A METHODOLOGY FOR SELECTION OF POST-DISASTER SHELTER

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Introduction

Bangladesh is faced with the perennial problem of floods and cyclones occurring every year. The existing housing for the majority of the population, particularly in the rural areas, is very weak and incapable of resisting the extreme loads generated during these natural calamities. The large-scale destruction of housing during these natural events demand major efforts for providing emergency shelter to the affected people. Assistance in providing post-disaster shelter is, therefore, one of the major concerns of the government. A large number of Government Agencies and Non-Governmental Organizations (NGO) of Bangladesh are involved in providing post-disaster assistance which includes materials for temporary shelters.

The people and agencies involved in post-disaster relief operations would naturally like to utilize their limited resources in best possible way. The various shelter options and technologies available in Bangladesh differ in cost, durability as well as quality of services provided by them. It was deeply felt that a rational approach for selecting the shelter option should be available. Bangladesh University of Engineering and Technology (BUET) was entrusted by the Aid Management Office of British High Commission, Dhaka to develop guidelines for selecting the appropriate shelter from among a wide range of alternatives. BUET organized a series of Workshops on "Post-Disaster Shelter Options" in 1994-1995, where the participants came from various national and international organizations involved in post-disaster management across the country, as well as academia. During the course of the workshops, various facts, figures and experiences concerning shelter options following a disaster was collected. BUET developed a methodology for evaluating the different shelter options, where a Value for Money (VfM) index is calculated for all options in a rational but simple manner. During the workshop deliberations, BUET showed the use of the method with the data collected from the participants. The objective of this paper is to present this methodology, which can be used by organizations involved in providing shelter materials to the poor community in the aftermath of a natural disaster. Numerical results are also presented to demonstrate the application of the method.

Post-disaster shelter options

Various shelter types have been used in post-disaster emergency situations in Bangladesh. Some of them have been meant to provide basic emergency short-term shelter and are weak in terms of strength and stability. Yet they are considered as viable choice and have been used extensively because of their low cost, easy handling and ease of fabrication. Other shelter options are much stronger and durable; however they naturally require more investment. It is necessary to weigh the relative advantages and cost of different options available for making the appropriate choice with available resources.

During the course of workshops, thirteen shelter options (S1 through S13) presented below were identified as likely choices which could be provided immediately after a disaster in Bangladesh.

Plastic Sheet-Bamboo (Shelter Option S1)

In this structure, the roof and side-walls are made of plastic sheeting tied to a bamboo framework with wire or rope (Fig.1). Bamboo poles are used as column supports. This shelter has the advantages of being the cheapest shelter, easy to handle (light weight, easy storage and transportation), salinity resistance and flexible applications. Superior quality plastic sheeting can subsequently be used to water-proof the roof of a thatch-bamboo house. Disadvantages include transparency (lack of privacy), susceptibility to fire hazard, hot in hot weather, inadequate protection against further storms due to lack of strength and short life (damage due to ultraviolet sunlight, may also be very easily damaged during use). Plastic sheets are produced locally in the country; however, superior plastic sheets may have to be imported.

Canvas Tarpaulin (Shelter Option S2)

Only jute/cotton canvas tarpaulins are delivered. The beneficiaries scavenge bamboos or tree branches to make a frame work to which the canvas is tied with wire or rope. In comparison to plastic sheeting, they are more expensive, more comfortable and provides privacy. Although they are about twice as heavy as plastic sheeting, they still have the advantage of easy handling (storage and transportation). Canvas tarpaulins can be numbered and tracked, which is preferable from a management point of view. Canvas is produced locally by a small number of firms, who may not be able to meet the large demands in the event of a major disaster. They are not available in the sub-national markets. Disadvantages include incompleteness requiring additional framework causing deforestation at those localities, high fire risk, vulnerability to insects and rodents during storage and use, inadequate strength against strong storms and short life (damage due to ultraviolet sunlight, rots if continuously wet as during monsoons, susceptible to tear).

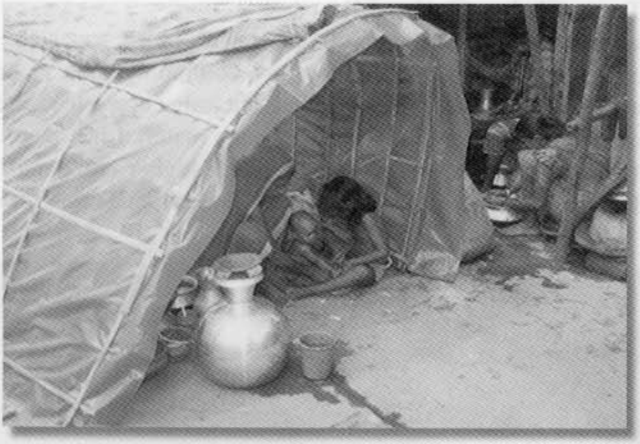

Figure 1 : Plastic sheet-Bamboo Shelter

Permatent (Shelter Option S3)

The Permatent is a complete one family emergency shelter and needs simple digging tools for its erection. It is manufactured in UK by David Sorril and Associates, UK but is being planned to be made in Bangladesh. Each Permatent unit consists of three British Steel trapezoidal profiled sheets, 1.1 m wide and 0.55 mm thick, which are crimp-curved and when interlocked together form a free standing shell type structure. (Fig. 2). The steel is hot dip galvanized, primed and a durable polyester coating applied to both surfaces. All steel sheets are marked for tracking convenience. The two endwalls are made of polyethylene backed jute canvas, one has a window and the other with the door. The floor space is about 135 sq. ft. The manufacturer claims that the Permatent has a projected minimum life of about 20 years and can be put to multiple use as temporary shelters for as many as 15 to 20 times. Advantages of such a system include completeness of structure that is easy to erect, high strength capable of resisting strong winds, maintenance free, fire resistant and easily repairable, polyester coating reflecting solar heat keeping interior cooler than other similar forms of roofing, multiple use if retrieved, re-use of permatent later as a roofing unit for a low-cost housing. Demerits are its high initial cost preventing its free distribution, large sheets being a little awkward to handle and transport, heat gain in hot weather and problems of socio-cultural acceptability of new structural form.

Canvas Tents (Shelter Option S4)

Canvas tents are distributed complete with poles, ropes etc. They are more acceptable to the people as they are commonly seen to be used by settlement officers, scouts or armed forces. They are complete shelter options, relative merits and demerits of use of canvas material has been discussed earlier. If imported, their prices may be much higher compared to locally produced tents. This type of shelter option is generally suitable for short term use.

Figure 2 : Permatent shelters

C.I. Sheet-Bamboo (Shelter Option S5)

In this option, a complete package of materials is supplied for the erection of a low-cost house with Corrugated Iron (C.I.) sheet roof with wooden or bamboo roof support and bamboo poles, and with bamboo fence side walls. Fig. 3 shows photograph of C.I. sheet-bamboo shelter. Advantages include ability to store and transport quite easily, availability of materials in local market, strength and durability, repairable locally, familiarity to local people, fire resistant, re-usable, galvanizing when new reflects sun's heat which however fades away in a few months. Disadvantages include requirement of additional tools for erection, danger of C.I. sheets fixed insecurely being flown away like giant flying blades in a major storm, susceptibility to damage in saline conditions, heat gain in hot weather. C.I. sheets are not normally marked by numbers and cannot be tracked. The critical element in such a housing would be to provide proper securing mechanism of the C.I. sheet with the framework.

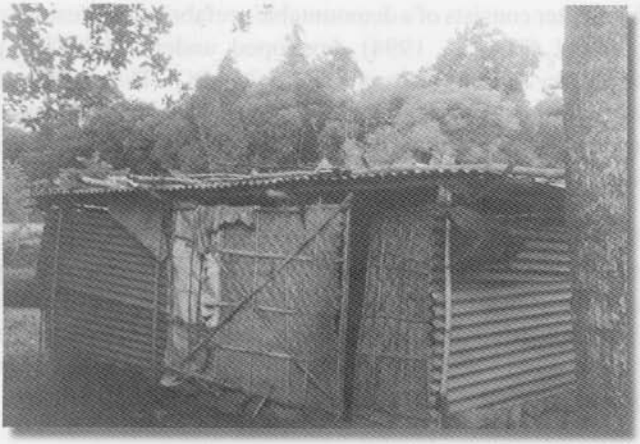

Figure 3 : CI sheet-Bamboo shelter

Thatch-Bamboo (Shelter Option S6)

This shelter option consists of a thatch (dried straw) roof supported on a bamboo frame and bamboo poles with bamboo fence walls. Figure 4 shows photograph of Thatch-bamboo shelter. The thatched roof should preferably contain polythene sheet between layers of thatch for waterproofing. This type of house would be very inexpensive but would have the disadvantage of being relatively weak against strong winds and having a much shorter life. The materials used are also very much vulnerable to fire.

C.I. Sheet-Wood-Bamboo-RC/PC columns (Shelter Option S7)

This shelter option would be similar to option S5 with the main difference of having reinforced concrete (RC) or prestressed concrete (PC) columns in addition to bamboo poles. Naturally such a house would be much stronger and resistant to winds. The pillars and poles may be embedded upto 2 feet below the ground level. The roof support system is wooden. A 10 ft. by 18 ft. house may have 6 RC columns with footing in addition to bamboo poles and have bamboo wall matting, wooden roof support and C.I. sheet roof. Such option would naturally be more expensive, require longer erection time and some skilled labour.

All PC Dryland Model (Shelter Option S8)

This shelter consists of a demountable prefabricated prestressed concrete housing model (MARC, 1994) developed under a UNCHS project by Multidisciplinary Action Research Centre (MARC). The manufacturer claims it to be sufficiently strong against cyclonic storms with speed upto 230 kmph. This long-term shelter would naturally be an expensive option and require skilled labour for erection.

Plastic Sheet only (Shelter Option S9)

Under severe circumstances, only Plastic or Polythene sheets may be distributed. The users scavenge bamboos, poles and branches to make a framework to which the sheet is fixed with rope or wire, if available. Relative merits and demerits of plastic sheeting have already been presented. A major disadvantage of not providing framework material is that deforestation at those localities will happen.

Figure 4 : Thatch-Bamboo shelter

C.I. Sheet only (Shelter Option S10)

C.I. sheets may be distributed alone without supplying materials for the framework of the shelter. The beneficiaries may prop the C.I. sheets on the ground leaning together to form a 'tent' like structure. Alternatively, they may scavenge bamboos or trees to make a framework and fix C.I. sheets as the roof using wire, ropes and nails. They themselves have to provide something such as bamboo mat walls for the side walls. Merits and demerits of using C.I. sheets have been presented earlier.

C.I. Sheet-Steel Truss (Shelter Option S11)

This shelter is similar to option S7 with the difference of having a stronger and durable roof support system consisting of steel truss instead of having a wooden roof support system.

LGED Model 10A (Shelter Option S12)

This is a long term shelter option developed by the Local Government Engineering Division (LGED) of Bangladesh. The house consists of RC pillars, ferrocement slabs for roofing on RC beam support systems and bamboo mat walls. This would require skilled labour for erection.

LGED Model 10E (Shelter Option S13)

This is another shelter option developed by the LGED and consists of steel angles as both columns and roof support system. Walls are bamboo matting and C.I. sheet are used as roofing.

Governing Factors

In developing a methodology for comparing among different shelter options, the different parameters are first identified. Factors to be considered in evaluating the Value for Money (VfM) indicator for each shelter option include the quality factors and the cost factor described below.

Quality Factor

The quality or benefit factors are the factors which the donor organization, providing shelters to disaster affected people, is looking for when deciding to buy the emergency shelter. Eleven quality factors for assessing emergency shelter options are found to be important.

1. Mobilization Time (includes procurement time plus transportation time to disaster site)
2. Ease of Storage
3. Possibility of Re-use and Multi-use
4. Time and Ease of Erection (whether tools or special skill are required)
5. Structural Strength and Stability (resistance to high winds; normally emergency shelters are placed in a place safe from surges or flood after the hazard has passed)
6. Health and Safety of Occupants (environmental protection, fire resistance etc.)
7. Social Acceptability (privacy, comfort etc.)

8. Completeness of shelter
9. Durability (life of shelter)
10. Ease of Administration (to prevent misuse and misappropriation of funds and resources)
11. Environmental Impact

Cost Factor

The cost factor is the cost per square foot of usable space inside the shelter considering use for one cycle of disaster only. This includes the following costs:

(i) Material cost
(ii) Labour cost
(iii) Transportation cost
(iv) Administration cost
(v) Storage cost

All available sources of information should be investigated to get a realistic estimate of the cost which for the same shelter option is likely to be quite different for different cases. It is quite obvious that costs for transportation, storage etc. would be very much dependent on factors such as location, locality, nature of disaster etc.

Methodology for evaluating options

A new methodology is proposed which integrates all pertinent factors into a single Value for Money (VfM) index. It is based on a methodology developed for overall technology assessment by Sharif and Sundararajan (1983). Their method, however, appears to be too rigorous and intricate for general use by the disaster managers. The suggested method is much simplified, yet rationally takes into account the interplay of all factors.

The different steps to be followed in the proposed methodology are described below. Numerical data received from the workshop participants including two reports by MARC (1994) and EDM (1994) are used in the demonstration of the method. Finally ranking of the different shelter options based on Value for Money is presented. It may be noted that this ranking cannot be directly used, since very limited data was obtained.

Weightage of Quality Factors

The weightage, in other words the relative importance index, for the different quality factors need to be established. The weightage reflects how important these factors are in meeting the objectives of the post-disaster shelter from the donor's point of view. The following procedure is recommended for the determination of weightage. First determine which factor is of the least importance. Put a score of 1 (one) for the least important factor. Now compare the other factors with this factor. If the other factor is equally important, put 1 for that factor also. If not, put a score to the other factor on a scale of 3 to 9 following the general guidelines given in Table 1. Further guidance is given in the table on page 78.

TABLE 1 : Guidelines for determining Weightage (scale of 1 to 9)
(Scores of 2,4,6,8 may be given if deemed appropriate.)

Weight-age	Definition	Explanation
1	Equal Importance	Importance of this factor and the weakest factor is similar
3	Weak Dominance	Experience or judgement slightly favours the factor over the weakest one
5	Strong Dominance	Experience or judgement strongly favours the factor over the weakest one
7	Demonstrated Dominance	Dominance of the factor over the weakest factor has been obviously seen from past experience
9	Absolute Dominance	Evidence favouring the factor over the weakest factor has been affirmed to highest possible level

The weightage (W_i) of the eleven quality factors is taken as the mean value of the data received from the workshop participants, as shown in Table 2. The maximum and minimum values received are also presented to give an indication of variation of participant response.

Relative Quality Scoring

Each of the shelter options is now given a relative Quality Score (Q_i) in a scale of 1 through 9, when considering each of the eleven quality factors. Each row of Table 3 presents relative scoring of the various shelter options when considering a particular quality factor. For the eleven quality factors, there are eleven sets of guidelines for scoring, which are listed in the Appendix. Table 3 represents average value of scores that were received from the workshop participants. The variation is not presented here, but it needs to be noted that significant variation can exist due to lack of knowledge about the different shelter options. The response received had also large variations for some cases and it is considered best to use the average value.

Table 2 : Weightage for the Quality Factors

Q.F. No.	Quality Factor (Q.F.)	Mean (W_i)	Maximum	Minimum
1	Mobilization time	8.5	9.0	7.0
2	Ease of storage	6.5	7.0	5.0
3	Reuse/multiuse	6.5	7.0	5.0
4	Erection	7.3	8.0	7.0
5	Strength/stability	5.8	7.0	5.0
6	Health/safety	5.8	9.0	2.0
7	Social acceptability	4.3	8.0	1.0
8	Completeness	6.3	7.0	5.0
9	Durability	6.0	7.0	5.0
10	Administration ease	7.3	8.0	7.0
11	Environmental impact	5.5	8.0	3.0

Value for Money (VfM)

The proposed methodology is based on the rational determination of a Value for Money (VfM) index for each shelter option. The "Value" is a measure of the overall quality of the option, while the "Money" stands for its cost. Based on available resources and VfM index, the donor can choose the appropriate shelter.

The "Value" of a particular shelter option is a complex combination of the different quality factors, some of which may be partially overlapping. A simple and rational method to obtain the Value would be:

$$\text{Total Value} = \sum_{i=1}^{11} W_i Q_i$$

The "Value" for a particular shelter option is thus determined by multiplying the different quality scores by their corresponding weightages (Table 2) and adding them up, as shown in Table 3. This Table (bottom row) also includes the total Cost per square foot of usable area for each shelter option. The "Value for Money" index (VfM) is obtained by dividing the "Value" by the "Cost".

$$\text{VfM} = \frac{\text{Total Value}}{\text{Total Cost per sq.ft. of usable space}}$$

Ranking of Shelter Options

Table 4 gives the VfM index and relative ranking of all shelter options, based on data of Table 3 . The option with the highest VfM score will naturally be the best choice to the post-disaster aid giving agency.

It should be noted that the VfM value for shelters may change for different disasters, regions, time periods, market situations etc. The relative ranking of various shelter options in Table 4 are based on the assumption that the materials used in making the shelters are not re-used.

If it is possible to retrieve shelter materials or obtain the cost from the disaster affected people at the end of crisis, for shelters of durable components, the possibility of re-use in future post-disaster situations opens. Re-use is considered for some shelter options, as described in Table 5. Due to re-use, the cost factor decreases (compare with Table 4) and the VfM index increases. Table 5 presents the new ranking for this case. Whether the shelter materials are at all retrievable from the poor people needs to be verified in the field, before considering re-use.

Table 3: Relative quality scoring of shelter options with respect

		Shelter Options				
QUALITY FACTORS	Wi	S1	S2	S3	S4	S5
Mobilisation time	8.5	5.3	7.3	4.3	6.3	5.0
Ease of storage	6.5	7.0	6.7	4.7	6.7	6.3
Reuse/multiuse	6.5	6.3	6.0	4.0	4.7	7.0
Erection	7.3	8.0	7.0	7.7	7.7	6.0
Strength/stability	5.8	2.0	3.0	7.0	4.3	5.3
Health/safety	5.8	2.7	3.3	6.0	4.3	5.0
Social acceptability	4.3	6.5	4.7	4.7	5.0	7.0
Completeness	6.3	7.0	5.0	7.0	7.3	6.3
Durability	6.0	2.3	4.0	7.3	4.0	5.7
Administration	7.3	5.7	7.0	6.0	7.3	5.0
Environmental impact	5.5	2.3	4.3	6.7	6.0	6.7
TOTAL VALUE SCORE		**357.3**	**382.7**	**413.5**	**411.5**	**412.0**
Cost, Taka/sqft (US$/sqft)		34 (0.75)	30 (0.66)	100 (2.22)	44 (0.98)	70 (1.56)

to selected quality factors (Average Value)

Shelter Options (continued)							
S6	S7	S8	S9	S10	S11	S12	S13
4.3	4.0	2.3	9.0	7.0	5.7	2.0	3.3
4.7	4.7	2.7	9.0	7.3	6.0	3.3	3.3
4.3	6.7	3.7	5.0	8.0	7.7	4.3	7.7
5.7	4.3	1.0	6.3	5.7	4.0	2.3	3.0
5.0	7.0	8.7	1.7	3.7	7.0	7.0	8.3
4.0	6.3	8.0	2.3	3.0	7.0	7.7	8.3
5.0	7.7	7.0	2.3	5.7	8.3	6.7	7.7
6.7	6.7	6.7	5.0	4.7	4.7	6.0	6.7
4.0	7.3	9.0	2.3	6.0	7.3	7.7	8.0
5.3	5.0	2.7	8.0	6.7	6.3	2.7	3.7
7.3	4.7	7.7	3.0	4.7	6.3	7.3	7.3
355.4	**398.1**	**353.7**	**310.7**	**404.3**	**437.6**	**321.4**	**408.2**
38 (0.84)	94 (2.09)	300 (6.66)	25 (0.56)	35 (0.78)	80 (1.78)	156 (3.47)	115 2.56)

TABLE 4 : VfM Score & Ranking of Shelter Options

Code	Shelter Option	Total Value	Cost (Tk/Sft.)	Value for Money (VfM)	Rank
S1	Plastic sheet-Bamboo	357	34	10.5	4
S2	Canvas Tarpaulin	383	30	12.8	1
S3	Permatent	414	100	4.1	10
S4	Canvas Tents	412	44	9.4	5
S5	C.I. Sheet-Bamboo	412	70	5.9	7
S6	Thatch-Bamboo	355	38	9.3	6
S7	C. I. sheet-Wood -Bamboo-RC/PC columns	398	94	4.2	9
S8	All PC Dryland Model	354	300	1.2	13
S9	Plastic Sheet only	311	25	12.4	2
S10	C.I. Sheet only	404	35	11.5	3
S11	C.I. Sheet-Steel Truss	438	80	5.5	8
S12	LGED Model 10A (PC-FC)	321	156	2.1	12
S13	LGED Model 10E (C.I. sheet-steel angle)	408	115	3.5	11

TABLE 5 : VfM Score & Ranking of Shelter Options (Considering Re-Use of Shelter Materials)

Code	Shelter Option	Total Value	Possibility of reuse	Cost (Tk/Sft.)	VfM	Rank
S1	Plastic Sheet-Bamboo	357	No re-use likely	34	10.5	7
S2	Canvas Tarpaulin	383	Second use of one third inputs	25	15.3	2
S3	Permatent	414	Four re-use of four fifth inputs	36	11.5	4
S4	Canvas Tents	412	Second use of one third input	36.5	11.3	5
S5	C.I. Sheet-Bamboo	412	Two re-use of half inputs	47	8.8	9
S6	Thatch-Bamboo	355	No re-use likely	38	9.3	8
S7	C. I. Sheet-Wood-Bamboo-RC/PC columns	398	Two re-use of half inputs	70	5.7	10
S8	All PC Dryland Model	354	No re-use, likely to be permanent	300	1.2	13
S9	Plastic Sheet only	311	No re-use likely	25	12.4	3
S10	C.I. Sheet only	404	Two re-use of	23	17.6	1
S11	C.I. Sheet-Steel Truss	438	Two re-use of three-fourth inputs	40	11	6
S12	LGED Model 10A(PC-FC)	321	No re-use, likely to be permanent	156	2.1	12
S13	LGED Model 10E (C.I. Sheet-Steel Angle)	408	Two re-use of three-fourth inputs	86.5	4.7	11

Discussions of the Results

The data that forms the basis of the results presented here are drawn from the response of workshop participants and reports (MARC, 1994; EDM, 1994) presented at the workshop. The outcome of this study cannot be directly applied as very limited response was received from the participants of the workshop. More extensive data is required for obtaining reliable VfM values that can directly be used.

The Value for Money (VfM) considered here is the value for the donor or aid-giving agencies' money. The unit costs (Taka per sq.ft of usable space) are considered for short term use for one cycle of disaster only, which is one year. Practical experience of NGOs and relief organizations working in Bangladesh indicate that most or all shelters are non-retrievable after distribution in a disaster. However, reuse and multi-use of shelter/shelter material by end users may still be considered an important shelter quality or attribute from the donor's point of view. The results are likely to be sensitive to changes in geographical location (with probable changes in transportation facilities and market facilities), type of disaster (flood or cyclone), etc.

Both the weightage of quality factors (Table 2) and relative quality scoring of shelter options against each of these factors (Table 3), were obtained as a mean of scores provided by the workshop participants. Their response showed a large difference in perception among different donor agencies with regards to some of the factors viz. Health/Safety, Social Acceptability, Completeness and Environmental Impact. Regarding the other quality factors there is a great similarity in view regarding their importance. If the sample size was large, statistical measures such as standard deviation and level of confidence would provide a valuable guide to the reliability of the scores obtained. As the sample size was very small such statistical analysis would be of no meaningful significance and was not carried out. A practically acceptable result can only be obtained after statistically evaluating responses received from a large group of participants.

Conclusions

Relief and rehabilitation programs for disaster affected communities, following floods and cyclones, have a regular occurrence in Bangladesh. The donor or aid giving agency, in the absence of an accepted analysis procedure, is often faced with the difficult problem of selecting a particular shelter from among a wide variety of shelter options available. A simple methodology has been proposed for the rational determination of a Value for Money (VfM) index for each shelter option. Evaluation of VfM is done from the relief manager or donor's point of view, keeping cost and quality of the shelter option as separate factors. The donors or disaster managers can use this index to judiciously select the shelter. The cost, hence the VfM index, for the same option may vary depending on factors such as geographical location, local market conditions, type of disaster, etc. The cost corresponds to use of shelters for short term (one year) only. If a particular shelter can be retrieved and re-used in future needs, the cost would be accordingly reduced. This, however, needs to be verified in practice. The purpose of presenting numerical results is to give an illustration of how to apply this methodology and to present an average representation of whatever limited data that was received. It is recommended that extensive data be collected in order to obtain a reliable assessment of the VfM index for the shelter options.

Acknowledgements

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Appendix:

Table A-1 : Guidelines for scoring different shelter options with respect to various quality factors

	Weightage		
Q. F. No.	9	5	1
1	< 1 day to mob.	15 days	>45 days
2	Easy	Average	Difficult
3	Always reused	Sometimes reused	Never reused
4	<1day to erect	10 days	>30 days
5	Stable under extreme hazards	Stable under normal conditions	Weak
6	Ensures health & safety under all situatons	Ensures health & safely under normalconditions	Always unsafe for occupants
7	Totally acceptable	Acceptable with reservations	Local people totally reject the option
8	Shelter provided is complete	Requires some additi-onal material by user	Requires maximam extra material by user
9	Shelter life> 20yrs	5 yrs	< 0.5yrs
10	perfectly manageable	Manager experiences some problems	Extreme manage-ment problems
11	No impact on environment	Average adverse impact	High adverse impact on environment