EXPLORING AND ANALYZING THE DESIGN METHODOLOGIES FOR DEVELOPING MULTI-CHANNEL E-GOVERNMENT WEBSITES: TOWARDS IMPROVING THE USABILITY OF E-GOVERNMENT WEBSITES OF BANGLADESH

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A thesis titled "EXPLORING AND ANALYZING THE DESIGN METHODOLOGIES FOR DEVELOPING MULTI-CHANNEL E-GOVERNMENT WEBSITES: TOWARDS IMPROVING THE USABILITY OF E-GOVERNMENT WEBSITES OF BANGLADESH" Submitted by S M Anisur Rahman, Roll No: 1014140003, Session: 2014-2015 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Science in Computer Science and Engineering on 10 September 2020.

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I hereby declare that this thesis is my original work and it has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in the thesis. The thesis (fully or partially) has not been submitted for any degree or diploma in any university or institute previously.

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SUMMARY

Usability and user experience (UX) used to be the key quality attributes of a software system, which one explicitly considered and evaluated to design and develop different types of applications including e-governance, e-commerce, e-learning, e-health etc. Existing studies showed that developers and practitioners are using different design technique to develop e-government websites, while a limited number studies have been conducted focusing on usability and user experience (UX) issues of e-government websites. Again, no specific design technique and usability factors were suggested in existing literature to design and develop any e-government website. Moreover, a number of e-government services are adopted in Bangladesh to provide digital services to the citizens, while a few studies explicitly focused to the design, develop, and evaluating usability issues of e-government websites of Bangladesh. Thus, it was a crucial issue to explore the usability standard of existing e-government websites of Bangladesh and understand the prevailing design methods for finding out the best suited technique to design e-government website with enhanced usability. Therefore, the objectives of this thesis were *firstly*, to understand the present usability standard of e-government websites in Bangladesh, *secondly*, to find and explore the best possible design technique for developing more user friendly e-governance websites. To attain *first* objective, two studies were carried out using heuristic and semiotic evaluation techniques, where six randomly chosen e-government websites of Bangladesh were investigated with the twenty two participants (evaluators). The outcomes of this study showed that e-government websites of Bangladesh were significantly suffering usability problems and the intuitiveness of the interface signs were required to be improved in order to improve the overall accessibility and acceptability of e-government websites by the citizens of Bangladesh. To attain *second* objective, two alternate e-government websites for a

disaster and relief management system were developed using best two possible design techniques i.e. Interactive Dialogue Model (IDM) and Card Sorting (CS). The performances of the websites were evaluated through laboratory based usability testing which was replicated with 18 participants following a within-subject experiment design approach. As outcomes, this study found the IDM technique as a most suitable design approach for developing an e-government website which would give better usability in terms of effectiveness, efficiency and user-satisfaction.

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LIST OF SYMBOLS

ACM	Association for Computing Machinery
BD	Bangladesh
C-IDM	Conceptual IDM
CMS	Content Management System
CS	Card Sorting
CSS	Cascading Style Sheets
DRRA	Disaster Risk Reduction Activities
EGDI	E-Government Development Index
EORM	enhanced object-relationship model
E-R	Entity Relationship
FAQ	Frequently Asked Questions
GUI	Graphical User Interfaces
HCI	Human Computer Interaction
HDM	Hypertext Design Model
HE	Heuristic Evaluation
HTML	Hyper Text Markup Language
HYTEA	Hypertext Applications
ICT	Information and Communications Technology
IDM	Interactive Dialogue Model
ISO	International Organization for Standardization
L-IDM	Logical IDM
MiLE	Milano Lugano Evaluation Method
MIST	Military Institute of Science and Technology
MRP	Machine Readable Passport
OOHDM	Object Oriented Hypermedia Design Model
PHP	Personal Home Page
P-IDM	Page IDM
QA	Quality Assurance
RMM	Relationship Management Methodology
SD	Standard Deviation
SE	Semiotic Evaluation
SIDE	Semiotic Interface Sign Design and Evaluation
SLR	Systematic Literature Review
SMS	Short Message Service
SQL	Structured Query Language
UEM	Usability Evaluation Methods
UEWDM	UML Extension Web Design Model

UI	User Interface
UML	Unified Modelling Language
UN	United Nations
UNeGovDD	United Nations E-Government Development Database
UNHCR	United Nations High Commissioner for Refugees
URL	Uniform Resource Locator
UX	User Experience
UXE	User Experience Evaluation
W3C	World Wide Web Consortium
WSDM	Web Site Design Method

CHAPTER 1
INTRODUCTION

This section briefly introduces the research topic, objectives, and the organization of the remaining chapters. First, a brief discussion on the research background is represented followed by highlighting the motivation and problem statements. Next, presents the research objectives followed by discussing the overview of research methodology. After that, the scopes of this research are highlighted and at the end, structure of the remaining sections is presented.

1.1 **Research Background**

The use of Internet has a growing influence on many aspects of our daily lives. Digital Bangladesh is also one of our nation's dreams. With the advancement of Internet, high-speed communication networks, and emerging technologies, the e-governance facilities in Bangladesh are also changing towards achieving the nation goal of Digital Bangladesh. For example, development of websites to provide numerous services to citizens like websites developed for different ministries provide related information to the citizens; tender system to submit the tender application online; Machine Readable Passport (MRP) and e-passport system to collect applications information online and process each steps through the digital systems; Educational websites facilitated to apply online for admission; online tax systems to pay taxes by the citizens and organizations; and the likes.

The year 2021 marks the 50th anniversary of independence of Bangladesh and the government has taken a vision to be a middle income country within this time [1]. As a part of the development, Bangladesh government is digitalizing the country by ensuring

an ICT based society where the government and other non-government or semi-government offices will able to perform their tasks using digital technology. With the continuation of remarkable development, the literacy rate of Bangladesh is improved from 68.40% [2] to 70% [3] within last 6 years, where computer literacy was an integral part of the citizen's education. Moreover about 29.4% [4] of individuals aged 5 years and above use internet at least once a day.

Bangladesh government has also developed a common frame work for its' 61 Ministries and divisions, 351 directorates & others, 8 divisions, 489 upazilas, 4550 unions to provide e-support to the computer literate people [5]. The country, having a population of 114 million with a high illiteracy rate and a low-income level, is striving with the challenge of accelerating development and administrative goals through effective use of ICTs. Barriers and potentials both are enormous. According to the UN survey in 2018 [6], Bangladesh secured the 115th place among 193 countries on the E-Government Development Index (EGDI) scoring 0.4862 and 51st place in E-Participation (EPI) with a score of 0.8034. The survey reflected that the EGDI score for Bangladesh was pulled down because among citizen very few users take the facilities of government services through e-governess where usability, user experience and user friendliness were considered as important issues. Again to provide door to door service via electric communication, e-government websites were introduced by various government organizations. The rapidly increasing of usage of e-government websites makes their usability issues a great concern among the users.

Usability is the key quality attribute of any computer applications including electronic or mobile commerce, electronic or mobile health, military applications, electronic

government, and the likes that refers to the user friendliness [7-10]. In other words, the usability is concern with how quickly and easily one can learn from it; how much efficient it is to use; how rapidly the application allows recovery from errors and how easy to remember it. According to ISO 9241 [11] usability is defined as the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments.

The key concern of user friendliness of a website is how easily the user may interact with the interface to accomplish their desired task accurately and efficiently [12, 13]. So the user satisfaction or usability is largely depends on the website design and interface [14, 15]. Thus the interface design is one of the key attribute of e-government website in the context of Bangladesh. At the same time developing a simple and cost-effective web solution for user is also necessary. However, an in-depth study on such a development is yet to be attempted in the literature.

1.2 **Motivation and Problem Statements**

Bangladesh government is gradually heading for providing e-services through various multichannel applications e.g. websites, mobile apps etc. Most of the ministries and government organizations have already started most of their services through digital systems. However, recent studies found that these e-services were not user friendly and well adopted by the citizen. Most of the applications are buildup on a common framework where a little attention is given for considering the standard guidelines of Human-Computer Interaction (HCI).

A number of research has been conducted focusing to evaluate the e-government websites, but a very few study has been found that focused to the usability issues of e-government websites of Bangladesh, while some of them has focused to assess the accessibility of e-government websites [16]. Similarly, no study has been conducted yet to assess the overall usability standard of e-government websites in Bangladesh.

Again, to design the e-government websites, practitioners required to know and get access to Citizen's charter and profiles. An effective design method also should be followed while designing the e-government application. Till date, no study has been found that recommend any particular design method for designing user-intuitive and usable e-government websites. Moreover, the existing e-government websites are not design and developed following any specific design methods. Thus, exploring a suitable design technique for designing usable e-government websites in Bangladesh is also an utmost important for the overall improvement of usability, UX and adoption of e-government websites in Bangladesh.

1.3 **Research Objectives**

The objectives of this thesis are, firstly, to understand the present usability standard of e-government websites in Bangladesh. Secondly, to find and explore the best possible design techniques' for developing more user friendly e-governance websites of Bangladesh.

To attain these objectives, this thesis explores the usability of existing e-government websites of Bangladesh, explore the existing design methods to find out the best suited design method for designing usable e-government websites. Two alternate e-government

systems were developed following two design techniques and evaluated their performance.

Thus, this research will broadly cover two general research fields, including Human Computer Interaction (HCI) and E-government. The outcomes of this research will greatly contribute to these fields as well.

1.4 **Methodological Overview**

The research was carried out in chronological manner. First, the related research focusing on e-government website in Bangladesh was reviewed to find out research gaps and define the thesis objectives. Second, usability of the selected e-government websites of Bangladesh were evaluated through heuristic evaluation and semiotic evaluation to assess the present usability standard of all e-government websites in Bangladesh. Third, among many, two design techniques were selected based on theoretical evaluation to design two e-government websites on the same topic (i.e., disaster management). Fourth, these designs were implemented to develop two prototypical e-government websites. Fifth, a comparative user study was carried out to compare the performance between these websites in terms of usability and user experience. Finally, the studied data were analyzed using both qualitative and quantitative data analysis methods to find out the more suitable design technique for developing any e-government website.

1.5 **Research Scope**

The scope of this thesis can be defined in several perspectives. This thesis explicitly focused to the design, development and evaluation of e-government websites and more specifically e-government websites for Bangladesh. Again, there numerous number of design methods are exist to design different types of computer applications like websites, mobile applications, desktop applications, embedded systems, wearable systems , and the likes [17]; but this research explored existing design methods that are explicitly focused to design the information intensive websites, since the electronic government websites are considered as the information intensive website [18]. Similarly, the performance of e-government can be measured from different perspective including usability, accountability, service quality, efficiency and productivity measures, and the likes [19], but the evaluation study conducted to compare the performance of two websites only in terms of usability and user experience. Moreover, several metrics are exist in literature to evaluated the usability and UX including effectiveness, efficiency, satisfactions, thoroughness, validity, reliability, learning ability, appropriateness, accuracy [20-23], while the metrics used in this research to measure the usability and UX of the developed websites were the effectiveness, efficiency, and satisfaction as suggested by the ISO [11].

1.6 **Organization of the Thesis**

This thesis is organized as follows:

i) Chapter 2 presents 'Theoretical Background and Literature Review', which includes the discussion on Human-Computer Interaction (HCI), e-government, design methodologies, and the brief introduction of the work related to this thesis by identifying, evaluating and interpreting all available research relevant to research question, or topic area, or phenomenon of interest.

ii) Chapter 3 presents ‘Methodology’ that briefly discusses the major phases of research methodology including the study procedure, data collection and data analysis.

iii) Chapter 4 presents ‘Usability Evaluation’ that presents how the usability of e-government websites of Bangladesh are evaluated and the findings of the evaluation study.

iv) Chapter 5 presents ‘Design and Development of E-government Websites’, which discuss the design and development of two e-government websites of Bangladesh.

v) Chapter 6 presents the ‘Experimental Study’, which presents the study objective, participants profile, study procedure, and data analysis of the comparative evaluation study to compare the performance of two developed websites.

vi) Chapter 7 presents ‘Discussion and Conclusion’, which summarizes main findings, thesis contributions, thesis limitation and the future work.

CHAPTER 2
THEORETICAL BACKGROUND & RELATED WORKS

This chapter discussed related background theories that focused to the design, development and evaluation of e-government systems. Next, the chapter summarized the design theories and showed a comparison among the technologies. After that the recent related works focusing to e-government system of Bangladesh were discussed followed by introducing the design issues of existing e-government websites. Finally, a critical summary was made to highlight the research gaps and select two design techniques for designing and developing effective e-government application in context of Bangladesh.

2.1 **E-Governance**

With the adoption of modern technologies most of the countries are trying to give services to their citizen through e-governance. The effectiveness of this services and satisfaction of the citizen regarding this e-governance activities directly depend on HCI, Usability, UI and UX. A better design and optimum use of computer technology focusing usability, UI and UX gives a sustainable e-governance service.

Electronic governance (e-governance in short) involves the use of Information and Communication Technology (ICT) and its numerous applications by the government for the provision of information and e-services (that is services by electronic means) to the citizens of the country [24]. Use of e-governance can make public administration fast and effective, provide better services, and respond to the demands of transparency and accountability. It can help the government to go green by effective management of natural resources aiding sustainability to environment. E-governance stimulates economic growth and promotes social inclusion of disabled and vulnerable sections of society. E-

governance can provide benefits in the form of new employment, better health, better education, knowledge sharing, skills developments and capacity building for sustainable development. Quick and fast e-services eliminate middlemen and save both time and money. Without such online services, cities and towns would have turned into more difficult places to live and the emergency services would have been impossible to manage by the human beings.

The United Nations E-Government Development Database (UNeGovDD) [6] is a benchmarking tool that provides a comparative assessment of the e-government development of UN Member States. It offers an interactive snapshot of each country's e-government development from a regional and global perspective.

2.2 **Human-Computer-Interaction (HCI)**

Human-computer interaction (HCI) might refer to the design process, evaluation and implementation of computing systems which would interact with human and its surrounding phenomenon [25]. The Association for Computing Machinery (ACM) also supported the definition by adding a word to 'surrounding phenomenon' i.e. major surrounding phenomenon [25]. Computer systems were designed to perform user specific day to day tasks seamlessly. Designers, as such, would be engaged to design these systems considering human behavior, their thinking process and knowledge on the system. Thus designers needed to consider the performance and experience from user perspective while designing the interaction with the system. Human performance evaluation process started with manual tasks in factories at the beginning of the last century [26]. Since the early 1980s, the term human–computer interaction (HCI) had been used worldwide.

HCI encompassed multi-disciplinary and interdisciplinary subjects. It involved Psychology, Sociology, Computer Science and Engineering, Cognitive Science, Ergonomics, Business, Graphic design and so on [27]. It combined both a craft and a science together. It provided beautiful and novel user interfaces that were artistically pleasing and capable of fulfilling human expectation and requirement [28].

2.2.1 **Usability**

Since HCI focused one the user intentions with computer systems, thus usability, user experiences and user interface designs are broadly discussed in the field of HCI. The interactive system need to be useful and usable to meet its end user goal, while the usability is reflected to the effectiveness to use, easy to learn and enjoyable to user experience [29].

According to ISO 9241-11 usability is "the extent to which a product could be used by specified uses to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" [11]. Effectiveness, efficiency and satisfaction are the criteria by which the quality of user-product interaction could be measured. Effectiveness refers to the performance fulfilling its expected outcome. On the other hand, efficiency refers to the numerous ways and means by which a user could perform intended tasks with minimum steps or effort. Again the term satisfaction defines the fulfillment of one's wishes, expectations, or needs, or the pleasure derived from any work. In HCI satisfaction refers to the fulfilment of the desire task with utmost pleasure using the computer systems.

In another work [30] utility, efficiency, learnability, effectiveness, safety, memorability etc. are also considered as the goal of usability. Generally utility is considered as a

measure of satisfaction an individual gets by doing any task. That means how much individual has enjoys the task. It is also a measurement of usefulness that a customer obtains from the work. Efficiency can be defined as a state or quality of being efficient, or able to accomplish something with the least waste of time and effort. Efficiency is achieved when someone is able to achieve the greatest amount of satisfaction by doing the task from available resources. The term ‘learnability’ refers how a new user can have effective interaction and achieve maximal performance while executing any task. Learnability is very important for a new user as it reduces the completion time. In HCI, effectiveness is defined as "the accuracy and completeness of users' tasks while using a system" [11]. The effectiveness can be measured quantitatively by comparing the final product provided and the actual needs given by the user. The evaluator needs to find out how closely the product matches the original design or the requirements of the client e.g. by asking questions like: How much satisfied you are with the system while performing the task? Safety risk assessment of HCI behavior is very important for safety design and management in any complex human-computer system. For example, while designing airplane cockpit monitoring and management system, overlooking any safety risk factor may cause severe damage to the aircraft as well as human life. Memorability is a measure of how easy an application is to remember after a substantial time-lapse between visits. If a website has good memorability, visitors are sure to keep coming back for more.

2.2.2 **User Interface (UI) Design**

User interface (UI) design is the process of making interfaces in software or computerized devices with a focus on looks or style. Designers aim to create designs users will find

easy to use and pleasurable. UI design typically refers to graphical user interfaces but also includes others, such as voice-controlled ones.

UI encompasses a numbers of elements like button, navigational links, icon, image etc [31]. These are the user interfaces that are used as access points where users interact with designs. Graphical user interfaces (GUIs) are designs' control panels *and* faces; voice-controlled interfaces involve oral-auditory interaction, while gesture-based interfaces witness users engaging with 3D design spaces via bodily motions. User interface design is a craft that involves building an essential part of the user experience; users are very swift to judge designs on usability and likeability. Designers focus on building interfaces users will find *highly usable* and *efficient*. Thus, a thorough understanding of the contexts users will find themselves in when making those judgments is crucial.

2.2.3 **User experience (UX)**

User experience (UX) means how a user feels about any application, product or service. This implies an interaction between them. For example, if a user wants to submit his Govt taxes online, the system will automatically give a feeling to the user how straightforward the checkout process is. This phenomenon is UX and UX design considers each and every element that shapes this experience. This involves the design of the entire process of acquiring and integrating the product, including aspects of branding, design, usability and function. The goal of UX design is to build easy, effective, applicable and all-round pleasant experiences for the user.

User experience evaluation (UXE) refers to a collection of approaches, assistances and tools utilized to disclose how a person identifies an application before, during and after interacting with it. A researcher has to select the right dimensions, constructs, and

methods and target the research for the specific area of interest for a successful UXE study. Often UXE is done by usability evaluation which is considered as one of the important part of it.

2.2.4 U**sability Evaluation Methods (UEM)**

Designing a system following guidelines only might not guarantee good usability of the system. The system needed to be evaluated after development so that users could use it with utmost satisfaction [29]. Usability Evaluation thus ensured that system meet the set requirements and fulfill users' desire. This evaluation was done throughout the design life cycle of a system. Designers needed to evaluate both design and functionality of a system and suggest solutions accordingly. This evaluation process involved checking the prescribed standards, comparing alternative design solutions and assessing the design against specified goals.

Usability evaluation was performed following different approaches. These were:

i. Analytical approach: This approach was based on design guidelines, theories and models e.g. cognitive walkthrough, heuristic evaluation etc.
ii. Empirical approach: This approach was based on quantitative/qualitative data collected from users e.g. lab/field usability testing, diary etc.

Usability evaluation also could be done in the following ways:

i. Formative approach: This approach supported the design process by collecting information. Generally, formative usability testing would be carried out in the

early development stage of a product or application. Basically information would accrue form the product's shape and design in formative approach. The main purpose of this approach was to identify any problem and remove usability problems before a product was fully developed.

ii. Summative approach: This approach measured the usability according to quantitative/qualitative criteria. It was otherwise a Quality Assurance (QA) type of test generally implemented at later development stage of a product or application. The summative approach used few criteria or success metrics to evaluate the product. After successful evaluation, the product could be released from a user experience perspective into the market.

Cognitive walkthrough evaluates a design without involving users. It evaluates how well the design supports user in learning task and identifies problems based on psychological principles [32]. Some expertise in cognitive psychology would be required to follow this method. This approach took into the consideration of the people's thought process and actions when they use an interface for the first time. Another approach was Pluralistic walkthrough [33] with a group of users. This Walkthrough could be performed on a paper-based prototype. These would require involvement of usability experts and developers. The purpose of this approach was to find usability problems and suggested improvements.

The other analytical approaches were Heuristic Evaluation (HE) and Semiotic Evaluation (SE). Heuristics were general principles for interaction design to find usability problems in a UI design. It would identify where design did not follow these principles. Some expert evaluators would be required who independently would check for compliance with usability principles (heuristics). Different evaluators would find different problems and

communicate their finding afterwards. Finally the findings would be aggregated and usability problems would be identified. Some notable heuristic evaluation methods were Nielsen's 10 Principles [34] (Table: 2.1), Gerhardt Powals' 10 principles [35] (Table: 2.2) and Susan Weinschenk and Dean Barker 20 Principles [36] (Table 2.3).

Table 2.1: Nielsen's 10 Principles

H1	Visibility of system status
H2	Match between system and the real world
H3	User control and freedom
H4	Consistency and standards
H5	Error prevention
H6	Recognition rather than recall
H7	Flexibility and efficiency of use
H8	Aesthetic and minimalist design
H9	Help users recognize, diagnose, and recover from errors
H10	Help and documentation

Table 2.2: Gerhardt Powals' 10 principles

1	Automate unwanted workload	6	Group data in consistently meaningful ways
2	Reduce uncertainty	7	Limit data-driven tasks
3	Fuse data	8	Include in the displays only that information needed by the user at a given time
4	Present new information with meaningful aids to interpretation	9	Provide multiple coding of data when appropriate
5	Use names that are conceptually related to function	10	Practice judicious redundancy

Table 2.3: Susan Weinschenk and Dean Barker 20 Principles

1	User Control	6	Aesthetic Integrity	11	Technical Clarity	16	Consistency
2	Human Limitations	7	Simplicity	12	Flexibility	17	User Support
3	Modal Integrity	8	Predictability	13	Fulfilment	18	Precision
4	Accommodation	9	Interpretation	14	Cultural Propriety	19	Forgiveness
5	Linguistic Clarity	10	Accuracy	15	Suitable Tempo	20	Responsiveness

For Semiotic Evaluation (SE) there were 5 dimensions under which there were total 17 evaluations criteria. The dimensions were syntactic, pragmatic, social, environment and semantic evaluation.

MiLE+ (Milano Lugano Evaluation Method – version 2) [37] was used as another evolution technique. This would be suitable for hypermedia and web applications. This was more systematic and structured than general usability evaluation methods like heuristic evaluation, cognitive walkthrough, pluralistic, task based testing etc. A key concept of MiLE+ was that an interactive application could be evaluated from user experience perspective rather than technical perspective.

In empirical approach record of one's direct observations or experiences was used as evidence. Later the data was analyzed through quantitatively or qualitatively approach or combination of both. In quantitatively approach evaluation was done following statistical, mathematical or computational techniques. In qualitatively approach evaluation was done by observations, interviews, analyzing the audio or video recordings.

2.3 **Design Techniques**

A better web means a better experience for everyone. Users should be able to reach what they need without worrying about how they're accessing the internet. Developers and designers should be creating sites that can be smoothly maintained and updated. At the same time user requirements must be satisfied with the higher priority. Keeping these views in mind few widely used web design techniques were introduced bellow:

2.3.1 **Semiotic Interface sign Design and Evaluation (SIDE) framework**

Semiotic Interface sign Design and Evaluation (SIDE) framework [21, 38, 39] focused on designing and evaluating intuitive interface signs to enhance web usability and user-centric process. This framework was based on five semiotic levels namely semantic, syntactic, pragmatic, environmental and social. Each level was constructed through several determinates. Again each determinate was having several attributes. For example 'colour' was one of the determinate of syntactic level semiotic interface which was having sign, contrast and brightness attributes. However this framework did not support multi-language and multi-channel facilities but supported response from user and offer easy navigation.

2.3.2 **Web Site Design Method (WSDM)**

Web Site Design Method (WSDM) was a user-centered web site designing approach for kiosk Web Sites was proposed in [40]. This designing method was mainly used for data driven website for different types of users. It first divided users into different classes and thereafter data was modeled based on class's viewpoints without implementation details. This model was then converted into programing language source code files before

implementation. It could maintain the consistency with multiple languages but did not support multi-channel. It required a high skill set of designers to design the website.

2.3.3 **Relationship Management Methodology (RMM)**

Relationship Management Methodology (RMM), a Hypermedia design and construction methodology was proposed in [41]. RMM designed and developed hypermedia applications following several steps namely slice design, user interface design, run-time behavior design, entity-relationship design, navigational design, conversion and construction design, testing etc. It provided easy navigation but did not support multi-channel and multi-language.

2.3.4 **Object Oriented Hypermedia Design Model (OOHDM)**

Object Oriented Hypermedia Design Model (OOHDM) proposed in [42]. It used navigational tools to map onto relationships of the conceptual model. The model allowed designers to design a low fidelity prototype and later removed the faults generated from the initial design. It helped to organize the navigational space as objects of conceptual model and separated interface issues from navigation issues [43]. This model helped the designers to build different web applications reusing a single conceptual schema. This design model provided easy navigation and multiple languages. However, it did not support multi-channel. It lacks portability, consistency, response and other important user friendly factors.

2.3.5 **UML Extension Web Design Model (UEWDM)**

The Unified Modeling Language (UML) was a general-purpose, developmental, modeling language in the field of software engineering that was intended to provide a

standard way to visualize the design of a system [44]. A Unified Modeling Language (UML) [45] based navigation design approach was proposed for modeling complex interactions in web applications was proposed called UML Extension Web Design Model (UEWDM). This approach provided a systematic and conceptual design modeling in complex web applications. In this approach, navigation design was done through two design models- Navigation Space Model and Navigation Access Model. Navigation space model defined what the users would see and the relationships among navigation classes. Navigation access model defined how the web users reach those classes. This model only provided the feature of Multiple Languages Support.

2.3.6 **Enhanced object-relationship model (EORM)**

The enhanced object-relationship model (EORM) proposed in [46] was an Object-oriented methodology based on three frameworks: Class framework, Composition framework and GUI framework. Class framework expressed the underlying information structure of the application. Composition framework expressed the rules through which navigation capabilities could be defined based on the class framework, and the GUI framework defined how the information and navigation elements were presented to the user. This model could not provide easy navigation but could maintain consistency and support multiple languages.

2.3.7 **Hypertext Design Model (HDM)**

F. Garzotto and P. Paolini [47] proposed the Hypertext Design Model (HDM) to describe hypertext systems. Hypertext development was a structured and systematic approach suitable for large and complex applications. This was developed as part of the HYTEA project by a European Consortium [48]. This system described classes of information

elements and navigational structures of complex system without implementation details in a system-independent manner. HDM was mainly used for large scale hypermedia applications where regularity, organization, modernization and consistency were contributing factors. This model had some similarities with the Entity Relationship (E-R) model. The features of HDM included identification of different categories of links with different representational roles. It also distinguished between hyper base and access structures and easily integrates the structure of a hypertext application with its browsing semantics. A significant number of links could be derived automatically from a conceptual-design level description. It could be used as modeling device by setting out the specifications of an application or as implementation device by designing tools that directly supported application development [48]. It provided the feature of easy to navigate, maintained consistency and supported multiple languages. But this design model did not support multichannel feature.

2.3.8 **Card Sorting**

Card Sorting is a design technique that is used to build the information architecture of an application, that is, how the content of an application will be identified, categorized and organized in accordance with users' convenience by labeling and classifying the entire content of an application. This design technique is mostly used for web applications that are rich in information, traversable but less operative and not considered as a convenient approach for multi-channel applications. A group of participants usually perform a Card Sorting session [49], where they use a number of small colorful cards. All the participants individually identify the user requirements of the application (i.e. what should be on the homepage, the hierarchy of content and the navigational structure etc.) by labeling the cards accordingly and further grouping them into different categories. The hierarchy of

different topic might be interpreted using cards with different colors. This Card Sorting session can be also performed using different software tools available online [50]. As Card Sorting is mainly a collaborative design technique, so it combines a set of possible variations for designing the features of a particular application contributed by the participants. Thus, this design technique eventually helps to design an application where similar user requirements can be recognized with a lot of variation. It is indeed a very simple, inexpensive, widely used and user-centered design process [51] mainly to design the structure of web applications regarding how the content will be organized but may not provide a strong analysis regarding end to end navigation process.

2.3.9 **Interactive Dialogue Model (IDM)**

The IDM [52] was a novel design model specifically tailored for multi-channel applications. The background research, moving from linguistic theories and practices, had led to the development of a channel independent design model (based on dialogue Primitives). IDM approach suggested to start the design in a conceptual channel-independent fashion, and then proceed into a further logical design for a specific channel (e.g. mobile, web). This sequence of technique offered many advantages without complexity. IDM had additional distinctive features: it was lightweight, provides a few sets of primitives (and a simple graphic notation), which were easy to learn and teach. Moreover, it was suitable for brainstorming and generating ideas at early stage during design (or during the shift from requirements to design). Finally, it was cost-effective (it requires little effort from designers) and modular (designers could take the part they wish, not being forced to all or nothing).

The reason IDM was called a dialogue model because using IDM we could consider a web experience as a dialogue between the user and the web site being used. User turns were articulated by selecting specific links, with their attached semantics. Machine turns consisted in providing pages to the user. An interactive application could be considered a kind of dialogue generator, i.e. a device capable of supporting several different conversations with different types of users. The designer of a web site must imagine interesting conversations for the user and provide navigation mechanisms to make them possible. This approach helped shaping an application in a more natural way, avoiding the designer to be concerned, from the beginning, with pages, or information units, or technologies to be used. IDM had been validated both in the academic and industry environments by designing the information intensive application like museum, e-governance sites, and also for the humanitarian and military applications [53, 54].

2.3.10 **Compare the Design techniques**

Among widely used 9 web design techniques, 3 design techniques were followed for web applications development. The techniques were Semiotic Interface sign Design and Evaluation (SIDE), Card Sorting and Interactive Dialogue Model (IDM). These three web design techniques were also found suitable for developing e-government applications. Among these three web design techniques, Card Sorting (CS) and Interactive Dialogue Model (IDM) were mostly used for e-government web application development. Again, most of the factors as presented in Table 2.4 are supported by the CS and IDM techniques.

Table 2.4: Comparison among different design techniques

Factors	Semiotic Interface sign Design and Evaluation (SIDE)	Web Site Design Method (WSDM)	Relationship Management Methodology (RMM)	Object Oriented Hypermedia Design Model (OOHDM)	UML Extension Web Design Model (UEWDM)	Enhanced object-relationship model (EORM)	Hypertext Design Model (HDM)	Card Sorting (CS)	Interactive Dialogue Model (IDM)
Multi-Channel Supportive	X	X	X	X	X	X	X	✓	✓
Portability	X	X	X	X	X	X	X	✓	✓
Response Supportive	✓	X	X	X	X	X	X	X	✓
Easy Navigational	✓	X	✓	✓	X	X	✓	✓	✓
Multiple Languages Supportive	X	✓	X	✓	✓	✓	✓	✓	✓
Consistency	X	✓	X	X	X	✓	✓	✓	✓
Channel Independency	X	X	X	X	X	X	X	✓	✓
High Skill Demanding	X	✓	X	X	X	X	✓	X	X
Application Based Website	✓	X	X	X	X	X	X	✓	✓

2.4 **Work related to E-government System**

A numbers of researches were carried out for e-government services of Bangladesh. Ferdous addressed [55] the issues affecting e-Governance implementation in Bangladesh

in consideration with a detailed usability analysis and directions for future development. Another research [16] concentrated on analyzing and evaluating the web accessibility of e-Government websites of Bangladesh according to the `W3C Web Content Accessibility Guidelines'. It also presented a recommendation for improvement of e-Government websites' accessibility in Bangladesh. Ahmed addressed [56] the issues affecting e-Governance implementation in developing countries like Bangladesh and proposed few guide lines that should be followed while implementing e-governance services especially for 3G mobile networks. Rahman proposed [57] an effective framework for implementing electronic governance (e-governance) and e-services in developing countries like Bangladesh. Islam focused [58] on Bangladesh e-government domain names and proposed a standard domain name system for all government web sites. Mahmud and Gope proposed [59] a SMS based model for e-government services that could fulfill most e-government services.

2.5 **E-government System of Bangladesh**

Till date 62 e-government websites of Bangladesh had been available, explored and analyzed [5]. Most of the websites followed the Hierarchical with interleaves (Table 2.5) web info architecture. In this architecture a hierarchical relationship was followed among the web pages. Each pages also had their individual leaf if needed.

Table 2.5: Web info architecture of e-government websites

Ser	Type of info architecture	Total
1	Pure Hierarchical	2
2	Hierarchical with interleaves	60
3	Hypertext	0
4	Hybrid	0
Total		62

While developing e-government websites all the web developer followed 5 particular design templates. About 79% of the e-governments websites were constructed following a general framework (Template A) given by the national authority of Bangladesh. About 8% of the e-governments websites were constructed following top-down hierarchical approach (Template B). About 7 % of the e-governments websites were constructed following sidebar child-parent relationship (Template C) methodology. 2 % of the e-governments websites were constructed following top-down hierarchical approach with graphical representation (Template D). All templates A-D (Fig 2.1) followed Hierarchical with interleaves web design info architecture.

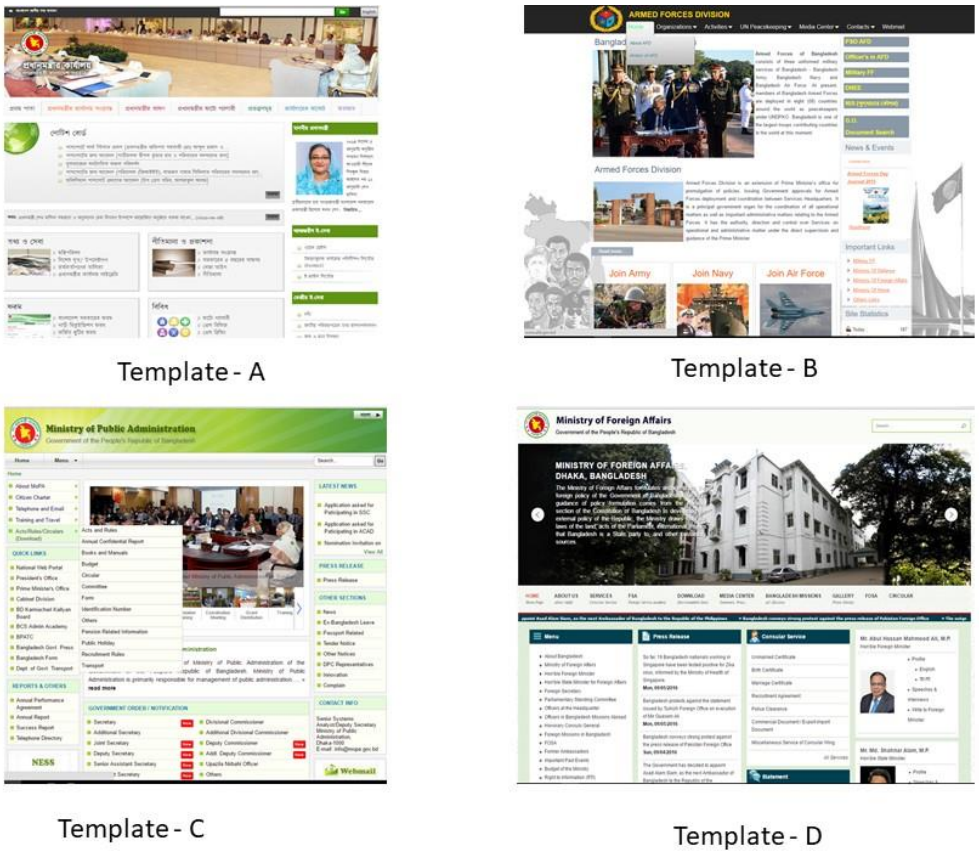

Fig 2.1: Template A-D

About 3 % of the e-governments websites were constructed following sidebar child-parent relationship (Template E) which followed Pure Hierarchical web design info architecture (Fig 2.2).

Fig 2.2: Template E

2.6 **Summary**

E-government websites were one of the important tools for providing services to the citizen of any nations. Various design architecture were introduced for building these applications. There were also few researches regarding these issues. Till now there was no study on web design technique for e-government web application development. In Bangladesh while developing e-government web application no particular design technique were followed. Subsequently there was a need of effective and efficient web design technique for its e-government web applications development.

CHAPTER 3
METHODOLOGY

This Chapter discusses the research methodology with its major phases. The major phases are discussed briefly to highlight the objectives, outcomes, and the approaches or methods adopted in a particular phase to collect and analyze the data. Finally, the summary of the methodology is presented.

3.1 **Define Research Objectives**

The overview of the research methodology is presented in Fig 3.1. In this research, firstly, the background theories focusing to the HCI, usability evaluation methods, UX, and e-government were studied followed by reviewing the research work relevant to this thesis topic, or phenomenon of interest. A systematic literature review approach was adopted to conduct the review study. The outcome of this phase guided us to understand the problem statement and for conducting the remaining phases. The outcomes of the review study showed that a few studies were conducted focusing on Usability and User Experience (UX) issues of e-government websites in context of Bangladesh (BD). Existing design techniques were not explicitly proposed for designing the e-government websites. None of the previous study explored the effect of usability performance with respect to the different design techniques while developing e-government website. Similarly, no comparative study was conducted to find out the more suitable design technique for e-government websites. Thus, there was a need to assess the existing of e-government websites of Bangladesh; explore the suitable techniques to develop e-governance applications; and find a better design technique to develop e-government websites through experiment which will give better user satisfaction

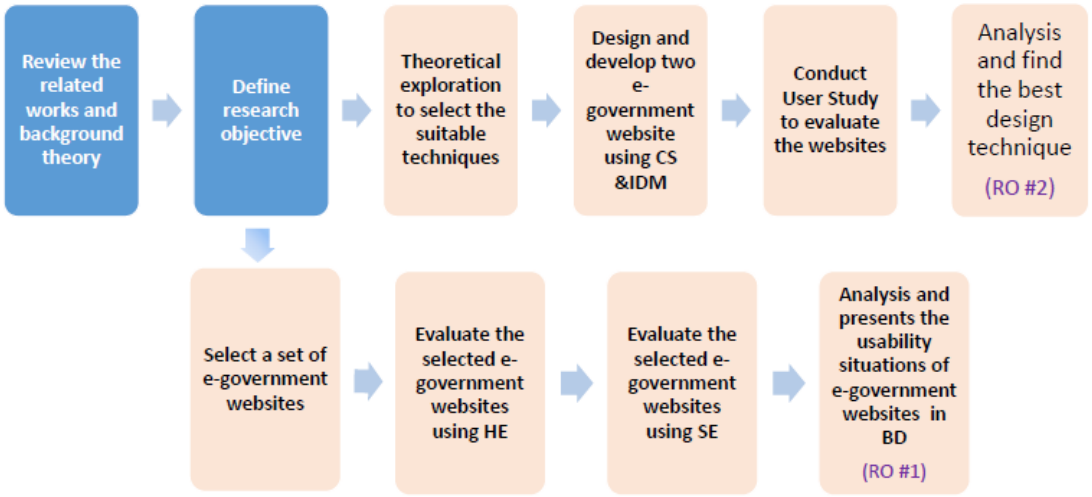

Fig 3.1. Overview of the research methodology

3.2 **Usability Evaluation of E-Government Websites**

In this phase, to evaluate the e-government websites of Bangladesh and to understand their current status, two usability evaluation studies were conducted. Firstly, a set of e-government websites of Bangladesh were selected for evaluation. Secondly, the selected websites were evaluated following the Heuristic Evaluation method followed by the Semiotic Evaluation method. Finally, the evaluation study data were analysis and present the overall usability state of e-government websites in Bangladesh, The Nielson's ten heuristics [60] were used for the Heuristic Evaluation, while the heuristics proposed in the Semiotic Interface Sign Design and Evaluation (SIDE) [21, 38] framework were followed to conduct the Semiotic Evaluation. The evaluation study was replicated with 22 participants having good familiarity with usability evaluation techniques and HCI. The table 3.1 and 3.2 represents the set of heuristics followed in Heuristic Evaluation and Semiotic Evaluation, respectively.

Table 3.1: Set of heuristics used in heuristic evaluation

H1	Visibility of system status
H2	Match between system and the real world
H3	User control and freedom
H4	Consistency and standards
H5	Error prevention
H6	Recognition rather than recall
H7	Flexibility and efficiency of use
H8	Aesthetic and minimalist design
H9	Help users recognize, diagnose, and recover from errors
H10	Help and documentation

Table 3.2: Set of heuristics used in semiotic evaluation

SEMIOTIC EVALUATION	
Syntactic	1. Present clearly the purpose of interactivity 2. Make effective use of color to design an interface sign 3. Make the representation readable and clearly noticeable 4. Make a sign presentation clear and concise 5. Create the representation context appropriately 6. Follow a consistent interface sign design strategy

Pragmatic	7. Place the interface sign at the proper position in a UI 8. Make effective use of amplification features in interface sign design 9. Create good relations among the interface signs of a UI 10. Retain logical coherence in interface sign design
Social	11. Design interface signs to be culturally sensitive or reactive, when necessary 12. Match with the reality, conventions, or real-world objects 13. Make effective use of organizational features in interface sign design 14. Map with metaphorical and attributing properties
Environment	15. Model the profiles of the focused end-users 16. Make effective use of ontological guidelines in interface sign design
Semantic	17. Achieve a match between a designer's encoded and a user's decoded meaning

3.3 **Design and Develop E-Government Websites**

In order to find and explore the best possible design technique for developing more user friendly e-government website of Bangladesh contemporary design techniques e.g. Hypermedia Design Model (HDM), Relationship Management Methodology (RMM), Interactive Dialogue Model (IDM), Card Sorting, Object Oriented Hypermedia Design Model (OOHDM) etc. were explored and analyzed. Two best possible design techniques namely Card Sorting and IDM were selected to design and develop an e-government website. An example case of an e-government website was selected considering the involvement of both the citizens and the government as end-users, and thus an e-government website for disaster management and relief was chosen. The e-government website for disaster management and relief was design using the selected design

techniques and thus, two version of the selected website were designed. The Bootstrap 4 (combination of HTML, CSS, and JavaScript framework) and WordPress 5.3 (combination with PHP and MySQL database) were used for developing the websites.

3.4 **Evaluate the Developed Websites**

Both the websites were evaluated through user study in terms of their effectiveness, efficiency, and satisfaction to find out the best suited design technique for designing the e-government website. The evaluation study was conducted following within-subjects research design and replicated with 28 participants. The following tools were used to record the study data: (a) *Screen-record-pro*: to record the activities of test-participants; (b) *Stopwatch*: to record the task conclusion timing of the participant; and (c) *Mousotron*: to record the tapping behavior, number of attempts, mouse wheel rotations, and number of times asking help from researcher to perform a particular task.

3.5 **Summary**

The related research focusing on e-government website in Bangladesh was reviewed through a *Systematic Literature Review (SLR)* [61] approach. Then two research objectives were set. To achieve the first research objective a usability evaluation was carried out to access the present usability standard of all e-government websites in Bangladesh through heuristic and semiotic evaluation.

To achieve second research objective two prototype websites of a particular e-government service were developed by contemporary design methods (which had not yet been used for e-government website). A comparative study was carried out among the two developed prototypes. Finally the studied data were analyzed using both qualitative

and quantitative data analysis methods to find out the best approach for developing any e-government website.

CHAPTER 4
USABILITY EVALUATION OF E-GOVERNMENT WEBSITES

This chapter briefly discuss the study objectives, participants profile, study procedures, data analysis and findings of the usability evaluation study that aimed to explore the overall usability standard in the e-government websites of Bangladesh.

4.1 **Study Objectives**

The aim of this evaluation study is to find out the usability problems of e-government websites of Bangladesh and to assess the overall usability standards of e-government website of Bangladesh. In order to attain this aim, two studies were carried out using two analytical usability evaluation methods that includes (a) heuristic evaluation (HE) using Nielson's heuristics [60] and (b) semiotic evaluation (SE) using the SIDE framework [38, 62, 63] to investigate six randomly chosen e-government websites of Bangladesh.

4.2 **Participants Profiles**

Twenty two post graduate students were participated in this study as expert usability evaluators. All participants had completed undergraduate degree program in Computer Science and currently pursuing the MSc in Computer Science and Engineering. Their average ages were 28-32 year. They have professional experience in computer related fields in average 4-6 years. Participants were enrolled in a postgraduate course name Human Computer Interaction (HCI), conducted combinedly by this thesis supervisor and student.

4.3 **Study Procedure**

An imperial research approach has been used in this study. At the beginning, enrolled students (participants) were taught and provided hands-on training on Nielsen's [60] heuristics and Islam & Bouwman's [38, 62] SIDE framework during the course work. The participants thus gathered considerable knowledge on analytical usability evaluation to evaluate any websites. At the end of the semester, participants (evaluators) were individually asked to evaluate 6 randomly chosen e-government websites of Bangladesh (see Table 4.1) using both the heuristic evaluation (HE) and the Semiotic Evaluation (SE) techniques. The qualitative and quantitative data were collected from the evaluation reports submitted by the evaluators (participants). The qualitative data analysis method and the descriptive statistics were used to analyse the retrieved data from the participants' reports. The evaluations of the assigned websites were considered as an assignment, and after a successful completion participants were given 10% marks of the total course marks. A written consent was also taken from each participant for their participation to comply with the ethical issues and to utilize the data anonymously in research and publication purpose.

Table 4.1: Selected Websites

Website	**URL**	**Short Form**
Bangladesh Government Web Portal	http://www.bangladesh.gov.bd	W1
Bangladesh Bureau of Educational Information and Statistics	http://www.banbeis.gov.bd	W2
Bangladesh Export Processing Zones Authority (BEPZA)	http://www.epzbangladesh.org.bd	W3
Department of Immigration and Passport	http://www.dip.gov.bd	W4
Bangladesh Computer Council (BCC)	http://www.bcc.gov.bd	W5
Bangladesh ICT Division	http://www.ictd.gov.bd	W6

4.4 **Heuristic Evaluation**

For the HE, the evaluators (participants) followed the Nielson's ten heuristics [60]. In HE, problems were identified with a severity rating (0 to 4) based on their frequency, impact and persistence [64] as shown in Table 4.2. For example, in website W2, under the link http://banbeis.gov.bd/data/index.php "Stat-2011" (see the Fig 4.1) was identified as a usability problem with a severity level 4. Here a list of articles is displayed with serial numbers and title. But the numbering of the article is not placed in exact location of each article. The serial numbers are placed in between and much closed to each title text, which may create confusion to end-users. This problem is found several times in some other pages of this website. So, this design violates the Nielsen's heuristics related to the consistency and aesthetics.

Table 4.2: Severity Rating

Severity	Description
0	Not a problem: I don't agree that this is a usability problem at all
1	Cosmetic problem: need not be fixed unless extra time is available
2	Minor usability problem: fixing this should be given low priority
3	Major usability problem: important to fix, should be given high priority
4	Usability catastrophe: imperative to fix this before product is released

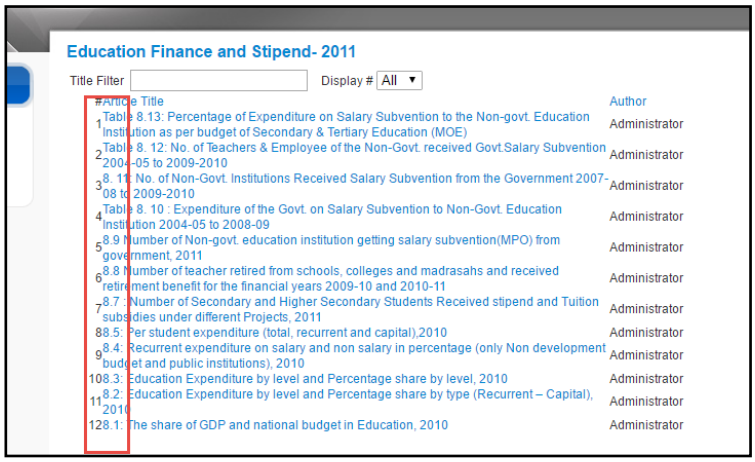

Fig.4.1: Screenshot (part-of) taken from Bangladesh Bureau of Educational Information and Statistics (W2) website

Table 4.3 summarized the average number of problems (i.e., violation of the usability guidelines) found with respect to each heuristic for each websites and the total number of problems found in each website. The problems identified under each heuristics are then weighted with given severity rating (see Table 4.4). The percent of the weighted average values to each heuristic are shown in Fig 4.2.

Table 4.3: Average Number of Problems Identified Using Neilsen's Heuristic

Website	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	Total
W1	9	10	26	31	6	10	28	20	5	3	148
W2	8	16	4	20	4	8	20	16	5	3	104
W3	16	5	11	10	3	2	15	10	5	6	83
W4	5	5	4	11	8	2	6	5	10	1	57
W5	5	5	3	10	9	3	6	10	2	2	55
W6	8	2	8	6	3	3	14	7	5	3	59

These results indicate that each websites has good number of usability problems, for example, more than hundreds problems are found in W1 and W2; while rest of them are shown more than fifty problems (see Table 4.3). Again, the results (see Table 4.4 and Fig 4.2) showed that the e-government websites of Bangladesh are mostly following H10, H5 and H6 Nielsen's Heuristics [60] (their values are low, they deviated less). Whereas mostly overlooked guidelines are H4 and H7 (their values are high, they deviated more). On the other hand H3, H8 and H1 are shown a considerable high value. The highest value of H4 indicates that while constructing the websites the developer mostly violated the *consistency and standard* of the websites.

Table 4.4: Average Weighted Values of Problems Identified Using Neilsen's Heuristic

Website	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10
W1	24.20	17.80	72.67	55.20	19.20	28.40	49.80	34.40	14.00	6.60
W2	26.33	48.00	13.33	54.67	15.33	26.67	58.33	39.33	18.67	12.67
W3	39.75	13.00	24.50	21.25	6.75	4.50	17.75	18.75	14.50	4.00
W4	11.00	12.50	10.25	24.50	20.50	5.25	15.25	11.00	25.00	2.75
W5	15.00	10.00	8.00	27.50	9.00	8.75	16.75	23.25	8.00	4.00
W6	19.00	3.00	19.00	13.50	9.00	7.00	31.50	14.00	15.50	9.50

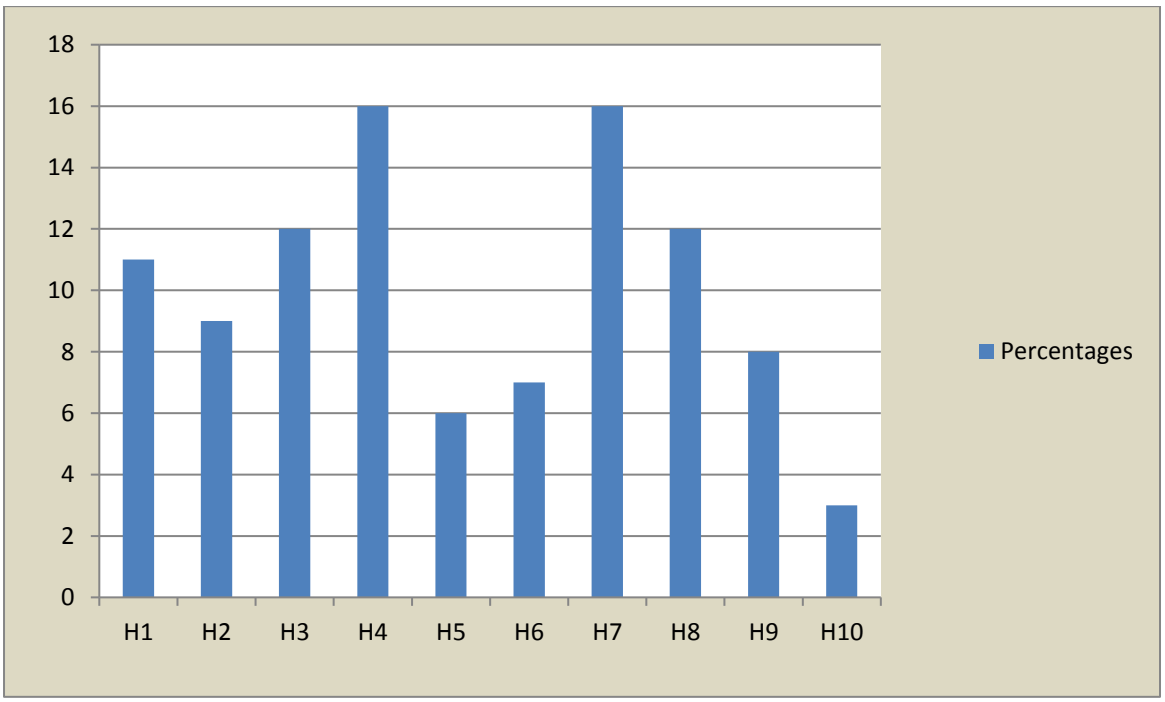

Fig.4.2: The weighted average values to each heuristics

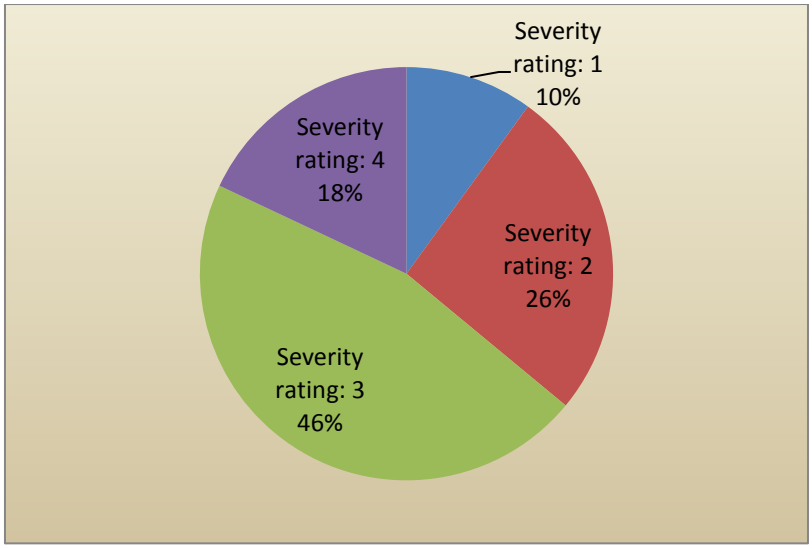

Fig.4.3:Percentages of usability problems belongs to each severity level

The study results also showed that about half of the usability problems (46%) are of severity rating 3 (see Fig 4.3). The severity rating 3 refers to the 'major *usability problem: important to fix, should be given high priority*' [64]. The findings thus indicate that the e-government websites have been designed and developed having noticeable number of major usability problems which must be rectified immediately.

4.5 **Semiotic Evaluation**

For SE, evaluators (participants) followed the heuristics (of five layers) as proposed in the SIDE framework [38, 62]. In this case, evaluators investigated the intuitiveness level (*high*, *low* or *moderate*) of each interface signs of the selected e-government websites usability. For example, a participant (evaluator) found in W1 that the sign 'Online Registration with icon' (see the Fig 4.4) is not intuitive (*less intuitive*); since the sing stands for providing online services for citizens but the appended icon represents walking for service. Online services are provided to citizens so that they do not need to come (walk) to office. The appended icon is conflicting with the text and it breaks the matching properties with the real-world conventions. Moreover, the icon is not logical coherent

with the sign text. The sign thus violated the semiotic heuristics no 8, 10 and 12 (see Table 4.1).

Fig 4.4: Screenshot of (part-of) homepage of Bangladesh National Portal (W1) website

An average number of problems identified under each semiotic layers of the SIDE framework is shown in Table 4.5. Each of the problems is then weighted according to the intuitive level of the observed interface signs as low, moderate and high. The *low* has lowest weight (=1) and the *high* has the maximum weight (=3). An average value was calculated for each website. The weighted average values against the problems are shown in Table 4.6.

The results showed that the SE fund comparatively less number of problems with respect to the findings using the HE (see the Table 4.3 and 4.5). However, the maximum number of problems are found in W1 and W2 using the SE, a similar outcomes like the findings of the HE (see Table 4.3). These results also showed that mostly followed semiotic heuristics to design the interface sign of e-government websites of Bangladesh are in Environment level (only 7% deviated), while the mostly overlooked layer is syntactic (56% deviated) (see Table 4.6). This indicates that the representational features of signs, structure, scheme and language, as well as the structural relationships between signs are

not properly considered in designing the interface signs of the e-government websites of Bangladesh.

Table 4.5: Average Number of Problems Identified To Each Semiotic Layers

Website	Syntactic	Pragmatic	Social	Environmental	Total
W1	44	23	17	9	93
W2	29	11	5	6	51
W3	23	8	5	3	39
W4	28	12	3	2	45
W5	28	9	6	0	43
W6	24	14	4	2	44

Table 4.6: Average Weighted Values of Problems Identified Using Side Framework

Website	Semiotic Layers			
	Syntactic	Pragmatic	Social	Environmental
W1	74.8	39.8	28.4	14.6
W2	39.7	17.7	6.3	9.3
W3	39	13.5	6.5	4.5
W4	51	21.5	5	2.75
W5	52.25	16.75	10	0
W6	18.5	11.25	3	1.5
Avg	45.87	20.08	9.87	5.45
%	56%	25%	12%	7%

4.6 **Overall Assessment**

Designing user-intuitive user interface to improve the usability has attracted the attention of human-computer interaction researchers and practitioners for almost few decades. Our main intention was to cast new light on the topics of ‘e-government’ and ‘usability’ by assessing the usability standard of e-government websites of Bangladesh using multiple usability evaluation methods. This study showed that e-government websites of Bangladesh are significantly suffering usability problems and the intuitiveness of the

interface signs are required to be improved in order to improve the overall accessibility and acceptability of e-government websites by the citizens of Bangladesh. The outcome of this study was published in the proceeding of an international conference [65].

CHAPTER 5
DESIGN AND DEVELOPMENTOF E-GOVERNMENT WEBSITES

This Chapter firstly discusses the design procedure of an e-government website for disaster and relief management using the IDM method followed by the development of this IDM-based website. After that, the chapter presents the design procedure of the same website using the Card Sorting method and then the development of the Card Sorting based e-government website for disaster and relief management.

5.1 **Designing the website using IDM**

Designing process of website for disaster and relief management using IDM was done in three phases. The phases were: Conceptual Design (C-IDM), Logical Design (L-IDM) and Page Design.

5.1.1 **Conceptual IDM (C-IDM)**

Conceptual design was the first step of the design process in IDM. It followed some strategy to plan the content of the system would. This was a conceptual schema which formulates necessary "dialogue strategies" for interacting with the application without specifying medium or channel like web, mobile application. It had three simple design elements: "topic," "relationship," and "group of topic" [52].

5.1.2 **Design Elements of C-IDM**

- **Topic:** Topic in C-IDM was viewed as conversation between the user and the interactive application as two persons in real world converses on some subjects. This conversation might be categorized by 'Single Topic' and 'Multiple Topics'. Single topic involved conversation on a single subject with single instance. On the other hand, 'multiple topics' encompasses multiple subjects with

multiple instances [40]. The subjects might be arranged or identified in different categories which were known as ‘Kind of Topic’.

- **Relationship:** It was the connection or transition between the topics**.** During a conversation multiple subjects might be discussed and subject might mingle or change from one to another. Relationship determines the strategy of switching from one kind of topic to another. It was represented by a directed line from one kind of topic to another kind of topic in the design with cardinalities. Cardinalities were indications of the number of topics instances [52]. This could be one-to-one (1:1) or one-to-many (1:n).
- **Group of Topics:** A group of topics was a set of instances of a multiple topic. It determined a specific group of topics or possible subject of conversation [52]. A family of group of topics represented ‘multiple groups of topics’.

5.1.3. C-IDM of the e-government website

Based on the above theoretical background, the C-IDM of the proposed prototype was designed as shown in Fig 5.1.

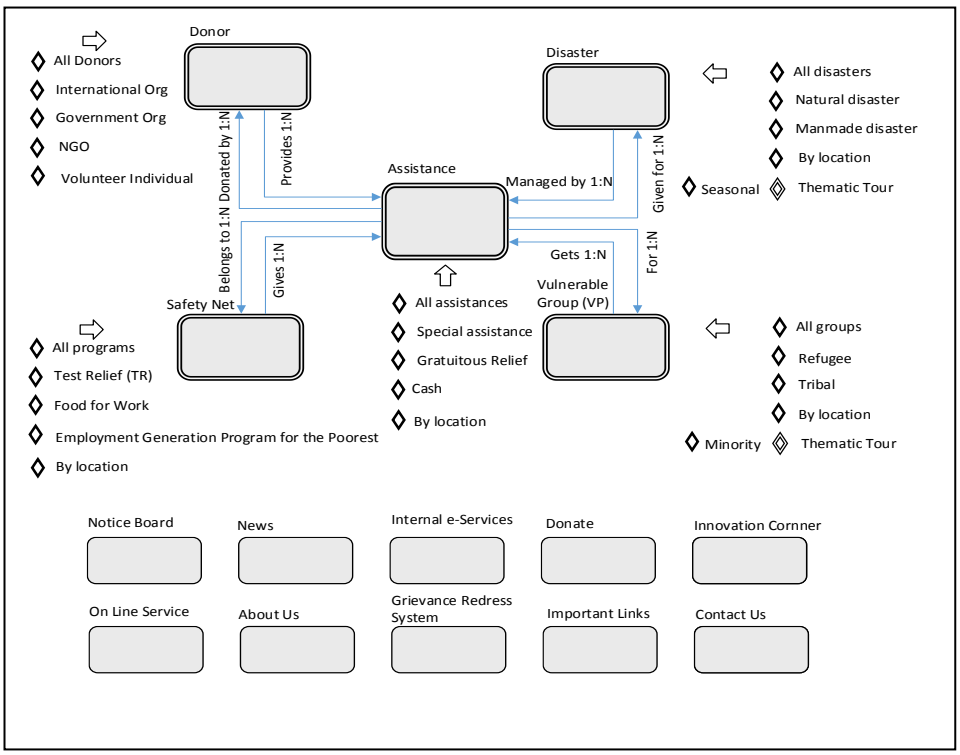

Fig 5.1: C-IDM of disaster and relief management website

There were five ‘Kind of Topics’ in the C-IDM for the website: ‘Donor’, ‘Disaster’, ‘Assistance’, ‘Safety Net’ and ‘Vulnerable Group’. Single Topics were Donate, FAQ, Notice Board, News, Contact Us, About Us, Important Links, etc. Relevant relations indicated the relations between two multiple topics with cardinality in the application. For example, each ‘Donor’ was allowed to provide various types of ‘Assistance’ i.e. Cash, Gratuitous Relief or any types of special assistance and at the same time, any types of ‘Assistance’ could be provided by several types of ‘Donor’. So there was a *n:n* (many-to-many) relationship. Similarly a ‘Disaster’ could be managed by various types of ‘Assistance’ and at the same time; any types of ‘Assistance’ could be provided by several types of ‘Disaster’ i.e. Natural disaster, Manmade disaster, Seasonal disaster etc. Again under ‘Safety net’ there were various programs e.g. ‘Test Relief’, ‘Food for Work’, ‘Employment Generation Program for the Poorest’ etc. This ‘Safety net’ program was allowed to give various types of ‘Assistance’ and at the same time, any types of ‘Assistance’ might be belonging to several types of ‘Safety net’. Similarly under ‘Vulnerable Group’ there were various groups of people e.g. ‘Refugee’, ‘Tribal’ etc. who all were allowed to get various ‘Assistance’ and at the same time, any types of ‘Assistance’ might be applicable for various ‘Vulnerable Group’. All the cases had *1:n* (one-to-many) relationship among them.

5.1.4 **Logical IDM (L-IDM)**

Logical design was the second step of the design process in IDM. After the conceptual design had been defined, logical design decided the channel through which the application might be conveyed [52]. It could be traditional web, an oral channel, an interactive TV or a mobile channel. The logical design could be seen as a detailed version of the conceptual design. It decided the constraints imposed by the type of device

available on a given channel like screen size, keyboard, smart pen, mouse etc. It also decided on the media being used like audio, visual text, images, graphics, or video etc. [52]. It took consideration of the expected performance and the typical scenarios of use like home or office desktop, walking or standing contexts, mobile use on car, etc. The level of details could change, according to the specific needs of the project. It was mainly a channel dependent design. It specified the movement of dialogue combined user experience [52]. It had three design elements: "Dialogue Act," "Transition Act" and "Transition Strategy".

5.1.4.1 **Design Elements of L-IDM**

- **Dialogue Act**: Dialogue was the conversation between user and application but dialogue act was the move of the dialogue within a topic which could be single or multiple. These acts were based on the channel specification and user needs.
- **Transition Act**: Single dialogue did not require addition act to change from a Kind of Topic to another Kind of Topic. However, when there was a need to change from subject to many new subjects, an addition dialogue was needed which was called transition act. A strategy should be developed in a way that a user could access all the new topics.
- **Introductory Act**: It allowed the exploration of a group of topics as a whole. It consisted of an introduction followed by a list of the topics belonging to the group. Introductory acts were the unique starting points for the dialogue, in the sense that any dialogue started with an introductory act. It supported the access and exploration of all the topics belonging to the group.

5.1.4.2 **L-IDM of the proposed application**

Following the C-IDM schema, L-IDM for the web version was developed.

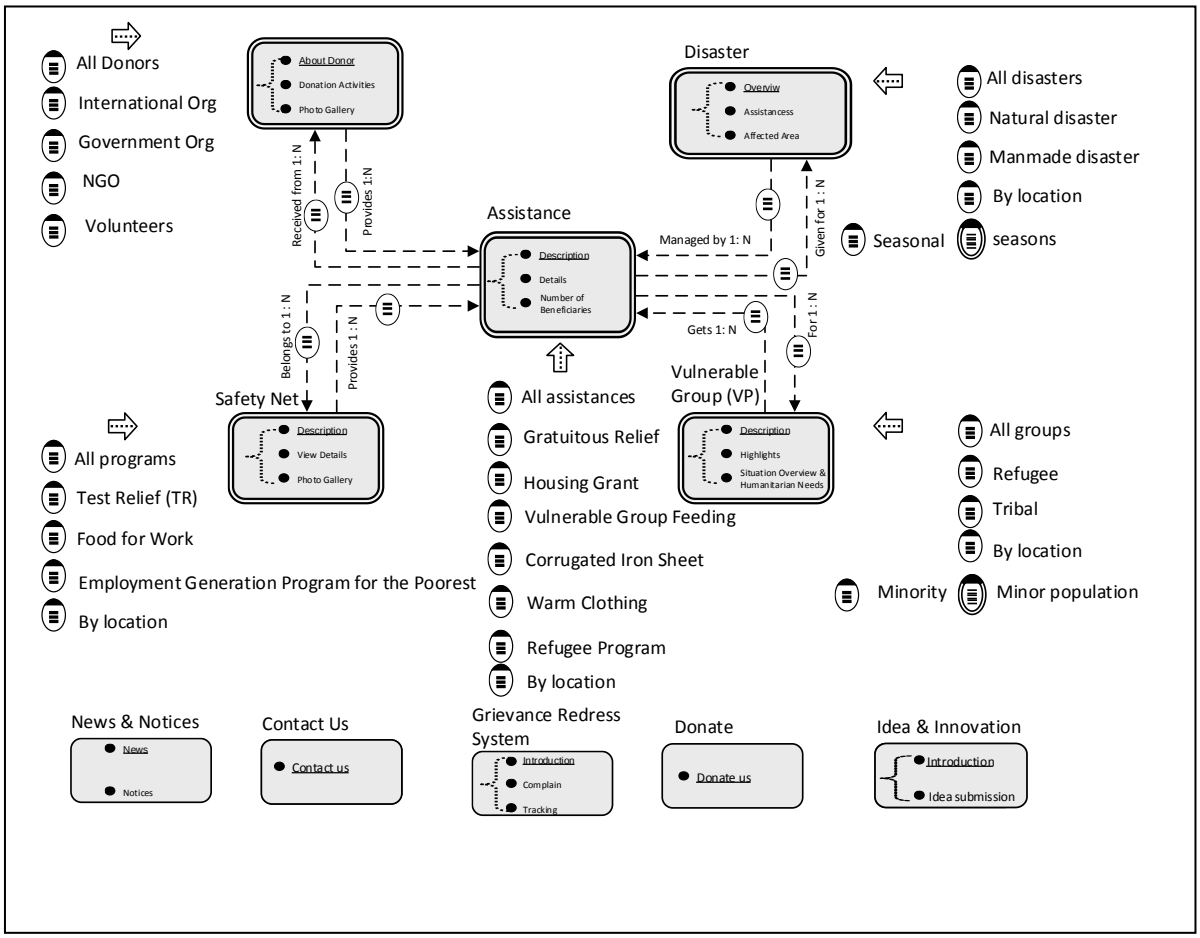

Fig 5.2: L-IDM of disaster and relief management website

Fig 5.2 represented the web application where kind of topics ‘Donor’ was fragmented into different dialogue acts such as ‘About Donor’, ‘Donation activities’ and ‘Photo gallery’ of each Donor. ‘About Donor’ was necessary for identification and verification of the Donor. ‘Donation activates’ of a particular was used to describe all the donation activities of a particular donor, while ‘photo gallery’ could be helpful to glorify the event. The

dialogue ‘About Donor’ was a default act which was shown as underlined. In the same way other kind of topics ‘Assistance’, ‘Disaster’, ‘Safety Net’ and ‘Vulnerable Group’ contained respective dialogue acts like ‘Description’, ‘Details’, ‘Highlights’, ‘Situation overview’ etc. All the kind of topics were different than others based on their role and activities. Single topic like ‘Donate’ had single dialogue act which briefly described the procedure as well as anyone could complete his donation process.

5.1.5 **Page IDM (P-IDM)**

According to the corresponding L-IDM design, pages were designed form each act containing the necessary elements of the dialogue [52]. During page designed each dialogue act, introductory act and transition act were converted into a page. Relevant topics, group of topics become landmarks of the page. At this stage page design did not consider wireframe, layout or graphic design. Later while pages were constructed, wireframe, layout or graphic design etc. came into consideration.

5.1.5.1 **P-IDM of the proposed application**

Following the P-IDM design technique numbers of pages were designed for the proposed application. Some of the pages design techniques are discussed below:

Landing (Home) Page: In the landing page (Fig 5.3) all the kind of topics were placed at the top. Moreover the most significant single topic 'Donate' was also placed beside the kinds of topics. Link of most important group of topics were placed left side of the page. Other important events like description of Ministry, messages etc. were placed right side of the page. Rest single topics were placed bottom of the page.

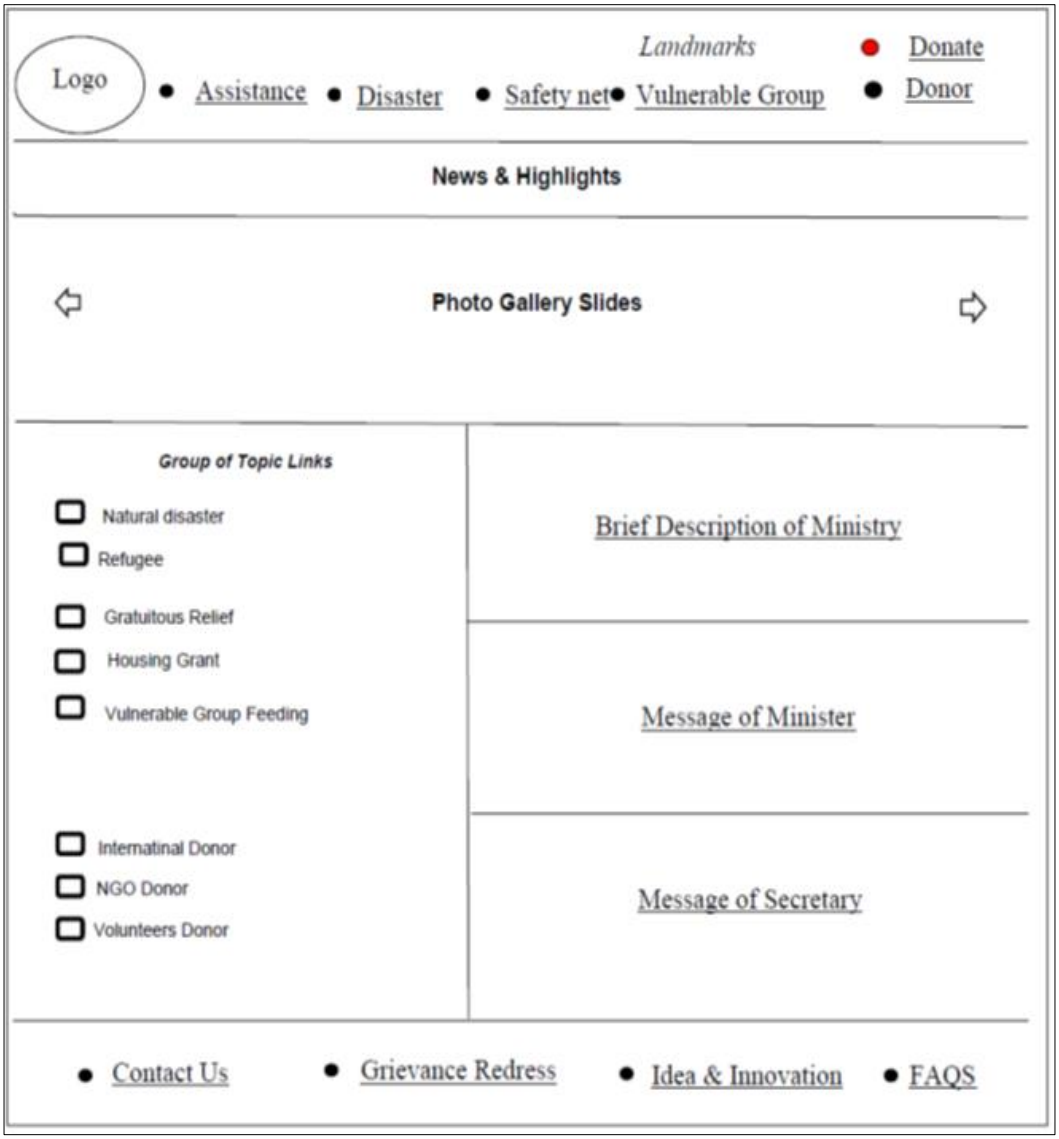

Fig 5.3: Landing page design

Page of Introductory Act for Donor: The main purpose of the donor page (Fig 5.4) was to introduce every donors according to their category. In the Donor page all the kind of topics and single topic 'Donate' were placed at the top. Link of group of topics related to donor were placed left side of the page. Each donor was introduced at the right side of the page. Rest single topics were placed bottom of the page.

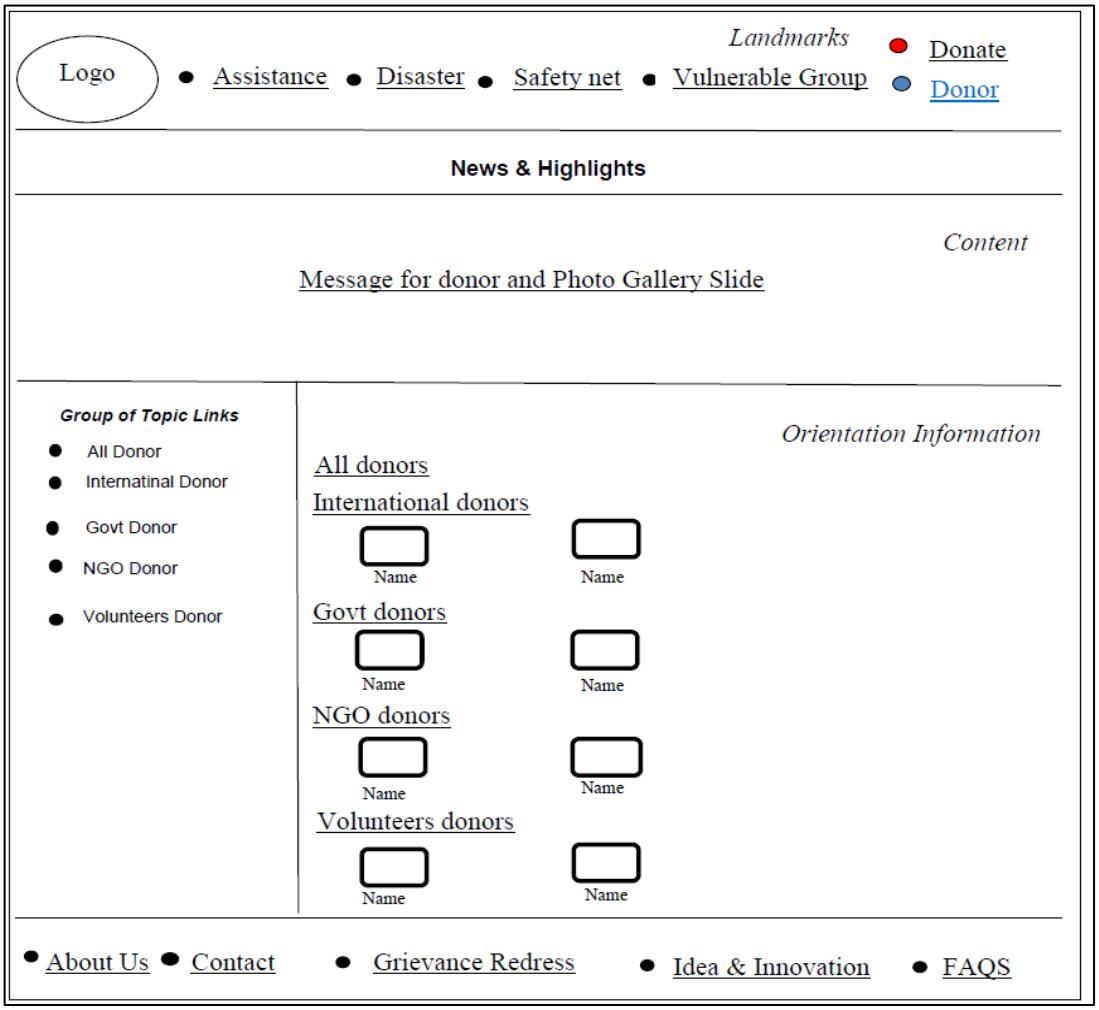

Fig 5.4: Introductory page of Donor

Page for Dialogue Act of a Multiple Topic for Donor: The main purpose of this page (Fig 5.5) was to introduce each donor in details i.e. title, content, structural link,

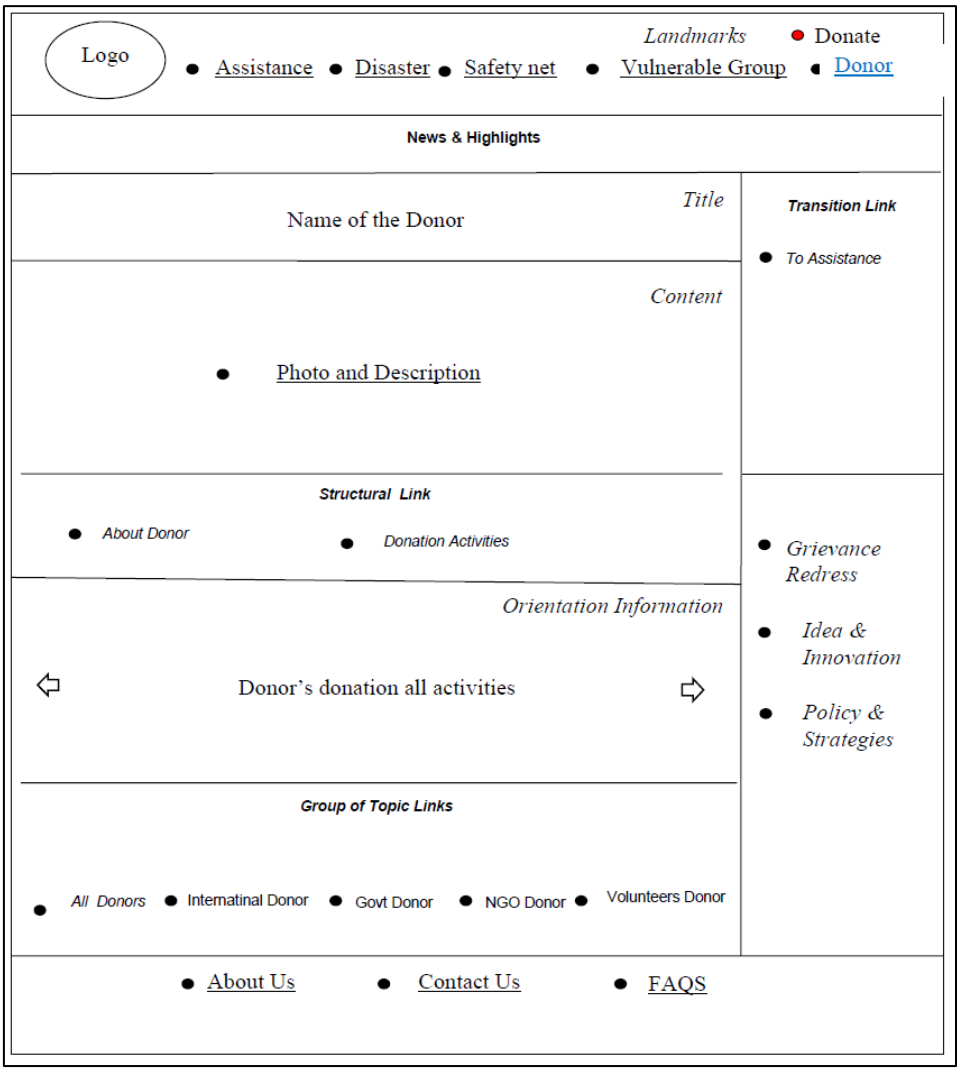

Fig 5.5: Dialogue act page of Donor

orientation information etc. There was also a transition link which was placed right top corner of the page. The purpose of the transition link was to navigate to the Assistance activities pages by the particular Donor. All the kind of topics and single topics were placed as like other pages following the symmetry.

Page for Transition Act from Donor: The main purpose of this page (Fig 5.6) was to introduce all assistance activities by a particular donor in details i.e. for 'Disaster', 'Vulnerable group' and 'Safety net'. Any visitor was able to navigate at any page related to assistance of a particular donor from this page. There was also a transition link which was placed bottom of the page. The purpose of the transition link was to back navigate to the particular Donor. All the kind of topics and single topics were placed as like other pages following the symmetry.

Fig 5.6: Transition act page of Donor

Page for Introductory Act of Assistance: The main purpose of the assistance page (Fig 5.7) was to introduce every assistance activities according to their category. In the assistance page all the kind of topics and single topic 'Donate' were placed at the top. Link of group of topics related to assistance activities were placed left side of the page. Each assistance was introduced at the right side of the page as orientation information. Rest single topics were placed bottom of the page following the symmetry.

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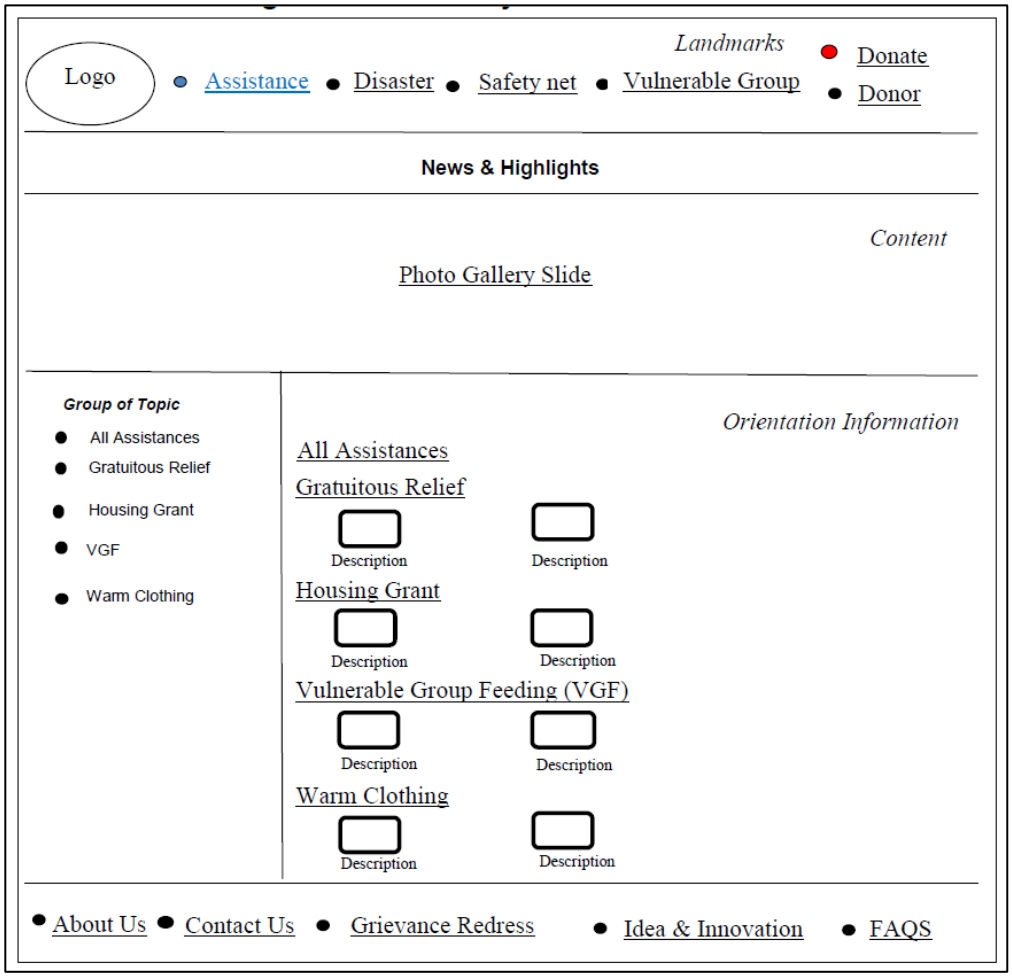

Fig 5.7: Introductory page of Assistance

Page for Dialogue Act of a Multiple Topic for Assistance: The main purpose of this page (Fig 5.8) was to introduce each assistance activities in details i.e. title, content, structural link, orientation information etc. There was also a transition link which was placed right top corner of the page. The purpose of the transition link was to navigate to the particular Donor/Disaster/ Safety net/ vulnerable group related to a particular

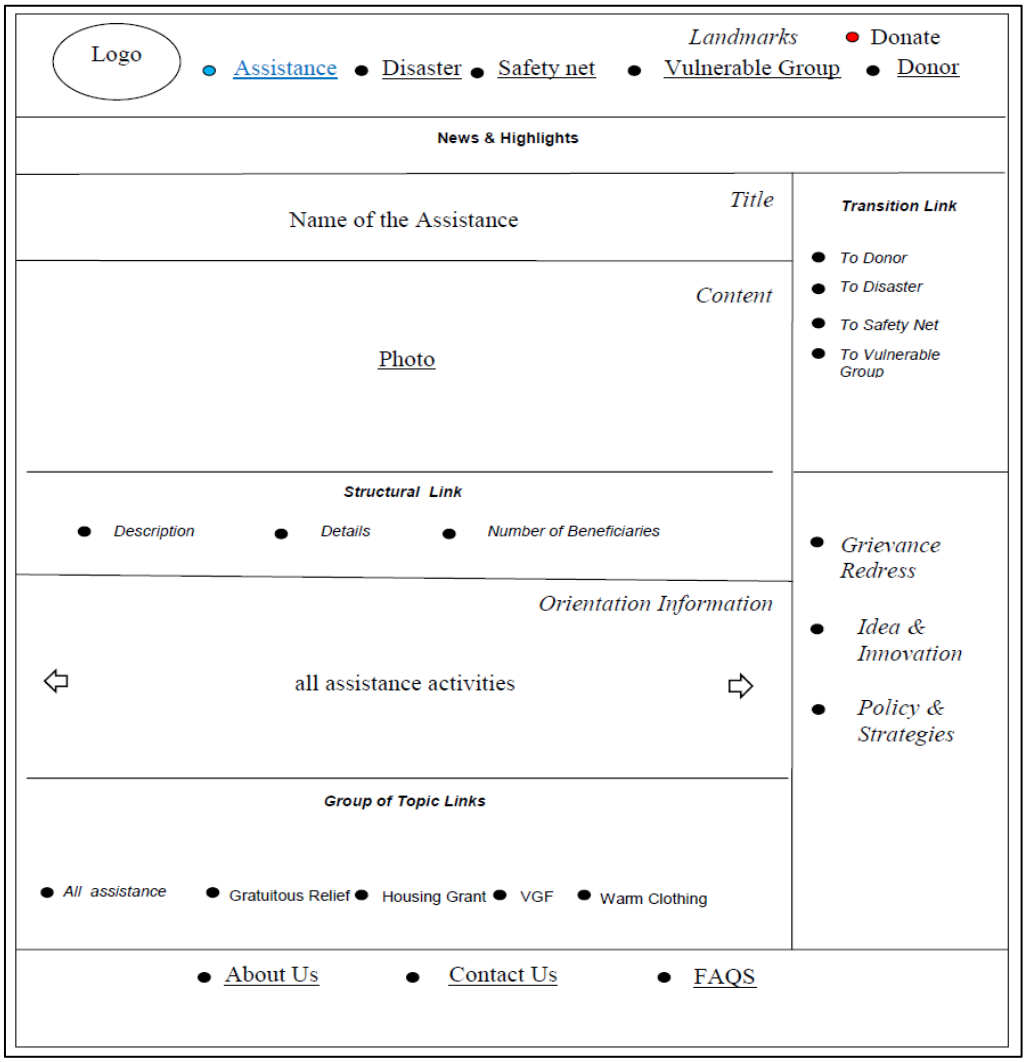

Fig 5.8: Dialogue act page of Assistance

assistance. All the kind of topics and single topics were placed as like other pages following the symmetry.

Page for Transition Act from Assistance: The main purpose of this page (Fig 5.9) was to introduce a particular types of assistance activities provided by all types of donor for any disaster/safety net/vulnerable group. A visitor was able to navigate at any page related to that assistance activities. There was also a transition link which was placed bottom of the page. The purpose of the transition link was to back navigate to the particular Assistance. All the kind of topics and single topics were placed as like other pages following the symmetry.

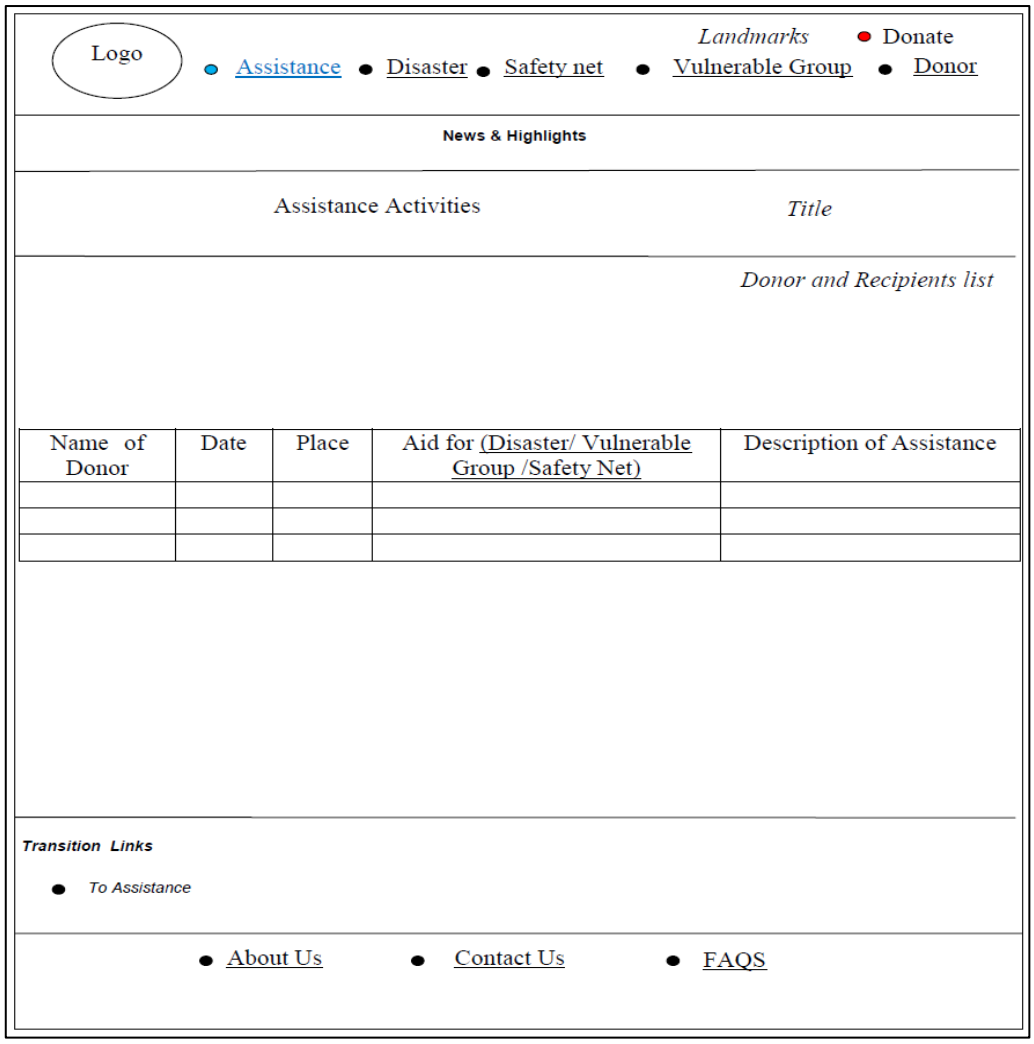

Fig 5.9: Transition act page of Assistance

Page for Introductory Act of Disaster: The main purpose of the donor page (Fig 5.10)was to introduce every Disaster according to their category. In the Disaster page all the kind of topics and single topic 'Donate' were placed at the top. Link of group of topics related to Disaster were placed left side of the page. Each disaster was introduced at the right side of the page. Rest single topics were placed bottom of the page following the symmetry.

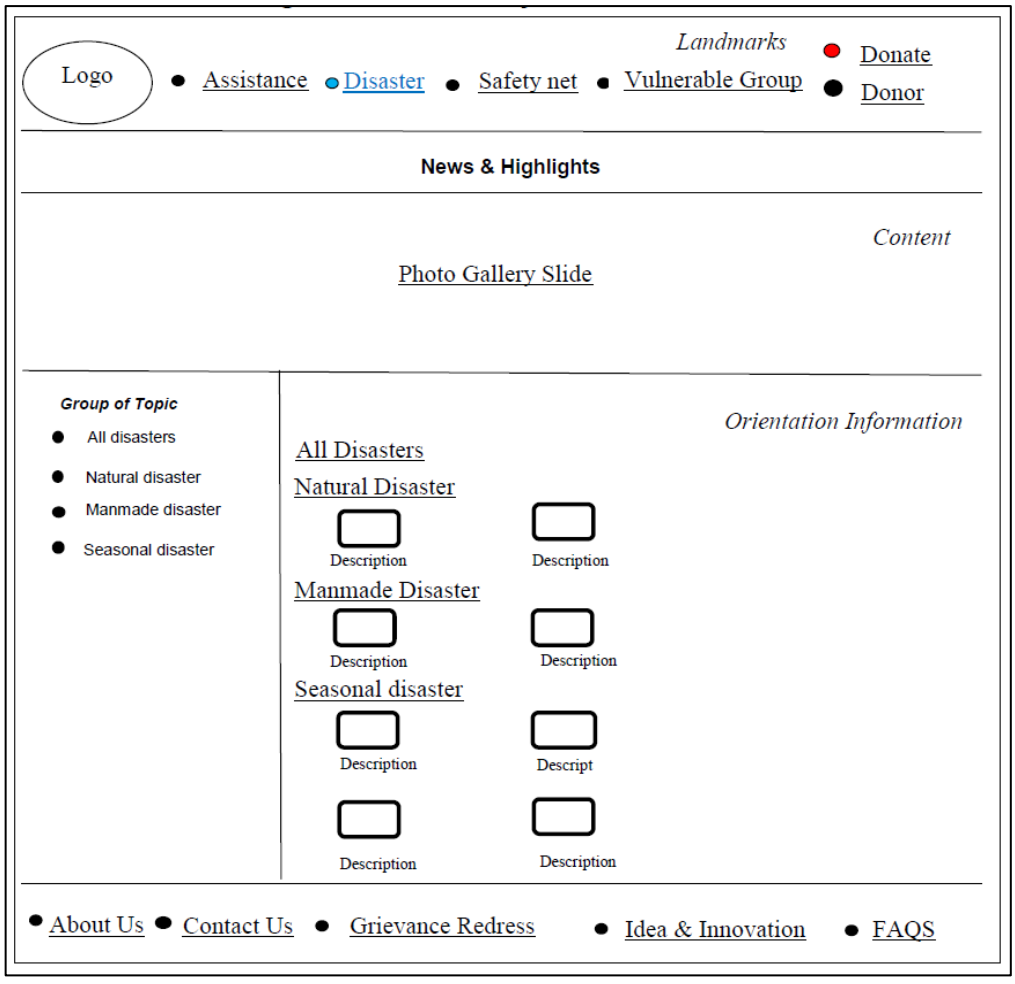

Fig 5.10: Introductory page of Disaster

Page for Dialogue Act of a Multiple Topic of Disaster: The main purpose of this page (Fig 5.11) was to introduce each Disaster in details i.e. title, content, structural link, orientation information etc. There was also a transition link which was placed right top corner of the page. The purpose of the transition link was to navigate to the Assistance activities pages applicable for the particular Disaster. All the kind of topics and single topics were placed as like other pagesfollowing the symmetry.

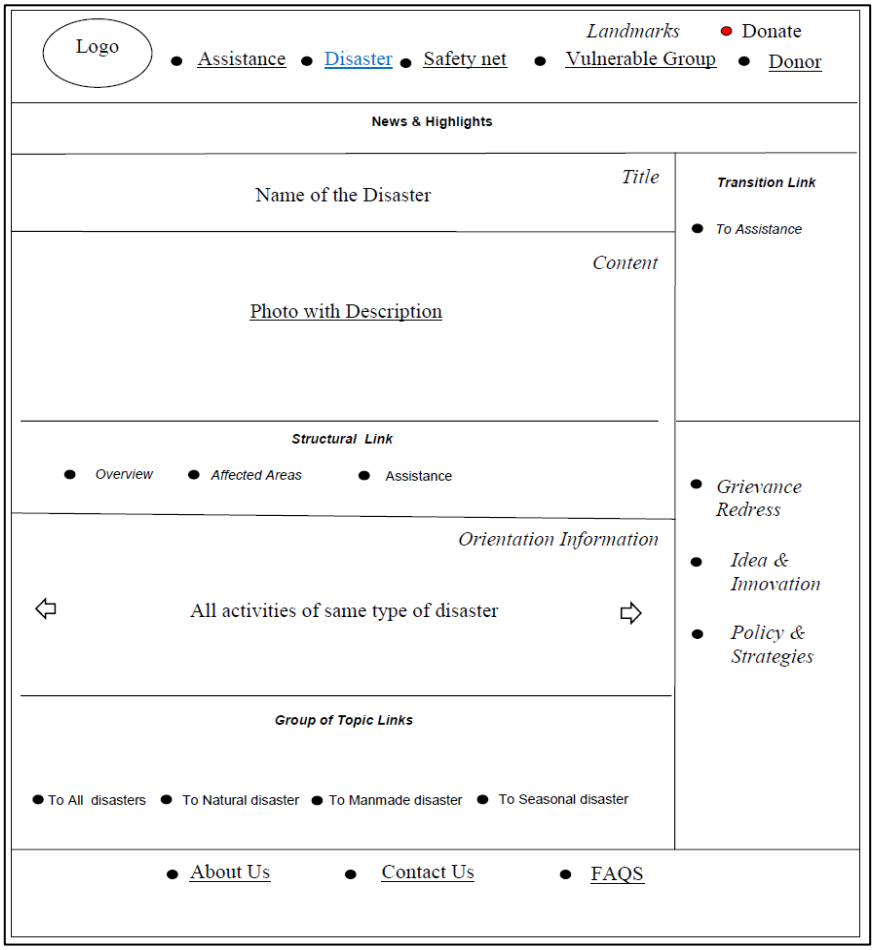

Fig 5.11: Dialogue act page of Disaster

Page for Transition Act from Disaster: The main purpose of this page (Fig 5.12) was to introduce all assistance activities for a particular disaster in details. There was also a transition link which was placed bottom of the page. The purpose of the transition link was to back navigate to the particular Disaster. All the kind of topics and single topics were placed as like other pages following the symmetry.

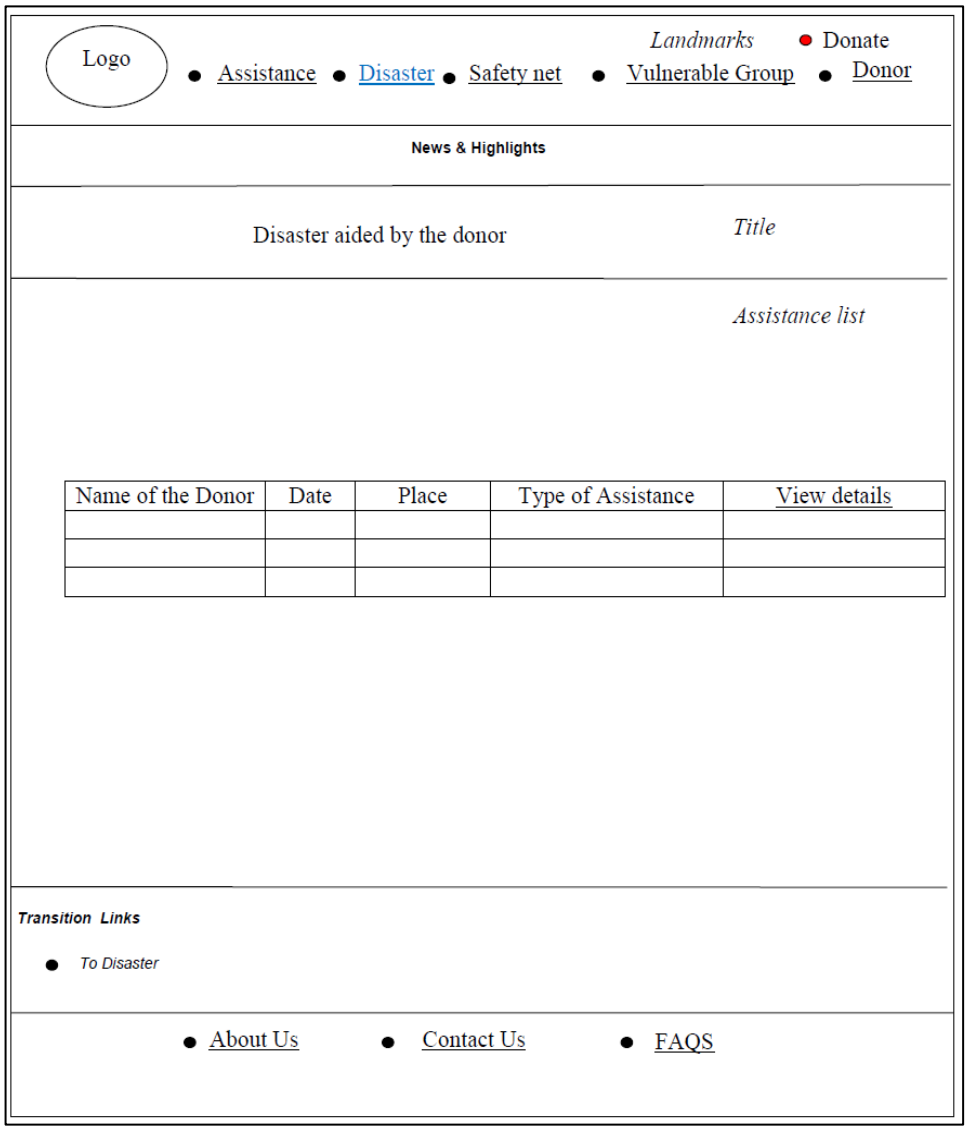

Fig 5.12: Transition act page of Disaster

Page of a Multiple Group Thematic Tour for Seasonal disaster: The main purpose of the thematic tour page (Fig 5.13) was to introduce every disaster according to their thematic category e.g. 'Seasonal disaster' was categorised as 'Flood', 'Heat wave', 'Cold-wave' and 'Storm' in group link. Again 'Flood' was categorised into 'Tidal', 'Flash' and 'Rain fall'. All the kind of topics and single topic 'Donate' were placed at the top. Rest single topics were placed bottom of the page following the symmetry.

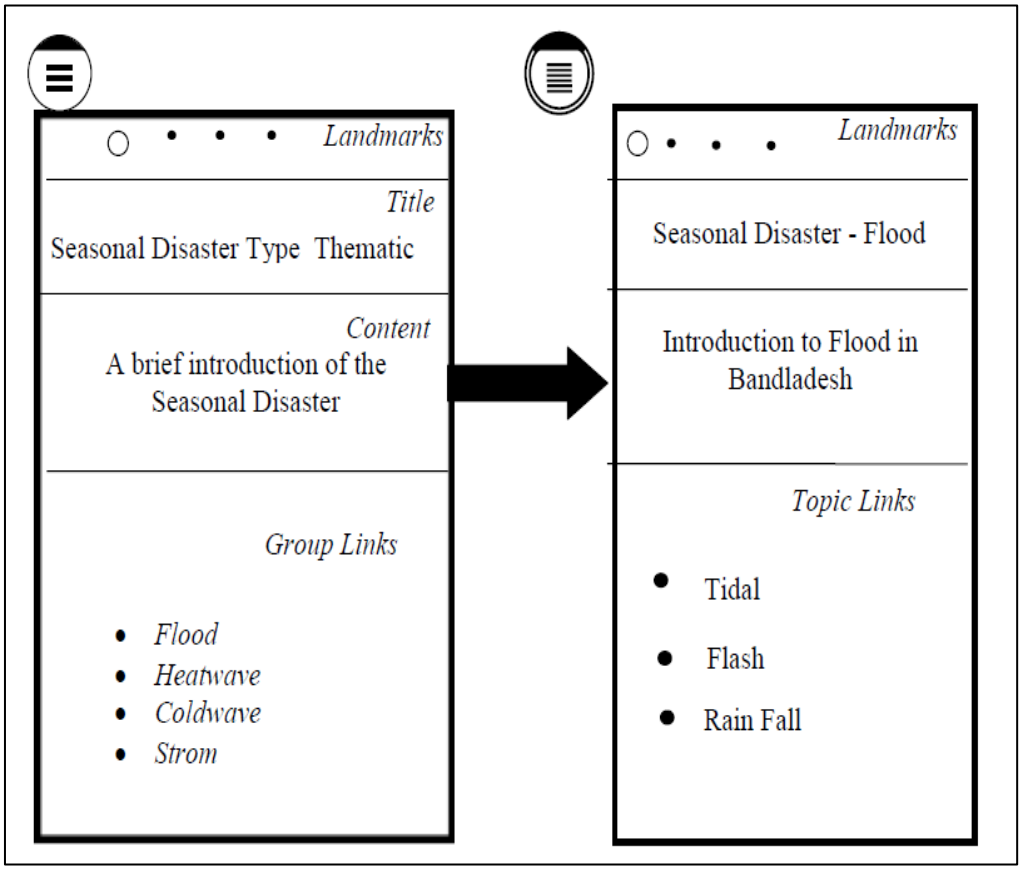

Fig 5.13: Thematic Tour page of Seasonal Disaster

Page for Introductory Act of Safety Net: The main purpose of the safety net page (Fig 5.14) was to introduce each safety net program according to their category. In the Safety net page, all the kind of topics and single topic 'Donate' were placed at the top. Link of group of topics related to Safety net program were placed left side of the page. Each type of Safety net program was introduced at the right side of the page. Rest single topics were placed bottom of the page following the symmetry.

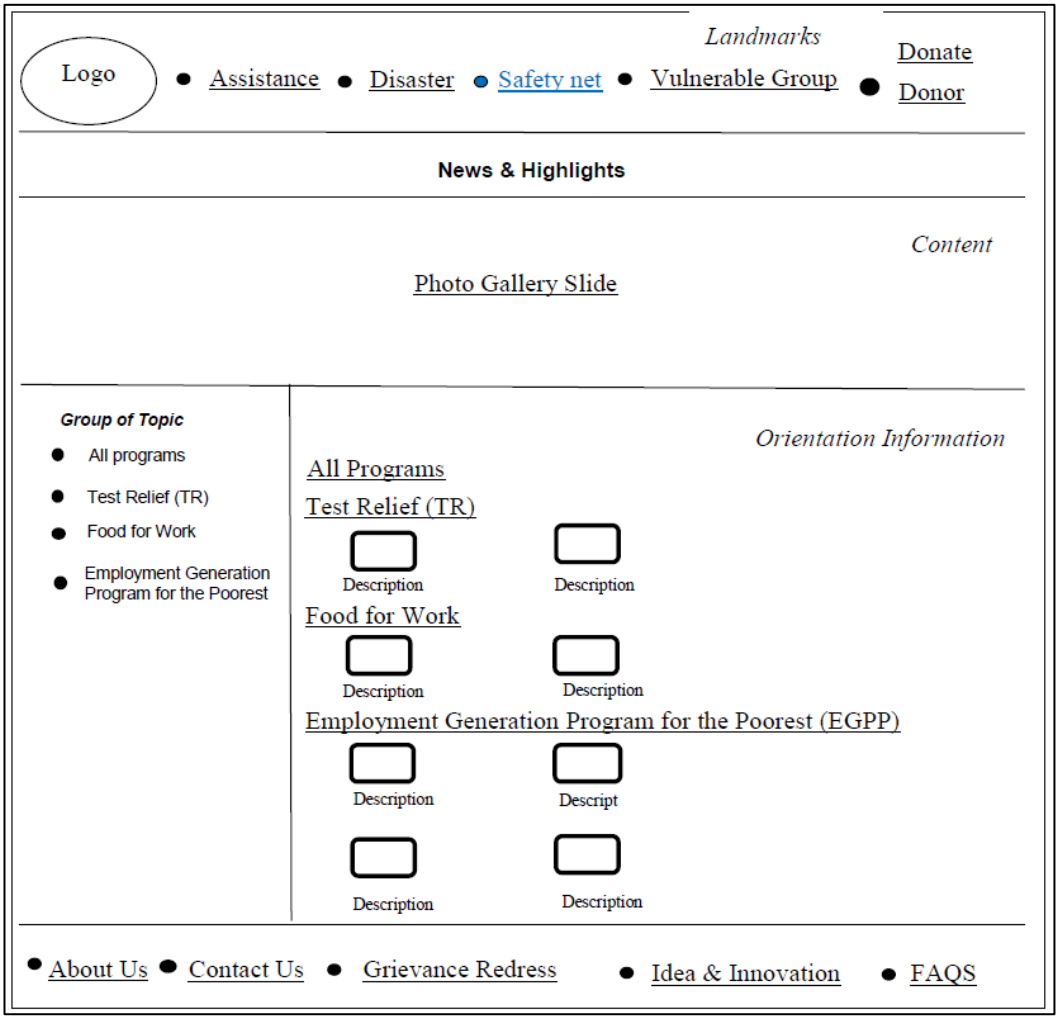

Fig 5.14: Introductory page of Safety Net

Page for Dialogue Act of a Multiple Topic of Safety net: The main purpose of this page (Fig 5.15) was to introduce each Safety net program in details i.e. title, content, structural link, orientation information etc. There was also a transition link which was placed right top corner of the page. The purpose of the transition link was to navigate to the Assistance activities pages applicable for the particular Safety net program. All the kind of topics and single topics were placed as like other pagesfollowing the symmetry.

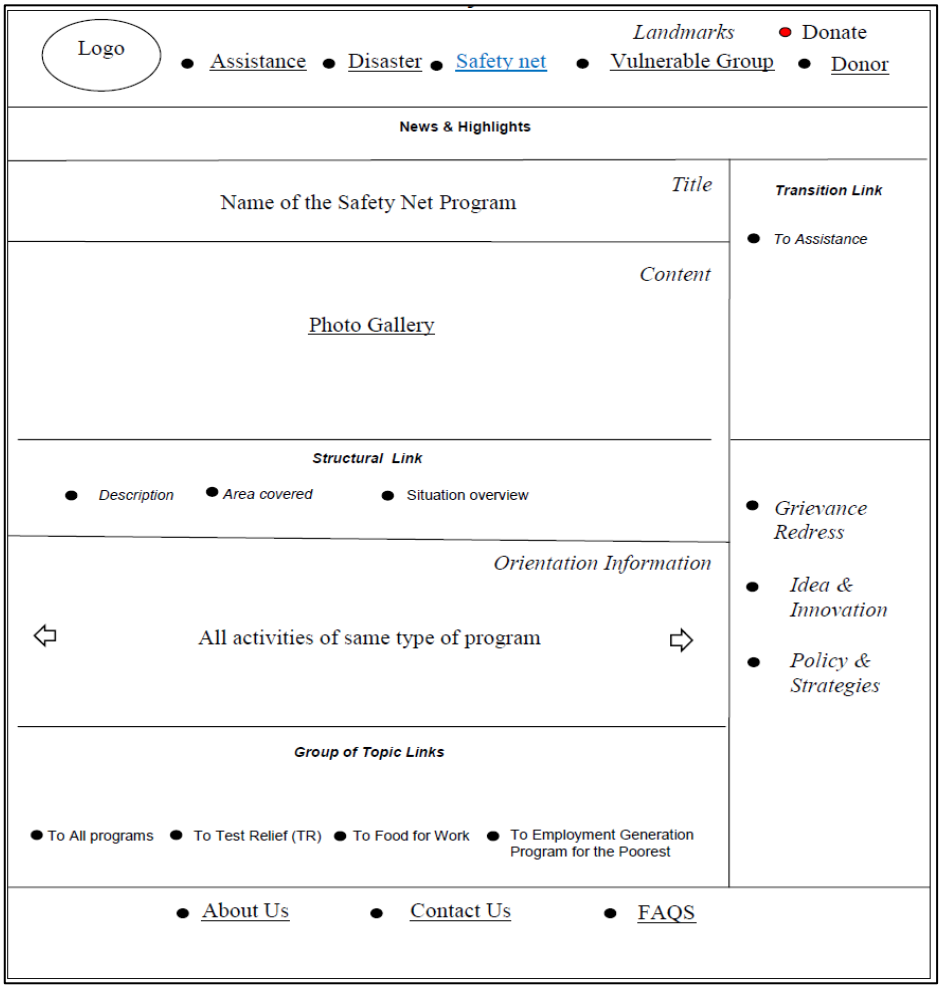

Fig 5.15: Dialogue act page ofSafety Net

Page for Transition Act from Safety net: The main purpose of this page (Fig 5.16) was to introduce all assistance activities for a particular safety net program in details. There was also a transition link which was placed bottom of the page. The purpose of the transition link was to back navigate to the particular safety net program. All the kind of topics and single topics were placed as like other pages following the symmetry.

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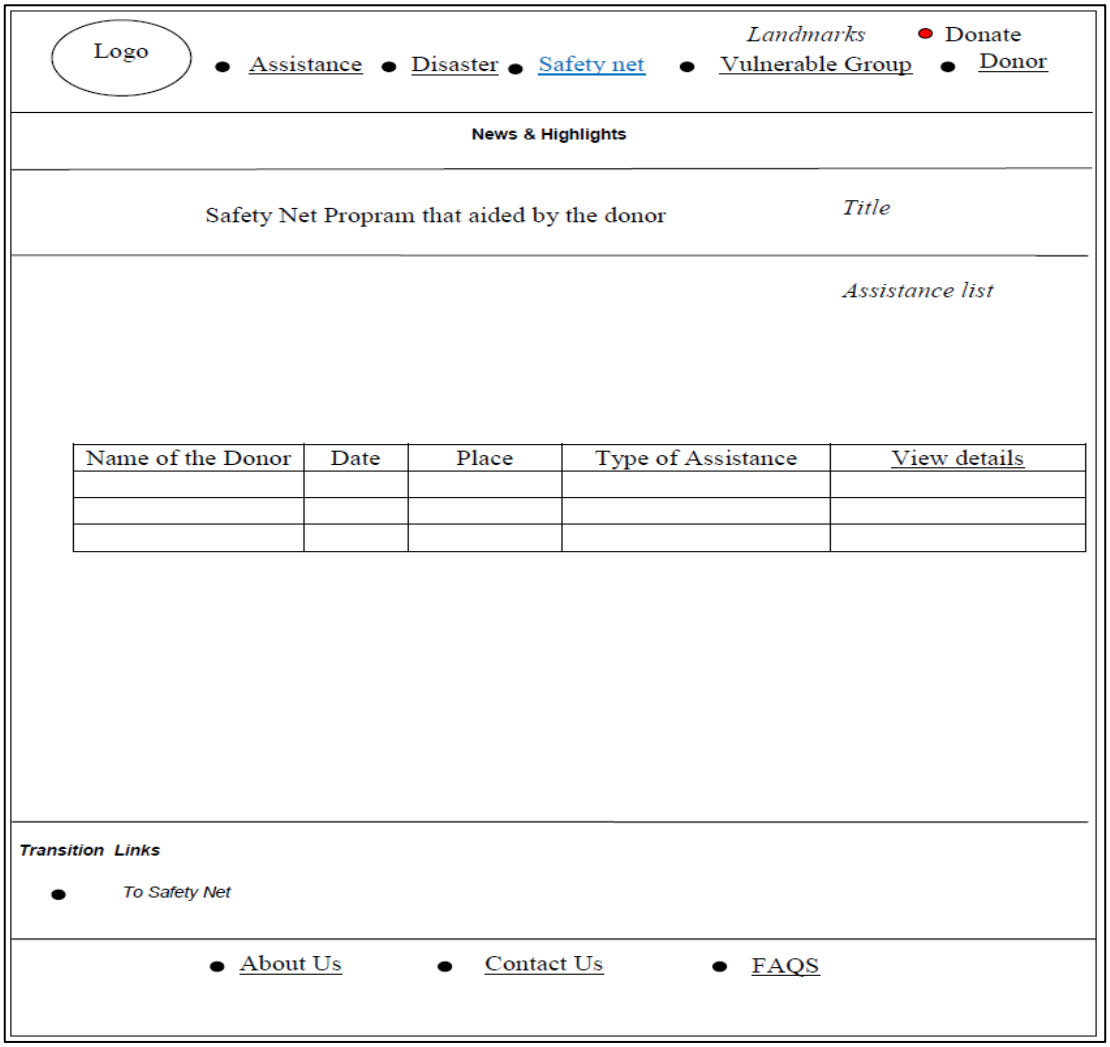

Fig 5.16: Transition act page of Safety Net

Page for Introductory Act of Vulnerable Group: The main purpose of the vulnerable group page (Fig 5.17) was to introduce each vulnerable group according to their category. In the vulnerable group page all the kind of topics and single topic 'Donate' were placed at the top. Link of group of topics related to vulnerable group were placed left side of the page. Each type of vulnerable group was introduced at the right side of the page. Rest single topics were placed bottom of the page following the symmetry.

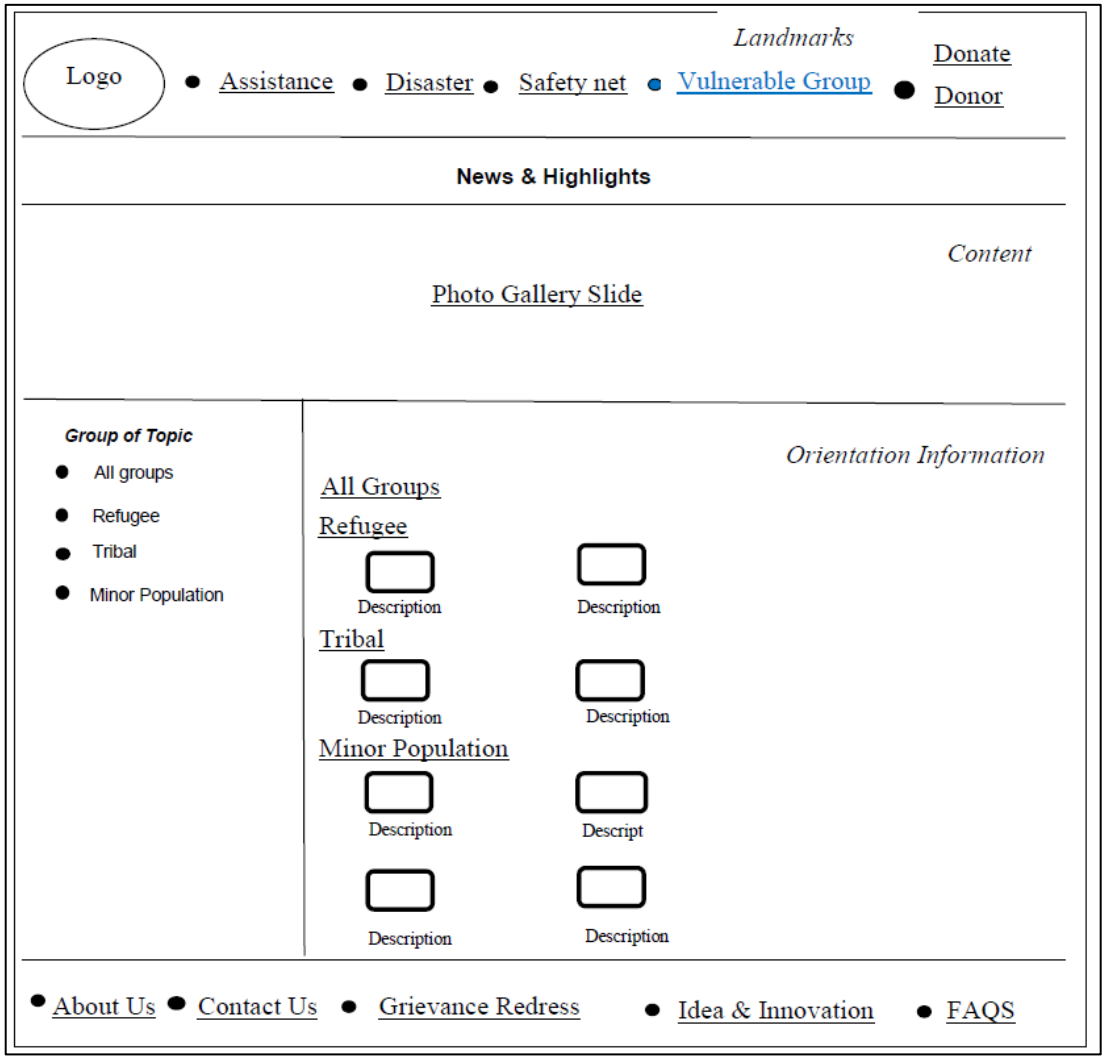

Fig 5.17: Introductory page of Vulnerable Group

Page for Dialogue Act of a Multiple Topic of Vulnerable group: The main purpose of this page (Fig 5.18) was to introduce each vulnerable group in details i.e. title, content, structural link, orientation information etc. There was also a transition link which was placed right top corner of the page. The purpose of the transition link was to navigate to the Assistance activities pages applicable for the particular vulnerable group. All the kind of topics and single topics were placed as like other pagesfollowing the symmetry.

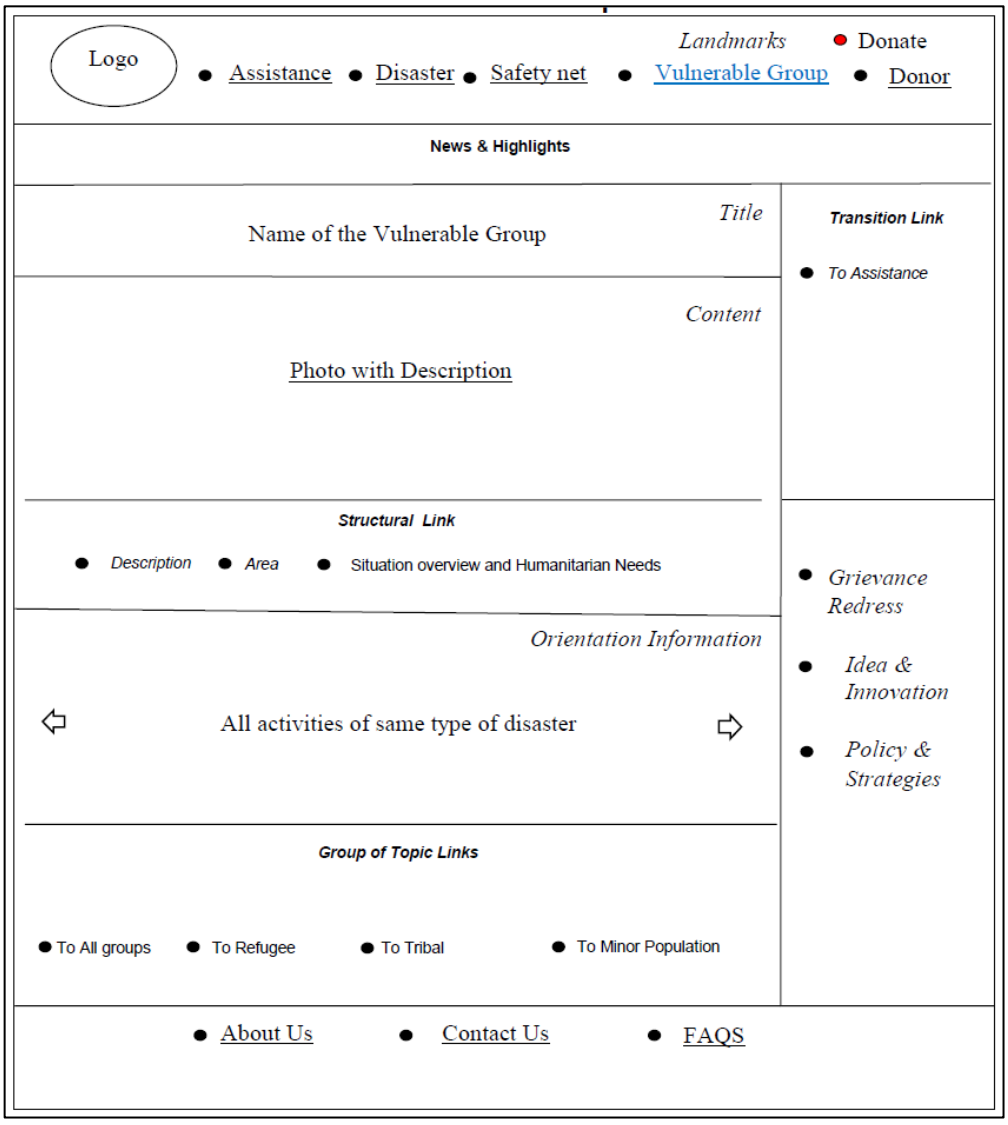

Fig 5.18: Dialogue act page of Vulnerable Group

Page for Transition Act from Vulnerable group: The main purpose of this page (Fig 5.19) was to introduce all assistance activities for a particular vulnerable group in details. There was also a transition link which was placed bottom of the page. The purpose of the transition link was to back navigate to the particular vulnerable group. All the kind of topics and single topics were placed as like other pages following the symmetry.

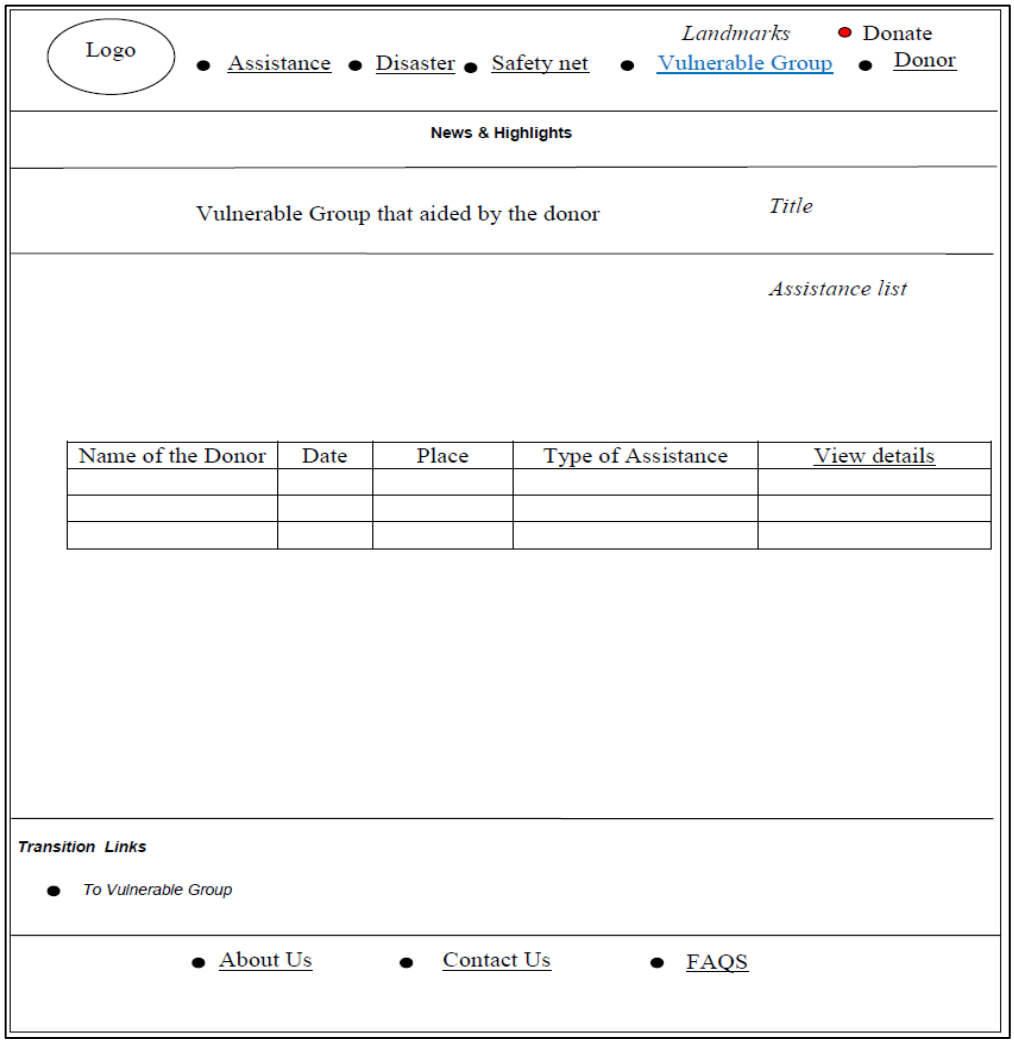

Fig 5.19: Transition act page of Vulnerable Group

Page for Introductory Act of Donate: The main purpose of the Donate page (Fig 5.20) was to introduce and collection of donation or assistance if anyone wanted to join in the donation activities. In the Donate page, a form has to be filled up by each donor as an orientation. The orientation was included essential information about the donor and what types of assistance they wanted to provide. After submitting the form by any donor the Admin of the website would responsible to update necessary information. In the page, all the kind of topics and single topics were placed as like other pages following the symmetry.

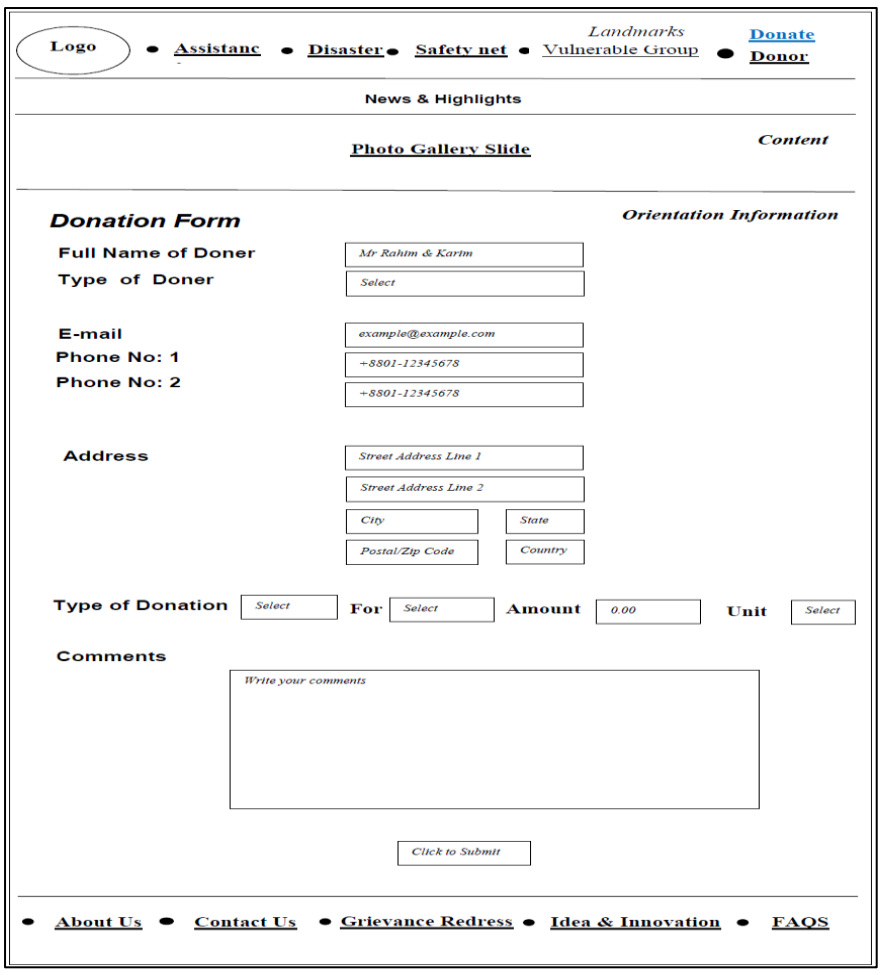

Fig 5.20: Introductory page of Donate

Page for Introductory Act of Policies and Governance: The main purpose of the Policies and Governance page (Fig 5.21) was to circulate the policies, rules and regulation about the Disaster and Relief Management System. In the page layout all the kind of topics and single topics were placed as like other pages following the symmetry. Any visitor would be able to see as well as download the policies, rules and regulation in their local machine.

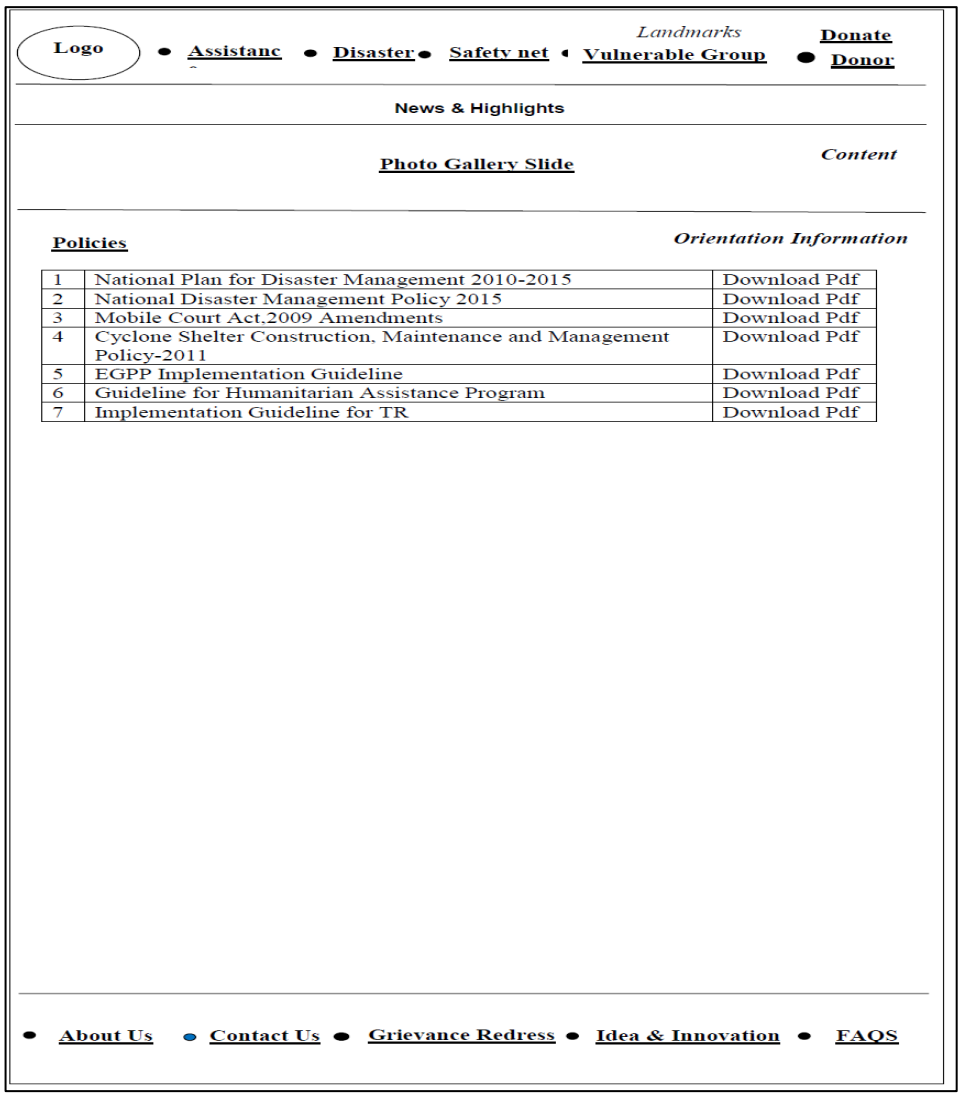

Fig 5.21: Introductory page of Policies and Governance

Page for Introductory Act of Frequently Asked Questions (FAQ): The main purpose of this page (Fig 5.22) was to provide the answers of frequently asked questions about the Disaster and Relief Management System. In the page layout all the kind of topics and single topics were placed as like other pages following the symmetry. Design for the FAQ was made in cluster concept i.e. question and answer related to same topics were clustered. This was done with a view to give more user more satisfaction.

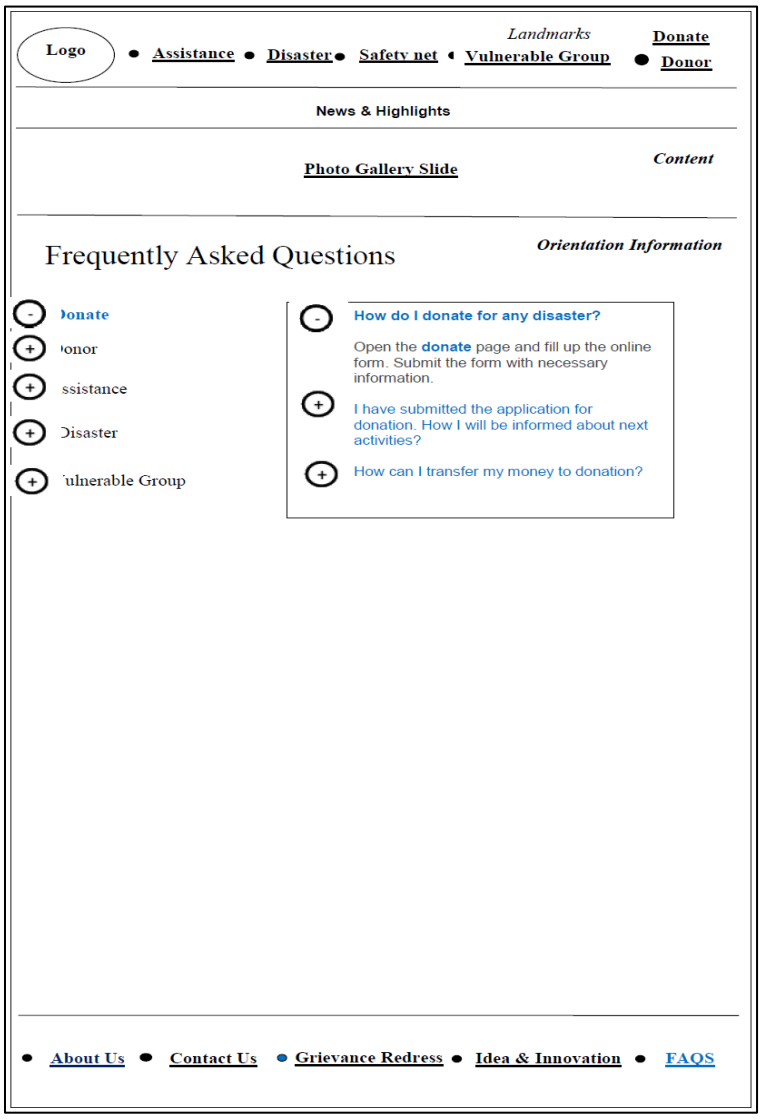

Fig 5.22: Introductory page of FAQ

5.2 **Developing the IDM based Website**

Bootstrap 4 (combination of HTML, CSS, and JavaScript framework) was used to build Content Management System (CMS) and webpages. The CMS was built to manage all assistance activities those would be visible in the webpages. Webpages were designed following the P-IDM. The navigation among the pages was followed the L-IDM.

5.2.1 **Content Management System (CMS) design**

There was an authentication system (Fig 5.23) to enter in the CMS. Provision was made to have multiple user login, so that more than one people could access the system. In the CMS the main panel was divided into two section according to their roll i.e. Dialogue Act of a Multiple Topic and Dialogue Act of a Single Topic. Multiple topic had several pages which will be automatically generated according to the no of Donor, Disaster, Vulnerable group etc.

Fig 5.23: Authentication System

5.2.1.1 **Dash board**

The Dash board was made according to the multiple topics and single topics. From the Dashboard (Fig 5.24) the admin was able to visit any of the tables which need to be updated when there would be a new disaster or assistance or donor. Besides it was possible to enter into any tables from the sidebar for better assimilation.

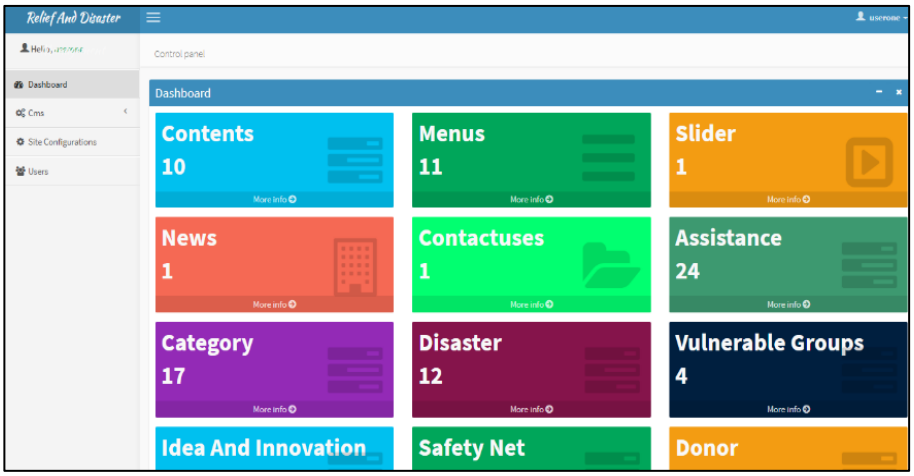

Fig 5.24: Dash board

5.2.1.2 **CMS for Multiple Topic**

Each of the multiple topics had their individual table which was needed to be updated by adding new row when there was a new event. Any event could be edited or deleted when there was a need. The CMS for multiple topics were Disaster (Fig 5.25), Safety Net (Fig 5.26), Vulnerable group (Fig 5.27), Assistance (Fig 5.28), Donor (Fig 5.29) and Donation (Fig 5.30).

Fig 5.25: CMS for Disaster

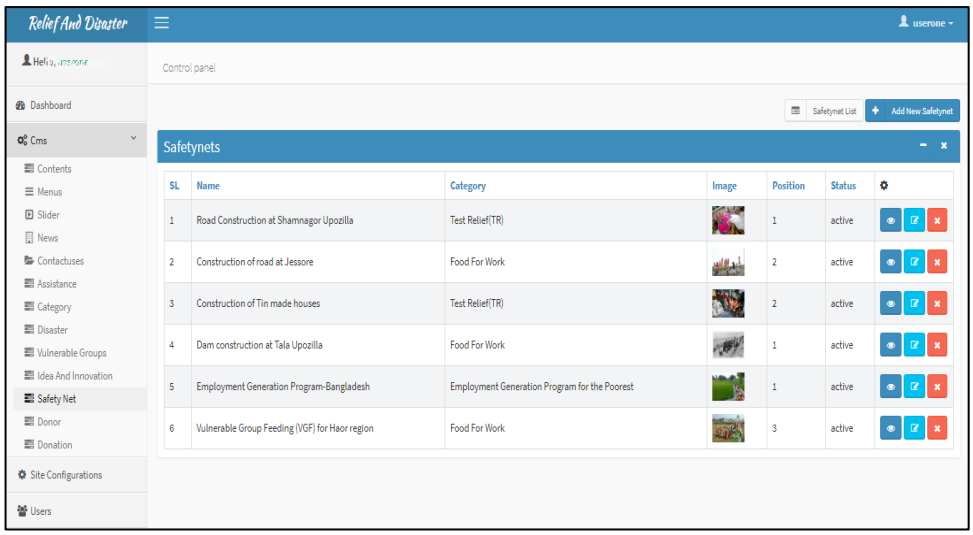

Fig 5.26: CMS for Safety net

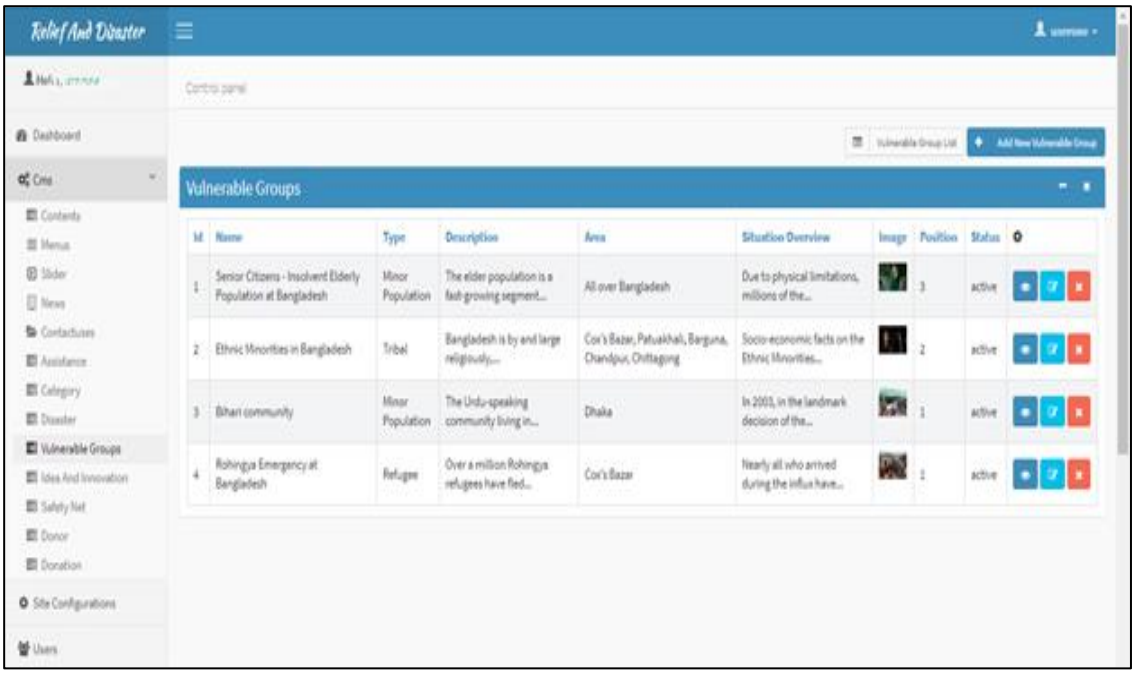

Fig 5.27: CMS for Vulnerable group

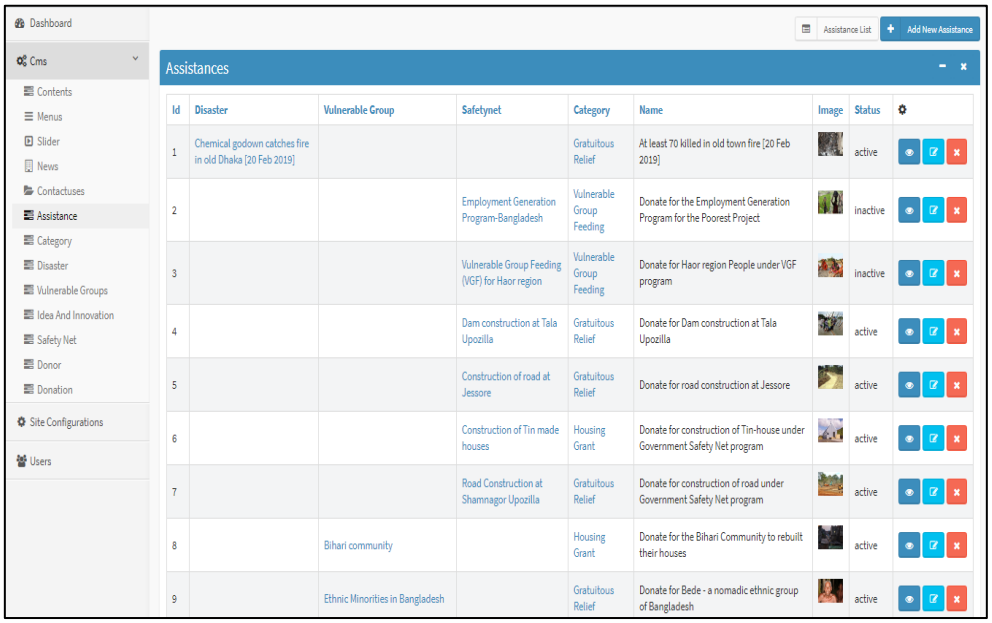

Fig 5.28: CMS for Assistance

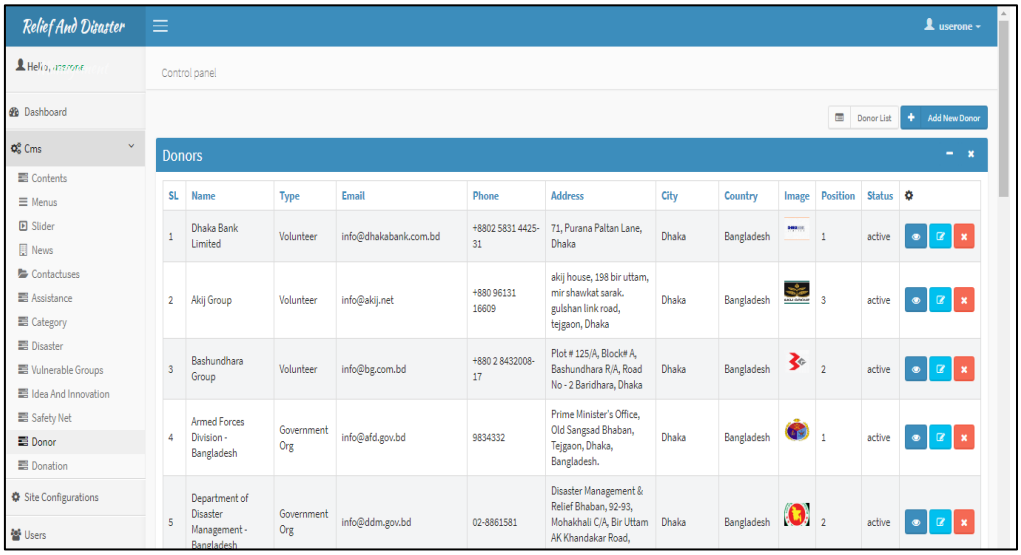

Fig 5.29: CMS for Donor

Fig 5.30: CMS for Donation

Whenever there was any new Disaster, Safety net program or vulnerable group, the related table in the CMS was updated and a new assistance was created in the 'Assistance' table. If any new or existing donor wanted to donate something for that assistance, he had to fill up the donation form. After submitting the form the table of 'Donation' automatically fetched the data. After getting the approval form higher authority the admin could publish the information in the related pages. For each of the activities new introductory pages would be automatically published. Similarly the transaction pages would be also updated.

5.2.1.3 **CMS for Single Topic**

All the single topics had a common single table (Fig 5.31) which was needed to be updated by adding new row when there was change of information or contents. There was a provision to add or delete any single topic. For any single topic there was a separate webpage. Only for the news there was a separate table (Fig 5.32).

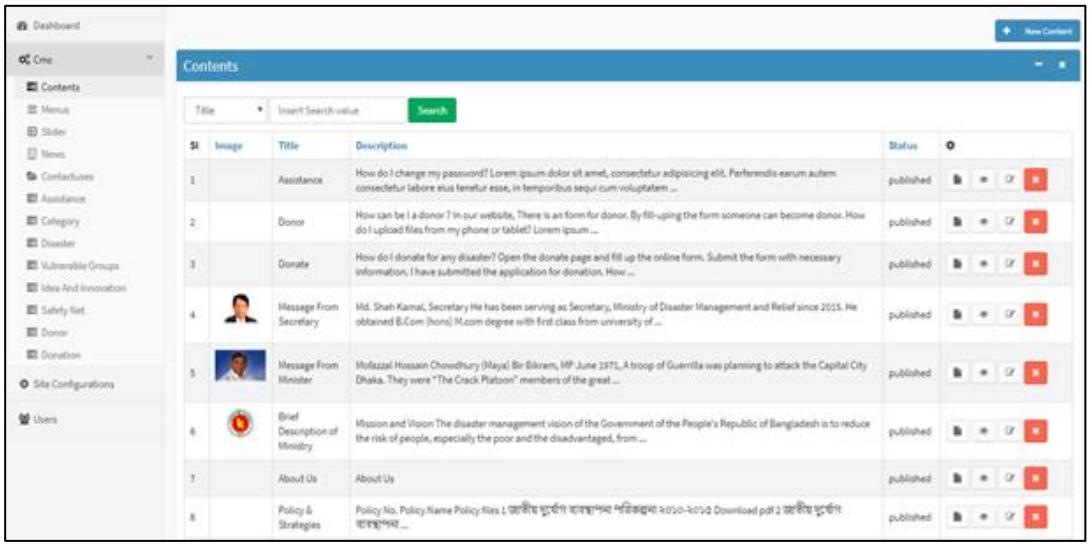

Fig 5.31: CMS for all Single Topic

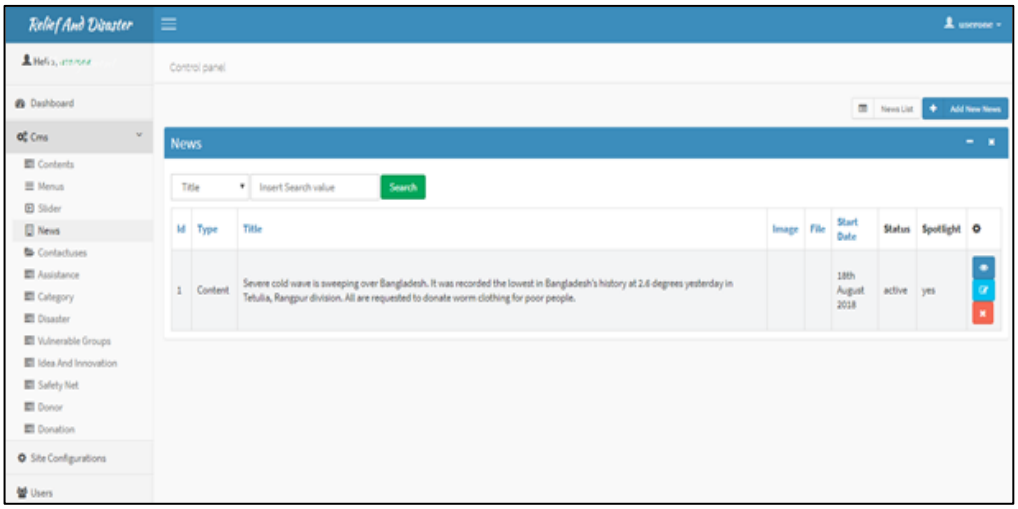

Fig 5.32: CMS for News

5.2.2 **Page design**

All the pages were built according to the P-IDM. Multiple pages were automatically created for all Multiple Topics. The Single topic had single page. The navigation among all pages followed the path given in the L-IDM. All kind of contents were managed by the CMS.

5.2.2.1 **Page for Multiple Topic**

Every elements of each of the multiple topics had their own pages. They were created, edited or deleted according to the corresponding CMS. The navigation among the pages followed the path given in the L-IDM. For example UNHCR was an international donor. Anyone could find its information from the introductory page (Fig 5.33) of donor. From the Introductory page by clicking its icon the orientation page (Fig 5.34) of donor would pop up.

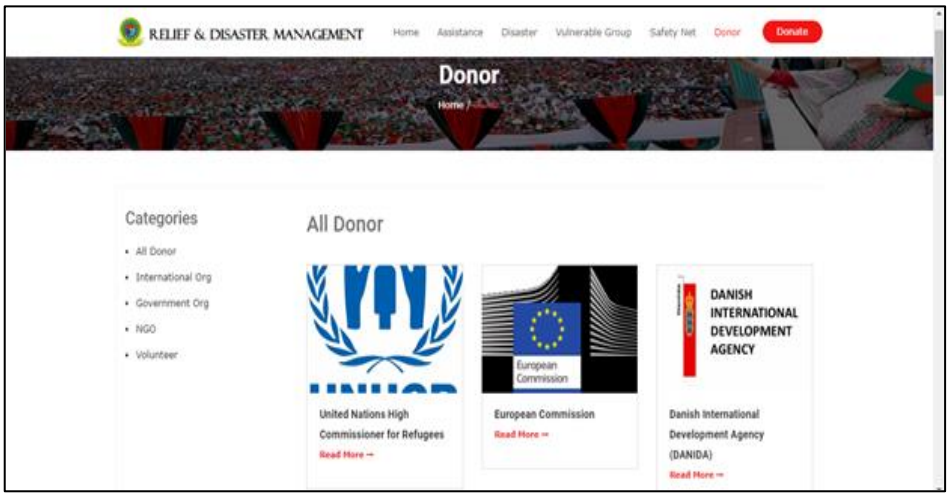

Fig 5.33: Introductory Page of donor

Fig 5.34: Orientation Page of donor

It was possible to see all the donation activities of UNHCR by clicking all its activities. Basically it was moving to the transaction page of UNHCR (Fig 5.35). From the transaction page it was possible to see the details activities of any donation given by UNHCR (Fig 5.36) by clicking the related field.

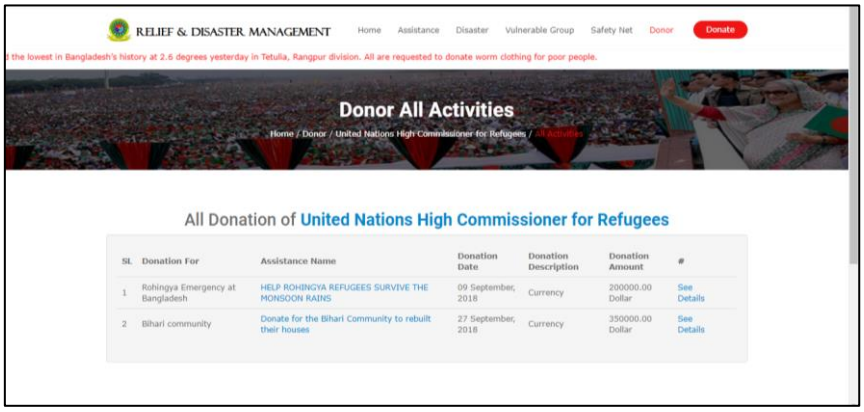

Fig 5.35: Transaction Page of donor

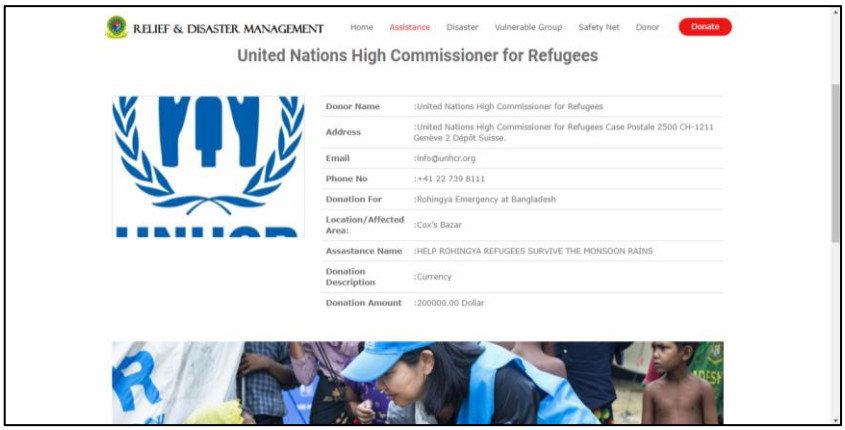

Fig 5.36: Particular donation activities of donor

Moreover from the donation activities page it was also possible to move to particular assistance page for whom the donation was given. Bellow figure 5.37 is showing that, UNHCR donated for the assistance 'Help Rohingya refugees surviving during monsoon rain'. Again it was possible to see all the donation activities for the assistance 'Help Rohingya refugees surviving during monsoon rain' by clicking all its activities (Fig 5.38).

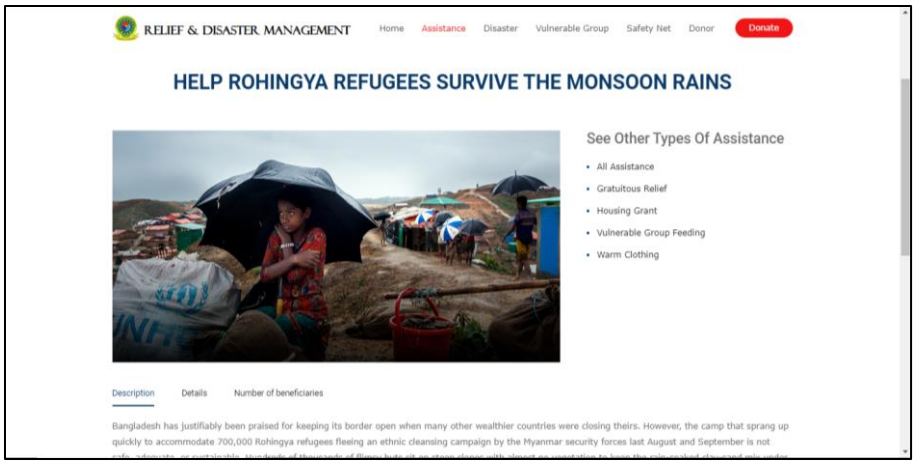

Fig 5.37: Assistance Page 'Help Rohingya refugees surviving during monsoon rain'

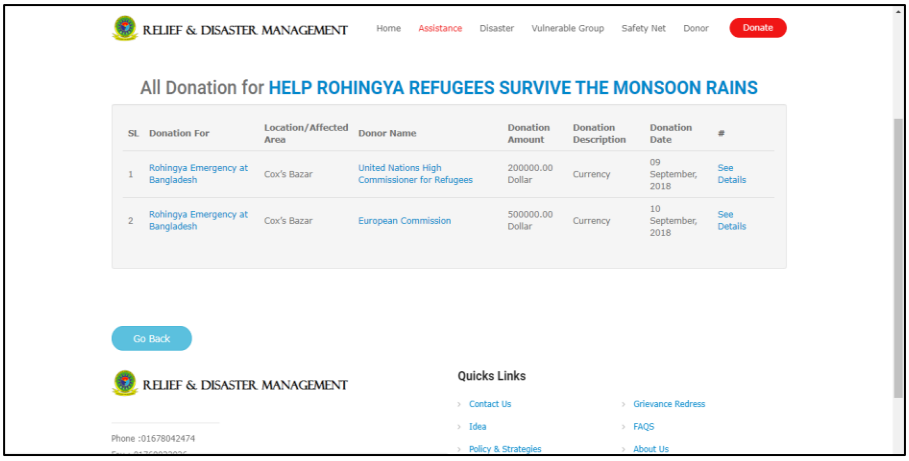

Fig 5.38: Page for all donation activities for the assistance 'Help Rohingya refugees surviving during monsoon rain'

5.2.2.2 **Page for Single Topic**

Every single topics had its own page. They were created, edited or deleted according to the corresponding CMS. For example the Policies & Strategies page (Fig 5.39), Donate page (Fig 5.40) etc. were the single pages.

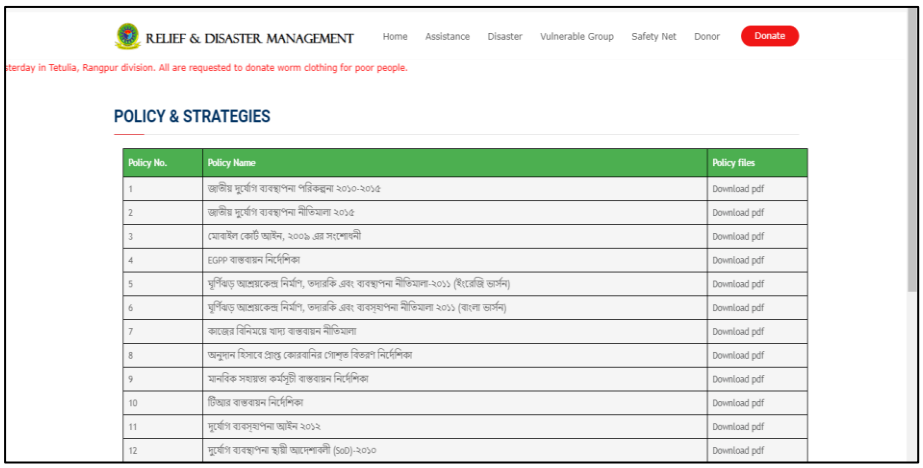

Fig 5.39: Page for Policies & Strategies

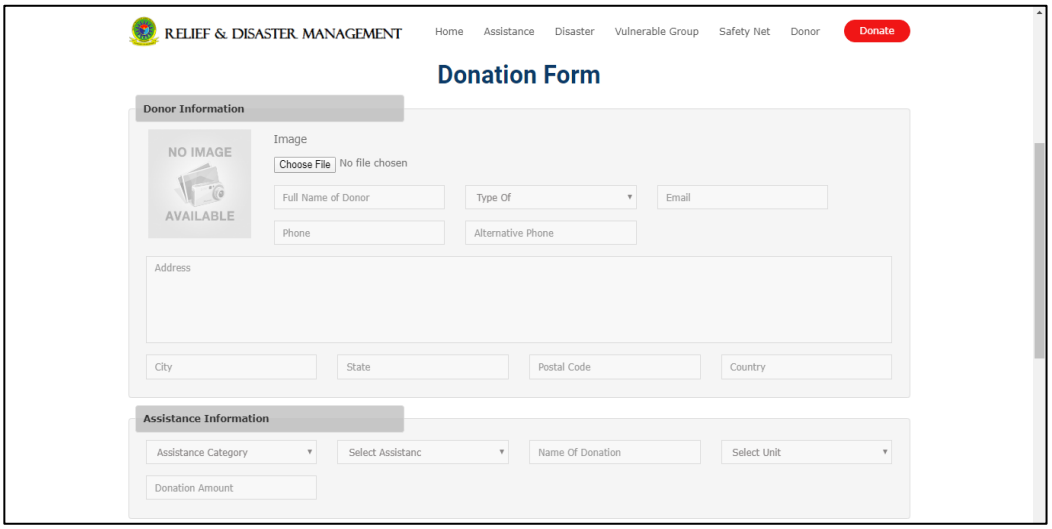

Fig 5.40: Page for Donation

5.3 **Designing the website using Card Sorting**

Designing process of website for disaster and relief management using Card Sorting was done in two phases. The phases were: (1) Decisive and Arranging Cards (2) Page Design.

5.3.1 **Decisive and Arranging Cards**

Here, group of contents for the webpage were determined using an open Card Sorting design technique [39]. Symmetric assumption on the contents was made based on website theme i.e. Disaster and Relief management to label any particular group. This technique determined what should be on the landing page (homepage) and how the group and sub-group of the content of the website would be structured. At first, different topics of the content on a number of small cards were labeled, then grouped altogether into different clusters and finally organized the subgroups into required clusters. Here, a total of eleven primary groups were found: 'Home', 'Mission & Vision', 'User Register', 'Donate', 'Risk Reduction', 'Job opportunities', 'About Us', 'Online Services', 'Training, Volunteers' and 'Admin panel'. The subgroups were such as 'Donate' consisted of 'Top donor list', 'Donor List' and 'Donate Now'. Again the sub group 'Donor List' was divided into 'Category', 'Area', 'Amount', 'Budget' and 'Achievement'. Similarly, 'Risk Reduction' consisted of 'Disaster Risk Reduction Activities (DRRA)', 'Awareness Seminars', 'Social safety' and 'Multimedia Information'. In this way, the entire content of the Disaster and relief management website was grouped and labeled accordingly which is shown in Fig 5.41.

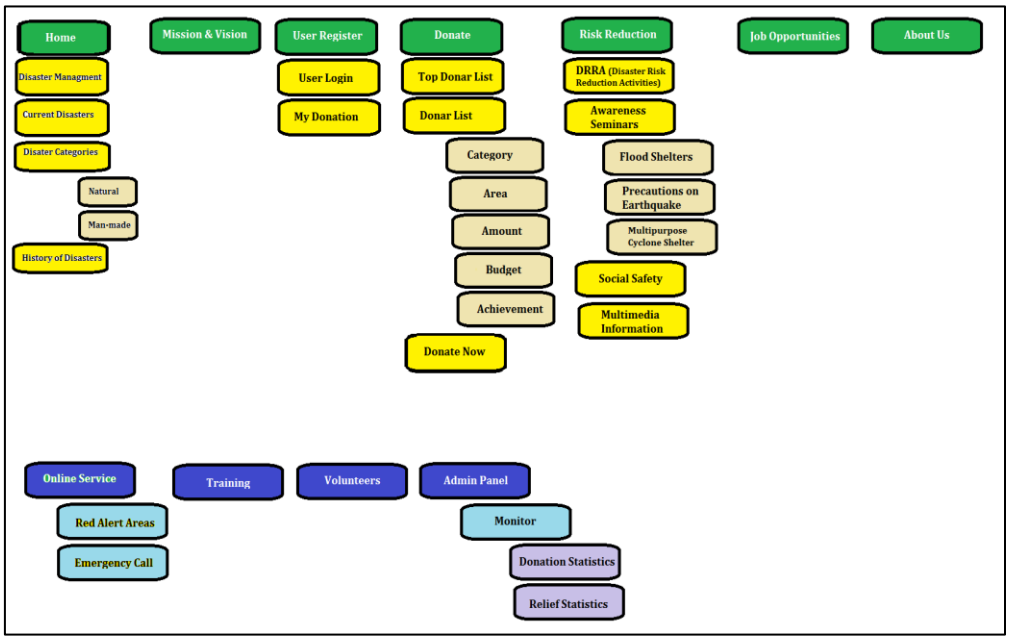

Fig 5.41: Arranging cards for disaster and relief management website

5.3.2 **Designing the Web Page Based on Card Sorting**

WordPress framework was used for the overall management of the apps. OceanWP theme was chosen to build the pages and manage the navigation among them. Webpages were designed following the how the card was arranged and clustered. The navigation among the pages was followed the same design.

5.3.3 **Content Management System (CMS)**

As WordPress framework was a complete frame work to build any web apps, so it was having an inbuilt CMS. There was an authentication system to enter in the CMS (Fig 5.42). There was also a provision to have multiple user login, so that more than one people could access the system. While developing the application the default WordPress structure was maintained all the time. For better functionality a total 15 plugins were

used. Effort was made to use the best plugins. The list of plugins used is shown in the table 5.1.

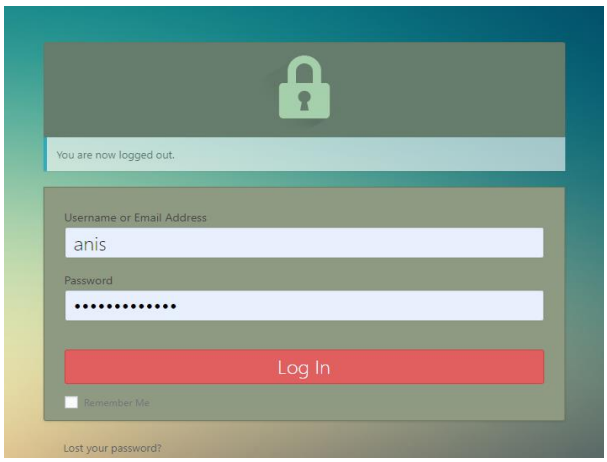

Fig 5.42: WordPress Authentication

Table 5.1: List of plug-in with their functionality

Ser	Plugin	Functionality
1	Akismet Anti-Spam	Used for protecting web apps from spam.
2	All-in-One WP Migration	Used for importing or exporting the content.
3	Beaver Builder Plugin	Used for frontend page building.
4	Ultimate Addons for Beaver Builder	Used for adding Addons for Beaver Builder.
5	Client Portal	Used for creating login portal and implement restricted-access, personalized page of content with links and downloads.
6	Conductor	Used for building content-rich layouts.
7	Conductor - Query Builder Add-On	Used to craft more complex queries with Conductor.
8	Custom Login Page Templates	Used for customizing login page.
9	Elementor	Used for frontend page building.
10	Ninja Forms	Used for creating webform.
11	Ninja Forms - Addon Manager	Used for installing Ninja Forms add-ons.
12	Ninja Tables	Used for creating tables.
13	Ocean Extra	Used to add widgets, metaboxes in the OceanWP theme
14	Profile Builder	Used for login, registration and edit profile short codes for the front-end.

Ser	Plugin	Functionality
15	Profile Builder - Email Confirmation Field	Used for adding email Confirmation field in the Manage Fields list from Profile Builder.

While using Card Shorting method, the main theme was to informing everyone about the disaster, collecting the donation from the donor and circulating the assistance activities. This process was done by creating and updating the tables (see Fig 5.43) by using Ninja

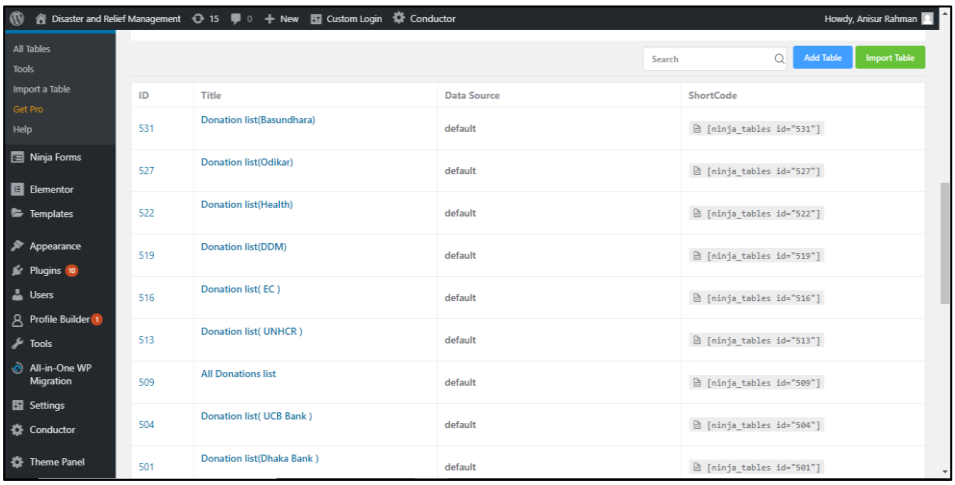

Fig 5.43: Ninja Tables

plugin (see Fig 5.44).

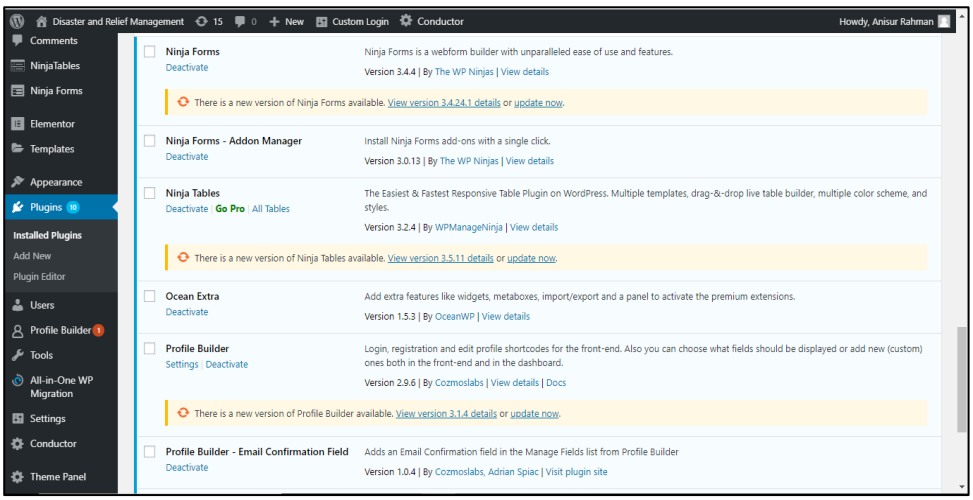

Fig 5.44: Ninja Table plugin

5.3.4 **Page design**

All the pages were built according to the card arrangement. All pages were constructed on OceanWP theme. Beaver Builder, Profile Builder and Elementor plugins were used for frontend design. From the ‘Home’ page (Fig 5.45) it was possible to see the information about the current and previous disaster. It was also possible to see the all types of disaster from the home page. Donation is the second important activities. From the donate page (Fig 5.46) it was possible to donate for a disaster. It was also possible to see top donor list, types of donor and their detailed assistance activities including the donor orientation

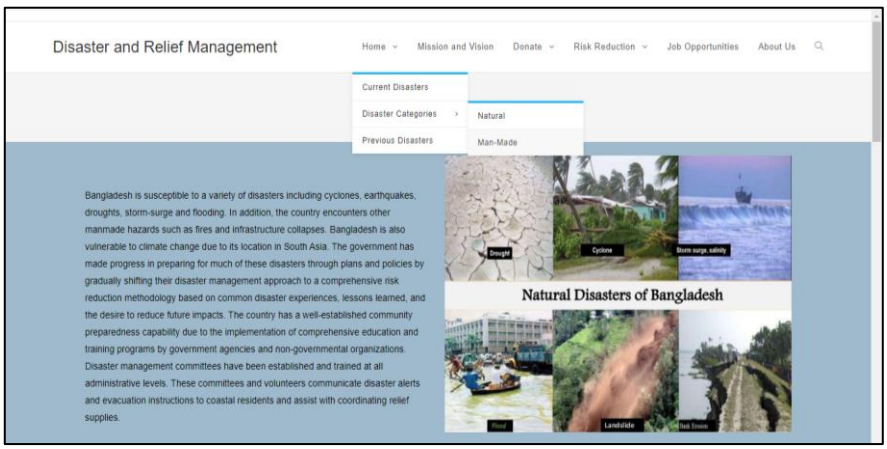

Fig 5.45: Home page

information from the same menu bar.

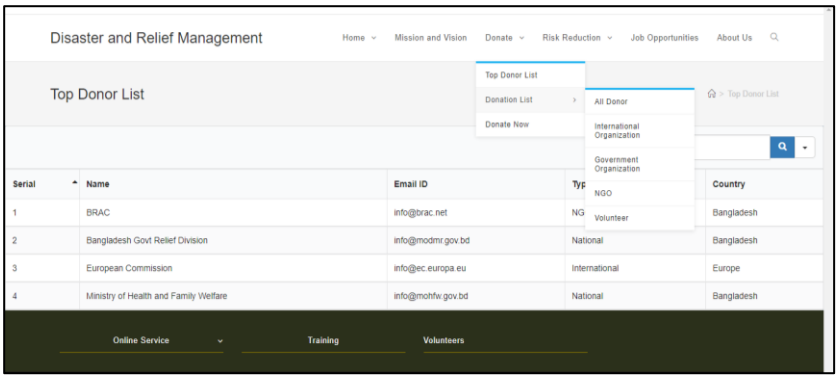

Fig 5.46: Donate page

Similarly from the ‘Risk Reduction’ page it was also possible to visit ‘Disaster Risk Reduction Activities (DRRA)’ page, ‘Awareness Seminars Social Safety’ page and ‘Multimedia Information’ page. There were few menu/bar which contained single page e.g. Training page (Fig 5.47), About Us page (Fig 5.48) etc.

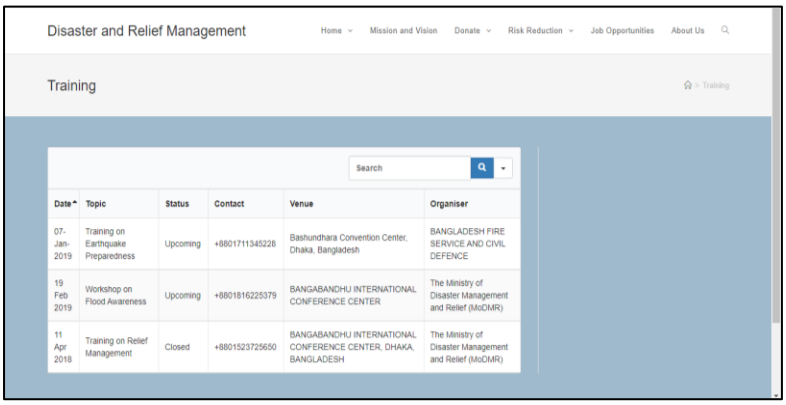

Fig 5.47: Training page

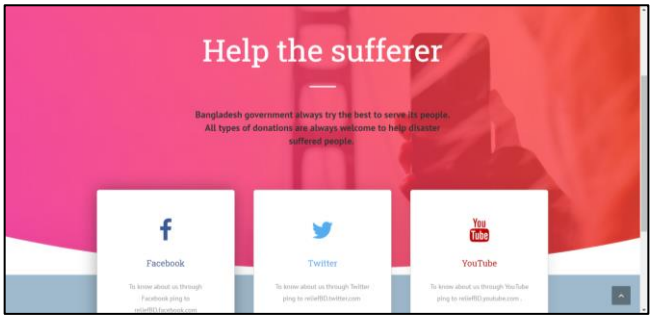

Fig 5.48: About Us page

CHAPTER 6
EXPERIMENT TO COMPARE DESIGN TECHNIQUE

This chapter describes how the evaluation experiment was conducted and the comparison was carried out between the two alternate design techniques. For this, the chapter discussed the objective of experimental evaluation study, participants' profiles, study procedure and the data analysis and findings.

6.1 **Study Objective**

This objective of this study is to evaluate the usability of both systems developed for the disaster and relief management, to explore the effectiveness of alternate design methods (Card Sorting and IDM), and to find out the most appropriate design method to design such e-government website. Eventually this will lead to understanding the e-government website development method. The experiment also unveiled the opportunity to discover future directions and improvements.

6.2 **Participants Profiles**

Since the Disaster and relief management system app will mostly be used by the donor and computer literate people, so the target participants were computer literate as well as having interest of giving assistance during any kind of disaster. Moreover no web administrators, data analysts, or project manager was included in the research, which largely reduced the pool of participants. The potential users were recruited through word of mouth from the researcher's working domain. They were mainly teacher, staff and student. There were mixtures of gender and knowledge level among the participants. They had general interest of using e-government services. They had the different level of ability based on the experience. None of them had prior experience working with relief

and disaster management web system. They understood the purpose of the experiment and agreed to participate voluntarily. Based on their availability, max 45 minutes time was scheduled for each participant to participate in this evaluation study followed by a written survey session for measuring satisfaction. These studies were held over the course of four weeks, and participants did not receive any remuneration for their participation. The study consisted of eighteen participants (referred to as P1… P18). The demography of the participants is shown in Table 6.1

Table 6.1: Demography of the participants

Age Group	Male	Female	Professionals	Non-Professionals
Age <25	5	3	2	6
25<Age <40	4	1	4	1
Age>40	4	1	3	2
Total	13	5	9	9

6.3 **Study Procedure**

The evaluation was mainly concerned with usability evaluation by collecting data through Laboratory Based Usability Testing Method and taking feedback through post-text questionnaires for exposing their satisfaction with both the prototypes.

The study was conducted individually with participants at the software engineering lab of MIST. Windows 10 Pro running the Google Chrome browser was used for presenting both the websites to the participants (Fig 6.1-2). To evaluate the system effectiveness and efficiency quantitative approach was followed by using screen-recorder-pro, Stopwatch and Mousotron software.

The participants were given a short brief for approximate five minutes about the main goal of this study and introducing with the two websites. It was informed to the participants that all visualizations in the prototypes were responsive and interactive, but the placements of the contents on both the websites were not disclosed to them. Moreover they were not briefed about the design architecture also. The participant was told ask for help if needed.

At first, once a participant agreed to be the test participant, his/her demographic information was collected, and a test-consent form was also signed

The test was conducted following think-aloud protocol [66]. For each participant, a separate session was conducted. In each session, participants were asked to complete five tasks within 30 minutes as showed in Table 6.2. This list of tasks was as comprehensive as possible with the given time constraints and covered the one of the most important features supported by both the web applications. At the end, participants were asked to response to a set of questions (Table 6.3) on both the systems for measuring satisfaction. The post-test questionnaires comprises five statements related to the overall satisfaction, future use, recommend to others, ease of use, and ease of learning; five questions related to know which websites performs well to complete a specific task and the remain four questions were related to overall opinion about a specific (best) website based on their experience while accomplishing the tasks. The statement questions were asked to respond in scale of 1 to 5, where 1 mean strongly disagree and 5 means strongly agree.

Thus, the study data were collected through four techniques that included the think-aloud protocol [66], author's notes from observations (tapping behavior, number of attempts,

completion time etc.), screen capture videos, and a written survey (post-test questionnaires). To record the screen, screen-recorder-pro software was used. For recording effectiveness and efficiency of the system Mousotron software was used. For recording each completion time stopwatch was used.

Table 6.2: List of tasks

Task	Task Description	Reasoning
T1	Find the overview and affected area due to "Cold wave sweeps over parts of country".	Measuring the effectiveness and efficiency of any Disaster
T2	Find the assistant activity "Need Worm Clothing for poor people" given for the disaster "Cold wave sweeps over parts of country" by a NGO; name Friendship.	Measuring the effectiveness and efficiency of any Donor, Disaster and assistance activities
T3	Find all the assistance activities related to "Cold wave sweeps over parts of country".	Measuring the effectiveness and efficiency of any assistance activities
T4	Find all donation activities of an international donor; name United Nations High Commissioner for Refugees (UNHCR).	Measuring the effectiveness and efficiency of any Donor
T5	Donate for "Need Worm Clothing for poor people".	Measuring the effectiveness and efficiency of any Donation activities

Table 6.3: List of post-test questionnaires

Question	Question Description
Q1	While executing Task 01 which website performed more satisfactorily? [Website1/Website 2]
Q2	While executing Task 02 which website performed more satisfactorily? [Website1/Website 2]
Q3	While executing Task 03 which website performed more satisfactorily? [Website1/Website 2]
Q4	While executing Task 04 which website performed more satisfactorily? [Website1/Website 2]
Q5	While executing Task 05 which website performed more satisfactorily? [Website1/Website 2]
Q6	Which website would you prefer overall to execute the given tasks? [Website1/Website 2]
Q7	While executing a particular task, had you ever feel puzzled regarding the completion of the respective tasks? [Yes [Website 1/ Website 2/ Both Websites]/No]

Question	Question Description
Q8	Describe briefly if you have any suggestion for Website 1 to improve navigation/ design/ any other aspects.
Q9	Describe briefly if you have any suggestion for Website 2 to improve navigation/ design/ any other aspects.

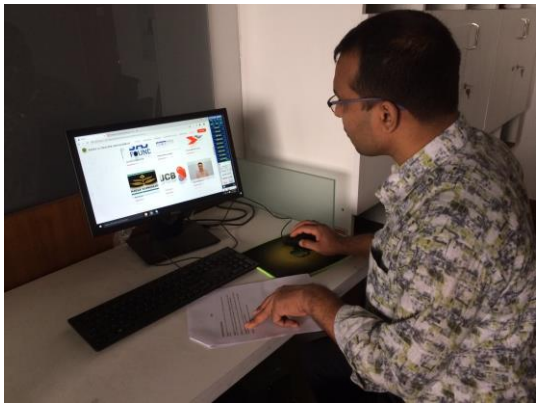

Fig 6.1: Task execution by participant

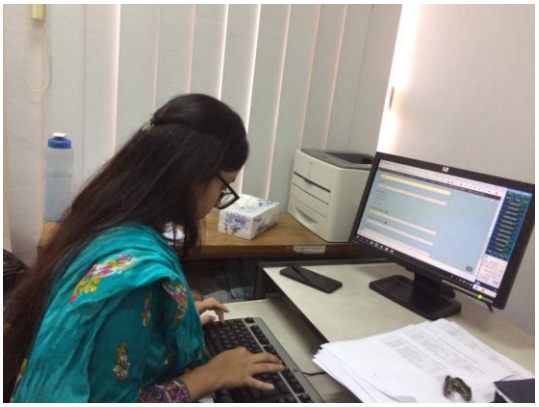

Fig 6.2: Task execution by participant

6.4 **Data analysis and Outcomes**

The study data was analyzed through descriptive and inferential statistics. The analysis is carried out in terms of effectiveness, efficiency and satisfaction for both the websites Fig 6.3). Finally, a comparison is showed between the IDM-based and the CS-based website.

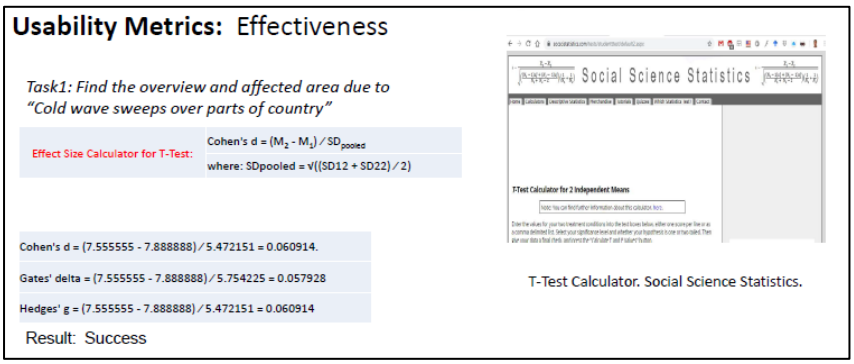

Fig 6.3: Usability Metrics

6.4.1 **Analysis the Results of IDM Based Website**

Effectiveness of IDM Based website was measured by analysing of tapping behaviour and counting nnumber of attempts for each task. Tapping Behaviour of a participant was measured by reading number of mouse click for each task, which was recorded automatically by the software during the experiment to reduce the human errors. The results of the effectiveness is showed in Table 6.4 .While measuring the effectiveness, the mean, standard deviation, min and max value was calculated for each of the five tasks.

In evaluation metrics 'Tapping Behaviour' for task 1 the participants completed the job by 5.33 mean no of click with 3.98 standard deviation. The min and max values were 1 and 14 respectively. Similarly, for task 2 the participants completed the job by 5.11 mean no of click with 4.53 standard deviation. The min and max values were 1 and 19 respectively. The mean value of task 3 was found 5.38 with a standard deviation of 4.04. The min and max values were 1 and 16 respectively. Similarly, the mean value of task 4 was found 4.00 with a standard deviation of 2.473. The min and max values were 1 and 9 respectively. For task 5 the participants completed the job by 6.55 mean no of click with 5.61 standard deviation. The min and max values were 1 and 12 respectively.

In evaluation metrics 'Number of Attempts' for task 1 the participants completed the job by 1.44 mean no of attempts with 0.51 standard deviation. The min and max values were 1 and 2 respectively. Similarly, for task 2 the participants completed the job by 1.61 mean no of attempts with 0.61 standard deviation. The min and max values were 1 and 3 respectively. The mean value of task 3 was found 1.77 with a standard deviation of 0.88. The min and max values were 1 and 4 respectively. Similarly, the mean value of task 4 was found 1.94 with a standard deviation of 1.11. The min and max values were 1 and 5

respectively. For task 5 the participants completed the job by 1.72 mean no of attempts with 1.02 standard deviation. The min and max values were 1 and 4 respectively.

Table 6.4: Effectiveness measures for IDM Based website

Evaluation Metrics	Data Type	Task	Mean ± SD	Min	Max
Effectiveness	Tapping Behaviour	T1	5.33 ± 3.98	1	14
		T2	5.11 ± 4.53	1	19
		T3	5.38 ± 4.04	1	16
		T4	4.00 ± 2.473	1	9
		T5	6.55 ± 5.61	1	22
	Number of Attempts	T1	1.44 ± 0.51	1	2
		T2	1.61 ± 0.61	1	3
		T3	1.77 ± 0.88	1	4
		T4	1.94 ± 1.11	1	5
		T5	1.72 ± 1.02	1	4

Following the similar procedures, efficiency of IDM Based website was measured by analysing of task completion time, number of times asking help from researcher and counting the mouse wheel rotation. Task completion time and mouse wheel rotation of a participant was measured by reading the data from software, which was recorded automatically during the experiment. The results are showed in Table 6.5. While measuring the efficiency, the mean, standard deviation, min and max value was calculated for each of the five tasks.

In evaluation metrics ‘task completion time’ for task 1 the participants completed the job by 16.00 mean sec with 81.55 standard deviation. The min and max value were 68 sec and 417 sec respectively. Similarly, for task 2 the participants completed the job by 93.44 mean sec with 47.82 standard deviation. The min and max value were 30 sec and 187 sec

respectively. The mean value of task 3 was found 63.77 sec with a standard deviation of 32.30. The min and max value were 10 sec and 114 sec respectively. Similarly, the mean value of task 4 was found 98.83 sec with a standard deviation of 81.43. The min and max value were 23 sec and 372 sec respectively. For task 5 the participants completed the job by 124.61 mean sec with 43.51 standard deviation. The min and max value were 56 sec and 253 sec respectively.

In evaluation metrics 'Asking help from researcher' for task 1 the participants completed the job by 0.88 mean time with a 0.83 standard deviation. The min and max values were 0 and 3 respectively. Similarly, for task 2 the participants completed the job by 0.88 mean time with 0.58 standard deviation. The min and max value were 0 and 2 respectively. The mean value of task 3 was found 0.88 with a standard deviation of 0.27. The min and max values were 0 and 2 respectively. Similarly, the mean value of task 4 was found 0.94 with a standard deviation of 0.99. The min and max values were 0 and 3 respectively. For task 5 the participants completed the task by 0.77 mean time with 0.42 standard deviation. The min and max values were 0 and 1 respectively.

In evaluation metrics 'Mouse Wheel Rotation' for task 1 the participants completed the job by 6.61 mean times with a 5.28 standard deviation. The min and max values were 2 and 20 respectively. Similarly, for task 2 the participants completed the job by 10.33 mean times with 3.85 standard deviation. The min and max values were 4 and 19 respectively. The mean value of task 3 was found 7.55 with a standard deviation of 4.18. The min and max values were 1 and 17 respectively. Similarly, the mean value of task 4 was found 7.27 with a standard deviation of 4.14. The min and max values were 1 and 17 respectively. For task 5 the participants completed the task by 3.88 mean time with a 1.74 standard deviation. The min and max values were 2 and 18 respectively.

Table 6.5: Efficiency measures for IDM Based website

Evaluation Metrics	Data Type	Task	Mean± SD	Min	Max
Efficiency	Task Completion time	T1	160.00 ± 81.35	68	417
		T2	93.44 ± 47.82	30	187
		T3	63.77 ± 32.30	10	114
		T4	98.83 ± 81.43	23	372
		T5	124.61 ± 43.51	56	253
	Number of times Asking help from researcher	T1	0.88 ± 0.83	0	3
		T2	0.88 ± 0.58	0	2
		T3	0.88 ± 0.27	0	2
		T4	0.94 ± 0.99	0	3
		T5	0.77 ± 0.42	0	1
	Mouse Wheel Rotation	T1	6.61 ± 5.28	2	20
		T2	10.33 ± 3.85	4	19
		T3	7.55 ± 4.18	1	17
		T4	7.27 ± 4.14	1	17
		T5	3.88 ± 1.74	2	18

Satisfaction of IDM Based website was measured by analysing of the Participants responded to the statement related questions. The questionnaires were made based on 5 fields i.e. Overall Satisfaction, Easy to Use, Easy to Learn, Future Use and Recommend Others. The results are presented in Table 6.6.

The participants expressed their 'Overall Satisfaction' by 4.44 mean value with 0.62 standard deviation. Similarly, the participants marked the 'Easy to Use' metric with 4.50 mean value with 0.62 standard deviation. 'Easy to Learn' metric were filled up by the participants by 4.72 mean value with a standard deviation of 0.57. Similarly, the mean value of 'Future Use' was found 4.61 with a standard deviation of 0.61. For 'Recommend Others' field the participants recommended by 4.17 mean value with 0.71 standard deviation. In all the cases the min and max values were 3 and 5 respectively.

Table 6.6: Satisfaction scores for IDM Based website

Usability Metrics	Data Type	Mean ± SD	Min	Max
Satisfaction	Overall Satisfaction	4.44 ± 0.62	3	5
	Easy to Use	4.50 ± 0.62	3	5
	Easy to Learn	4.72 ± 0.57	3	5
	Future Use	4.61 ± 0.61	3	5
	Recommend Others	4.17 ± 0.71	3	5

6.4.2 **Analysis the Results of CS Based Website**

Effectiveness of CS Based website was also measured by analysing of tapping behaviour and counting number of attempts for each task. Tapping Behaviour of a participant was measured by reading number of mouse click for each task, which was recorded automatically by the software during the experiment. This reduced the human errors. Then Mean, Standard deviation (SD), Min and Max value (Table 6.7) was calculated for statistical analysis.

In evaluation metrics 'Tapping Behaviour' for task 1 the participants completed the job by 7.33 mean no of click with 4.715 standard deviation. The min and max values were 3 and 19 respectively. Similarly, for task 2 the participants completed the job by 11.55 mean no of click with 11.03 standard deviation. The min and max values were 2 and 43 respectively. The mean value of task 3 was found 7.88 with a standard deviation of 4.60. The min and max values were 3 and 19 respectively. Similarly, the mean value of task 4 was found 5.55 with a standard deviation of 4.27. The min and max values were 2 and 18 respectively. For task 5 the participants completed the job by 3.66 mean no of click with 2.35 standard deviation. The min and max values were 1 and 8 respectively.

In evaluation metrics 'Number of Attempts' for task 1 the participants completed the job by 1.88 mean no of attempts with 0.56 standard deviation. The min and max values were 1 and 3 respectively. Similarly, for task 2 the participants completed the job by 2.66 mean no of attempts with 1.41 standard deviation. The min and max values were 1 and 5 respectively. The mean value of task 3 was found 2,27 with a standard deviation of 0.75. The min and max values were 1 and 4 respectively. Similarly, the mean value of task 4 was found 1.77 with a standard deviation of 0.94. The min and max values were 1 and 4 respectively. For task 5 the participants completed the job by 1.44 mean no of attempts with 0.61 standard deviation. The min and max values were 1 and 3 respectively.

Table 6.7: Effectiveness calculation for CS Based website

Evaluation Metrics	Data Type	Task	Mean ± SD	Min	Max
Effectiveness	Tapping Behaviour	T1	7.33 ± 4.715	3	19
		T2	11.55 ± 11.03	2	43
		T3	7.88 ± 4.60	3	19
		T4	5.55 ± 4.27	2	18
		T5	3.66 ± 2.35	1	8
	Number of Attempts	T1	1.88 ± 0.56	1	3
		T2	2.66 ± 1.41	1	5
		T3	2.27 ± 0.75	1	4
		T4	1.77 ± 0.94	1	4
		T5	1.44 ± 0.61	1	3

Similarly, efficiency of CS Based website was measured by analysing of task completion time, number of times asking help from researcher and counting the mouse wheel rotation. Task completion time and mouse wheel rotation of a participant was measured by reading the data from software, which was recorded automatically during the experiment. This reduced the human errors. Mean, Standard deviation (SD), Min and Max value (Table 6.8) was then calculated for statistical analysis.

In evaluation metrics ‘task completion time’ for task 1 the participants completed the job by 225.61 mean sec with 89.76 standard deviation. The min and max value were 68 sec and 433 sec respectively. Similarly, for task 2 the participants completed the job by 122.22 mean sec with 69.31 standard deviation. The min and max value were 40 sec and 298 sec respectively. The mean value of task 3 was found 113.55 sec with a standard deviation of 77.09. The min and max value were 21 sec and 355 sec respectively. Similarly, the mean value of task 4 was found 115.27 sec with a standard deviation of 76.93. The min and max value were 22 sec and 296 sec respectively. For task 5 the participants completed the job by 147.61 mean sec with 49.91 standard deviation. The min and max values were 100 sec and 311 sec respectively.

In evaluation metrics ‘Asking help from researcher’ for task 1 the participants completed the job by 1.38 mean time with 0.36 standard deviation. The min and max values were 0 and 4 respectively. Similarly, for task 2 the participants completed the job by 1.38 mean time with 0.77 standard deviation. The min and max value were 0 and 3 respectively. The mean value of task 3 was found 1.33 with a standard deviation of 0.76. The min and max values were 0 and 3 respectively. Similarly, the mean value of task 4 was found 1.61 with a standard deviation of 1.37. The min and max values were 0 and 5 respectively. For task 5 the participants completed the task by 1.11 mean time with 0.58 standard deviation. The min and max values were 0 and 2 respectively.

In evaluation metrics ‘Mouse Wheel Rotation’ for task 1 the participants completed the job by 9.33 mean time with 4.75 standard deviation. The min and max values were 3 and 17 respectively. Similarly, for task 2 the participants completed the job by 11.72 mean

time with 5.02 standard deviation. The min and max values were 2 and 23 respectively. The mean value of task 3 was found 10.27 with a standard deviation of 4.33. The min and max values were 4 and 18 respectively. Similarly, the mean value of task 4 was found 8.05 with a standard deviation of 4.14. The min and max values were 2 and 15 respectively. For task 5 the participants completed the task by 7.72 mean time with a 3.02 standard deviation. The min and max values were 4 and 18 respectively.

Table 6.8: Efficiency calculation for CS Based website

Evaluation Metrics	Data Type	Task	Mean ± SD	Min	Max
Efficiency	Task Completion time	T1	225.61± 89.76	68	433
		T2	122.22 ± 69.31	40	298
		T3	113.55 ± 77.09	21	355
		T4	115.27 ± 76.93	22	296
		T5	147.61 ± 49.91	100	311
	Number of times Asking help from researcher	T1	1.38 ± 0.36	0	4
		T2	1.38 ± 0.77	0	3
		T3	1.33± 0.76	0	3
		T4	1.61 ± 1.37	0	5
		T5	1.11 ± 0.58	0	2
	Mouse Wheel Rotation	T1	9.33± 4.75	3	17
		T2	11.72± 5.02	2	23
		T3	10.27 ± 4.33	4	18
		T4	8.05 ± 4.14	2	15
		T5	7.72 ± 3.02	4	18

Satisfaction of CS Based website was measured by analysing of the written opinion given by each of the participants. There were five data fields where the participants answered the relevant questions. Then the data was used for calculating Mean, Standard deviation (SD), Min and Max value (Table 6.9) for statistical analysis.

The participants expressed their ‘Overall Satisfaction’ by 3.67 mean value with 0.59 standard deviation. The min and max values were 3 and 5 respectively. Similarly, the

participants marked the 'Easy to Use' metric with 4.06 mean value with 0.80 standard deviation. The min and max values were 3 and 5 respectively. 'Easy to Learn' metric were filled up by the participants with 4.28 mean value with a standard deviation of 0.67. The min and max values were 3 and 5 respectively. Similarly, the mean value of 'Future Use' was found 3.39 with a standard deviation of 0.50. The min and max values were 3 and 4 respectively. For 'Recommend Others' field the participants recommended by 3.50 mean value with 0.51 standard deviation. The min and max values were 3 and 4 respectively.

Table 6.9: Satisfaction calculation for CS Based website

Usability Metrics	**Data Type**	**Mean ± SD**	**Min**	**Max**
Satisfaction	Overall Satisfaction	3.67 ± 0.59	3	5
	Easy to Use	4.06 ± 0.80	3	5
	Easy to Learn	4.28 ± 0.67	3	5
	Future Use	3.39 ± 0.50	3	4
	Recommend Others	3. 50 ±0.51	3	4

6.4.3 **Comparing the Evaluation Outcomes**

A t-test (inferential statistics) was conducted to explore the potential differences between the outcomes of the IDM-based and CS-based website. The results of t-test are showed in Table 6.10. The results showed that all the metrics of effectiveness and efficiency provided significantly better results in case of IDM-based website. In case of satisfaction, the four out of five metrics showed significantly better satisfaction for the IDM-based website. Though while comparing 'ease-of-use' metric, t-test did not show any significant scores between IDM and CS-based website, but IDM represented a better scores in terms of the mean values. Thus the results indicated that in a broader perspective IDM-based websites showed a better performances comparing to the CS-based website.

Table 6.10: Overall Comparison between IDM and CS Based website

Evaluation Metrics	Data Type	IDM (Mean±SD)	CS (Mean ± SD)	t-value	P-value	Results ($p < .05$)
Effectiveness	Tapping Behaviour	5.28 ± 4.24	7.20 ± 6.57	-2.33	.02	Significant
	Number of Attempts	1.7 ± 0.85	2.01± 1.01	-2.23	.03	Significant
Efficiency	Task Completion Time	1.80 ± 1.13	2.41 ± 1.39	-3.23	.001	Significant
	Number of times asking help from researcher	0.88 ± 0.68	1.377 ± 0.94	-3.99	<.001	Significant
	Mouse Wheel Rotation	7.13 ± 4.49	9.42 ± 4.51	-3.41	<.001	Significant
Satisfaction	Overall Satisfaction	4.44 ± 0.62	3.67 ± 0.59	3.85	<.001	Significant
	Easy to Use	4.50 ± 0.62	4.06 ± 0.80	1.86	.071	Not Significant
	Easy to Learn	4.72 ± 0.57	4.28 ± 0.67	-2.89	.006	Significant
	Future Use	4.61 ± 0.61	3.39 ± 0.50	6.58	.001	Significant
	Recommend Others	4.17 ± 0.71	3. 50 ±0.51	3.23	.003	Significant

The Mean values of ‘Tapping Behaviour’, ‘Number of Attempts’, ‘Task completion Time’ and ‘Mouse wheel rotation’ were low in the IDM than Card Sorting (Fig 6.4). This articulated that effectiveness and efficiency both were better in IDM than Card sorting.

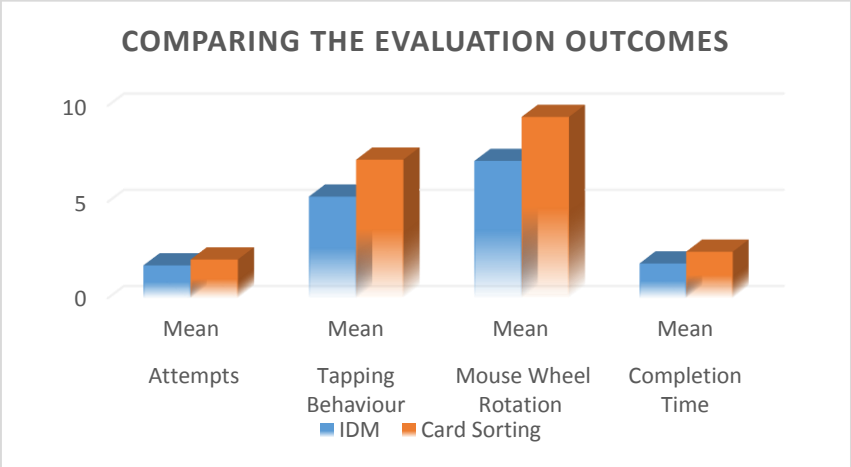

Fig 6.4: Comparative results related to IDM and CS

The participants' feedback on 'Easy to Use', 'Easy to Learn', 'Future Use' and 'Recommend for Others' were the important issues for measuring user satisfaction. On average, the participants expressed their satisfaction for IDM rather than Card Sorting (Fig 6.5) on this evaluation metrics. Moreover in the post questionnaires majority of the participant expressed more satisfactory performances in the IDM based website than CS based website (Table 6.11).

Table 6.11: Satisfaction Level (IDM vs CS)

Satisfaction Level	IDM	Card Sorting
Experiences more satisfaction while performing Task 01	15	3
Experiences more satisfaction while performing Task 02	17	1
Experiences more satisfaction while performing Task 03	16	2
Experiences more satisfaction while performing Task 04	17	1
Experiences more satisfaction while performing Task 05	17	1
Experiences puzzled or complicated to perform the assigned tasks	0	5

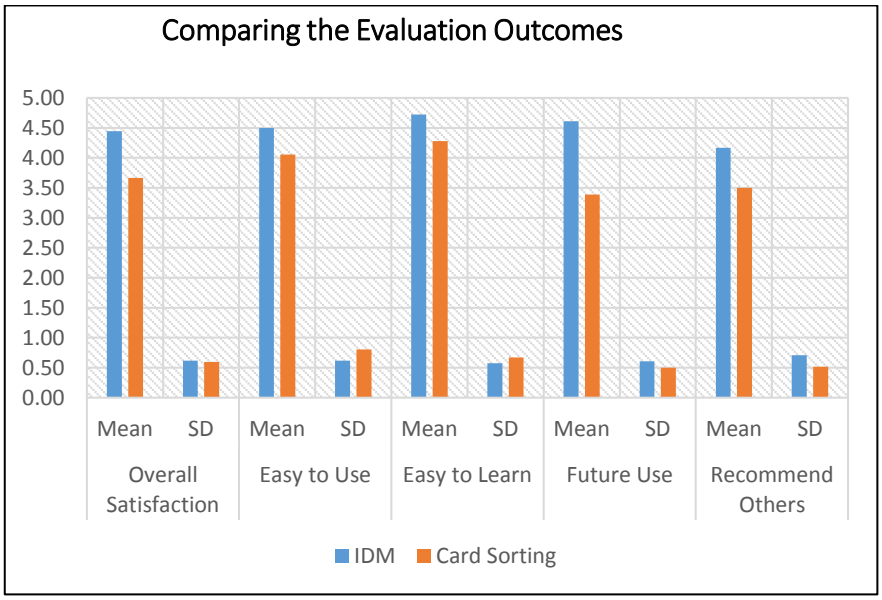

Fig 6.5: Comparative results related to Satisfaction

6.4.4 **Comparing the Outcome in Tasks-Level**

T-test also carried out for all the measuring parameter based on evaluation metrics to explore the potential differences between outcomes of the IDM-based and CS-based website. The results of t-test for the metric 'numbers of attempts' (for each task) are showed in Table 6.12. The results showed that out of five tasks, three tasks were completed with significantly better results in case of IDM-based website. The Task 04 showed a non-significant result but considering the mean values it showed a better performance for the IDM-based website. Again, though the Task 05 showed better performance (less number of attempts) for the CS-based website by considering their mean values, but the value was not statistically significant.

Table 6.12: Number of attempts in IDM vs CS Based Website

No. of Attempts									
Task No	Mean		Median		Standard Deviation		t-p Value		Significant
	IDM	Card Sorting	IDM	Card Sorting	IDM	Card Sorting	t Value	p Value	at p < .05
1	1.44	1.89	1.00	2.00	0.51	0.76	-2.06155	0.046962	significant
2	1.61	2.67	2.00	2.00	0.61	1.41	-2.29149	0.006342	significant
3	1.78	2.28	2.00	2.00	0.88	0.75	-1.83487	0.075287	significant
4	1.74	1.94	2.00	1.50	1.11	0.94	0.48554	0.630409	not significant
5	1.72	1.44	1.00	1.00	1.02	0.62	0.99072	0.328821	not significant

Similarly, t-test also carried out for 'Tapping Behaviour'. The results (for each task) of t-test are showed in Table 6.13. The results showed that out of five tasks, three tasked presented significantly better results in case of IDM-based website. Both the Task 04 and 05 showed a non-significant result but considering the mean values they showed a better performance for the IDM-based website.

Table 6.13: Usability Metrics - Effectiveness Comparison (Tapping Behaviour): IDM vs CS Based Website

Tapping Behaviour									
Task No	Mean		Median		Standard Deviation		t-p Value	Significant	
	IDM	Card Sorting	IDM	Card Sorting	IDM	Card Sorting	t-Value	p-Value	at p < .05
1	5.33	7.33	4	5.5	3.99	4.72	-1.37437	0.1783190	not significant
2	5.11	11.56	3.5	8.5	4.54	11.04	-2.29149	0.0282540	significant
3	5.39	7.89	5	6	4.05	4.66	-1.71789	0.0949130	not significant
4	4.00	5.56	3	4	2.47	4.27	-1.33664	0.1902180	significant
5	3.67	6.56	3	6	2.35	5.62	1.955340	0.0588030	significant

T-test also carried out for ‘Completion Time’. The results (for each task) of t-test are showed in Table 6.14. The results showed that out of five tasks, two tasked presented significantly better results in case of IDM-based website. Task 02, 04 and 05 showed a non-significant result but considering the mean values they showed a better performance for the IDM-based website.

Table 6.14: Usability Metrics - Efficiency Comparison (Completion Time): IDM vs CS Based Website

Completion Time									
Task No	Mean		Median		Standard Deviation		t-p Value		Significant
	IDM	Card Sorting	IDM	Card Sorting	IDM	Card Sorting	t-Value	p-Value	at $p < .05$
1	160.22	225.61	144	223.5	82.35	89.76	-2.27744	0.02917	significant
2	93.44	122.22	145	224.5	47.82	69.31	-1.45001	0.15622	not significant
3	63.78	113.56	63.5	88.5	32.30	77.09	-2.52668	0.01634	significant
4	98.83	115.28	85.5	107	81.44	76.93	-0.62276	0.53760	not significant
5	124.61	147.61	126.5	137.5	43.51	49.91	-1.47386	0.14972	not significant

T-test also carried out for ‘Number of Mouse Wheel Rotation’. The results (for each task) of t-test are showed in Table 6.15. The results showed that out of five tasks, three tasked presented significantly better results in case of IDM-based website. Both the Task 02 and 04 showed a non-significant result but considering the mean values they showed a better performance for the IDM-based website.

Table 6.15: Usability Metrics - Efficiency Comparison (No. of Mouse Wheel Rotation): IDM vs CS Based Website

No. of Mouse Wheel Rotation									
Task No	Mean		Median		Standard Deviation (SD)		t-p Value		Significant
	IDM	Card Sorting	IDM	Card Sorting	IDM	Card Sorting	t-Value	p-Value	at p < .05
1	6.61	9.33	5	8	5.28	4.75	-1.62544	0.113304	significant
2	10.33	11.72	9.5	11	3.85	5.03	-0.93059	0.358625	not significant
3	7.56	10.28	7	11	4.49	4.34	-1.85070	0.072917	significant
4	7.28	8.06	7	7.5	4.14	4.41	-0.54529	0.589114	not significant
5	3.89	7.72	3	7	1.75	3.03	-4.65634	.000048	significant

Comparison also made for the usability metrics (effectiveness and efficiency) by the mean value of each task's measuring parameters. Except one case, all the comparison charts represented by Fig 6.6 to Fig 6.9 showed IDM contributed better for developing e-government websites.

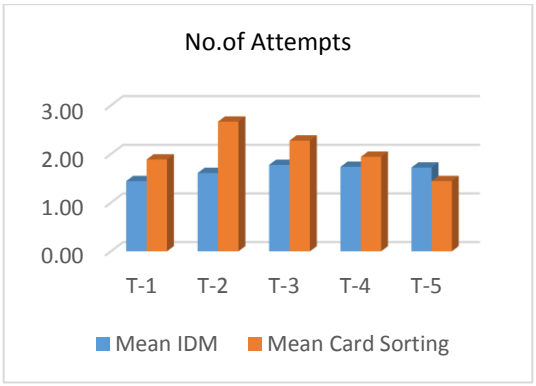

Fig 6.6: Analysing the 'No of Attempts'

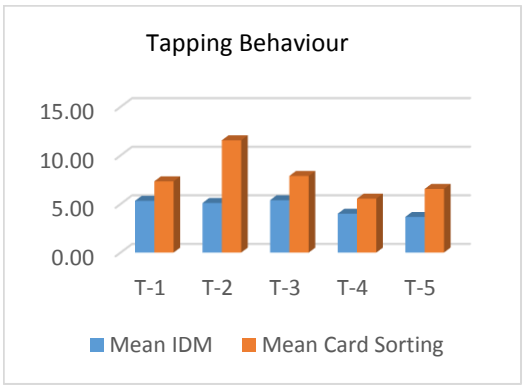

Fig 6.7: Analysing the 'Tapping Behaviour'

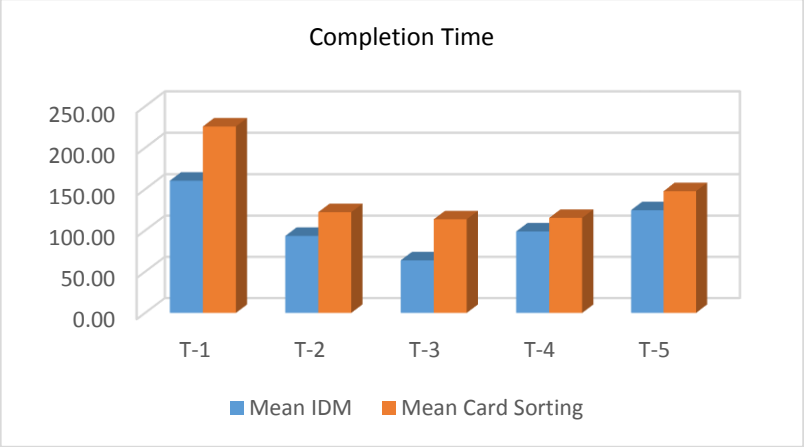

Fig 6.8: Analysing the 'Completion Time'

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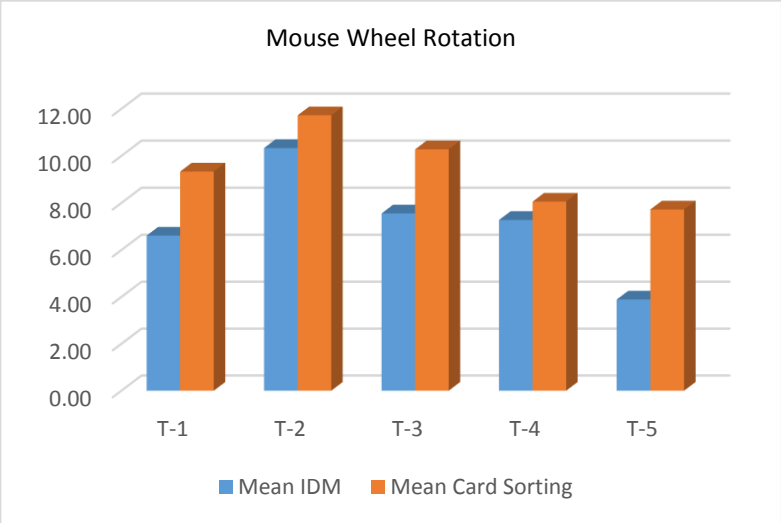

Fig 6.9: Analysing the 'Mouse Wheel Rotation'

CHAPTER 7
DISCUSSIONS AND CONCLUSIONS

This chapter briefly presents the main outcomes of the thesis followed by highlighting the contribution of this thesis. Finally, the limitation and potential scope of the future research are presented.

7. 1 **Thesis Outcomes**

The thesis provides the following outcomes: Firstly, assess the usability of the e-government websites of Bangladesh. This study showed that e-government websites of Bangladesh were significantly suffering usability problems. It was also found that the intuitiveness of the interface signs were required to be re-designed in order to improve the overall accessibility and acceptability of e-government websites by the citizens of Bangladesh. Thus the practitioners (web designers and developers) should follow the existing design guidelines to design/re-design the e-government websites of Bangladesh. Apart from these, during the development process of e-government websites, practitioner should conduct the usability evaluation from the early stage of web development.

Secondly, the researcher explored nine widely used web design techniques, that includes Semiotic Interface sign Design and Evaluation (SIDE), Web Site Design Method (WSDM), Relationship Management Methodology (RMM), Object Oriented Hypermedia Design Model (OOHDM), UML Extension Web Design Model (UEWDM), Enhanced object-relationship model (EORM), Hypertext Design Model (HDM), Card Sorting (CS) and Interactive Dialogue Model (IDM). Through analysis the features of these design techniques the thesis found that the Card Sorting (CS) and the Interactive Dialogue Model (IDM) were the mostly used techniques for designing information intuitive web applications.

Thirdly, an e-government website on ‘Disaster and Relief management’ was designed and developed using Card Sorting and Interactive Dialogue Model (IDM) techniques to find out the more suitable design technique. The disaster and relief management topic was chosen since Bangladesh was prone to various kinds of disasters and an information intensive website for this domain is utmost important for the government and citizens of Bangladesh. Two prototypes of websites were developed using Card Sorting (CS) and Interactive Dialogue Model (IDM) website design techniques. The theme and the purpose of the website remained same, only the design and architectures were different. The Bootstrap 4 (combination of HTML, CSS, and JavaScript framework) was used to build Content Management System (CMS) and the webpages, while following IDM website design technique. The WordPress framework was used as CMS while following CS website design technique. OceanWP theme was chosen to build the pages and manage the navigation among them. For better functionality a total of fifteen plugins were used.

Finally, this thesis showed that usability of an e-government system varied depending on using different website design techniques for developing the website, even though the theme and the purpose of the website remained same. A web designer must understand and follow the usability and UX guidelines while designing the user-interface of e-government websites. The comparison study between IDM and CS design techniques unveiled that effectiveness, efficiency and satisfaction levels were better in the e-government website which followed IDM website design technique.

In a nutshell, the thesis provide the usability status of the existing of e-government websites in Bangladesh; explore the suitable techniques (CS and IDM) to develop e-

governance applications, design and develop the prototype of an e-government website; and finally, found that the IDM is the technique to develop e-government websites with enhanced usability.

7.2 **Thesis Implications**

A few studies had been conducted focusing on Usability and User Experience (UX) issues of e-government websites developed in Bangladesh. Again, existing design techniques were not explicitly explored for designing the e-government websites. Similarly, none of the previous study explored the effect (or realtion) of usability performance with respect to adopting the different design techniques to develop e-government websites. Furthermore, no comparative study had been conducted to find out the more suitable design technique for e-government websites. The outcome of this research strived to address these research gaps to some extent. Thus the outcome of this thesis work have a great impact in the field of human-computer interaction and e-government.

This thesis also showed that designing the information architecture played a great role to achieve better usability and UX, while most of the e-government websites in Bangladesh followed only a few general templates and there many rooms are exist to improve the usability of the existing e-government websites. Thus, the outcome of this thesis will facilitate the government and the stakeholders to concern about the use of better design techniques to address the usability factors more effectively. Again, outcome of the thesis lead HCI practitioners (web designers, web developers, usability evaluators) to be aware of the present usability status of e-government websites and the common problems that need to be addressed to enhance the overall usability of such websites. A low usability

index (EGDI = 0.4862) was found for e-government websites of Bangladesh, but e-participation score was higher (EPI = 0.8034) which indicated that much people joined in e-participation in Bangladesh but did not use e-government services. Since, lack of usability is treated as one of the major concern for the poor adoption of e-government services in Bangladesh. Thus the outcomes of this thesis will lead the government of Bangladesh to aware about the overall usability status and may take necessary initiatives to design and develop usable, useful and accessible e-government websites.

7.3 **Limitations of the thesis**

The thesis has a few limitations as well because of the subject's diversity as presented below:

a) **Limited number of websites were evaluated to assess the usability of e-government websites.** Bangladesh government has a common framework of e-government website for most of its ministries and the associated department/branch/sections to provide e-support. There are also different design templates for few ministries and their under command due different roles. Among these, only six websites were evaluated to investigate the usability of e-government websites in Bangladesh. Though, the chosen six websites were different in applications, roles and designs, but considering more website in the usability evaluation could provide a more effective and generalizable outcomes.

b) N**umber** of **participants was not adequate.** Twenty two post graduate students having sufficient knowledge on HCI participated in usability evaluation study of e-government websites as usability evaluators. Again during the comparison of website design technique, eighteen participants took part in the comparative experimental study. For the usability evaluation study there were constrained to get HCI evaluators

as participants for the usability evaluation study as they need spatial knowledge on the subjects. However, though maximum effort was taken to maximize the participation during each study, but recruiting a more participants could provide a more viable outcomes.

c) **Limited methods were used to evaluate the usability.** Among the four usability evaluation approaches i.e. analytical approach, empirical approach, formative approach and summative approach, analytical approach was used for assessing the usability status of the e-government websites. Under this approach, only two (heuristic evaluation and semiotic evaluation) methods were followed in evaluation. Other methods belongs to other approaches could be adopted to get more diverse problems of the studied websites.

d) **Only one e-government website was developed.** Bangladesh governments run its administrations and governance through 61 Ministries and divisions and 351 directorates. So there were lots of options for developing e-government websites but in this thesis only one website was developed as an example case study. However, while choosing the e-government website for development, consideration was given for having the scope to contribute from both the ends i.e. government and citizen. Keeping the purpose in mind development of e-government website for disaster and relief management was chosen.

e) **No mobile application was designed and evaluated.** At present all the e-government activates in Bangladesh is run by websites. So only website design issue was taken into consideration, not any mobile application, was designed and evaluated.

7.4 **Future Work**

Future research would be conducted to re-solve many open issues that were observed through this research. Firstly, other existing e-government websites could be evaluated following different usability evaluation methods to provide a broader and generalized usability situation of e-government websites in Bangladesh. Secondly, a few more websites could be designed and developed following both the IDM and CS techniques and compare their usability performance to generalize and validate the outcomes of this thesis. Thirdly, following the similar research approach, two mobile applications could be designed, developed, and evaluated to explore the outcomes in other (mobile) platform. Finally, further potential research might be conducted focusing to the effectiveness and efficiency of applying different design techniques from designers/practitioners perspective.

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