An AHP-QFD integrated approach for mitigating barriers of corporate sustainability

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ABSTRACT

Corporate sustainability is now considered as one of the major policy issues by the businesses due to the high profile corporate failures in an attempt to promote good governance. Corporate social responsibility is also a vital part of staying competitive as it helps to retain talented staff and to satisfy customers' expectations. Although a limited number of research works can be found on the barriers of corporate sustainability but the endeavour to mitigate those barriers is still scarce. Therefore, this study attempts to identify the critical barriers of corporate sustainability and demonstrate the process of mitigating those barriers with AHP integrated QFD framework with a comprehensive case study. Study finds that the mitigation requirements fall under strategic, tactical and operational management areas.

Keywords: Corporate sustainability, AHP, QFD, Mitigation, Barriers.

1. INTRODUCTION

The terminology 'sustainability' is an evaluation on more conventional phrases describing ethical and moral corporate practice. Corporate sustainability (CS) is about business dedication to contribute to sustainable development, more specifically for environment, society, economic development and to consider the need of all stakeholders' expectation. The World Business Council for Sustainable Development (WBCSD) brought widespread attentions to the notions of sustainability and sustainable development to the boardrooms of organizations (Schaltegger & Burritt, 2000). The United Nations (UN) world summit 2005 describes the three pillar of sustainability: environmental sustainability, social sustainability, and economic sustainability. These pillars or the "triple bottom line" served as a common ground for numerous sustainability standards in business, such as, Global Reporting Initiative (GRI), the Dow Jones Sustainability Index (Jones, 2005), and International Standard Organizations (ISO) 14001(Delai & Takahashi, 2011). Figure 1 shows the three dimensions of CS.

Environmental sustainability refers the maintenance of natural capital (Goodland, 1995). Scholars argue that the depreciation of natural capital cannot go on endlessly (Lovins, Lovins, & Hawken, 1999). Social sustainability mainly focuses on the corporate social responsibility (CSR) practice of the businesses. CSR is the obligation of the firm to its stakeholders – people and groups – who can affect or who are affected by corporate policies and practices. The fulfilment of these obligations is intended to minimize any harm and maximize the long run beneficial impact of the firm on society (Bloom &

Gundlach, 2000). Economic sustainability focuses on that segment of the natural resources base that provides physical inputs, both renewable and exhaustible, into the production process (Goodland, 1995). For example, financial capital, such as, debt-equity, tangible capital and intangible capital need to be managed sustainably to produce maximum outputs. In recent years, CS is considered as a major policy issue due to the high profile corporate failures in an attempt to promote good governance (Aaronson, 2002). Violation of social and environmental issues is not unlikely in the corporations of many countries such as Bangladesh, Pakistan and others (Naeem & Welford, 2009) and more specifically in human intensive organizations such as ready-made garment (RMG) industry (Islam and Deegan, 2008; Ahmed, 2009). These sorts of non-compliance of social and environmental issues often cause unrest in corporations and create barrier to the route of sustainability (Hossan, Sarker, & Afroze, 2012). The study of Hossain, Rowe and Quaddus (2012) also extracted some of the barriers of corporate sustainability. Whilst a diminutive number of research works can be found on the drivers and barriers of CS but the endeavour to mitigate those barriers of sustainability is still scarce. But CSR is now a vital part to stay competitive, because it helps to retain talented staff and to satisfy customers' expectations (Lo & Sheu, 2007). Consequently, this study will identify the barriers of CS and show the process of mitigating those barriers with AHP integrated QFD framework. The following section of the article covers the background of this research. Section 3 explicates the research methodology used for this approach. A comprehensive case study with sustainability barriers and mitigation approach is covered in Section 4. Section 5 is consists of discussion on findings and further research direction; and finally, Section 6 concludes the article.

2. BACKGROUND

2.1 Sustainability and barriers

Organizations now face lot of pressures for sustainable behaviour from the stakeholders such as employee, community groups, NGOs, environmental activists, governments and regulatory authorities (Setthasakko, 2009). Previous studies explore the drivers and determinants of CS and analyse managerial perceptions on CS and related concepts (See, for example, (Bansal & Roth, 2000; Belal &

Owen, 2007; Bowman, 1978; Hossain, et al., 2012)). These studies mainly examine the managerial motivations towards CSR or CS. Due to the pressures from internal and external stakeholders such as regulators, internal competition within industry, customers and investors, organizations practice sustainability (Haigh & Jones, 2006). International buyers also create pressure on companies to comply with the sustainability rules (Belal & Owen, 2007; M. A. Islam & Deegan, 2008). Scholars have emphasized on the contextual factors of the sustainability, such as, country of origin, political environment, economic, social, cultural, ethical, media and NGO pressures towards sustainability (Sobhani, Amran, & Zainuddin, 2011). Many studies have been done on the drivers of sustainability, too. But to date, a very little research has been done to concentrate on identifying barriers of CS. Setthasakko (2009) conducted exploratory in-depth analysis which identified three key barriers towards CS: lack of sustainable framework, absence of top management commitment, and cultural diversity. A recent study by Hossain, Rowe and Quaddus (2012) explore the barriers of corporate, social, and environmental practices within developing country context. They report that lack of regulatory framework, socio economic problems, lack of awareness and sustainable education, lack of initiative from government, resource constraints and tendency to disobey laws are the main barriers perceived by senior managers. Maximiano (2005) find that lack of resources is the main barriers for CS followed by lack of linkage between sustainability and business strategy, and lack of awareness among employees. Although a very few scholars have emphasised on the barriers of CS but the attempt to mitigate those barriers of sustainability is rare. In this theoretical lacuna this study identifies the barriers of CS and shows the process of mitigating those barriers with QFD framework.

2.2 Theoretical background

A wide range of theories have been use to explain the organizations social, environmental and economic sustainability (Deegan, 2009). In corporate sustainability literature, it is observed that the frequently used theories are legitimacy theory and stakeholder theory. Legitimacy theory asserts that organizations survival depends on both by the market forces and community expectations. Therefore, it is essential to understand the community expectation for the organizational survival in the society (M. Islam, 2009). It is evident that to become legitimate, organizations may confirm with, or in a

number of different ways, attempt to alter social perceptions, expectations, or values as a part of legitimating process (See, for example, (Dowling & Pfeffer, 1975; Lindblom, 1994; O'Donovan, 2002)). The CS practices, such as, social, environmental, and economic sustainability can change the stakeholder perceptions and that ultimately help organizations to gain legitimacy. Donaldson and Preston (1995) argue that stakeholder theory gain continuous research attention, which is apparent by the dozen of books and more than 100 journals, published in very recent time. According to Freeman's stakeholder theory, organizations have responsibilities to their shareholders and other interested groups (Freeman, 1984). To Freeman, the task of management is to maintain a balance among the conflicting interests and claims of stakeholders. If a balance cannot be ensured organizational sustainability will be questioned. With the passage of time organizations are experiencing different types of internal and external changes and challenges from a customers, suppliers, government, competitor, pressure groups and so on (Freeman, 1984). In this situation organizations need the capacity to change of concept and strategies to respond for mitigating uncertainties and barriers to gain sustainability (Freeman, 1984). In line with this it can also be advocated that a management framework and response are needed to mitigate the sustainability barriers existing in the businesses. Motivated from the previous research, this paper also uses the application of the above mention theories to mitigate the CS barriers using QFD approach.

2.3 Methodological background

Recently, companies are successfully using QFD as a powerful tool that addresses strategic and operational decisions in businesses (Mehrjerdi, 2010). This tool is used in various fields for determining customer needs (Stratton, 1989), developing priorities (C. H. Han, Kim, Choi, & Kim, 1998), formulating annual policies (Philips, Sander, & Govers, 1994), manufacturing strategies (Crowe & Cheng, 1996; Jugulum & Sefik, 1998), and environmental decision making (Berglund, 1993). Chan and Wu (2002) and Mehrjerdi (2010) provide a long list of areas where QFD has been applied. According to Vinod and Cintha (2011), QFD enables the organisation to identify the

improvement areas thereby enabling the improvement in sustainability. Therefore, the QFD model can also be used to identify the important sustainability barriers and to develop design requirements corresponding to those barriers. QFD, in this approach, will be applied as the main tool to analyse the sustainability barriers. It will also be used to develop and select design requirements to mitigate those barriers based on organisations' strategic, tactical, and operational capability for the sustainability of the businesses (See Figure 4). In QFD modelling, 'requirements' are referred as WHATs and 'how to fulfil the requirements' are referred as HOWs (See Figure 2). The process of using appropriate HOWs to meet the given WHATs is represented as a matrix. Six sets of input information are required in a basic QFD model: (i) WHATs; (ii) IMPORTANCE of WHATs (iii) HOWs; (iv) CORRELATION MATRIX; and (v) RELATIONSHIP MATRIX (Mukherjee, 2011).

Analytic Hierarchy Process (AHP) was originally developed by Saaty (1980) which is an established multi-criteria decision making approach that employs a unique method of hierarchical structuring of a problem and subsequent ranking of alternative solutions by a paired comparison technique. AHP is frequently used in QFD process, for instance, Georgiou et al. (2008), Han et al. (2001), Das and Mukherjee (2008) Lu et al. (1994), Armacost et al. (1994), Park and Kim (1998), Mukherjee (2011), Koksal and Egitman (1998), Bhattacharya et al.(2005), Hanumaiah et al. (2006), Lam and Zhao (1998), Chan and Wu (1998), Han et al. (2001), Xie et al. (1998), Wang et al. (1998) and more. In this research approach, based on the requirements of sustainable development AHP will be used to prioritize the sustainability barriers before developing design requirements in QFD process.

3. RESEARCH METHODOLOGY

Research paradigm can be classified as two types: positivist and interpretivist (Onwuegbuzie & Leech, 2005). In positivist research reality is independent from the researcher and the research is objective oriented (Johnson & Onwuegbuzie, 2004; Smith, 1983) and data collection, analyses are value-free rather than subjective interpretation (Krauss, 2005). Further, positivist paradigm is associated with the quantitative research based on specific research question and hypotheses testing (Creswell, 2003; Johnson & Onwuegbuzie, 2004). On the other hand, interpretivist paradigm relies on the qualitative

method and there is subjective interpretation of researcher because the advocates of this paradigm believe that the researcher should have interaction and subjective involvement with issues being researched (Creswell, 2003). This research approach complies with the framework of positivist paradigm as the research is very much objective oriented. This research approach has the objective to identify critical sustainability barriers and corresponding mitigation requirements using AHP integrated QFD. QFD has been used frequently in object oriented research. In a QFD analysis the following steps are followed:

Step 1: Identification of sustainability barriers that are termed as WHATs;

Step 2: Relative importance ratings of WHATs are determined by using AHP method;

Step 3: Design requirements (HOWs) to mitigate barriers are generated;

Step 4: Correlation between design requirements (HOWs) are determined;

Step 5: Relationships between WHATs and HOWs are determined;

Step 6: Relative importance of HOWs are determined;

Step 7: Based on the rankings of weights of HOWs the design requirements are selected.

Before developing the QFD framework the relative importance ratings of WHATs are determined by using AHP method (Quaddus & Siddique, 2001) as shown in Figure 3. In developing the QFD framework the relationship between sustainability barriers and corresponding mitigation design requirement (DR) is described as *Strong, Moderate, Little,* or *No* relationship which are later replaced by weights (e.g. 9, 3, 1, 0). These weights are used to represent the degree of importance attributed to the relationship. Thus, as shown in Table 1, the importance weight of each design requirement can be determined by the following equation:

$$D_w = \sum_{i=1}^{n} A_i R_{iw} \qquad \forall_w,\ w = 1, \ldots\ldots, m \quad \ldots\ldots\ldots (1)$$

Where,

D_w = Importance weight of the wth design requirement;

A_i = Importance weight of the ith sustainability barriers;

R_{iw} = Relationship value between the ith sustainability barriers and w th design requirement;

m = Number of design requirements;

n = Number of sustainability barriers.

In Table 2, social sustainability barriers, environmental sustainability barriers and economic sustainability barriers are considered as part of the overall sustainability barriers. The importance weight of the sustainability barriers is calculated using AHP by discussion with the executives of companies. According to the QFD matrix the absolute importance of the sustainability barriers can be determined by the following equation:

$$AI_i = \sum_{i=1}^{n} R_i D_w \qquad \forall_w,\ w = 1, \ldots\ldots, m \qquad \ldots\ldots\ldots\ldots\ldots (2)$$

Where,

AI_i = Absolute importance of the ith sustainability barrier (VR_i);
R_i = Importance weight of the ith sustainability barrier;
D_w = Importance weight of the wth capability design requirement;

Therefore, the absolute importance for the 1st social sustainability barrier (VR_{i1}) will be:

$$AI_{i1}^{SC} = R_{i1}D_{w1} + R_{i1}D_{w2} + \ldots\ldots + R_{i1}D_{wm}$$

Thus, the relative importance of the 1st social sustainability barrier (BVR_{i1}) will be:

$$RI_{i1}^{SC} = \frac{AI_{i1}}{\sum_{i=1}^{n} AI_i} \qquad \ldots\ldots\ldots\ldots\ldots (3)$$

Where,

RI_{i1}^{SC} = Relative importance of the 1st social sustainability barrier (VR_{i1});
AI_{i1}^{SC} = Absolute importance of the 1st social sustainability barrier (VR_{i1});

Similarly, the absolute importance and the relative importance of all other vulnerabilities (SCs, ENs, and ECs) can be determined by following the Equations (2) and (3). Now, the absolute value for the first design requirements (DR_1) will be:

$$AI_{d1} = R_{i1}D_{w1} + R_{i2}D_{w1} + \ldots\ldots + R_{in}D_{w1}$$

In the same way, the relative importance of the 1st design requirements can be determined by the following equation:

$$RI_{d1} = \frac{AI_{d1}}{\sum_{d=1}^{n} AI_d} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where,

RI_{d1} = Relative importance of the 1st capability design requirement (DR_1);

AI_{d1} = Absolute importance of the 1st capability design requirement (DR_1);

If we assume that there are n total barriers which include n_1 social sustainability barriers, n_2 environmental sustainability barriers, $and\ n_3$ economic sustainability barriers and then,

$$n_2 = n - (n_1 + n_3 + n_4)$$
$$n_3 = n - (n_1 + n_{2+n_4})$$

Again, if we consider w_c, w_b, and w_p as the weights of the social sustainability barriers (SCs), environmental sustainability barriers (ENs), and economic sustainability barriers (ECs) decided by the decision makers respectively, then,

$$w_H + w_O + w_F + w_D = 1$$

Therefore, the relative importance of sustainability barriers can be determined as follows:

$$RI_i^{VR} = w_H RI_i^{HV} \qquad i = 1,2,\ldots\ldots,n_1$$
$$RI_i^{VR} = w_O RI_i^{OV} \qquad i = n_1+1, n_1+2,\ldots\ldots,n_2$$
$$RI_i^{VR} = w_F RI_i^{FV} \qquad i = n_2+1, n_2+2,\ldots\ldots,n3$$
$$RI_i^{VR} = w_D RI_i^{DSV} \qquad i = n_3+1, n_3+2,\ldots\ldots,ns$$

Now if we assume that there are n number of sustainability barriers and for them we need m number of capability design requirements then the rating R_{qt} between each pair of the q^{th} social sustainability barriers (SCs) and the t^{th} design requirements (DR_t) is acquired from a teamwork (Özgener, 2003; H.-F. Wang & Hong, 2007) with the weighting value of 0-1-3-9 to represent no, weak, moderate, or strong relationship. The initial absolute importance and the relative importance of all other design requirements can be determined by following the Equation (1) and (4). Based on the example of social sustainability barriers weights in Equation (2) and Equation (3) we can determine the normalised ratings of social sustainability barriers and mitigation design requirements.

4. CASE STUDY

Bangladesh, a small country of south Asia, has gained substantial economic progress and considered one of the growth generating countries of the world. Despite its achievements within 41 years of independence, the country is still struggling for its poor socio political condition and governance and

lack of a sustainable development plan (Belal & Owen, 2007). Most of the companies are found to be failing to comply with the aspects of corporate social, and environmental issues (Naeem & Welford, 2009). Bangladeshi organizations are accused of existing poor working conditions, inadequate factory health and safety measures, violation of human rights, environmental pollution, and the use of child labour (Belal & Owen, 2007; M. A. Islam & Deegan, 2008); (Naeem & Welford, 2009). These issues are often highlighted in western media and created negative image of Bangladeshi products in the mind of consumers (M. A. Islam & Deegan, 2008). There are a number of issues that are responsible for poor corporate, social, and environmental practices. For example, lack of written corporate, social, and environmental policies (Naeem & Welford, 2009), lack of intention of the owners of the firms lack of corporate governance are few among the lot.

Social and environmental issues are more vibrantly echoed in RMG industry of Bangladesh because of the nature of industry and its economic importance for the country. RMG industry is an economic propeller of Bangladesh and accounts for 76% of total export earnings and over 3.5 million employments of which 80% are women. Moreover, the industry has grown from 31.57 million US dollar business in 1983 to 10699.8 million US dollar in 2008 (BGMEA report 2007-2008); and Bangladesh is the second largest exporter of RMG in the world. Sustainability in RMG supply chain is necessary as RMG supply chain is facing a climax situation owing to social, environmental and economic challenges. These challenges are inhibiting the sustainability of the industry. Labour unrest for breaching social compliance issues such as poor wages, poor and hazardous working environment, human rights often occurs in the industry (Ahmed, 2009). Moreover, political instability, interruption in utility supply especially power shortage, inefficiency in customs and port management, exchange rate fluctuation, disruption in supply of raw material in time, increased competition, inefficiency in operation, intensive competitive pressure from China and India, failure to comply social and environmental issues demanded by the buyers are highlighted barriers in the route to sustainability of the industry (BGMEA, 2009; Haider, 2007; M. A. Islam & Deegan, 2008; Paul-Majumder, 2001); often create. Furthermore, increased lead time and costs due to disruptions in procurement and shipment of goods (Nuruzzaman, 2009), lack of linkages and co-ordination among related industries in

the value chain and dependence on imported inputs and limited variety finished products (Nuruzzaman, 2009; Quasem, 2002), fall of order because of global economic downturn (BGMEA, 2009) are considerable threats to RMG industry of Bangladesh. The prevalence of such barriers to sustainability and existence of theoretical gap regarding mitigation of sustainability barriers have motivated the researchers to conduct the study particularly, on RMG industry of Bangladesh.

4.1 Identification of sustainability barriers (WHATs):

a) **Internal social barriers of the company:** (i) Lack of awareness and knowledge of the employees (Awareness of employees); (ii) Lack of awareness and knowledge of the employer (Awareness of employer); (iii) Noncompliance of some social issues in organization (Noncompliance); (iv) Lack of interest of the owners to comply the social issues (Interest); (v) Absence of sustainability as organizational strategy and culture (Strategy and culture); (vi) Adequate governance by the supply chain members (SC governance); (vii) Lack of written policies and reporting practice (Written policies SC governance); (viii) Cost and resource constraint to comply social issues (Resource); (ix) Absence of Social and environmental reporting (Reporting); (x) Lack of regulatory framework and enforcement of law (Law); and (xi) Lack of regulatory framework and enforcement of law (law). (See Figure 5)

b) **Internal environmental barriers of the company:** (i) Lack of awareness and knowledge of the employees (AW EMS); (ii) Lack of awareness and knowledge of the employers (AW EMR); (iii) Lack pollution controlling measures by the organizations (POLN CTR); (iv) Lack of interest of the owners to comply with environmental issues (Interest); (v) Absence of sustainability as organizational strategy and culture (SUS ST); (vi) Adequate governance by the supply chain members regarding environmental issues (SC GOV); (vii) Lack of written policies and reporting practice (Wrt pol); (viii) Cost and resource constraint to comply environmental issues (Cost); (ix) Lack of regulatory framework and enforcement of law (legal); and (x) Lack of government incentives (GOV inct). (See Figure 6)

c) **Economic issues:** (i) Infrastructure problem such as port, customs, transportation problem (Infstr); (ii) Utility problem (Utility); (iii) Dependence on imported material (Imp Mat); (iv) Lack of

backward linkages (Bck Link); (v) Lack of skilled and efficient employees (Eff emp); (vi) Shortage and high cost of fund (Fund); (vii) Political instability (POL inst); (viii) Operational disruptions (Op dis); and (ix) Fluctuation of raw material price and currency price (price fln). (See Figure 7)

4.2 Identification of mitigation techniques (design characteristics):

a) **Strategic management area:** (i) Setting standard be strict to compliance policy; (ii) Social and environmental certification; (iii) Sustainability as organizational strategy and culture; (iv) Developing backward linkage facility as far as possible; and (v) Having a compliance department and chief compliance officer.

b) **Tactical management area:** (i) Meeting social and environmental compliance; (ii) Improving working environment for employee satisfaction; (iii) Internal and external audit regarding compliance issues; and (iv) Sharing and cooperation with supply chain partners regarding social and environmental issues.

c) **Operational management area:** (i) Efficiency and skill development training to employees; (ii) Using efficient machinery and technology; (iii) Counselling and training of employees regarding compliance; (iv) Back up facilities and alternatives.

5. DISCUSSION AND FUTURE RESEARCH DIRECTION

In this paper, based on the interview with decision makers of three RMG manufacturers a number of sustainability barriers have been listed. Among those twenty six barriers, fourteen of them are identified as important barriers. Then AHP method has been used for determining importance of the social, environmental and economic sustainability barriers (See Table 2). Among the eight social sustainability barriers five barriers are identified with higher importance. Out of these five highly important barriers *Lack of awareness and interest of management (SC2)* has the highest importance score of 34.4% followed by *Absence of adequate governance by the supply chain members* (16.2%) and *Noncompliance of some social issues in organization* (13.4%) as the 2nd and 3rd. Likewise, among the nine environmental sustainability barriers five barriers are identified with higher importance.

Among those five highly important barriers *Lack of awareness and interest of management* has the highest importance score of 23.4% followed by *Absence of adequate governance by the supply chain members* (19.6%) and *Absence of pollution control measures* (14.4%) as the 2nd and 3rd. Furthermore, among the nine economic sustainability barriers four barriers have received higher importance. Out of those four highly important barriers *Utility problem* has the highest importance score of 25.9% followed by *Lack of efficiency of employees* (19.1%) and *Dependence on imported material* (13.7%) as the 2nd and 3rd most important economic sustainability barriers.

Corresponding to the most important social sustainability barrier *Lack of awareness and interest of management (SC2)*, capability design requirements such as *Sustainability as organizational strategy and culture (DR3), Internal and external audit regarding compliance issues (DR8)* and *Sharing and cooperation with supply chain partners regarding social and environmental issues (DR9)* are more important. Similarly, corresponding to the most important environmental sustainability barrier, *Lack of awareness and interest of management (EN3), Social and environmental certification (DR2), Sustainability as organizational strategy and culture (DR3),* and *Internal and external audit regarding compliance issues (DR8)* get higher importance to the decision makers; and corresponding to the most important economic sustainability barrier *Utility problem (EC1),* and *Development of back up facilities and alternatives (DR13)* are most important. Besides the corresponding design requirements to combat specific sustainability barrier, *sustainability as organizational strategy and culture (DR3), Internal and external audit regarding compliance issues (DR8)* and *Social and environmental certification (DR2)* are considered as more important design requirements. (See Table 3)

Developing and improving these design requirements will help to combat sustainability barriers and assist in building sustainability. However, how much cost and investment are involved in building these capabilities is to be analysed in the further research. It will be interesting if the further research be conducted on the supply chain of a particular RMG since that will explore the scenario of whole chain rather than an individual entity. A multiple case study can be conducted on a particular ready-made garments (RMG) supply chain including garments manufacturer, supplier and buyer.

6. CONCLUSION

There are a number of implications of this study. First, it identifies the critical sustainability barriers of the businesses. Second, it suggests corresponding design requirements to mitigate those barriers to develop and ensure sustainability. Finally, it has an indication to conduct future research to explore barriers and corresponding mitigation approach in overall value chain of corporations. Based on the opinion of decision makers of the companies an illustrative empirical study has been drawn that identifies fourteen sustainability barriers and thirteen design requirements to mitigate those barriers. It is found that the most important social sustainability barrier is *Lack of awareness and Interest of management (SC2)*. Similarly, *Lack of awareness and interest of management* and *Utility problem* respectively are the most important environmental and economic sustainability barriers. Corresponding to these barriers *Sustainability as organizational strategy and culture, Internal and external audit regarding compliance issues* and *Social and environmental certification* are considered as crucial mitigation requirements.

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FIGURES AND TABLES:

Figure 1: Three dimensions of sustainability (adapted from Dyllick and Hockerts, 2002):

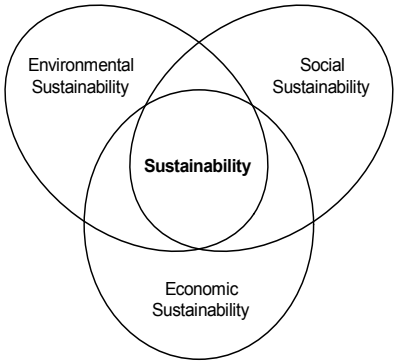


Figure 2. QFD layout:

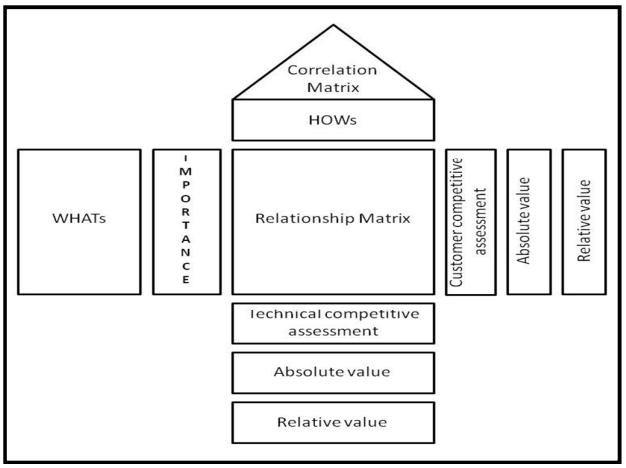


Figure 3: Weighting of WHATs using AHP:

$$\mathbf{A} = \begin{array}{c|cccc} & A_1 & A_2 & \dots & A_n \\ \hline A_1 & W_1/W_1 & W_1/W_2 & \dots & W_1/W_n \\ A_2 & W_2/W_1 & W_2/W_2 & \dots & W_2/W_n \\ \vdots & & & & \\ A_n & W_n/W_1 & W_n/W_2 & \dots & W_n/W_n \end{array}$$

Figure 4: Research model:

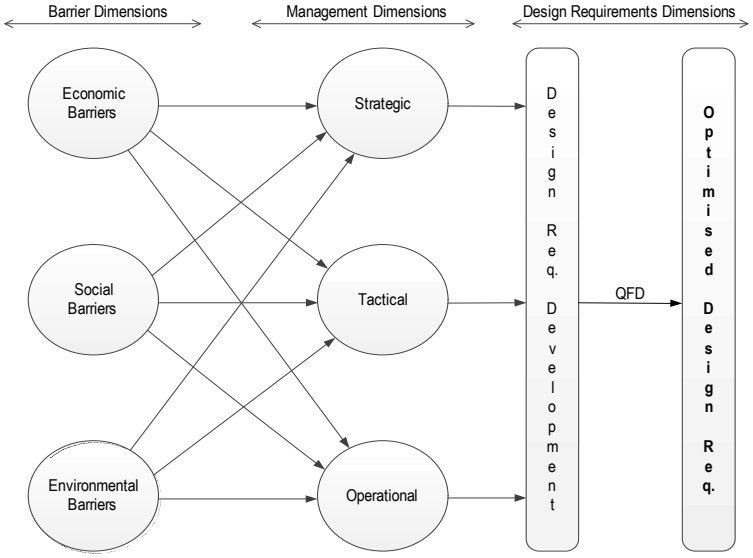


Figure 5: Prioritisation of social barriers:

Priorities with respect to:
Goal: social sustainability barriers

Awareness of employees	.100	
Awareness and interest of employer	.344	
Noncompliance	.134	
Strategy and culture	.128	
Supply Chain governance	.162	
Written policies and reporting practice	.044	
Resource constraint	.060	
Legal and regulatory factor	.028	

Inconsistency = 0.07
with 0 missing judgments.

9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9

Compare the relative importance with respect to: Goal: social sustainability barriers

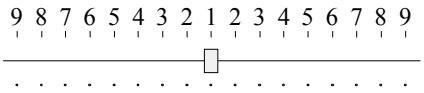
	Awareness em	Awareness and	Noncomplian	Strategy and cul	Supply Chain gov	Written policies a	Resource constr	Legal and regulatory factor
Awareness employees		(3.0)	1.0	(3.0)	(4.0)	2.0	3.0	6.0
Awareness and interest of e			3.0	4.0	5.0	6.0	3.0	6.0
Noncompliance				2.0	1.0	3.0	2.0	5.0
Strategy and culture					1.0	3.0	2.0	4.0
Supply Chain governance						3.0	4.0	5.0
Written policies and reportin							(2.0)	2.0
Resource constraint								2.0
Legal and regulatory factor	Incon: 0.07							

Figure 6: Prioritisation of environmental barriers:

Priorities with respect to:
Goal: Env sustainability barrier

AW EMS	.099
POLN CTR	.144
Awareness and Interest	.232
SUS ST	.114
SC GOV	.196
Wrt pol	.062
Cost	.081
legal	.043
GOV inct	.029

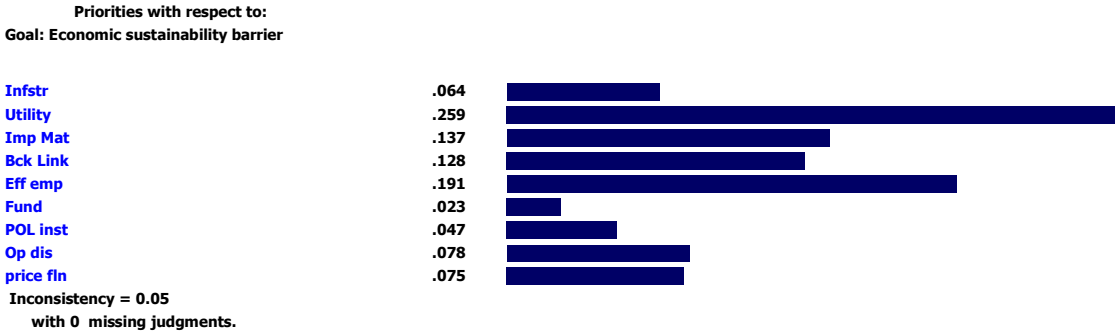
Inconsistency = 0.05
with 0 missing judgments.

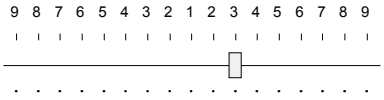


Compare the relative importance with respect to: Goal: Env sustainability barrier

	AW EMS	POLN CTR	Awareness an	SUS ST	SC GOV	Wrt pol
AW EMS		1.0	(4.0)	(2.0)	(3.0)	3.0
POLN CTR			(2.0)	2.0	1.0	3.0
Awareness an				3.0	1.0	4.0
SUS ST					(2.0)	2.0
SC GOV						4.0
Wrt pol						
Cost						
legal						
GOV inct	Incon: 0.05					

Figure 7: Prioritisation of economic barriers:





Compare the relative importance with respect to: Goal: Economic sustainability barrier

	Infstr	Utility	Imp Mat	Bck Link	Eff emp	Fund	POL inst	Op dis	price fln
Infstr		(3.0)	(2.0)	(3.0)	(4.0)	4.0	3.0	(2.0)	(2.0)
Utility			4.0	2.0	2.0	6.0	4.0	3.0	4.0
Imp Mat				2.0	(2.0)	5.0	3.0	2.0	3.0
Bck Link					(2.0)	4.0	3.0	3.0	2.0
Eff emp						7.0	4.0	3.0	2.0
Fund							(3.0)	(4.0)	(5.0)
POL inst								1.0	(2.0)
Op dis									2.0
price fln	Incon: 0.05								

Table 1: QFD matrix:

Sustainability barriers		DR_1	DR_2	.....	DR_m	A. I.	R. I.
SCs	VR_{i1}	$R_{i1}D_{w1}$	$R_{i1}D_{w2}$	.....	$R_{i1}D_{wm}$	AI_{i1}	RI_{i1}
	VR_{i2}	$R_{i2}D_{w1}$	$R_{i2}D_{w2}$	.....	$R_{i2}D_{wm}$	AI_{i2}	RI_{i2}

	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	VR_{in}	$R_{in}D_{w1}$	$R_{in}D_{w2}$	.....	$R_{in}D_{wm}$	AI_{in}	RI_{in}
ENs	VR_{j1}	$R_{j1}D_{w1}$	$R_{j1}D_{w2}$	.....	$R_{j1}D_{wm}$	AI_{j1}	RI_{j1}
	VR_{j2}	$R_{j2}D_{w1}$	$R_{j2}D_{w2}$	.....	$R_{j2}D_{wm}$	AI_{j2}	RI_{j2}
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	VR_{jn}	$R_{jn}D_{w1}$	$R_{jn}D_{w2}$	.....	$R_{jn}D_{wm}$	AI_{jn}	RI_{jn}
ECs	VR_{k1}	$R_{k1}D_{w1}$	$R_{k1}D_{w2}$	.....	$R_{k1}D_{wm}$	AI_{k1}	RI_{k1}
	VR_{k2}	$R_{k2}D_{w1}$	$R_{k2}D_{w2}$	.....	$R_{k2}D_{wm}$	AI_{k2}	RI_{k2}
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	VR_{kn}	$R_{kn}D_{w1}$	$R_{kn}D_{w2}$	.....	$R_{kn}D_{wm}$	AI_{kn}	RI_{kn}
A. I.		AI_{d1}	AI_{d2}	….	AI_{dm}		
R. I.		RI_{d1}	RI_{d2}	….	RI_{dm}		

Note: A.I.= Absolute importance; R.I.= Relative importance; DR= Design requirements; SCs= Social sustainability barriers; ENs= Environmental sustainability barriers; ECs = Economic sustainability barriers.

Table 2: Weights of the prioritised sustainability barriers:

Social Factors	AHP weight	Order of importance
Lack of awareness and knowledge of the employees	.100	5
Lack of awareness and interest of management	.344	1
Noncompliance of some social issues in organization	.134	3
Absence of sustainability strategy	.128	4
Absence of adequate governance by the supply chain members	.162	2
Environmental Factors		
Lack of awareness and knowledge of the employees	.099	5
Absence of pollution control measures	.144	3
Lack of awareness and interest of management	.232	1
Absence of sustainability strategy	.114	4
Absence of adequate governance by the supply chain members	.196	2
Economic factors		
Utility problem	.259	1
Dependence on imported material	.137	3
Supply disruptions	.128	4
Lack of efficiency of employees	.191	2

Table 3: Correlation matrix of WHATs and HOWs:

	DR1	DR2	DR3	DR4	DR5	DR6	DR7	DR8	DR9	DR10	DR11	DR12	DR13	AI
SC1	.100	.100	.900	0	.100	.300	.100	.100	.300	.100	0	.900	0	
SC2	.344	1.032	3.096	0	1.032	.344	.344	3.096	3.096	.344	.344	1.032	0	
SC3	1.206	1.206	1.206	0	1.206	1.206	.402	1.206	.402	.134	.134	.402	0	
SC4	1.152	.342	1.152	0	.342	.342	.342	1.152	.342	.128	.128	1.152	0	
SC5	.162	1.458	1.458	.162	.162	0	0	1.458	.162	0	0	0	0	
EN1	.099	.099	.891	0	.099	.099	.099	.297	.297	.099	0	.891	0	
EN2	1.296	1.296	1.296	0	1.296	.432	0	0	1.296	.144	.432	.432	0	
EN3	.696	2.088	2.088	0	.232	.232	.232	2.088	.696	0	.232	.696	0	
EN4	1.026	1.026	1.026	0	.342	1.026	.114	1.026	.342	.114	.342	1.026	0	
EN5	.196	1.764	.588	.196	.196	0	0	1.764	.196	0	0	0	0	

EC1	0	0	0	0	0	0	0	0	0	.259	.259	0	2.331	
EC2	0	0	0	1.233	0	0	0	0	0	0	0	0	1.233	
EC3	0	0	0	1.152	0	0	0	0	0	0	0	0	1.152	
EC4	0	0	.191	0	.191	0	.573	0	0	1.719	.573	.191	0	
A.I	6.277	10.411	13.892	2.743	5.198	3.981	2.206	12.187	7.129	3.041	2.444	6.722	4.716	80.947
R.I	0.0775	0.128	0.171	0.033	0.064	0.049	0.027	0.150	0.088	0.037	0.030	0.083	0.058	