, the present research study about the "performance evaluation of coconut palm climbing aids by AHP and QFD techniques" was taken up with the following specific objectives.

1. To conduct survey on the different types of coconut palm climbing aids performance in the market.
2. To survey the improvements needed in the different types of palm climbing aids with the regard to design, ergonomic, material and production process.
3. Select and evaluate performance of different climbing aids through AHP and QFD approach.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

A brief review of the work done on the aspect of our project is being reported in this chapter. The important reviews of different coconut climbing devices and analytical hierarchy process (AHP) which is related to the weightage evaluation different scenario present in the climbing aids requirements by users are discussed here. And by taking the relative weights from the AHP or by the investigation, the design criteria required are taken in to account on "what's" of the customer requirements. The customer requirements are related with machine or climbing aid specifications through the house of quality. The interrelationship between climbing aid specifications are evaluated. The relationship between the customer requirements and technical specifications are analysed by quality function deployment (QFD) approach.

2.2 Types of palm and their characteristics

There are many types of palm present in the world and they are mainly Bismarck palm, Cabbage palm, date palm, Carpentaria palm, Chinese fan palm, fish tail palm, coconut palm etc., are the main palms present in the nature. They have tall structures, palmate leaves that grow in a bunch at the end of stem and the fruits are formed at the top of the structure and harvesting of these fruits or nuts are by done climbing the top of the trees. The average height of the coconut tree is about 50-60 feet for all varieties. The diameter of the coconut tree is 20-35 cm and when it goes to taller, the diameter is reduced by 15-20 cm at top and in the mid portion of the tree is about 20 to 30 cm. Other feature is that it is fibrous stem and has rough surface which increases when it goes upwards.

2.3 Traditional palm climbing aids

The traditional palm climbing aids are the coir fibre rope (thala) or any other gripping aids that can be used for the legs and hands for climbing trees. During past when coir was not available, the people usually used banana plant fibres, ropes for making gripping aid for climbing palm trees. The main problems with traditional type of gripping aids are that they are not safe and fail without any external indication of failure which eventually results in death or fatal fall to life time disability. Also, the traditional gripping aids cannot maintain steady grip all throughout the climbing operation. The climbing person cannot take rest or stop a while, is a main problem of using traditional grip aids. Therefore, traditional grip aids are not safe and it will result in the direct falling and succumbing to death.

2.4 Types of modern palm climbing aids

Many types of climbing aids have been developed according to the user needs and design requirements like safety measures and easiness of use etc. Many published papers are related to the design criteria and the construction features of climbing aids and continued efforts are on to improve and modify the climbing aids. The climbing aids so far developed are mainly classified according to the working posture of the climber and it is either sitting type or the standing type or both sit and stand type. In the market, we are presently dealing with the sitting and the standing type of climbers.

2.4.1 Sitting type climber

2.4.1.1 Sit and climb type (TNAU MODEL)

Plate:2.1 TNAU model

A coconut climbing device was developed under the All India Coordinated Project on farm coconut climbing devices and machinery in TNAU during the year 2006. The device comprises of an upper frame and lower frame which are independently movable and position able along the coconut trunk. The upper frame member is tubular frame with a rectangular cross section consisting of a rigid base section and as an adjustable palm gripping section. The rigid base section carries a seating arrangement for seating the user, front support rail, cross rear rail and side rail. The user can sit comfortably facing the palm and receive support from the cross rear rail and the side rail.

The lower frame member is a tubular frame work consisting of a rigid base section and a palm trunk gripping section similar to upper frame member except that the rigid base section is located adjacent to the palm trunk to support the weight of the user when the upper frame is repositioned on coconut palm. The rigid base section carries a pair of parallel tubular bar with rubber bushes for the user to insert his feet and lift the unit.

The upper and lower frame members are connected with canvas belt to prevent operator from slipping down the palm trunk. Handles provided on the side rails of the upper frame to enable the user to lift the unit while ascending the palm. After reaching the coconut palm top, the unit can be fitted to one of the fronds with the help of hook so that the user can harvest coconuts.

The spacing of the gripping members is set initially to engage both the upper and lower frames with outer most ends such that the inclination of the seat and foot rest is horizontal or parallel to the ground. To ascend the coconut palm, the user the places his feet on the lower frame member, and then rests his weight on the seating section of the upper frame while using feet and legs pull the lower frame upward. The user then stands by resting his feet on the lower frames and uses his hand to raise the upper frame to waist high position. The user then sits again raises the lower frame with his feet and legs.

2.4.1.2 KAU coconut palm climbing device (developed at KCAET)

PLATE:2.2 KAU COCONUT CLIMBER

This model was developed by KAU with modifications over the TNAU model. The material of construction of the upper frame has been changed to GI pipe and lower frame to aluminium to reduce the total weight of the equipment thus making it more easy to use. The palm gripping portion of the both upper and lower frame has been changed from a square frame to a “U” frame. The “U” frame helped to reduce the clearance space between the coconut trunk and climbing aid at all location, thus reducing the sway of the equipment. The rubber bush for gripping is provided in the middle of the U frame. Safety lock pins have been added to ensure better safety. Specially designed footwear is also introduced to the lower frame for easier use and it is one of the main advantage over the models. The equipment weighs about 9.45 Kg

2.4.1.3 Kerasuraksha coconut climbing device (developed at ARS Mannuthy

PLATE 2.3 KERASURAKSHA ARS MODEL

Kerasuraksha model was developed in ARS Mannuthy. This is a simple device consisted of an upper frame, the seating unit, lower frame and the pedal unit, which are independently movable and position able along coconut palm trunk. The upper frame member is a tubular frame work made of stainless steel and consists of a rigid base section and an adjustable palm gripping section. The rigid base section carries a seating arrangement for accommodating the user, side rail for hand support on one side, a V- shaped portion with rubber blocks on both V's that grips to the coconut trunk from front side and a hand rail running above the V- section. The seating structure is like a chair and is linked to the V- shaped portion mentioned earlier. Hand support on one side provides safety and easier entry and exit for the climber from the climbing aid.

2.4.2 Standing type climber

2.4.2.1 Standing type climber (Chemberi model)

This coconut climbing device was developed by Sri. M.J.Joseph, a farmer from Chemberi village of Kannur district in Kerala. The device has two frames (left and right). The main frame is made of 12 mm diameter mild steel rod. Each frame comprises of flexible adjustable encircling the iron rope of 8 mm diameter and length 1060 mm mounted around a palm and palm gripping semi-circular pad made of worn out tyre rubber pad fitted against the palm trunk. One end of the iron rope, holes provided to change the rope length according to girth of the palm trunk. The adjustable holes comprise of bolts and wings of nuts to fasten the iron ropes. The mains frames have foot rest comprises of safety strap to prevent accidental slip during the engagement with the climber feet while ascending or descending the palm trunk. The two main frames are fitted on the palm trunk on either sides enabling the operator to lift the frames conveniently using the sliding member keeping the frame supporting the weight of the operator.

Plate 2.4.CHEMBERI MODEL

Before climbing, the climber mounts the climbing device, both left and right units to the palm trunk with help of wire rope provided. The climber holds the handles of both units and climbs by keeping both legs in the foot rest provided. Then, the right frame unit of the device is lifted by hand to about 30-40 cm after loosening the rope with the help of the right leg. After lifting the unit, the foot is pressed downwards to hold the coconut palm firmly by the rope and pad provided. The operation is repeated by the left unit without releasing the body weight from the left unit. The operation is repeated to reach the required height.

b) CPCRI model coconut climber

Plate 2.5 CPCRI MODEL

This model was developed in CPCR Kasaragod. This model is almost same as that of Chemberi model. They have carried out a small modification in standing type (Chemberi model) by incorporating a safety device for the safety and comfort of the climbers to climb the coconut tree. For that, the main frame of the climbing devices is provided with two metal loops at the bottom of the handle. A steel rope is having 6 mm diameter is provided with hooks at both ends. The wire rope can be taken through the loops provided in the climbing device and the take around the palm to make it noose and free end is connected to a body harness which the climber has worn. The wire rope moves up and down along with climbing machine during operation. In case of failure or accidental falling of the climber from the machine, the wire rope noose gets tightened to the coconut trunk and prevents further falling.

2.5 Ergonomical performances of coconut palm climbers

2.5.1 Energy cost of operation

. A study was conducted by the Hameeda Bindhu vahab *et al,* in 2015 at KCAET on the ergonomical performance of different climber The mean heart rate, oxygen consumption and energy expenditure of each subject were averaged. In TNAU model, the average value of energy cost was 25.81 kJ per minute and that of Chemberi model was 24.24 kJ per minute, in KAU model the mean value energy consumption rate was 25.41 kJ per minute. In Kera-Suraksha it was about 25.43 kJ per minute, and finally in the CPCRI model it was 24.27 kJ per minute.

2.5.2 Grading of work

The Study was conducted by the Hameeda Bindhu vahab *et al,* in 2015 at KCAET. According to the Sen (1969) classification of work is based on grade. The TNAU model climbing aid was too heavy according to the grade of work. The results reported that all the climbers expressed too heavy work load in using climbing aids.

2.5.3 Acceptable work load (AWL)

A Study was conducted by the Hameeda Bindhu vahab *et al,* in 2015 at KCAET has reported that acceptable work load for Indian workers for the work consuming 35 per cent of volume of oxygen (Saha *et al*, 1979). While comparing with all the climbing aids, the average AWL was too high since they are performing a risky task.

2.5.4 Limit of continuous performance (LCP)

A Study was conducted by the Hameeda Bindhu vahab *et al,* in 2015 at KCAET. Work pulse is the difference between working pulse and resting pulse. The average values of the heart rate at rest level and at working conditions were used for calculating resting pulse and working pulse. LCP is very high for all the climbers and it was 40 beats per minute for continuous 8 hr.

2.5.5 Time requirement for the climber

It is observed that people take more time (89.98 sec) for climbing in TNAU model and minimum time for Chemberi at is (65.56 sec) was operating time and for KAU model it was 72.46 sec. Study was conducted by the Hameeda Bindhu vahab *et al,* in 2015 at KCAET.

2.5.6 Subjective rating scales

In this performance part we are mainly dealing with overall discomfort rate (ODR), overall easiness rate (OER), overall safety rating (OSR) and body part discomfort score (BPDS). Considering ODR it was found out that Chemberi has no discomfort with the working in comparison to KAU, CPCRI models and TNAU models have moderate discomfort. In the case of OSR, it was most safe in Chemberi only and all others have much more risky. Considering the OER, the subjects expressed easy climbing using Chemberi model and KAU model but TNAU and CPCRI models had some difficulties. Considering the BPDS Chemberi and KAU models have less discomfort scores in comparison with TNAU and CPCRI models had some problems in case of BPDS. Study was conducted by the Hameeda Bindhu vahab *et al,* in 2015 at KCAET.

2.6 Ergonomical performance of agricultural tools

Thyagarajan *et al*. (2012) stated that ergonomic evaluation of farm tools was necessary to improve the needs between the physical demands of the tools and the workers who performs the work.

Shiru and Snehu (2012) reported about the performance of operators operating the cassava grating machines of various ages. The anthropometric data collected were tested statistically and the statistical results was used for modification of existing machines for better ergonomical performance by designing new machines and sitting facilities (stools and chairs) for operating the machines.

Thyagarajan *et al.* (2012) studied the suitable ergonomic design refinement in the two row finger type rotary weeders for enhanced comfort to the operator without jeopardising the efficiency of tool. The two row finger type rotary weeder with ergonomical refinements had enhanced the comfort of the subject with 15.16, 21.69, 21.68, 221.7, 36.78, 21.78 and 36.54 percent reduction in heart rate, oxygen consumption, energy expenditure, AWL, LCP, ODR and BPDS respectively.

Naieni *et al*. (2014) highlighted that ergonomists are capable of providing a safer work environment for the agricultural workers in both developing and developed countries. In addition, the results show that it needs global cooperation of international organisation to enhance the occupational health intervention in agriculture

2.7 DEVELPOMENT IN COCONUT PALM CLIMBING DEVICES

Different the palm climbing aids and the studies related to their functioning and performance are reported in this section.

Amacker (1992) developed a universal compact and versatile palm climbing stand with a seating section having at least one pair of longitudinal side members supporting seat and the means for gripping a palm connected at one end of the side members. A cross member was provided so as to reversibly extend the seating section. Foot supporting section can also be removed from the seating section. A foot supporting the section with a rectangular frame is divided into two frame structures. The two frame structures could be separated so that the frame could be reassembled for climbing and disassembled to reduce the length of the foot of the supporting section for transportation and storage. The seating section can also be used as a hand climber.

Gardener (1992) developed a palm climbing stand. The device for climbing the palm comprises of two frames, each frame having a rigid base portion with flexible adjustable band mounted encircling palm trunk. A turn buckle was connected to the end of each band for drawing together and separating the ends so as to change the effective length of the band. The rigid base portion of each frame had palm trunk gripping edges which together with the bands and resiliently biased braces act to secure each frame to the palm. Adjustment of turn buckles changes the altitude of the base relative to the ground. One of the frames is positioned above the other on the palm trunk and they are alternatively raised up the palm or lowered down the palm. The upper frame has seat which hangs from the rigid base and is slideable, vertically adjustable and pivot-able relative to the base. The lower frame has a platform upon which the foot of user rests while standing or sitting on the seat. A pivotable brace member mounted on each base and resiliently urged against the palm aids in holding each frame against the palm during the climbing phase and the upper brace member functions as a back rest for the user.

Joseph (2006) developed a coconut climbing device having two frames (left and right). Each frame has flexible adjustable encircling iron rope mounted around the palm and a palm gripping rubber pad. Each frame member had adjustable lock for changing rope length according to the girth of the palm. An elastic strap helps the climber to hold his feet inside strap. The two main frames fitted on the palm side by side enabling the operator to lift the frames conveniently while the sliding member.

Mohankumar *et al*. (2013) developed an ergonomically refined coconut climbing device. The tree holding section was made with a triangular gripping aid which replaced with telescopic I-section and U-shaped gripping member. The U shaped member with single gripping aid encircles the girth of coconut tree aiding in gripping the trunk of the tree. As the user ascends the trees, with decrease in diameter of trunk the upper frame becomes exactly horizontal and parallel to the ground. This prevents shifting of centre of gravity of the user to unsafe position and stability. Back rest was also provided for purpose of operator safety.

2.8 ANALYITICAL HEIRARCHY PROCESS (AHP)

Analytic Hierarchy Process (AHP) is one of Multi Criteria decision making method founded by Saaty in 1980.It is a popular and widely used method for multi-criteria decision making. Allows the use of qualitative, as well as quantitative criteria in evaluation.

Steps to be followed for doing the AHP

1) To develop a graphical representation of the problem in terms of the overall goal, the criteria, and the decision alternatives. (i.e., the hierarchy of the problem)

2) To specify his/her judgments about the relative importance of each criterion in terms of its contribution to the achievement of the overall goal.

3) To indicate a preference or priority for each decision alternative in terms of how it contributes to each criterion.

4) Given the information on relative importance and preferences, a mathematical process is used to synthesize the information (including consistency checking) and provide a priority ranking of all alternatives in terms of their overall preference).

According to AHP we have to find the relative weights so that finding of weighted averages can be found out.

1. Decompose the decision-making problem into a hierarchy

2. Make pair wise comparisons and establish priorities among the elements in the hierarchy

3. Synthesize judgments (to obtain the set of overall or weights for achieving your goal) or weights for achieving your goal)

4. Evaluate and check the consistency of judgments

The basic procedure is as follows:

1. Develop the ratings for each decision alternative for each criterion by for each criterion by

   - developing a pair wise comparison matrix for each criterion
   - normalizing the resulting matrix
   - averaging the values in each row to get the corresponding rating
   - calculating and checking the consistency ratio

Pair wise comparison can be done using the hierarchical process or combination in permutation.

2. Develop the weights for the criteria by

   - developing a pairwise comparison matrix for each criterion
   - normalizing the resulting matrix
   - averaging the values in each row to get the corresponding rating
   - calculating and checking the consistency ratio

There are 3 steps to arrive at the consistency ratio:

1. Calculate the consistency measure.

2. Calculate the consistency index (CI).

$$CI = \frac{\lambda max - n}{n-1}$$

3. Calculate the consistency ratio (CI/RI where RI is a random index).

$$CR=CI/RI$$

Table- 2.1.- customer preference in AHP

Rating of the customer preference in analytical hierarchical process		
INTENSITY OF IMPORTANCE	DEFINITION	EXPLANATION
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one activity over another
5	Strong importance	Experience and judgment strongly favor one activity over another
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	For compromise between the above values	Sometimes one needs to interpolate a compromise judgment numerically because there is no good word to describe it

These are the values that are assigned to give as the priority number while having the comparison with the criteria and this value used in the matrix system to have them according to the availability or the need of the customer. The values will be assigned according to our needs and by this only we will be giving to the matrix in that the value that assigned on the left of the criteria will be taken as the true value for the matrix and the value that is in the left side of the middle value is taken as the one by of the number.

Hierarchical form of the pair wise comparison of the criteria and finally reaching the goal is given below

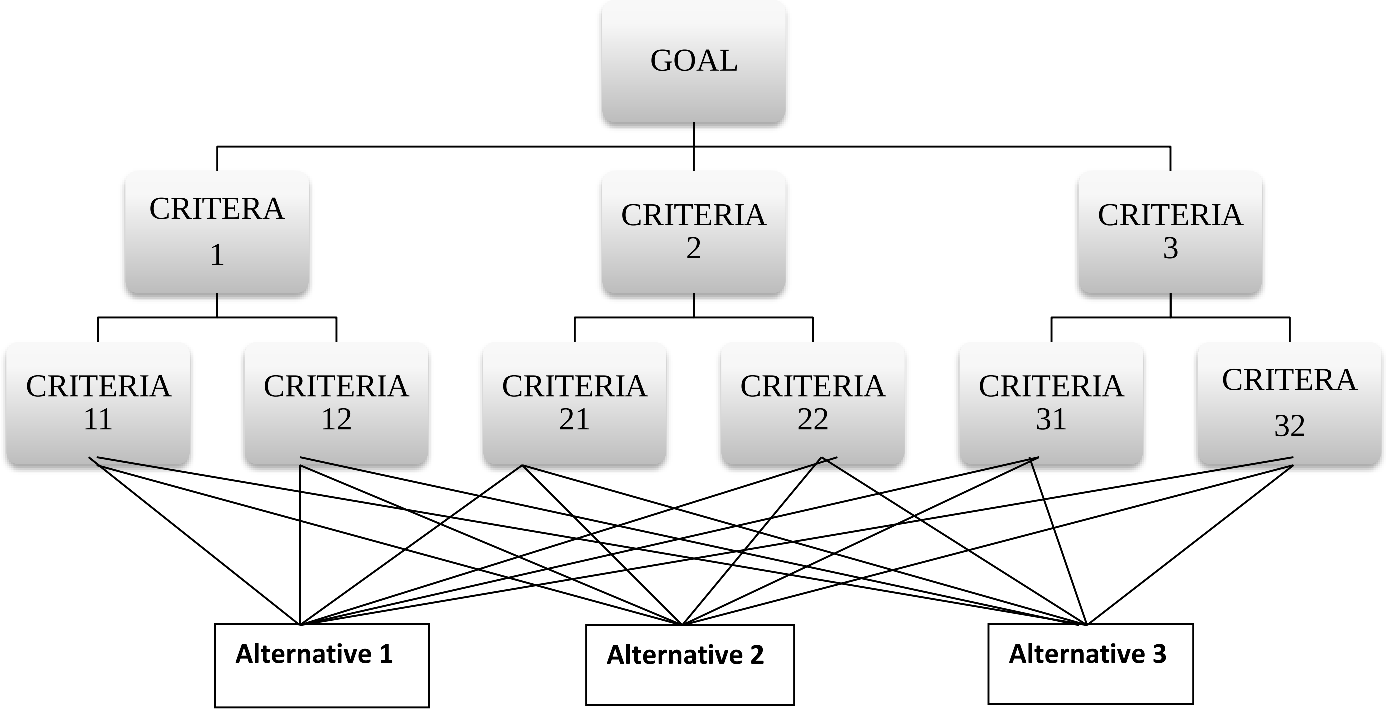

Figure No. 2.1

Firstly, we have to find out the different factors or criteria's that influence in achieving the goal among the alternatives. Accordingly, the main criteria related in achieving the goal, and the secondary or sub criteria and tertiary or sub-sub criteria are listed in hierarchical levels as shown in above chart, Figure No. 2.8. According to each and every factor having the sub criteria and each and every sub criteria will be compared with each other sub criteria using the normal Saaty scale. The pair wise comparison of sub criteria factors using Saaty scale is being found by experts and the values will be matrix form and matrix is solved according to the hierarchical format. After finding these Saaty values, the matrix is solved in excel software as given in the steps given in appendix-A and thus result in the finding the weightage of the customer requirement criteria. This weightage value is used for the QFD analysis in relative importance of customer requirement criteria to determine the improvements and selection of the climbing aids. The consistency ratio calculated to determine relative index. With AHP, we can measure the degree of consistency and if it is unacceptable, revise pair wise comparisons through fresh interview. Summary will equal n and therefore, the CIs will be equal to zero and so will the consistency ratio. If this ratio is very large (Saaty suggests > 0.10) is inconsistent.

2.8.1 Applications of AHP for relative Weight Analysis.

Kamal M. Alsubhi Al harbi *et al* (2001) has done the project on the application of the AHP in construction project management. The paper presents the AHP as a potential decision making method for use in project management. The contractor prequalification problem is used as an example. A hierarchical structure is constructed for the prequalification criteria and the contractors wishing to prequalify for the project and AHP analysis is carried out.

Ahmad. M.N *et al* (2017) had done Conceptual design selection of manual wheelchair for elderly by analytical hierarchy process method. The purpose of this study was to select the best design concept of manual wheel chair for elderly people. The study has been carried out to identify the problems that encountered by elderly people during transferring and using wheel chair, besides to improve the design of the existing wheel chair model that will reduce physical fatigue and enhances their independence or ability among elderly people.

Das. D et al (2008) has applied the AHP frame work for designing a tourism product. A tourism product characterised by its non-amenability to uniform product specification, is considered to be an amalgam of different tangible and intangible elements. Keeping in view of this heterogeneity. Perish ability and the uniqueness involved in tourism product.This study resulted in the study of finding the tourism product. Which takes care of the touristic needs of touriststhis was done according to the surveying of the professionals and the tourist members. Finally the pair wise comparison lead the strategies to prioritized and evaluated, which enabled the design of tourism product incorporating the diverse needs of tourist.

Another main important application of AHP was in automobile industry and in robotic industry. Bhattacharya. A (2014) studied on integrating AHP with QFD for the of selection robots in industrial application.

As of now, there are so many application of this technique applied since it requires simple calculation only which is the main advantage of this method. In this study, we are dealing with customers so that relative weights found is the relative importance of the requirement value determined from the AHP method will be used in the QFD. So that the application of both will decide the customer requirement and technical requirements due to the short comings in product part design and manufacturing process. Customers aspirations are fulfilled by further design modifications or by the changes or modifications in the product and also for selecting the product.

2.9 QUALITY FUNCTION DEPLOYMENT (QFD)

Quality function deployment (QFD) is a quality assurance tool that helps to ensure that the voice of the customer is heard and followed in the development of a product or service (pitman *et al*, 1996). Ermer (1995) emphasized that QFD is a design tool that matches customer's requirement with necessary system design elements. This structured approach gives increased focus to understanding customer's requirement. According to Hwang and Teo (2001), QFD is a methodology for the development or deployment of features or attributes, or functions that give a product or service of high quality. QFD can be very useful in answering the question on how to deliver quality products and services based on the needs of customers. It is simply a planning tool that begins with market research that identifies 'what' the customer like, which is called the voice of customers (VOC). It is through the QFD process that the VOC is translated into system and product part requirements. Today, the QFD is used successfully by manufacturers of electronic appliances, clothing, and construction equipment firms such as General motors, ford, Mazda, Motorola, Xerox, Kodak, IBM, Procter and gamble.

According to pitman et al. (1996), the fundamental tasks of the QFD are:

- To identify the customers.

  In identifying the customers, the organisation must objectively determine the group that best describe its current and desired customer base. After the customer's base has been identified, the wants of the customers or VOC are determined.
- To determine what the customers wants.

These wants are commonly referred to as the *whats*, and can be derived by using a wide variety of methods. When collecting information on these *whats*, it is critical for the organisation to use the terms, phrases and languages of the customers. After collecting the *whats*, the QFD team will work with customers to determine priorities of the *whats*.

- Once these *whats* are identified, the QFD team will determine the mechanism that would satisfy the *whats*. These mechanisms are commonly referred as the *hows*. The *whats* are expressed in customer terms, whereas the *hows* are expressed in technical, corporate terms.

  With the *whats* and *hows* in place, the QFD team establishes relationship between them. Evans and Lindsay (2005) noted that the purpose of the relationship is to show whether the final technical requirements (*hows*) have adequately addressed to the customers' requirements. In indicating the relationship between the *whats* and *hows,* the QFD team assigns a strength value of none, weak, medium or strong to each relationship.

After the relationship matrix has been developed, there is a need to place a priority on each issue that was considered in the design process. By using the value of 9 (high), 3 (medium), 1 (low), 0 (none) as weights, a design issue's importance weighting measure can be calculated by taking the weighted sum of its relationship i.e., ∑ [(value of relationship strength) *(customer importance rating)]. Thus, the value of the weighting measure will indicate the rank of the design issue. The highest weighting measure will indicate the importance of the design issue in fulfilling the voice of customers and vice versa.

The translation process uses a series of matrices, commonly known as the house of quality (HoQ) as shown in figure 2.9.1. Normally, a HoQ diagram consists of the following information:

- What's(voice of customers),
- How's (design requirements),
- Relationship matrix,
- Correlation matrix,
- Customers assessment,
- Technical assessment.

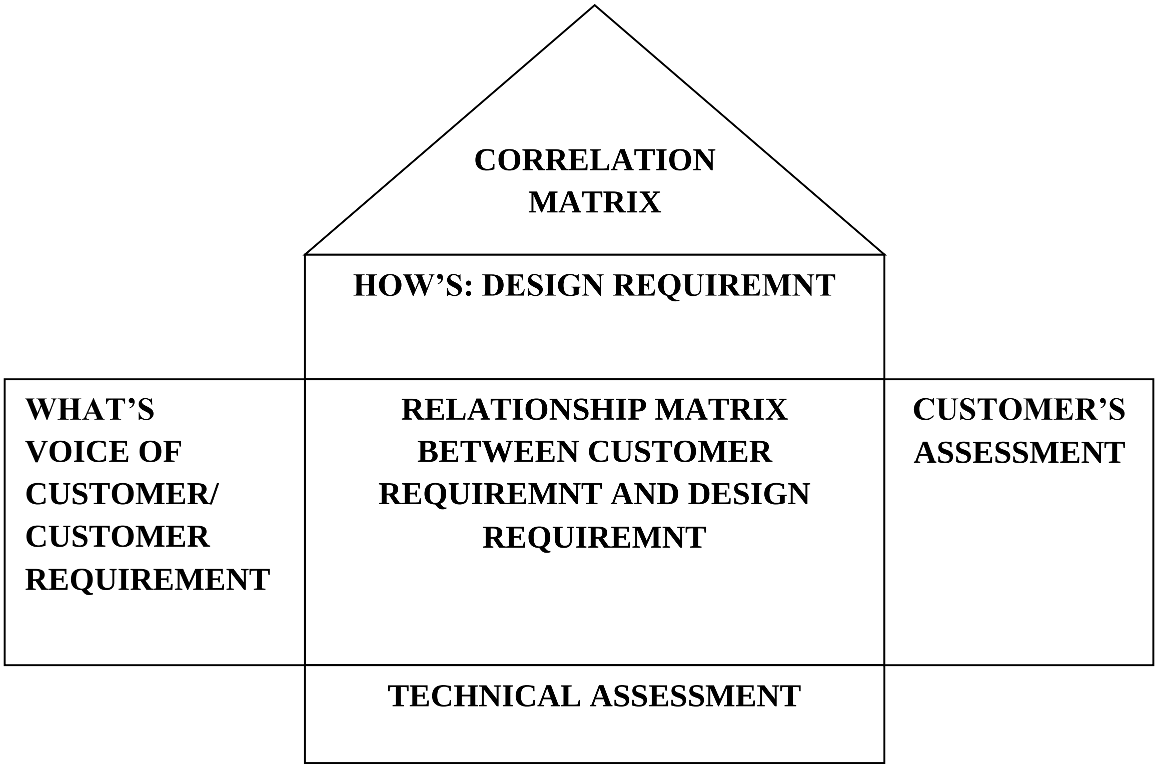

Figure 2.2 – House of quality

2.9.1 Application of QFD for product development

Quality function deployment (QFD) is a methodology for capturing and translating the voice of the customer (VOC) into engineering characteristics of products or services. In addition, the process prioritizes and deploys these customer-driven characteristics throughout the product or service development to meet the VOC (that is, customer needs, wants, and expectations). QFD determines effective development of targets for the prioritized product and service characteristics. The QFD process has been used and documented extensively in product development. The service industry, however, lacks in the application of this process. The purpose of this paper is to show practitioners and researchers how this process, in its entirety, can be used as a planning process to link customer requirements and service characteristics in the hospitality industry. A case study was developed focusing on a specific hotel to illustrate the application of the QFD process in a five-star hotel**.**

QFD was originally developed and implemented in Japan at the Kobe Shipyards of Mitsubishi Heavy Industries in 1972. It was observed that Toyota was able to reduce start up pre-production costs by 60% from 1977 to 1984 and to decrease the time required for its development by one-third through the use of QFD (Hauser and Clausing, 1988; Ertay, 1998; Hsiao, 2002). Early users of QFD include Toyota, Ford Motor Company, Procter, 3M Corporation, Gamble, AT&T, Hewlett Packard, Digital Equipment Corporation, etc. (Cohen, 1995).

The American Supplier Institute (ASI) in Dearborn, Michigan and GOAL/QPC (Growth Opportunity Alliance of Lawrence/Quality Productivity Center) in Methuen, Massachusetts, have been the primary organizations offering an overview and workshop-type training since QFD was introduced to the United States in the early 1980s (Prasad, 1998).

Later QFD use had been extended to the fields such as design, planning, decision-making, engineering, management, teamwork, timing and costing (Chan and Wu, 2002). QFD is a useful tool for developing new product standards and its benefits are well documented (Clausing and Cohen, 1994; Cohen, 1995; Hauser and Clausing, 1988; King, 1989).

Various definitions of QFD have been given, such as “an overall concept that provides a means of translating customer requirements into the appropriate technical requirements at each stage of product development and production (i.e. marketing, planning, product design, engineering prototype evaluation, production process development, and production sales)” (Sullivan, 1986) or “QFD is a customer-driven design process and its use is essential in product design” (Cohen, 1995; Akao, 1990).

Now as in the modern generation we have to face different types of commodities in that which one is the best product will be confusion. So what we will usually prefer is the product which is most popular among the interacting persons who has used it or the experiences of persons for the better selection of the product. So in this case many have raised how to select the best product was first analysed by the AHP. Later, the AHP application was integrated with other techniques like QFD to identify the customer needs *whats* and *hows* of the customer and product. The QFD emerged as a leading method to identify what the customer needs are and many studies focused on it which resulted in finding or finding the good or new products.

As of now the QFD is used in industrial and business purposes to collect information on how actually the people can be impressed by the product by survey and taking the needs or requirements of the people and finally incorporating the need in the product and selling them.

Erkarslan and Yilmaz (2011) optimized the product design for a ceramic basin by the application of QFD and AHP. They examined that if QFD was applied during production phase, it increased satisfaction of a number of customer which also resulted in increasing sales of the company.

Chun-Yu Yeh & Hsin-Chang Lo *et al*, (2008). Application of Quality Function Deployment in Design of Mobile Assistive Devices Quality function deployment (QFD), a strategy of product planning, provides a systemic process of systematizing and constructing which priorities to enhance the energies of the product development team. QFD with design-oriented nature serves not only as a valuable resource for designers but also a way to summarize and convert feedback from customers into information for designers. Regarding most manual wheelchair users having suffered injuries on shoulder, wrist and elbow, most researchers have concentrated their attention on propelling efficiency or biomechanics issues, not operation interface based on users' requirements. Though some innovative devices have been developed from the engineering aspect, they are not as popular as expected in clinics because of the lack of requirements from customers, therapists and technical professionals that are critical points in the development process for new assistive devices. The present study utilized the systematic strategy, QFD, to extract bottleneck techniques in design of an assistive device. A case study was performed and a new power-assisted wheelchair was developed to overcome the disadvantages of traditional manual wheelchairs.

Costa *et al*., (2001) applied QFD method to study the ketchup quality management. They discussed about the benefits, problems, challenges & flaws when QFD is implemented in Food Research and Development. Bayazit (2004) said that purpose of AHP is to bring out the best inference in decision making in case of multiple criteria. He used it in a tractor manufacturing plant for decision making in Flexible Manufacturing Systems.

2.9.2 Application for product evaluation and improvement.

Shrivastha.P *et al.*, (2014) reported the application of quality function deployment to improve customer satisfaction in hotel industry. The research aimed to get QFD model to improve the service quality using customer needs and priorities in a five star hotel. In the research study, the customer satisfaction and importance degree of each needs are investigated using survey method. Information was collected from the customers, employees, and managers of the hotel to determine the factors affecting the customer satisfaction. After identifying the factors a questionnaire was given to the managers and employees to rank their satisfaction received from the hotel. The QFD method steps were followed and finally came to a conclusion that from the point of view of customers, making bills correctly, personal attention, clean rooms, qualified food, professional staff and affordable price were more important requirements of customers.

Marvin E. Gonzalez *et al*., (2003) reported about improving the school furniture design using QFD in developing countries. This paper presented a quality function deployment (QFD) analysis of the design of school furniture in Costa Rica as the baseline. The dynamic hierarchy process model for QFD was used by the product development team make effective decision in satisfying the requirements of the customer. A number of total quality management (TQM) tools were used during the development of school furniture solution. A dynamic cross-functional team organisation was used for the study. A simple form of quality function deployment was used to identify the desirable product design, safety, service features.

Azilah Aniz and Rfikul Islam reported about improving teaching efficiency through the application of QFD in AHPHSBL university college in Malaysia. The survey conducted by the faculty of business (FB) of HSBL found that the students were not fully satisfied with the teaching and learning system of the college. The present work has been carried out to identify the FB student’s requirements to improve the efficiency of the teaching and learning system. Having identified the requirements, a number of lectures were contacted to extract the design requirements that would address the students’ needs. The novelty of the paper is that quality function deployment and analytic hierarchy process both have been applied to derive the priorities of the design requirements. The results obtained through the above two methods have shown close resemblance.

Bouchereau.V and Rowlands.H (2018) reported a study about a project to learn the methods and techniques about quality function deployment (QFD). Quality function deployment (QFD) is a management tool that provides a visual connective process to help teams to focus on the needs of the customers throughout the total development cycle of a product or process. It provides the means for translating customer needs into appropriate technical requirements for each stage of a product or process development life-cycle. It helps to develop more customer-oriented, higher-quality products. The structure provided by QFD method was significantly beneficial and it is not a simple tool to use. The article outlines how the techniques such as fuzzy logic, artificial neural networks, and Taguchi method could be combined with QFD to resolve some of its drawbacks and proposes a synergy between QFD and other three methods.

Kapuria.T.K and Rahman,M, [2018] reported a study about the ready-made garment industry in Bangladesh. The paper fuzzy quality function deployment (FQFD) model to identified customer requirements and the related design and production process to improve the quality of the T-shirts according to the customer requirements. To overcome the shortcomings of the traditional QFD, the fuzzy set theory was integrated with HOQ. It will capture the vagueness of the customer requirements and facilitate to prioritise QFD information. For building HOQ, the design process starts with the data collection and ends with making some suggestions for improvement. Factors which improve the quality of the T-shirts have been identified from the HOQ matrices to develop some suggestions for improvements. The proposed improvements include the development of standard production operation of T-shirts, training workers, implementation of quality management department and development of flexible production schedule.

Poel (2007) had studied on the QFD and the study where mainly dealing with the Methodological problems in QFD and directions for future development. Quality function deployment (QFD) is a popular tool for product development in industry. QFD aims at setting targets for product characteristics so that products optimally meet customer demands.

As in the present scenario, the use these kinds of techniques are very much important since the population is increasing day by day and the need for the new products and processes including services is also leaping too much. Thus, these kinds of studies will result in the improvement of machine and better products and services can be available in the market. The main advantage of this technique is that it full fills the customer's requirement by meeting products overall quality can be supplied in the market.

Chapter 3

Materials and methods

The main study is related to the three climber aids performance and the improvements that can be made and they are compared by QFD and AHP approach. QFD is used to study the customer requirements related to the design of climbers. The AHP is applied to determine the weightage of the customer needs.

3.1 Understanding customer choice decisions.

The application of QFD to NPD (New product design) requires that the VOC be integrated into every stage of the product planning to ensure customer satisfaction. This approach helps companies to avoid the need for costly redesign. In the current competitive market, product success rate is vital for any customer-driven business. To achieve product success, companies must understand customer needs and desires. The first step toward understanding customer needs is to identify attributes and customer consequences. Attributes are defined as the physical or abstract characteristics of a product. They are objective, measurable, and reflect the producer's perspective. The Consequences are a result of using the attributes. Customers judge products based on their consequences, not their attributes. In other words, customers judge a product on its outcome, or by experience of using them. A product has many attributes, and each may have more than one consequence (Fisher and Schutta, 2003). This is the most crucial step in the QFD since the products are mainly for the customers only, so the voices of customers are inevitable. A survey was conducted to extract the requirements of climbing aids from users to study the necessary redesign of climbing aids through questionnaire which was prepared after consulting users, experts in the field.

3.2 Affinity diagram or fish bone diagram

The VOC are organized to differentiate and re-arrange the various factors which had been collected via interview process. The collected data based on the factors related to the performance climbing aids are organized using affinity diagram. It will be effective in finding a better picture about merits and demerits of the climbing aid's performance.

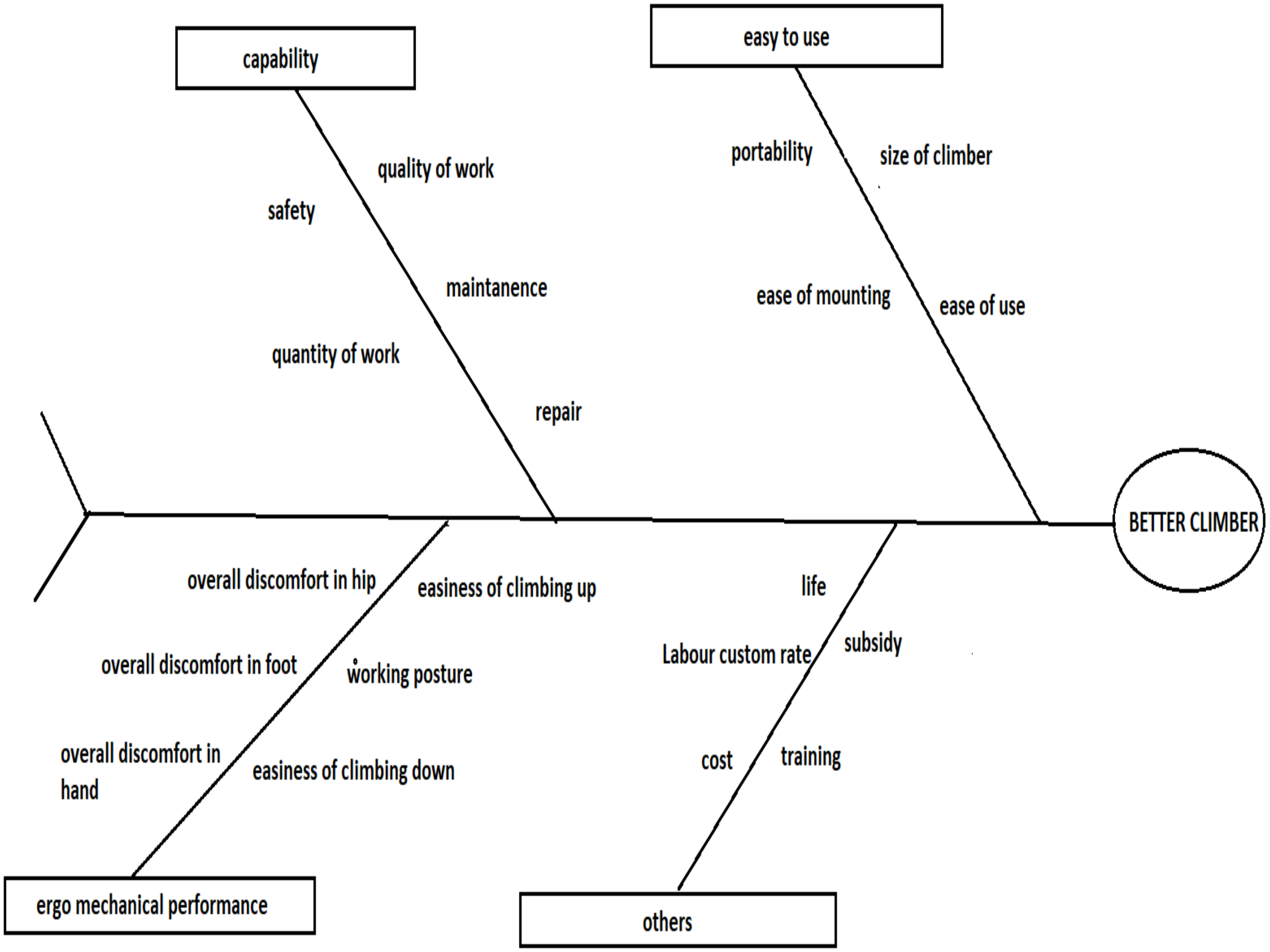

Fig. 3.1 Affinity diagram

3.3 Survey

The next step was to obtain the importance rating and rankings of each consequence from the customer base. A survey was conducted from 10 customers or climbing aid users regarding the relative importance of the 20 consequences. The reason behind this was to avoid misinterpretation of the customer's overall attitude or satisfaction towards the product that could lead to poor prediction of the customer's using behaviour. Customers do not place equal importance on all consequences. It is well known fact that the customer requirements are very different according to each and every person and it changes so therefore an exact and thorough evaluation is needed for the achieving a better result. Now as you know that the climbers are using the standing type climbing aid from our primary investigation due to operational performance from point of climbing time factor and other effectiveness in working. A brief description of each climbing aid is provided in section 2.4, to make a nonbiased decision on ratings and rankings of each consequence relative to each climber. The weighted rating values were obtained by multiplication of the importance (rank) and rating together. The weighted rating is a means of obtaining a comprehensive measure by evaluating both what is important to a customer and how well the customer thinks each product is doing on what is important to them. This is also used as a means to evaluate importance of each VOC, as if the customer base feels that a company is lacking on consequences that they deem very important, more focus can be applied to improving this, which may ultimately improve the climbing aid performance. Conversely, if a customer-base feels that a product excels on consequences that are of no importance to them, the attention can be can be given to parts or components which needs improvement. The survey's main purpose was to gather more specific information on potential customer or user the desires and needs. For an effective the result, the QFD method was applied. The survey is the backbone of the system since QFD is the ultimate analysis of the customer needs and requirement by the “what’s” and technical requirements of the climbing aids by “how’s” of the customers.

After completion of the survey, the results that we got from the customers or users are tabulated in the form so that comparison can be made easier and their weighted average values of the each and every criterion are found out using the technique of analytical hierarchical process and subsequently this will be added in the house of quality. And finally the assigned values are given in the house of quality, and then results are used in finding the customer needs and the modification needs for the climbing aids.

This is the survey for house of quality construction after primary interview to find out the requirements of customers, through questionnaire formulated to survey the performance of palm climbing aids.

3.4 Development of technical requirement

After the customer consequences were analyzed, the next step is in the construction of HoQ for the development of technical requirements. The technical requirements are the design specifications that should satisfy customer needs. This aspect of QFD is the basic concern of the organization, and therefore should focus on design specifications, and measurable design aspects which ensures that end product meets the customer needs. The technical requirements are called the "how's" and are placed on the top of the house of quality. Each consequence has one or more technical requirements. Technical requirements are within the control of the manufacturer. It must also be measurable to enable designers to determine, if the customer's needs are fulfilled. Experts from the field, designers and markets develop the technical requirements in confirmation with the industry standards. Fourteen technical requirements were developed and organized. One of the four management tools, the tree diagram is a hierarchical structure of ideas built from the top down using a logic and analytical thought process. It contained the design concepts derived from the customer's voice and the corresponding technical requirements were considered as design specification their, their measurement units and values.

3.5 Relationship matrix

Once the climbers' or customer consequences or requirements are identified and the climbing aids technical requirements are developed, the relationship matrix is constructed. The matrix defines the correlation between customer attributes and technical attributes as weak, moderate, or strong using a standard 9-3-1 scale. For this scale the following notations are used Strong (H) = 9, Moderate (M) = 3, and Small (S) = 1 (Chan, 2007).

Each customer consequence was matched with each technical requirement. The relationship between them was then determined and placed in the relationship matrix that constitutes the centre of the HoQ. This matrix identifies the technical requirements that satisfy most customer consequences and determines the appropriate investment of resources for each. The technical requirements that addressed the most customer consequences should be dealt into the design process to ensure a customer or user approved product. Ideally in the QFD analysis, no more than 50% of the relationship matrix should be filled, and a random pattern should result (Fisher and Schutta, 2003). Relationships were determined here on the basis of survey conducted on climbing aids and users.

3.6 Planning matrix (Customer competitive analysis)

After completion of the relationship matrix, the focus of the study is shifted to the construction of the planning matrix. This matrix defines how each customer consequence has been addressed by the competition between each climbing aids. It provides user’s opinion, market data thus facilitates strategic goal setting for the evaluation of product performance and permits prioritization of the climbers’ desires and needs. It also compares the product to its key competing climbing aids. A standard 5-point Likert scale was used. Each climber was represented by different symbol. A square symbol was used for the Chemberi model, circle for Kera-Suraksha.

CHEMBERI MODEL : □

KERASURAKSHA MODEL : ○

Fig 3.2 showing the symbols used in customer assessment rating

3.7 Technical correlation

Following completion of the planning matrix, technical correlations were determined. These form the roof of the HoQ. The roof maps the relationships and interdependencies among the technical requirements. The analysis of which forms the development process, revealing the existence and nature of design bottlenecks. The relationships among technical requirements were plotted and given a value. Past experience and test data were used to complete the roof of the HoQ. Symbols are used to represent the strength of the relationship between the technical requirements and are assigned by the research team. Here, the correlation-ship between the technical requirements of the climbing aids were studied and values were assigned.

3.8 Technical matrix

Next, a technical matrix was constructed to form the foundation of the HoQ. This matrix addresses the direction of improvement, standard values, units of measurement, the relative importance of technical requirements and technical evaluation. The direction of improvement indicates the type of action needed to ensure that the technical requirements are sufficient to make the product competitive.

The customer design provides information regarding consequences, technical requirements, and their units and values. It contains design concepts derived from the VOC and detailed design considerations.

The relative importance of each technical requirement was calculated by multiplying the value assigned to its relationship with a specific consequence (9, 3, or 1) multiplied by the importance of that consequence. The values of all consequences were then added to yield the final weight for the technical requirement. These weights were placed in a row at the bottom of the HOQ. A final weight is a comprehensive measure that indicates the degree to which the specific technical requirement relates to the customer consequences.

The technical evaluation of the competition and the product to be developed is carried out by the engineering and technical staffs who design the product. The process establishes strategic goals for the product (palm climbing aid) development process to ensure the satisfaction of the user. For each technical requirement, the climbing aid was compared to its competitors and a technical evaluation was performed. Thus, the construction of the HOQ was completed.

3.9 Prioritising (product improvement and comparison with competitors)

The collected information from the above methods helped in the development of strategic decisions. An important performance grid was developed to prioritize the usage of resources for improvement on the most critical customer benefits. After finding all the values and weights using the values from the house of quality table we will come to the results and the needs of the customers. The final result leads us to a decision, according to the percentage of the values of each and every roof value will be the primary criteria that must be related to the manufacturers so that according to the value only there will be design improvement possible which will be effective. Customer required product is designed according to the QFD methodology so that it can be market based easily hence the product manufacturing is easy or the NPD possible implemented. Relationship matrix values will be changing subsequently but the matrix calculation will be giving the mode value of the customers. The main characteristics of the technique is that finally we are comparing the criteria with each other and their interdependency, relation and the design criteria are taken from the customers or the feedback that is a taken from customers will give the decision to design or design the product.

CHAPTER 4

RESULTS AND DISCUSSION

Palm climbing aids got prominence in coconut harvesting due to the scarcity of traditional palm climbers in the Kerala. The innovative palm climber model –Chemberi make is so popular among the users different from climbing aids available in the market. Ergonomical studies were conducted to evaluate the performance of the palm climbing aids. However, the palm climbers' opinions on the performance of climbing aids were not conducted for further improvements and climber's requirements. In this context, a climbers' survey was conducted with climbers to evaluate the Chemberi climbing aid performance in this study. The study revealed the climber's requirements and improvements in the design to improve climbing aid performance.

4.1 Customer or climber survey

According to the questionnaire prepared a survey of 8 coconut palm climbers were conducted with a set of 25 questions. The survey included the very minute aspect of the coconut palm climbing aid with the traditional and present available climbing aids in the present on market. The survey resulted in the finding of different climbing aid design parameters that are common with different climbing aids developed and available now. This is the maiden the study on palm climbing aids in which that customer voices were studied with respect to the design specifications of palm climbing aid.

4.2 Analysis of climber requirements

Accordingly, a survey was conducted with palm climbers to elicit the customer or climbers' requirements with respect to the present design of Chemberi climbing aid. As of the survey the primary requirements are "easy to use", "capability", "ergo mechanical performance", and "others". The primary climbing aid requirements were further sub divided further for each primary requirements as stated below. Thus, hierarchy was formed for the analysis to determine the priority of factors affecting customer or climbing aid performance of man-machine system by analytical hierarchy process. The hierarchy thus formed is shown in Figure 4.1

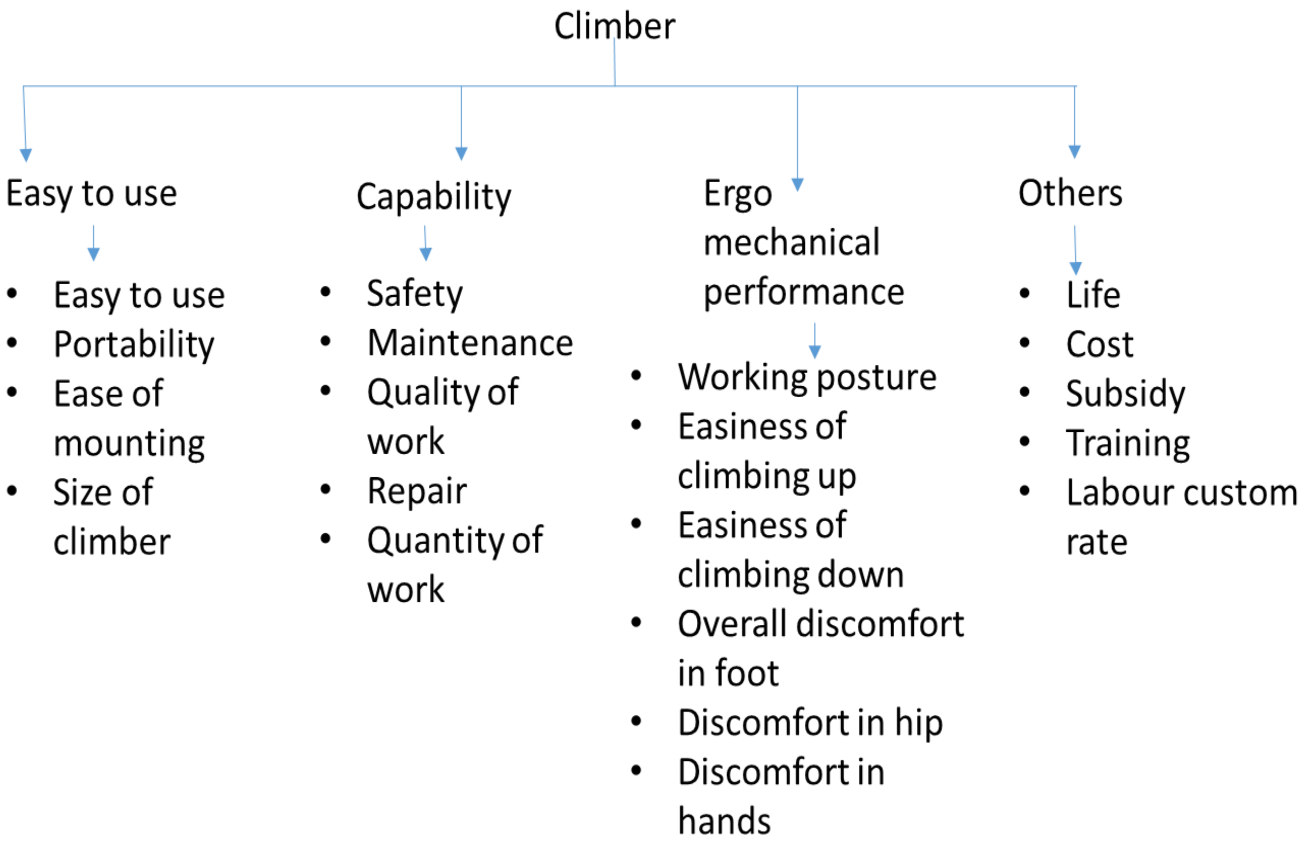

Figure 4.1 hierarchy formation

Accordingly, the climber requirements were classified as the criteria's. The weightage of each criterion were compared by pairwise comparison of criteria by analytical hierarchy process. The requirements of the customers were rated in the range of one to nine scale of Saaty (2001). The pairwise comparison matrixes of secondary requirements were computed to determine the Eigen values. The calculation of relative weight procedure is shown in Appendix-A . According to the above analysis, the relative weights of each sub-criterion were determined and presented in Table-4.1 below.

Table-4.1 Relative weight of customer requirements of palm climbing aid

Sl. No.	Primary Requirements	Secondary Requirements	Importance or relative weights of secondary criteria's
1	Easy to use	Easy to use	4.30
2		Portability	4.13
3		Ease of mounting	4.17
4		Size of climber	4.24
5	Capability	Safety	5.41
6		Maintenance	5.21
7		Quality of work	5.21
8		Repair	5.16
9		Quantity of work	5.20
10	Ergo-mechanical performance	Working posture	6.41
11		Easiness of climbing up	6.31
12		Easiness of climbing down	6.36
13		Overall discomfort in foot	6.33
14		Discomfort in hands	6.31
15		Discomfort in hip	6.30
16	Others	Life	5.41
17		Cost	5.22
18		Subsidy	5.26
19		Training	5.34
20		Labour custom rate	5.27

The pairwise comparisons were made for the subjective opinion of the individual palm climbers' judgments. The degrees of inconsistency of the personal judgments of climbers were verified by computing consistency ratio (CR). This is the one of the most advantage of the AHP method which is discussed in section 4.3.

4.3 Consistency ratio [CR] of customer requirement criteria

Having made all the pairwise comparison, the consistency is determined by using the Eigen values lambda max, to calculate the consistency index, CI as follows CI = $\frac{\lambda max-n}{n-1}$, where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate Table-4.2. The CR is acceptable, if it does not exceed 0.10, if it is more than 0.1 is not acceptable. The consistency of the judgements of climber requirements of each sub-criteria compared by pairwise comparison matrix is given in Appendix-A .

Table. 4. 2 The consistency test for the criteria

Size of matrix (n)	1	2	3	4	5	6	7	8	9	10
Random consistency (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The details of calculation of Eigen values and consistency check for all customer requirements are presented here. Thus, for us all the criteria, the values were less than 0.1 and relative weights are given in Table-4.2

4.4 Technical requirements of palm climbing aid

Basically, the most important technical requirements of a coconut palm climber is concerned with the working principle of climbing aid, material, properties and manufacturing, anthropometrical aspects repair and maintenance and other factors like safety, reliability, locking device etc. There are mainly structural and anthropometrical design affects the working and life of the climbing aid. Safety is of utmost important factor so do the reliability of climbing aid as a device overall. The important and different technical assessment parameters of climbing aid that affects the climber performance and customer requirements are given below.

- Structural design
    - Type of material
    - Strength in terms of stress/ strain
    - Weight
    - Weldability of material
- Anthropometry
    - Body mass index (BMI)
    - Height
    - Weight
- Design working principle
    - Sitting type
    - Standing type
    - Dragging type by legs and hands
    - Alternate use of legs and hands
- Others
    - Reliability
    - Safety devices
    - Locking devices

4.5 Relationship analysis of voice of customer and technical requirement

The house of quality is the relation between the voice of the customer or climber and the technical specifications and properties requirement of the palm climbing aid being correlated. The relation between the what's and how's are evaluated by the climbers. The climbers rate the relationship according to the values assigned by symbols that diamond shape [♦] for the strong relation with a value of '9' and medium relation is for the circular shape [○] of '3' value and triangle shape [Δ] with value '1' represented as weak relationship. This relationship between climber requirements and technical requirements of eight climbers surveyed are given in Appendix -B The values of their relationship obtained were computed to determine the absolute weight of technical requirements with respect to the climber requirements relative weight. Also, the relative absolute weight of technical requirements was calculated to determine the rank the importance of technical requirements.

4.5.1 Absolute weights of technical requirements

The house of quality relation between how's and what's of the customers/climbers and technical requirements of eight climbers in Table-4.3 below. The relative weights of what's of the customer/climber are multiplied by the value of the shape that we have assigned. The each column shapes represented by their values are multiplied by the respective relative weight or row value of climber requirement and summed for each technical requirement column. Then finally they are added for each column and total is calculated in the bottom of the house quality table as presented for each climber in Appendix-B1 to B8

Table-4.3 Absolute weight of technical requirement parameters of palm climbing aids

Absolute weight of technical assessment parameters for each palm climber														
Climber	Structural design				Anthropometry			Design working principle				Others		
	Type of material	Strength in terms of stress/ strain	Weight	Weldability of material	BMI	Height	Weight	Sitting type	Standing type	Dragging type by legs and hands	Alternate use of legs and hands	Reliability	Safety devices	Locking devices
Climber A-Chandran	149.62	97.38	168.81	64.47	107.19	237.91	259.59		484.4		466.13	183.99	362.05	238.07
Climber B-Vijaya Kumar	144.79	101.68	219.4	149.03	126.03	275.98	204.37		451.52		421.14	178.47	324.27	199.28
Climber C-Satheeshkumar	224.2	101.68	233.13	149.03	178.02	314.68	223.51		451.52		421.14	178.47	362.13	218.18
Climber D-Sudheesh	208.57	101.68	219.4	149.03	100.86	275.98	248.07		451.52		421.14	178.47	362.13	199.28
Climber E-Aabdu Salam	196.06	101.68	295.47	149.03	152.28	118.27	272.2		443.98		421.14	178.47	362.13	237.98
Climber F-Babu	177.76	101.68	219.45	149.03	100.86	219.19	338.31		478.56		467.05	211.17	362.05	238.07
Climber G-Prabhakharan	162.13	97.38	313.03	154.25	100.86	138.24	223.52		435.71		437.79	194.28	362.13	199.28
Climber H-Vijeesh	224.2	101.68	219.43	149.03	173.85	85.53	272.2		451.52		421.4	178.47	362.13	199.28
Average	185.91625	100.605	236.015	139.113	129.99	208.223	255.22		456.09125		434.616	185.224	357.378	216.178
Standard deviation	32.046	1.991	46.434	30.215	33.399	84.142	41.657		16.699		20.550	11.861	13.377	19.198

The absolute weight obtained for each climber surveyed for the technical assessment parameters given in Table-4.3 revealed that design working principle of standing type and alternate use legs and hands recorded maximum values. The climbers expressed that the standing type design is easy in handling and climbing with least standard deviation in the range of 16.99 which is related to most of the technical requirements for all climbers. The need of safety device in Chemberi climbing aid by shoulder safety belt is needed as second priority of customers or climbers with least standard deviation of 13.38. The weight of the climbing aid is the third technical parameter that influenced the climbers which indicated that climbing aid weight should be reduced as light as possible to meet climber requirements. The weight is also related to the type of material and sections size used in the fabrication of climbing aid. The height and weight influenced climber requirements revealed that the climber had proportionate height as well as weight which is indirectly shown by the low absolute value of BMI as 129.99. This indicated the climbers physique was of correct BMI as per the body size standards. The reliability of climbing aid expressed by the different climbers were the same due to very low standard deviation but with average absolute weight of 185.22 for the climber requirements. For the locking devices parameter absolute weight was 216.17 with standard deviation of 19.19. The climbers expressed that the strength of material used in the fabrication of climbing parts was the same and had least standard deviation.

4.5.2 Relative weight of technical requirement of climber

After finding all the absolute weight of technical requirements these are added together to determine the total. Then for each technical requirement their relative weights were determined to rank the importance.

Table-4.4 Relative weight of technical requirement parameters of palm climbing aids

Relative weight % of technical assesment parameters														
Customer	Structural design				Anthropometry			Design working principle				Others		
	Type of material	Strength in terms of stress/ strain	Weight	Weldability of material	BMI	Height	Weight	Sitting type	Standing type	Dragging type by legs and hands	Alternate use of legs and hands	Reliability	Safety devices	Locking devices
Customer A-Chandran	5.38	3.5	6.07	2.32	3.85	8.56	9.34	0	17.42	0	16.76	6.62	13.02	7.17
Customer B-Vijaya Kumar	5.18	3.64	7.85	5.33	4.54	9.87	7.31	0	16.14	0	12.34	6.38	11.59	7.12
Customer C-Satheeshkumar	7.34	3.33	7.63	4.88	5.83	10.3	7.31	0	14.78	0	13.78	5.84	11.85	7.14
Customer D-Sudheesh	7.15	3.49	7.53	5.11	3.46	9.46	8.51	0	15.48	0	14.44	6.12	12.42	6.83
Customer E-Aabdu Salam	6.69	3.47	10.09	5.09	5.2	4.04	9.29	0	15.16	0	14.38	6.09	12.36	8.13
Customer F-Babu	6.19	3.54	7.64	5.19	3.51	7.63	11.77	0	16.66	0	14.26	6.89	12.6	8.29
Customer G-Prabhakharan	4.09	3.44	11.04	5.44	3.56	4.88	7.89	0	15.37	0	15.45	6.85	12.78	7.03
Customer H-Vijeesh	7.9	3.58	7.73	5.25	6.12	3.01	9.59	0	15.91	0	14.84	6.29	12.76	7.02
Average	6.24	3.499	8.198	4.826	4.51	7.219	8.876	0	15.865	0	14.531	6.385	12.423	7.341
Standard deviation	1.281	0.0934	1.586	1.027	1.09	2.849	1.478	0	0.861	0	1.275	0.376	0.486	0.548
Rank	**9**	**11**	**5**	**10**	**12**	**7**	**4**		**1**		**2**	**8**	**3**	**6**

The relative weight of each technical requirement parameters of the Chemberi model climbing aid ranked one was for the design of standing type working principle compared to sitting method of climbing palms in some other models which facilitated in the distribution of body weight along longitudinal plane of the body with much shifts in the centre gravity during climbing compared to sitting posture models. The next technical parameter that influenced climbers was the alternate use of legs and hands which enabled climbers avoiding the continuous stress of the joints and muscles extension and contraction of body segmental links. The least affected technical parameters were the body mass index, strength and weldability of material which indicated that structural superiority in the material that resulted least failures of the main frame and the sizes of section elements used.

The safety requirement needs much attention since standing posture is adopted while climbing the coconut palms. The shoulder body track wound safety belt with adjustable hooking device with coconut trunk can be adopted for Chemberi climbing aid without sacrificing the longitudinal upward and downward movement of the climber. The technical parameters viz., weight of the climbing aid as well as climbers' weight significantly affected climbers in carrying, manoeuvring and adjustments of climbing aid performances to a great extent during working.

4.6 Climber assessment of Chemberi model coconut palm climbing aid

The customer assessment of climbing aid by eight climbers is given Table-4.4. The eight palm climbers expressed score values for different climber requirements as given in the Table-4.4. The variations in score values depict that the climbing aid users have different opinion about the climber requirements. The highest assessment score above four were for training, subsidy and work output because these were the initiatives by the government and non-government agencies involved in training the coconut palm climbers to use climbing aids to overcome the scarcity of traditional climbers and train new entrants in the vocation to earn their livelihood. Even traditional climbers switched to climbing aids to reduce the risk and safety in their work in addition to the considerable work output without much drudgery. The trainees were given free climbing aids and insurance coverage for a year. The insurance coverage of climbers against is renewable annually. The ease of use, ease of climbing up and down wards, discomfort in hands and legs, life and cost were assessed above a score of three. The maintenance and working posture also assessed above score value of three by the climbers when evaluating performance of Chemberi climbing aids.

Table-4.5 Customer/climber competitive assessment rating

CUSTOMER COMPETITIVE ASSESMENT RATING																				
	Easy to use					Capability				Ergomechanical performance						Others				
Climbers	easy to use	portability	ease of mounting	safety	size of climber	maintanence	quality of work	repair	quantity of work	working posture	easiness of climbing up	easiness of climbing down	overall discomfort in foot	discomfort in hands	discomfort in hip	life	cost	subsidy	training	labour custom rate
Climber A-Chandran	4	2	2	2	2	3	4	2	4	3	4	4	3	4	4	4	4	4	5	4
Climber B-Vijaya Kumar	3	2	2	2	2	3	4	3	5	3	3	3	2	3	3	4	4	4	5	4
Climber C-Satheeshkumar	4	3	2	2	2	3	4	2	4	4	4	4	3	4	4	4	4	5	5	5
Climber D-Sudheesh	4	2	3	2	3	3	4	2	5	4	4	4	3	3	4	4	4	5	5	5
Climber E-Aabdu Salam	4	3	3	3	3	4	4	3	4	4	4	4	4	4	4	4	4	4	4	3
Climber F-Babu	4	3	5	3	4	3	3	3	3	2	3	4	4	3	4	3	4	4	4	4
Climber G-Prabhakharan	4	3	3	3	2	3	4	3	5	4	4	4	4	4	4	4	4	5	5	5
Climber H-Vijeesh	4	2	3	2	3	3	4	2	5	3	3	3	2	3	3	4	3	4	4	4
Average	3.875	2.5	2.875	2.375	2.625	3.13	3.875	2.5	4.375	3.375	3.625	3.75	3.125	3.5	3.75	3.88	3.9	4.38	4.63	4.25
Standard deviation	0.354	0.535	0.991	0.518	0.744	0.35	0.354	0.535	0.744	0.744	0.518	0.463	0.835	0.535	0.46	0.35	0.4	0.52	0.52	0.707

The customer requirements viz., portability, repair and safety were assessed for score value of 2.5 and below. This implies that the overall weight and size to be further reduced to enable climbers in the climbing aid carrying by palm climbers in different types of farm land terrain. The safety aspect in the use of palm climbers succinctly voiced by the climber which is one of the most important area for research and development in standing types of palm climbers.

4.7 Correlation of technical requirements of climbing aid (Roof of HOQ)

. The roof of house quality is the correlation between the technical requirements of coconut palm climbers are shown in figure. 4.7. The type of material was in strong correlation with material stress/strain properties and weight. Similarly the height and weight of the palm climbers were in strong relation with body mass index (BMI). The type of material and weight of climber were moderately correlated with the standing type of climbers since the entire weight of palm climber is supported by the frame and steel rope used to wound around the coconut tree trunk.

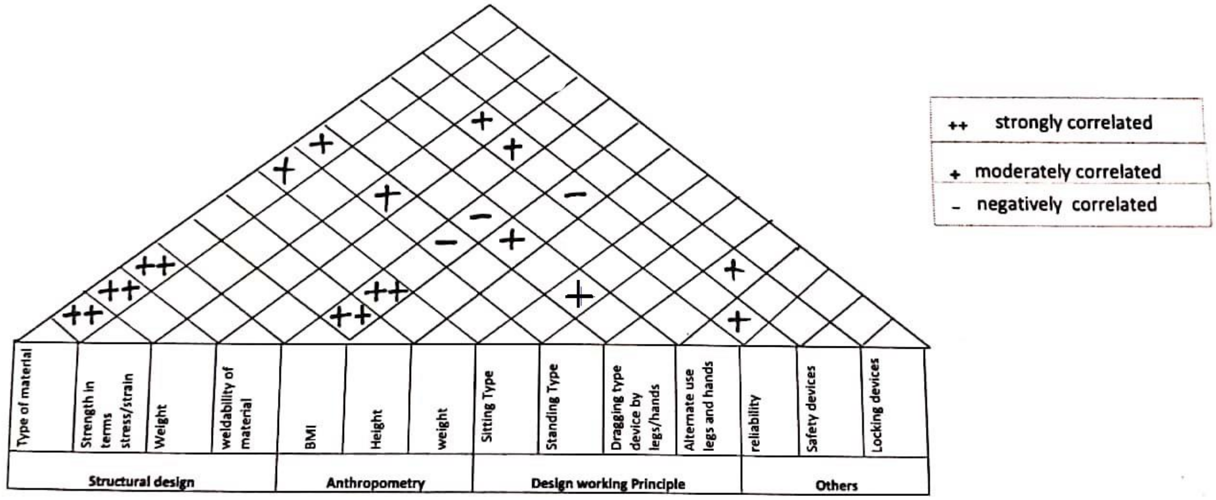

Fig -4.2 roof of house of quality

The body mass index and standing or sitting type palm climbers were correlated negatively. Similarly, the type of weight of palm climber is not correlated with use hands and legs for climbing. The dragging hands and legs of climber during climbing is correlated in sitting type climbers since bottom leg support of climbing is dragged up.

In the correlation of technical parameters each and every parameter are related with each other. The relation shown in the appendix. This is known as house of qualitative correlation will be regarded and then for each correlation we will be assigning symbols for highly correlated we are using double plus sign and moderate correlated one plus sign and for no correlation or negative correlation there is zero symbol.

4.8 Engineering assessment on climbing aids

The engineering assessment of Chemberi coconut climbing aid was made based on a 5 point scale. The study resulted in finding the improvements needed for the Chemberi model climber the engineering assessment factors are given in table below. The type of material, weldability of material, reliability, safety devices, locking devices etc., requires improvement, so that engineer has to assess these design and manufacturing parameters that affect the overall performance of climbing aid. However, the operational and user/climber factors are also to be considered while improvements are made in Chemberi model.

Table -4.6 Engineering assessment of Chemberi climbing aid

Engineering Parameters												
primary requirements		Structural design				Design working principle				Others		
secondary requirement	scale	Type of material	Strength in terms of stress/ strain	Weight	Weldability of material	Sitting type	Standing type	Dragging type by legs and hands	Alternate use of legs	Reliability	Safety devices	Locking devices
engineering assesment	5						5			5		
	4			4					4			
	3	3	3								3	3
	2				2							
	1											

4.9 Direction of improvement

In the individual climbers' QFD charts presented in Appendix -B1 to B8 , the direction of improvement is marked either by a upward arrow (↑) or downward arrow (↓) provided for the target value. The technical factors whose weights are above target value need not be improved but the target value whose weights are below target value need to be improved. Direction of the improvements are marked in the QFD charts so that upward direction of arrow shows the indication for improvement and downward direction of arrow shows the indicates that there is no need of improvement or depending upon the technical parameter assessed line weight climber and parameter is as per the target value. The direction for improvement can observed from the QFD charts in Appendix B1to B8

4.10 Performance selection of climbing aids by QFD analysis

From the AHP-QFD study of coconut palm climbing aids, the most important requirements of the climbers were studied in relation with technical and ergonomical factors that affect the overall performance of the climbing aid. Our study came to conclusion that the so many factors affect the climbers' performance but there are some factors that are very crucial and critical to climbers' which will be regarded as the most important parameters to be considered as the basis for the design of coconut palm climbing aids. From the chart of QFD in the Appendix- B1 to B8, it is concluded that the Chemberi model is the most commonly used climbing aid by the users mainly because of the ease of operation and secondly, the ease of transportation. Even though, these two factors are rated high but the climbers demand is for further reduction weight using appropriate selection of material. Then, while calculating all the ergonomically parameters they are also high in case of Chemberi while comparing with other climbers. The main factors are standing type relative absolute weight (average value 15.865, table no 4.4) and alternate use of hands and legs, safety devices, weight of customer etc are considered as the basic functional and significant parameter of climbing aid from the QFD analysis which is given appendix B1 to B8.

4.11 Design and manufacturing Improvements of palm climbing aids

The main improvements in the design of Chemberi palm climbing aid required are the type of material and their sectional sizes used, climber should have optimum body mass index range as per recommend standard, safety devices to developed for standing posture of the climber, locking devices of climbing aid after mounting on coconut tree trunk, the users/climbers' skill and training are common factors which needs attention for further improvements in case of standing type climbing aids the climber has more degree of freedom of movements to the body segmental links. The main criteria to be considered redesign in the Chemberi type model is the wear and tear and the welded joints steel frames, which are subjected to fracture and crack. The welded joints break or rupture which needs attention for improvement

4.11.1 Design improvements based on survey

Wear and tear part

Plate 4.1 improvements in model Chemberi

In this climbers given suggestion that the sliding part is having more wear and tear so this must be reduced by either with a good metal or by adding any rubber bushes between them

Cracking part

Plate 4.2 Improvements needed in pedal part

The joints of the standing part of the climbing aid has to be modified and the once it broken we have to replace it weldability of the metal should be considered a strong metal has to be used for the manufacturing of such junction

CHAPTER 5

Summary and Conclusions

Kerala is the land of coconut and it is one of the most important cash crops in the state. Coconut has influenced the day today life of Keralites in their social and religious beliefs. As of now, there are many climbing aids available in the market. The traditional palm climbers are almost withdrawn from the field due to old age and illness and the state faced with an acute situation of scarcity coconut palm climbers. The Coconut Development Board, Government of India took a very bold decision to train and distribute the Chemberi palm climber at free of cost to all climbers with the networking of training centers mode throughout Kerala using Krishi Vigyan Kendra and other NGO agencies promoting agriculture and allied vocation activities. The initiative was an exemplary example for the diffusion technology which was very much needed to showcase a simple product which lying in background without any promotion but now have become the bread earners for a lot professional persons in this vocation as professionals.

In this study, the objective was to evaluate the users about the performance of Chemberi model palm climber to elucidate their opinions for improving the quality in terms of the materials techniques and fabrication followed in the fabrication, the man-machine aspect of the aid and other factors like training, cost, safety etc. For this, a survey was conducted among the professional climbers and their experiences with the Chemberi palm climbers were taken on above aspects. Other types of coconut types of palm climbers were also covered in the study but only very few have adopted this. This study mostly confined to Malappuram and Thrissur areas. Unlike other types of studies, this study was oriented to evaluate the quality and performance of coconut palm climber by analytical hierarchical process and quality functional deployment methods.

The survey conducted revealed the details of the customer or climber requirements. The related technical requirements of the climbing aid aid and ergonomical factors were deduced from the survey. The relative importance of each climber requirements was determined by analytical hierarchy process. The relationship between the climber requirements and technical requirements were sought from climbers. This relationship was rated on scale and represented in QFD chart. The total absolute weight of each technical requirement was determined and their relative weight. The design principle working of in standing and use of hands and legs alternatively were ranked highest among the technical requirements for Chemberi model climbing aid. The customer or climber assessment was rated on five point scale revealed that the training, cost free climbing aid, quantity of work output were rated high, over four point value by climbers for customer requirements. Easy to use, quality of machine, working posture and easiness in climbing up and downwards, discomfort hip and hands were rated above three point. However, the weight of aid in carrying, repair and safety were rated at point 2.5 and below which indicated that the factors have to be improved and needs immediate attention. The correlations between the technical requirements were compared in the roof of QFD chart. The correlations were either positive or negative in nature and other factors were not related at all from the chart. The engineering assessment of technical requirements and directions for improvements are given in QFD charts. The design and improvements in fabrication are discussed with inputs received from the climbers who are traditional professionals.

The study highlighted the climber requirements and also the technical needs to improve in design and fabrication of Chemberi climbing aid. The siting posture type climbing aids are not popular among the professional climbers due to the low work output and ergonomical factors like lifting the lower part of the aids by dragging up along the tree trunk. The training and free gift of climber to users are the vital factors in its adoption. However, the users pointed out the need for making it further light and safety requirement which needs further improvements and development in case of coconut palm climbing aids.

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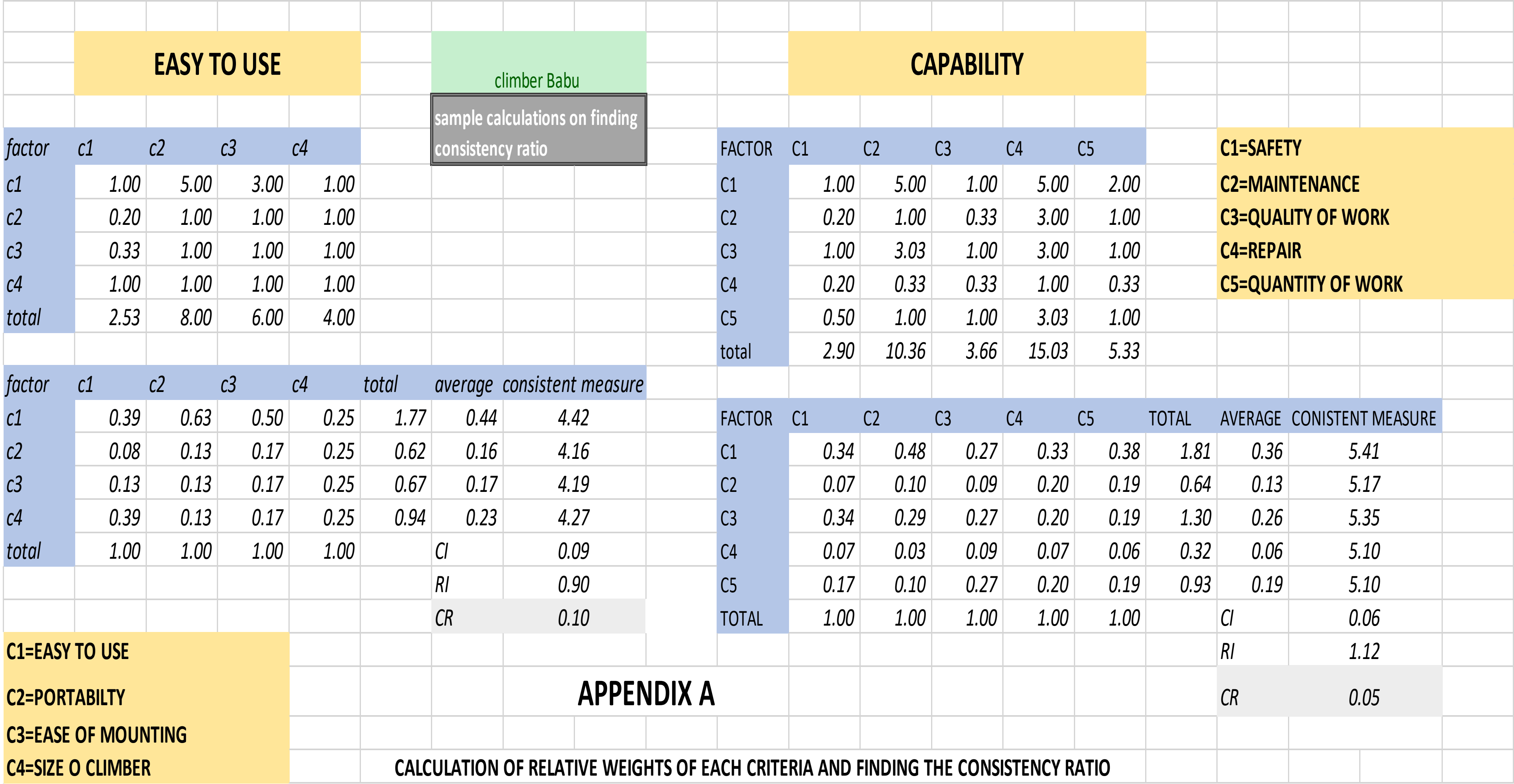
APPENDIX A



climber Babu

sample calculations on finding consistency ratio

EASY TO USE

factor	c1	c2	c3	c4
c1	1.00	5.00	3.00	1.00
c2	0.20	1.00	1.00	1.00
c3	0.33	1.00	1.00	1.00
c4	1.00	1.00	1.00	1.00
total	2.53	8.00	6.00	4.00

factor	c1	c2	c3	c4	total	average	consistent measure
c1	0.39	0.63	0.50	0.25	1.77	0.44	4.42
c2	0.08	0.13	0.17	0.25	0.62	0.16	4.16
c3	0.13	0.13	0.17	0.25	0.67	0.17	4.19
c4	0.39	0.13	0.17	0.25	0.94	0.23	4.27
total	1.00	1.00	1.00	1.00		CI	0.09
						RI	0.90
						CR	0.10

C1=EASY TO USE
C2=PORTABILTY
C3=EASE OF MOUNTING
C4=SIZE O CLIMBER

CAPABILITY

FACTOR	C1	C2	C3	C4	C5
C1	1.00	5.00	1.00	5.00	2.00
C2	0.20	1.00	0.33	3.00	1.00
C3	1.00	3.03	1.00	3.00	1.00
C4	0.20	0.33	0.33	1.00	0.33
C5	0.50	1.00	1.00	3.03	1.00
total	2.90	10.36	3.66	15.03	5.33

C1=SAFETY
C2=MAINTENANCE
C3=QUALITY OF WORK
C4=REPAIR
C5=QUANTITY OF WORK

FACTOR	C1	C2	C3	C4	C5	TOTAL	AVERAGE	CONISTENT MEASURE
C1	0.34	0.48	0.27	0.33	0.38	1.81	0.36	5.41
C2	0.07	0.10	0.09	0.20	0.19	0.64	0.13	5.17
C3	0.34	0.29	0.27	0.20	0.19	1.30	0.26	5.35
C4	0.07	0.03	0.09	0.07	0.06	0.32	0.06	5.10
C5	0.17	0.10	0.27	0.20	0.19	0.93	0.19	5.10
TOTAL	1.00	1.00	1.00	1.00	1.00		CI	0.06
							RI	1.12
							CR	0.05

APPENDIX A

CALCULATION OF RELATIVE WEIGHTS OF EACH CRITERIA AND FINDING THE CONSISTENCY RATIO

ERGO MECHANICAL PERFORMNACE

FACTOR	C1	C2	C3	C4	C5	C6
C1	*1.00*	*1.00*	*1.00*	*1.00*	*2.00*	*2.00*
C2	*1.00*	*1.00*	*1.00*	*3.00*	*2.00*	*2.00*
C3	*1.00*	*1.00*	*1.00*	*2.00*	*3.00*	*0.33*
C4	*1.00*	*0.33*	*0.50*	*1.00*	*1.00*	*0.33*
C5	*0.50*	*0.50*	*0.33*	*1.00*	*1.00*	*0.33*
C6	*0.50*	*0.50*	*3.03*	*3.03*	*3.03*	*1.00*
total	*5.00*	*4.33*	*6.86*	*11.03*	*12.03*	*5.99*

FACTOR	C1	C2	C3	C4	C5	C6	TOTAL	AVERAGE	CONSTSENT MEASURE
C1	*0.20*	*0.23*	*0.15*	*0.09*	*0.17*	*0.33*	*1.17*	*0.19*	*6.72*
C2	*0.20*	*0.23*	*0.15*	*0.27*	*0.17*	*0.33*	*1.35*	*0.22*	*6.67*
C3	*0.20*	*0.23*	*0.15*	*0.18*	*0.25*	*0.06*	*1.06*	*0.18*	*6.27*
C4	*0.20*	*0.08*	*0.07*	*0.09*	*0.08*	*0.06*	*0.58*	*0.10*	*6.33*
C5	*0.10*	*0.12*	*0.05*	*0.09*	*0.08*	*0.06*	*0.49*	*0.08*	*6.35*
C6	*0.10*	*0.12*	*0.44*	*0.27*	*0.25*	*0.17*	*1.35*	*0.23*	*6.72*
total	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*		*CI*	*0.10*
								RI	*1.24*
								CR	*0.08*

C1=WORKING POSTURE
C2=EASINESS OF CLIBING UP
C3=EASINESS OF CLIMBNG DOWN
C4=OVERALL DISCOMFORT IN FOOT
C5=DISCOMFORT IN HAND
C6=DISCOMFORT IN HIP

OTHERS

FACTOR	C1	C2	C3	C4	C5
C1	*1.00*	*5.00*	*5.00*	*2.00*	*3.00*
C2	*0.20*	*1.00*	*0.50*	*0.25*	*0.25*
C3	*0.20*	*2.00*	*1.00*	*1.00*	*1.00*
C4	*0.50*	*4.00*	*1.00*	*1.00*	*4.00*
C5	*0.33*	*4.00*	*1.00*	*0.25*	*1.00*
total	*2.23*	*16.00*	*8.50*	*4.50*	*9.25*

FACTOR	C1	C2	C3	C4	C5	TOTAL	AVERAGE	CONSISTEN MEASURE
C1	*0.45*	*0.31*	*0.59*	*0.44*	*0.32*	*2.12*	*0.42*	*5.40*
C2	*0.09*	*0.06*	*0.06*	*0.06*	*0.03*	*0.29*	*0.06*	*5.21*
C3	*0.09*	*0.13*	*0.12*	*0.22*	*0.11*	*0.66*	*0.13*	*5.43*
C4	*0.22*	*0.25*	*0.12*	*0.22*	*0.43*	*1.25*	*0.25*	*5.51*
C5	*0.15*	*0.25*	*0.12*	*0.06*	*0.11*	*0.68*	*0.14*	*5.19*
total	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*		*CI*	*0.09*
							RI	*1.12*
							CR	*0.08*

C1=LIFE
C2=COST
C3=SUBSIDY
C4=TRAINING
C5=LABOUR CUSTOM RATE

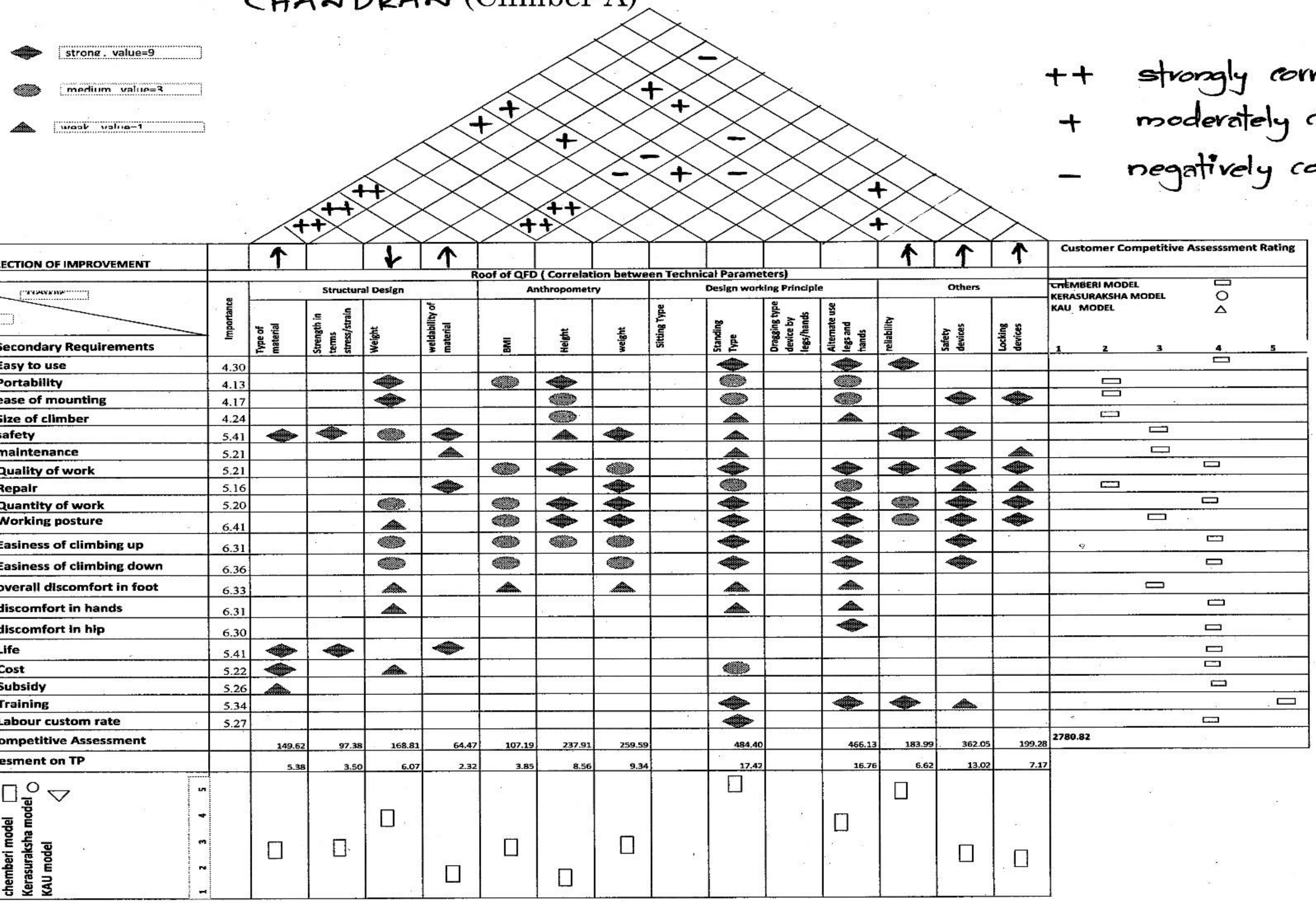
CALCULATION OF RELATIVE WEIGHTS OF CRITERIAS OF PRIMARY REQUIREMENT

APPENDIX B

APPENDIX B1

CHANDRAN (Climber A)

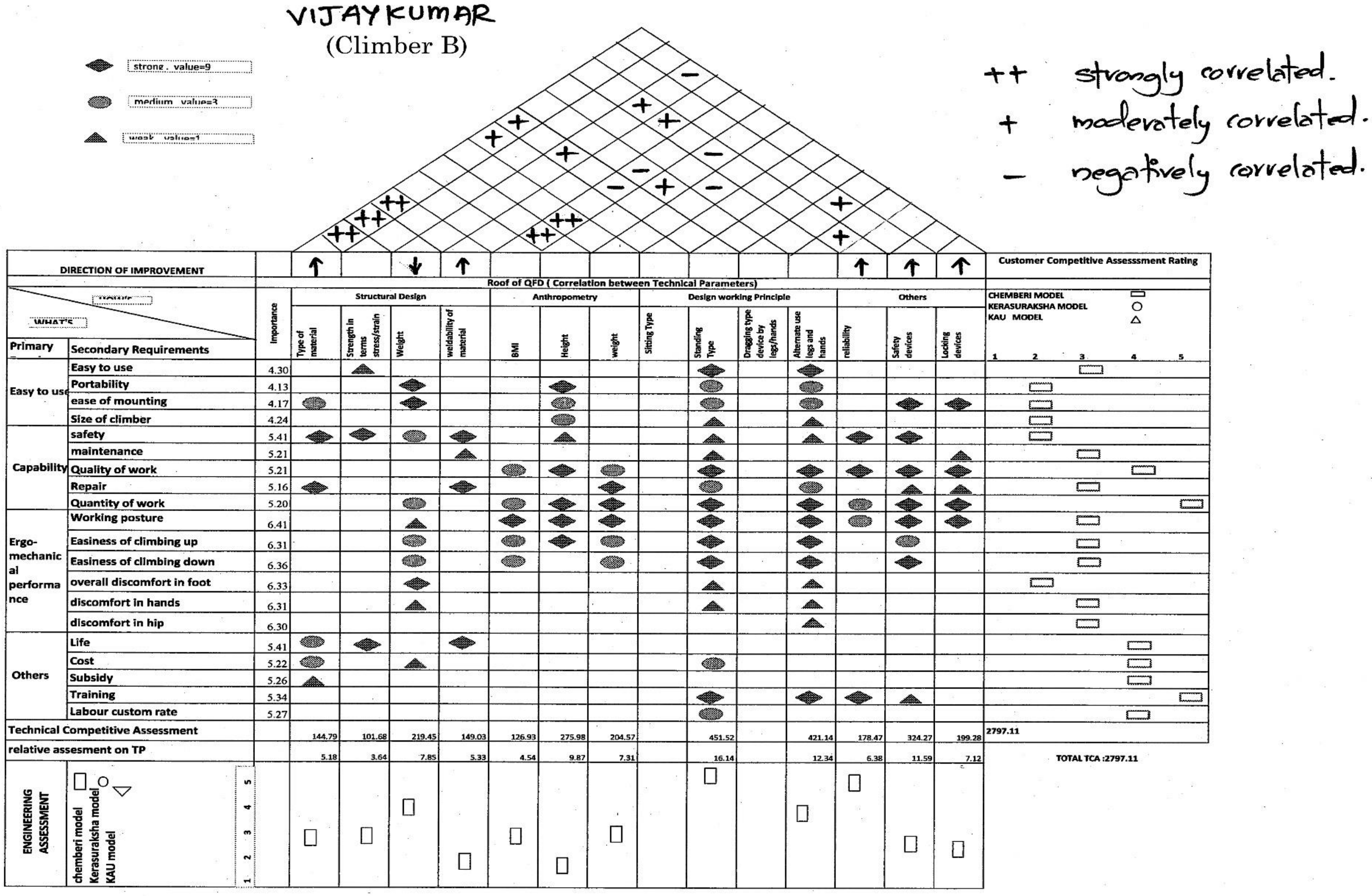
++ strongly correlated.
\+ moderately correlated.
– negatively correlated.



DIRECTION OF IMPROVEMENT			↑		↓	↑								↑	↑	↑
			Structural Design				Anthropometry			Design working Principle				Others		
Primary	Secondary Requirements	Importance	Type of material	Strength in terms stress/strain	Weight	weldability of material	BMI	Height	weight	Sitting Type	Standing Type	Dragging type device by legs/hands	Alternate use legs and hands	reliability	Safety devices	Locking devices
Easy to use	Easy to use	4.30									◆		◆	◆		
	Portability	4.13			◆		●	◆			●		●			
	ease of mounting	4.17			◆			●			●		●		◆	◆
	Size of climber	4.24						●			▲		▲			
Capability	safety	5.41	◆	◆	●	◆		▲	◆		▲			◆	◆	
	maintenance	5.21				▲					▲					▲
	Quality of work	5.21					●	◆	●		◆		◆	◆	◆	◆
	Repair	5.16				◆			◆		●		●		▲	▲
	Quantity of work	5.20			●		●	◆	◆		◆		◆	●	◆	◆
Ergo-mechanical performance	Working posture	6.41			▲		●	◆	◆		◆		◆	●	◆	◆
	Easiness of climbing up	6.31			●		●	●	●		◆		◆		◆	
	Easiness of climbing down	6.36			●		●		●		◆		◆		◆	
	overall discomfort in foot	6.33			▲		▲		▲		▲		▲			
	discomfort in hands	6.31			▲						▲		▲			
	discomfort in hip	6.30											◆			
Others	Life	5.41	◆	◆		◆										
	Cost	5.22	◆		▲						●					
	Subsidy	5.26	▲													
	Training	5.34									◆		◆	◆	▲	
	Labour custom rate	5.27									◆					
Technical Competitive Assessment			149.62	97.38	168.81	64.47	107.19	237.91	259.59		484.40		466.13	183.99	362.05	199.28
relative assesment on TP			5.38	3.50	6.07	2.32	3.85	8.56	9.34		17.42		16.76	6.62	13.02	7.17

2780.82

APPENDIX B2



VIJAYKUMAR
(Climber B)

◆ strong , value=9
● medium value=3
▲ weak value=1

++ strongly correlated.
+ moderately correlated.
− negatively correlated.

Roof of QFD (Correlation between Technical Parameters)

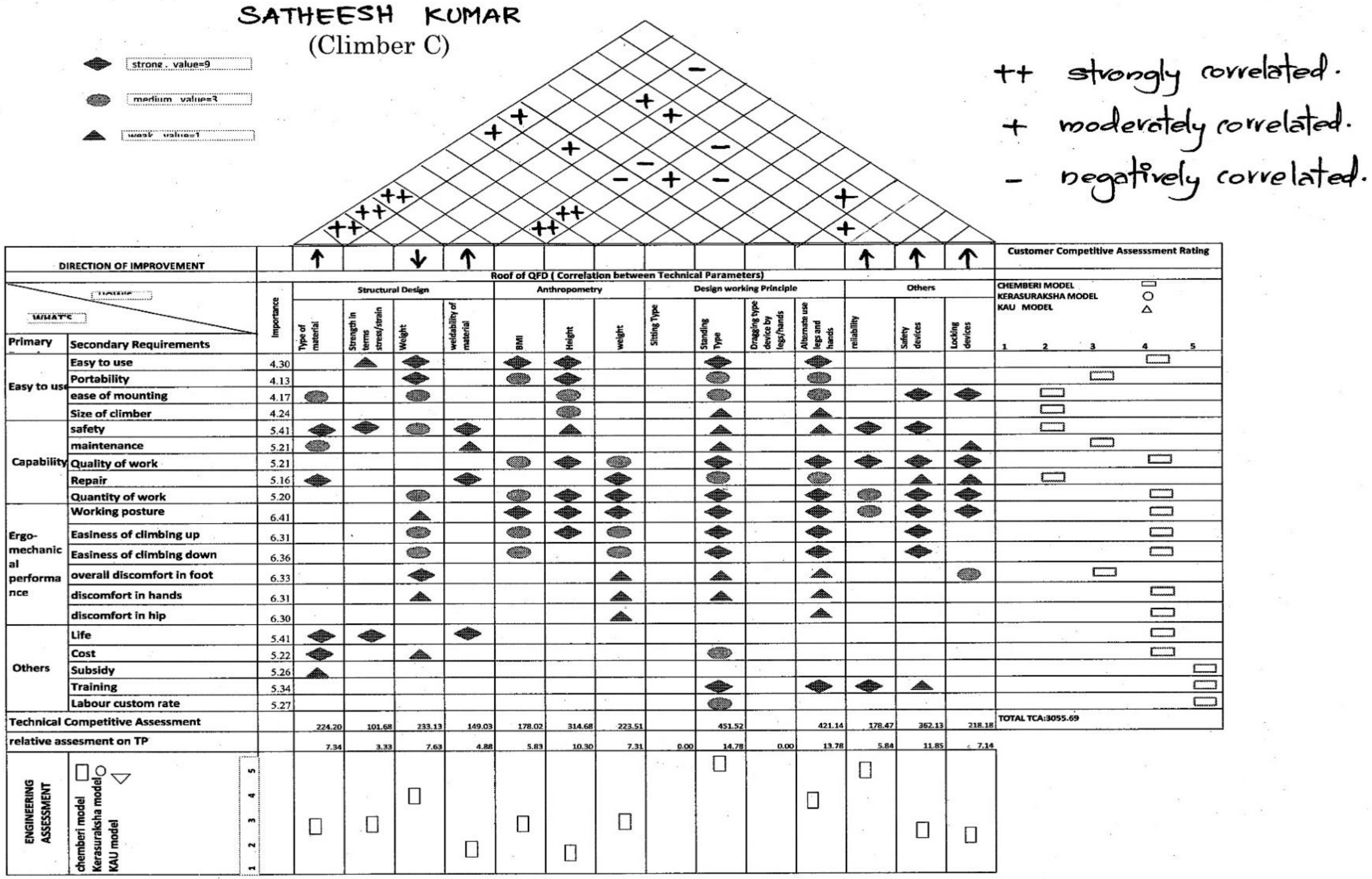
			Structural Design				Anthropometry			Design working Principle				Others			Customer Competitive Assesssment Rating				
DIRECTION OF IMPROVEMENT			↑		↓	↑								↑	↑	↑					
Primary	Secondary Requirements	Importance	Type of material	Strength in terms stress/strain	Weight	weldability of material	BMI	Height	weight	Sitting Type	Standing Type	Dragging type device by legs/hands	Alternate use legs and hands	reliability	Safety devices	Locking devices	1	2	3	4	5
Easy to use	Easy to use	4.30		▲							◆		◆						▭		
	Portability	4.13			◆			◆			●		●					▭			
	ease of mounting	4.17	●		◆			●			●		●		◆	◆		▭			
	Size of climber	4.24						●			▲		▲					▭			
Capability	safety	5.41	◆	◆	●	◆		▲			▲		▲	◆	◆			▭			
	maintenance	5.21				▲					▲					▲			▭		
	Quality of work	5.21					●	◆	●		◆		◆	◆	◆	◆				▭	
	Repair	5.16	◆			◆			◆		●		●		▲	▲			▭		
	Quantity of work	5.20			●		●	◆	◆		◆		◆	●	◆	◆					▭
Ergo-mechanical performance	Working posture	6.41			▲		◆	◆	◆		◆		◆	●	◆	◆			▭		
	Easiness of climbing up	6.31			●		●	◆	●		◆		◆		●				▭		
	Easiness of climbing down	6.36			●		●		●		◆		◆		◆				▭		
	overall discomfort in foot	6.33			◆						▲		▲					▭			
	discomfort in hands	6.31			▲						▲		▲						▭		
	discomfort in hip	6.30											▲						▭		
Others	Life	5.41	●	◆		◆														▭	
	Cost	5.22	●		▲						●									▭	
	Subsidy	5.26	▲																	▭	
	Training	5.34									◆		◆	◆	▲						▭
	Labour custom rate	5.27									●									▭	
Technical Competitive Assessment			144.79	101.68	219.45	149.03	126.93	275.98	204.57		451.52		421.14	178.47	324.27	199.28	2797.11				
relative assesment on TP			5.18	3.64	7.85	5.33	4.54	9.87	7.31		16.14		12.34	6.38	11.59	7.12					

CHEMBERI MODEL ▭
KERASURAKSHA MODEL ○
KAU MODEL △

TOTAL TCA :2797.11

ENGINEERING ASSESSMENT
□ chemberi model
○ Kerasuraksha model
▽ KAU model
1 2 3 4 5

APPENDIX B3



SATHEESH KUMAR

(Climber C)

◆ strong . value=9

● medium value=3

▲ weak value=1

++ strongly correlated.

\+ moderately correlated.

\- negatively correlated.

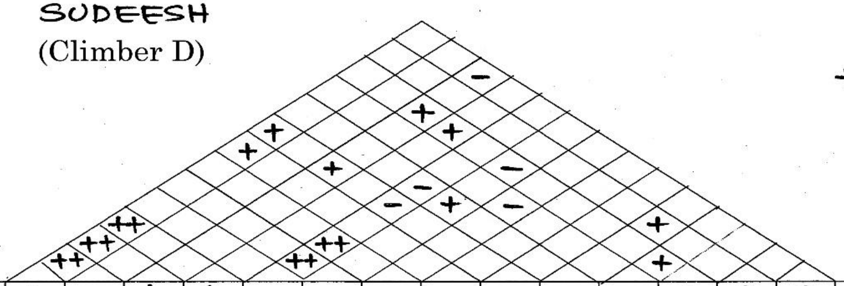
DIRECTION OF IMPROVEMENT			↑		↓	↑								↑	↑	↑	Customer Competitive Assesssment Rating				
			Roof of QFD (Correlation between Technical Parameters)																		
		Importance	Structural Design				Anthropometry			Design working Principle				Others			CHEMBERI MODEL ▭ KERASURAKSHA MODEL ○ KAU MODEL △				
Primary	Secondary Requirements		Type of material	Strength in terms stress/strain	Weight	weldability of material	BMI	Height	weight	Sitting Type	Standing Type	Dragging type device by legs/hands	Alternate use legs and hands	reliability	Safety devices	Locking devices	1	2	3	4	5
Easy to us	Easy to use	4.30		▲	◆		◆	◆			◆		◆							▭	
	Portability	4.13			◆		●	◆			●		●						▭		
	ease of mounting	4.17	●		●			●			●		●		◆	◆		▭			
	Size of climber	4.24						●			▲		▲					▭			
Capability	safety	5.41	◆	◆	●	◆		▲			▲		▲	◆	◆			▭			
	maintenance	5.21	●			▲					▲					▲			▭		
	Quality of work	5.21					●	◆	●		◆		◆	◆	◆	◆				▭	
	Repair	5.16	◆			◆			◆		●		●		▲	▲		▭			
	Quantity of work	5.20			●		●	◆	◆		◆		◆	●	◆	◆				▭	
Ergo-mechanical performance	Working posture	6.41			▲		◆	◆	◆		◆		◆	●	◆	◆				▭	
	Easiness of climbing up	6.31			●		●	◆	●		◆		◆		◆					▭	
	Easiness of climbing down	6.36			●		●		●		◆		◆		◆					▭	
	overall discomfort in foot	6.33			◆				▲		▲		▲			●			▭		
	discomfort in hands	6.31			▲				▲		▲		▲							▭	
	discomfort in hip	6.30							▲				▲							▭	
Others	Life	5.41	◆	◆		◆														▭	
	Cost	5.22	◆		▲						●									▭	
	Subsidy	5.26	▲																		▭
	Training	5.34									◆		◆	◆	▲						▭
	Labour custom rate	5.27									●										▭
Technical Competitive Assessment			224.20	101.68	233.13	149.03	178.02	314.68	223.51		451.52		421.14	178.47	362.13	218.18	TOTAL TCA:3055.69				
relative assesment on TP			7.34	3.33	7.63	4.88	5.83	10.30	7.31	0.00	14.78	0.00	13.78	5.84	11.85	7.14					
ENGINEERING ASSESSMENT	▢ chemberi model ○ Kerasuraksha model ▽ KAU model	1 2 3 4 5	▢	▢	▢	▢	▢	▢	▢		▢		▢	▢	▢	▢					

APPENDIX B4

SUDEESH
(Climber D)

◆ strong . value=9
● medium value=3
▲ weak value=1

++ strongly correlated
\+ moderately correlated
− negatively correlated.



DIRECTION OF IMPROVEMENT			↑		↓	↑								↑	↑	↑	Customer Competitive Assesssment Rating				
			Roof of QFD (Correlation between Technical Parameters)																		
HOW'S / WHAT'S		Importance	Structural Design				Anthropometry			Design working Principle				Others			CHEMBERI MODEL □ KERASURAKSHA MODEL ○ KAU MODEL △				
Primary	Secondary Requirements		Type of material	Strength in terms stress/strain	Weight	weldability of material	BMI	Height	weight	Sitting Type	Standing Type	Dragging type device by legs/hands	Alternate use legs and hands	reliability	Safety devices	Locking devices	1	2	3	4	5
Easy to use	Easy to use	4.30		▲							◆		◆							□	
	Portability	4.13			◆		●	◆	◆		●		●					□			
	ease of mounting	4.17	●		◆			●			●		●		◆	◆			□		
	Size of climber	4.24						●			▲		▲					□			
Capability	safety	5.41	◆	◆	●	◆		▲			▲		▲	◆	◆				□		
	maintenance	5.21				▲					▲					▲			□		
	Quality of work	5.21					●	◆	●		◆		◆	◆	◆	◆				□	
	Repair	5.16	◆			◆			◆		●		●		▲	▲		□			
	Quantity of work	5.20			●		●	◆	◆		◆		◆	●	◆	◆					□
Ergo-mechanical performance	Working posture	6.41			▲		●	◆	◆		◆		◆	●	◆	◆				□	
	Easiness of climbing up	6.31			●		●	◆	●		◆		◆		◆					□	
	Easiness of climbing down	6.36			●		●		●		◆		◆		◆					□	
	overall discomfort in foot	6.33			◆				▲		▲		▲						□		
	discomfort in hands	6.31			▲						▲		▲						□		
	discomfort in hip	6.30											▲							□	
Others	Life	5.41	◆	◆		◆														□	
	Cost	5.22	◆		▲						●									□	
	Subsidy	5.26	▲																		□
	Training	5.34									◆		◆	◆	▲						□
	Labour custom rate	5.27									●										□
Technical Competitive Assessment			208.57	101.68	219.45	149.03	100.86	275.98	248.07		451.52		421.14	178.47	362.13	199.28	TOTAL TCA:2916.18				
relative assesment on TP			7.15	3.49	7.53	5.11	3.46	9.46	8.51	0.00	15.48	0.00	14.44	6.12	12.42	6.83					
ENGINEERING ASSESSMENT	□ ○ ▽ chemberi model Kerasuraksha model KAU model	5									□			□							
		4			□								□								
		3	□	□			□		□						□	□					
		2				□		□													
		1																			

2916.18

APPENDIX B5

ABDUL SALAM.(Climber E)

◆ strong , value=9

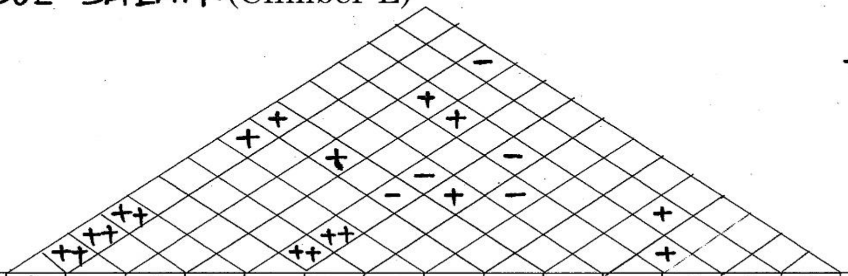
● medium , value=3

▲ weak , value=1

++ strongly correlated.

\+ moderately correlated.

– negatively correlated.



Roof of QFD (Correlation between Technical Parameters)

Customer Competitive Assessssment Rating

CHEMBERI MODEL ▭

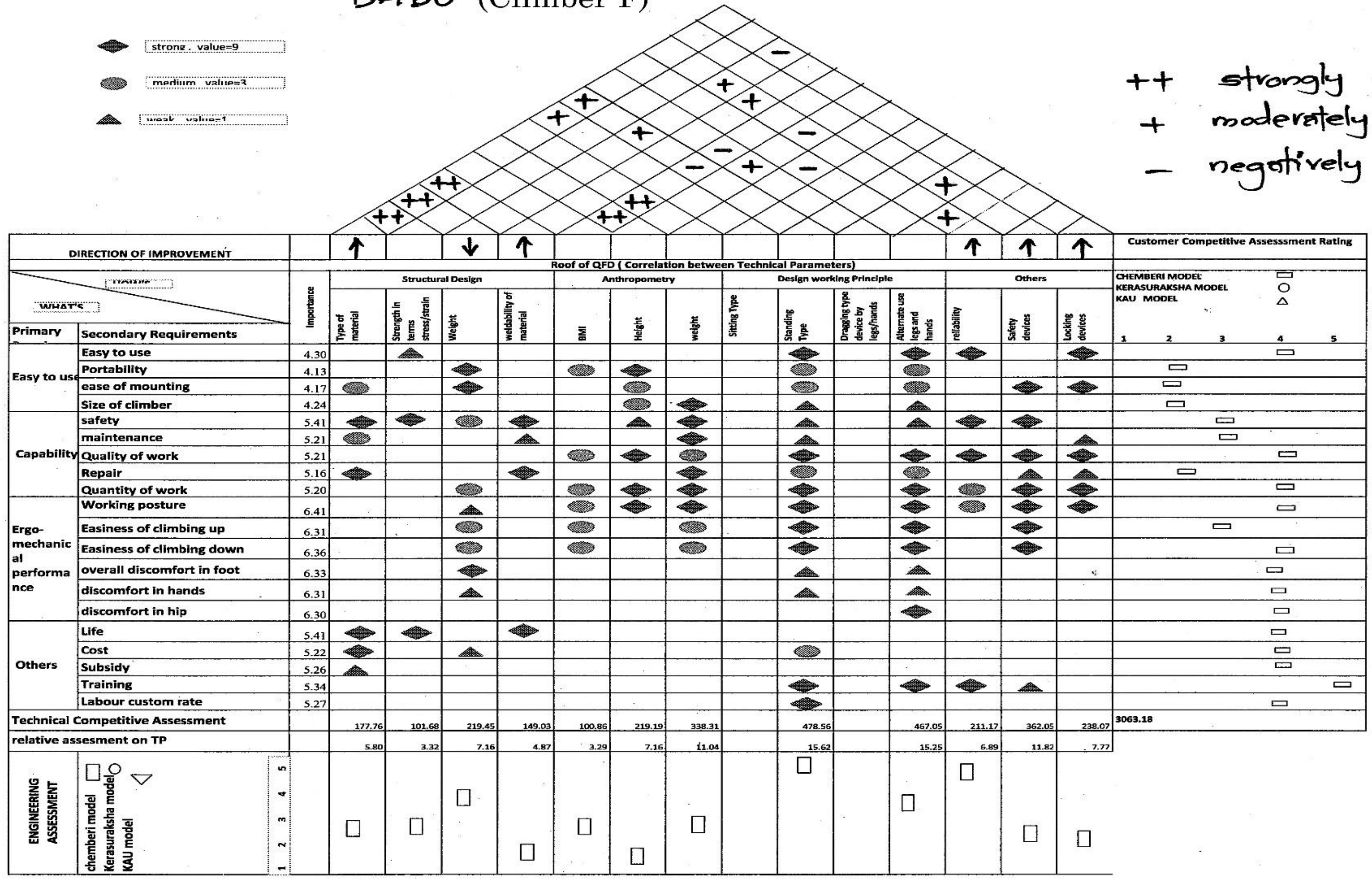
KERASURAKSHA MODEL ○

KAU MODEL △

Primary	Secondary Requirements	Importance	Structural Design				Anthropometry			Design working Principle				Others							
WHAT'S	HOW'S		Type of material	Strength in terms stress/strain	Weight	weldability of material	BMI	Height	weight	Sitting Type	Standing Type	Dragging type device by legs/hands	Alternate use legs and hands	reliability	Safety devices	Locking devices	1	2	3	4	5
DIRECTION OF IMPROVEMENT			↑		↓	↑								↑	↑	↑					
Easy to use	Easy to use	4.30		▲			◆				◆		◆			◆				▭	
	Portability	4.13			◆		●	◆			●		●						▭		
	ease of mounting	4.17			◆			●			●		●		◆	◆					▭
	Size of climber	4.24					●	●			▲		▲						▭		
Capability	safety	5.41	◆	◆	●	◆		▲	◆		▲		▲	◆	◆					▭	
	maintenance	5.21				▲					▲					▲			▭		
	Quality of work	5.21					●	◆	●		◆		◆	◆	◆	◆			▭		
	Repair	5.16	◆			◆			◆		●		●		▲	▲			▭		
	Quantity of work	5.20			●		●	◆	◆		◆		◆	●	◆	◆				▭	
Ergo-mechanical performance	Working posture	6.41			▲		●	◆	◆		◆		◆	●	◆	◆		▭			
	Easiness of climbing up	6.31			◆		●		●		◆		◆		◆				▭		
	Easiness of climbing down	6.36			◆		●		●		◆		◆		◆					▭	
	overall discomfort in foot	6.33			◆				▲		▲		▲							▭	
	discomfort in hands	6.31			▲				▲		▲		▲						▭		
	discomfort in hip	6.30							▲				▲							▭	
Others	Life	5.41	◆	◆		◆													▭		
	Cost	5.22	◆		▲						●									▭	
	Subsidy	5.26	▲																	▭	
	Training	5.34									◆		◆	◆	▲					▭	
	Labour custom rate	5.27									▲									▭	
Technical Competitive Assessment			196.06	101.68	295.47	149.03	152.28	118.27	272.20		443.98		421.14	178.47	362.13	237.98	2928.69				
relative assesment on TP			6.69	3.47	10.09	5.09	5.20	4.04	9.29		15.16		14.38	6.09	12.36	8.13					
ENGINEERING ASSESSMENT	□ chemberi model ○ Kerasuraksha model ▽ KAU model	5									□			□							
		4			□								□								
		3	□	□			□		□						□	□					
		2				□		□													
		1																			

APPENDIX B6

BABU (Climber F)



++ strongly correlated.
+ moderately correlated.
− negatively correlated.

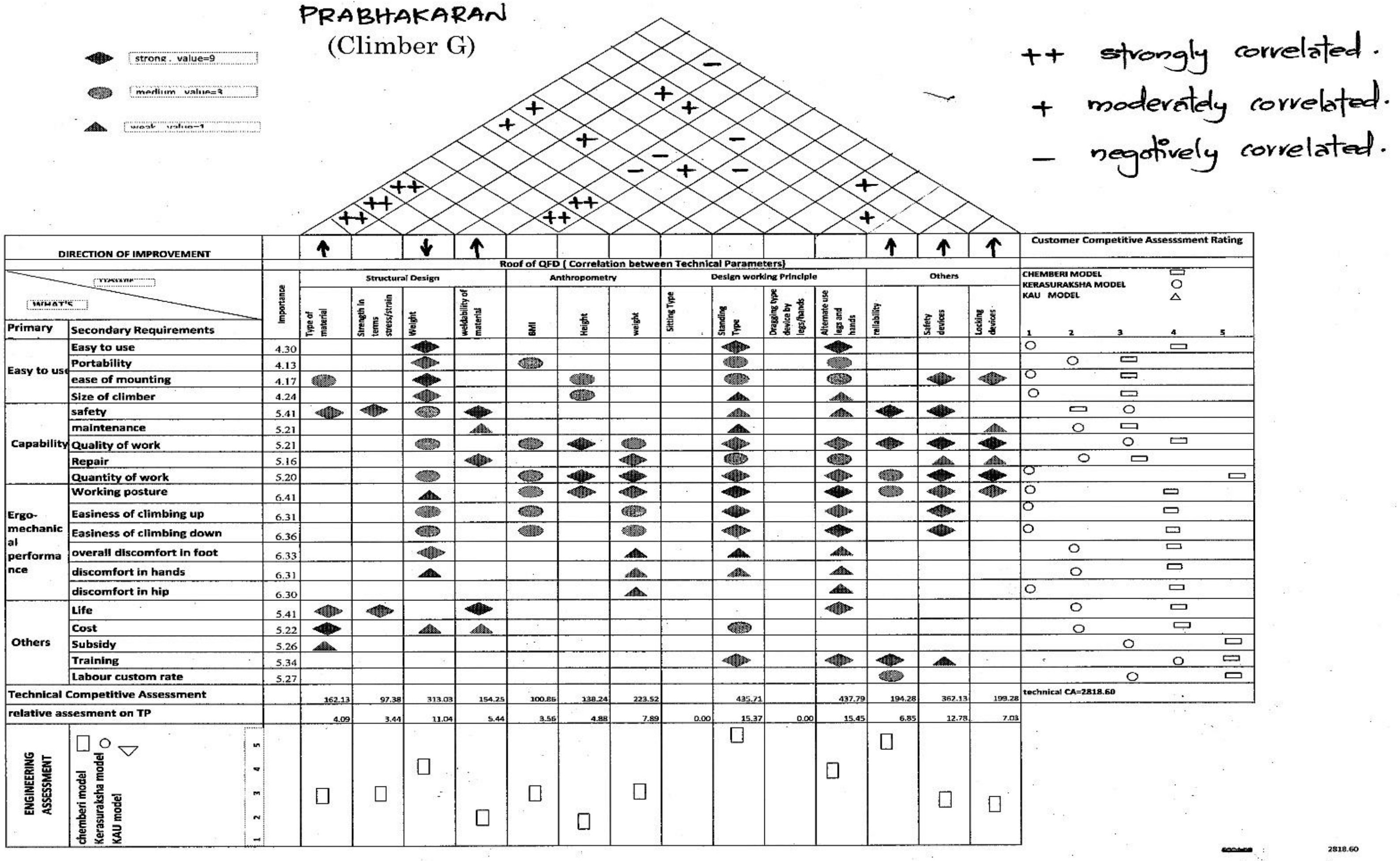
DIRECTION OF IMPROVEMENT			↑		↓	↑								↑	↑	↑	Customer Competitive Assesssment Rating				
			Roof of QFD (Correlation between Technical Parameters)																		
WHAT'S		Importance	Structural Design				Anthropometry			Design working Principle				Others			CHEMBERI MODEL ▭ KERASURAKSHA MODEL ○ KAU MODEL △				
Primary	Secondary Requirements		Type of material	Strength in terms stress/strain	Weight	weldability of material	BMI	Height	weight	Sitting Type	Standing Type	Dragging type device by legs/hands	Alternate use legs and hands	reliability	Safety devices	Locking devices	1	2	3	4	5
Easy to use	Easy to use	4.30		▲							◆		◆	◆		◆				▭	
	Portability	4.13			◆		●	◆			●		●					▭			
	ease of mounting	4.17	●		◆			●			●		●		◆	◆		▭			
	Size of climber	4.24						●	◆		▲		▲					▭			
Capability	safety	5.41	◆	◆	●	◆		▲	◆		▲		▲	◆	◆				▭		
	maintenance	5.21	●			▲			◆		▲					▲			▭		
	Quality of work	5.21					●	◆	●		◆		◆	◆	◆	◆				▭	
	Repair	5.16	◆			◆			◆		●		●		▲	▲		▭			
	Quantity of work	5.20			●		●	◆	◆		◆		◆	●	◆	◆				▭	
Ergo-mechanical performance	Working posture	6.41			▲		●	◆	◆		◆		◆	●	◆	◆				▭	
	Easiness of climbing up	6.31			●		●		●		◆		◆		◆				▭		
	Easiness of climbing down	6.36			●		●		●		◆		◆		◆					▭	
	overall discomfort in foot	6.33			◆						▲		▲							▭	
	discomfort in hands	6.31			▲						▲		▲							▭	
	discomfort in hip	6.30											◆							▭	
Others	Life	5.41	◆	◆		◆														▭	
	Cost	5.22	◆		▲						●									▭	
	Subsidy	5.26	▲																	▭	
	Training	5.34									◆		◆	◆	▲						▭
	Labour custom rate	5.27									◆									▭	
Technical Competitive Assessment			177.76	101.68	219.45	149.03	100.86	219.19	338.31		478.56		467.05	211.17	362.05	238.07	3063.18				
relative assesment on TP			5.80	3.32	7.16	4.87	3.29	7.16	11.04		15.62		15.25	6.89	11.82	7.77					

ENGINEERING ASSESSMENT

chemberi model ☐
Kerasuraksha model ○
KAU model ▽

	Type of material	Strength in terms stress/strain	Weight	weldability of material	BMI	Height	weight	Sitting Type	Standing Type	Dragging type device by legs/hands	Alternate use legs and hands	reliability	Safety devices	Locking devices
5									☐			☐		
4			☐								☐			
3	☐	☐			☐		☐						☐	☐
2				☐		☐								
1														

APPENDIX B7



PRABHAKARAN
(Climber G)

◆ strong . value=9
● medium value=3
▲ weak value=1

DIRECTION OF IMPROVEMENT			↑		↓	↑								↑	↑	↑	Customer Competitive Assesssment Rating				
			Roof of QFD (Correlation between Technical Parameters)																		
WHAT'S		Importance	Structural Design				Anthropometry			Design working Principle				Others			CHEMBERI MODEL □ KERASURAKSHA MODEL ○ KAU MODEL △				
Primary	Secondary Requirements		Type of material	Strength in terms stress/strain	Weight	weldability of material	BMI	Height	weight	Sitting Type	Standing Type	Dragging type device by legs/hands	Alternate use legs and hands	reliability	Safety devices	Locking devices	1	2	3	4	5
Easy to use	Easy to use	4.30			◆						◆		◆				○			□	
	Portability	4.13			◆		●				●		●					○	□		
	ease of mounting	4.17	●		◆			●			●		●		◆	◆	○		□		
	Size of climber	4.24			◆			●			▲		▲				○		□		
Capability	safety	5.41	◆	◆	●	◆					▲		▲	◆	◆			□	○		
	maintenance	5.21				▲					▲					▲		○	□		
	Quality of work	5.21			●		●	◆	●		◆		◆	◆	◆	◆			○	□	
	Repair	5.16				◆			◆		●		●		▲	▲		○	□		
	Quantity of work	5.20			●		●	◆	◆		◆		◆	●	◆	◆	○				□
Ergo-mechanical performance	Working posture	6.41			▲		●	◆	◆		◆		◆	●	◆	◆	○			□	
	Easiness of climbing up	6.31			●		●		●		◆		◆		◆		○			□	
	Easiness of climbing down	6.36			●		●		●		◆		◆		◆		○			□	
	overall discomfort in foot	6.33			◆				▲		▲		▲					○		□	
	discomfort in hands	6.31			▲				▲		▲		▲					○		□	
	discomfort in hip	6.30							▲				▲				○			□	
Others	Life	5.41	◆	◆		◆							◆					○		□	
	Cost	5.22	◆		▲	▲					●							○		□	
	Subsidy	5.26	▲																○		□
	Training	5.34									◆		◆	◆	▲					○	□
	Labour custom rate	5.27												●					○		□
Technical Competitive Assessment			162.13	97.38	313.03	154.25	100.86	138.24	223.52		435.71		437.79	194.28	362.13	199.28	technical CA=2818.60				
relative assesment on TP			4.09	3.44	11.04	5.44	3.56	4.88	7.89	0.00	15.37	0.00	15.45	6.85	12.78	7.03					
ENGINEERING ASSESSMENT	□ chemberi model ○ Kerasuraksha model ▽ KAU model	1 2 3 4 5	□	□	□	□	□	□	□		□		□	□	□	□					

++ strongly correlated.
\+ moderately correlated.
− negatively correlated.

2818.60

APPENDIX B8

VIJEESH

(Climber H)

◆ strong , value=9

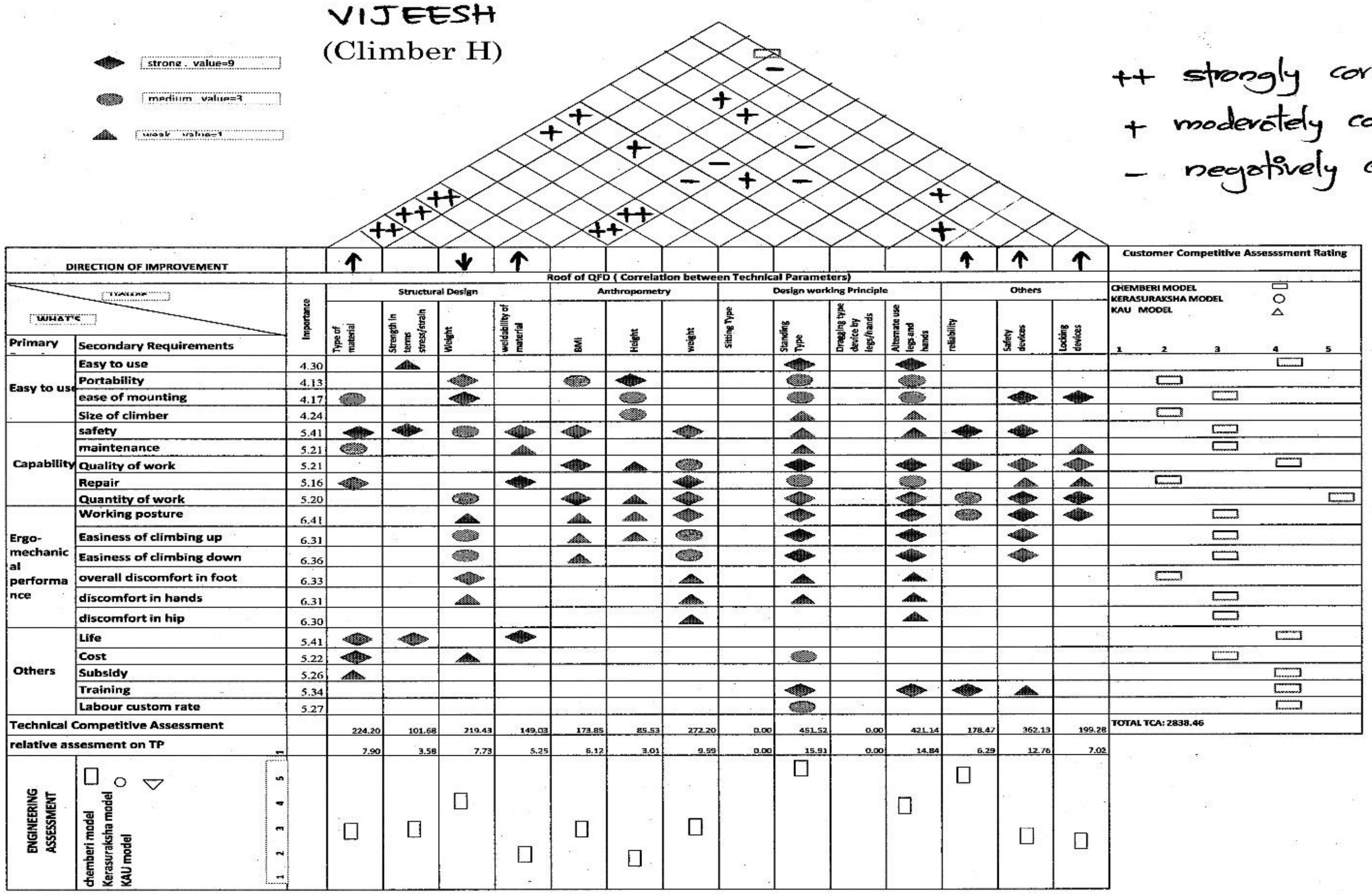
● medium value=3

▲ weak value=1

++ strongly correlated.

\+ moderately correlated.

− negatively correlated.



Roof of QFD (Correlation between Technical Parameters)

			Structural Design				Anthropometry			Design working Principle				Others			Customer Competitive Assesssment Rating				
DIRECTION OF IMPROVEMENT			↑		↓	↑								↑	↑	↑					
WHAT'S	HOW'S	Importance	Type of material	Strength in terms stress/strain	Weight	weldability of material	BMI	Height	weight	Sitting Type	Standing Type	Dragging type device by legs/hands	Alternate use legs and hands	reliability	Safety devices	Locking devices	1	2	3	4	5
Primary	Secondary Requirements																				
Easy to use	Easy to use	4.30		▲							◆		◆							□	
	Portability	4.13			◆		●	◆			●		●					□			
	ease of mounting	4.17	●		◆			●			●		●		◆	◆			□		
	Size of climber	4.24						●			▲		▲					□			
Capability	safety	5.41	◆	◆	●	◆	◆		◆		▲		▲	◆	◆				□		
	maintenance	5.21	●			▲					▲					▲			□		
	Quality of work	5.21					◆	▲	●		◆		◆	◆	◆	◆				□	
	Repair	5.16	◆			◆			◆		●		●		▲	▲		□			
	Quantity of work	5.20			●		◆	▲	◆		◆		◆	●	◆	◆					□
Ergo-mechanical performance	Working posture	6.41			▲		▲	▲	◆		◆		◆	●	◆	◆			□		
	Easiness of climbing up	6.31			●		▲	▲	●		◆		◆		◆				□		
	Easiness of climbing down	6.36			●		▲		●		◆		◆		◆				□		
	overall discomfort in foot	6.33			◆				▲		▲		▲					□			
	discomfort in hands	6.31			▲				▲		▲		▲						□		
	discomfort in hip	6.30							▲				▲						□		
Others	Life	5.41	◆	◆		◆														□	
	Cost	5.22	◆		▲						●								□		
	Subsidy	5.26	▲																	□	
	Training	5.34									◆		◆	◆	▲					□	
	Labour custom rate	5.27									●									□	
Technical Competitive Assessment			224.20	101.68	219.43	149.03	173.85	85.53	272.20	0.00	451.52	0.00	421.14	178.47	362.13	199.28	TOTAL TCA: 2838.46				
relative assesment on TP			7.90	3.58	7.73	5.25	6.12	3.01	9.59	0.00	15.91	0.00	14.84	6.29	12.76	7.02					
ENGINEERING ASSESSMENT	□ chemberi model ○ Kerasuraksha model ▽ KAU model	1 2 3 4 5	□	□	□	□	□	□	□		□		□	□	□	□					

CHEMBERI MODEL □

KERASURAKSHA MODEL ○

KAU MODEL △

2838.46

APPENDIX C

DETAILS OF THE FARMERS USING CLIMBING AIDS

Name of respondent	**Address**
Vijayakumar	Kottaparamb house, Muthuvallur (po) Kondotty Malappuram
Chandran N K	Nellikulangara house Tavanur Malappuram
Babu N K	Nellikulangara house Tavanur Malappuram
Abdul Salam	Thareparambil house Konnallur Anandhoroor
Vijeesh	Thekkepurath house Kuttypuram Nagaparamb Maniyamkaadu Malappuram
Prabhakaran	Otturkara Thrisshur
Satheesh Kumar	Akithathpadi Kumaranellur Palakkad
Sudheesh P K	Plakkattil house Tavanur Malappuram
Ramesh	Kotteruvalappil house Athalur Tavanur Malappuram

PERFORMANCE EVALUATION OF COCONUT PALM CLIMBING AID BY ANALYTICAL HIERARCHY PROCESS AND QUALITY FUNCTION DEPLOYMENT TECHNIQUES

AMAL KUMAR VP (2015-02-004)

ASWIN N (2015-02-012)

SREERAG K P (2015-02-038)

ABSTRACT

Submitted in partial fulfillment of the requirement for the degree of

Bachelor of Technology

in

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Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Farm Machinery and Power Engineering

Kelappaji College of Agricultural Engineering & Technology,

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2019

Abstract

Agricultural machinery demand is increasing day by day due to lack of skilled human power availability and increasing cost of cultivation. The growth of agro-machinery industry depends on the farmer's desire to produce more farm produce to meet requirement of food for exploding population. Coconut tree is known as "Kalpavirksham" in Kerala due to its complete utilization coconuts and wood for many other purposes. Coconut climbing is a risky job since climbers are subjected to injuries on calf muscles, wrist, hands, overall discomfort in foot, body trunk in hip etc. Above risks of palm climbers have to be overcome by using appropriate climbing aids. Today we have different types of coconut palm climbing aids in the market and under development research organizations. These climbing aids work on either sitting or standing working posture mode. No studies have been conducted yet to evaluate the needs of farmers from palm climbing aids technical specifications and other parameters. Hence, a study was conducted to evaluate the performance of the climbing aids from the climber's requirement as well as from the engineering requirements with possibility of improving design and fabrication point of view with other models of climbing aids. So, a survey study conducted and information were gathered from the coconut climbing customers and these feedbacks were evaluated according to their primary and secondary requirements. Thereafter, these customer requirements were found and accordingly the technical specifications and parameters that affect system were studied by analytical hierarchy process and quality functional deployment techniques. The relative weights of the different criteria were determined by the AHP method and it was applied in the QFD chart. The QFD chart was based on relationship between both customer as well as the engineering parameters. The survey results were applied for the development climber requirements and technical assessment of climbers. The palm climbing aids studied were mainly the Chemberi, Kerasuraksha and KAU Make models. Most of the traditional and experienced climbers preferred standing type model from the feedback survey. This project study revealed that the palm climbers' requirements were elucidated from the study based on the feedback from farmers. The climbers' opinions were sorted out and analysed by QFD approach to identify the major needs and problems the climbing aids face in the development of designing and performance.