**Department of Civil Engineering**

# Project Management and Quality Decision-Making Towards Improved Life-Cycle Infrastructure Design and Construction in Rough Terrain and Inclement Environments

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# DECLARATION

To the best of my knowledge I believe this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

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# ABSTRACT

Infrastructure development is time consuming and costly, especially for roadways in rugged mountainous terrains and flood-prone plains. Road infrastructure development involves huge perpetual investments, and requires cost effective design and fit-for-purpose specification before construction and maintenance decisions are made. This study aims to evaluate the current practices in road design, construction and maintenance and their impact on the environment, road users and the economy of the Hindukush/Ganges-Delta regions. The major objectives of this study were to identify the budgetary, scheduling, risk and contractual variables, the environmental variables as well as to conduct an examination of the overarching quality-management decision-making processes. Qualitative research methods, with reference to specific targeted regional case studies, were chosen for this study; a semi-structured interview data-gathering approach sought to provide data of a greater richness than quantitative methods alone. It was found that stakeholders (often international/charity organisations charged to realise regional infrastructure development) were lacking in (management) structures able to appropriately identify and mitigate risks, address environmental issues, implement regional (non)contractual expectations, and take appropriate account of religious/cultural issues and that this, in turn, had a knock-on effect for the civil-engineering solutions proposed. This study has developed a set of (quality-control) guidelines for use by road infrastructure project managers when making decisions related to the differing stages of projects in mountainous and flood prone areas. Recommendations are provided in order to improve decision making in future projects.

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# BACKGROUND

## 1.1 Introduction

Infrastructure development is time consuming and costly, especially for highways in rugged mountainous terrains. According to Hearn and Massey (2009) landslides and roadside slope failures cause road and pavement damage and road blockages which result in recurrent economic losses in most mountainous (and flood prone) regions across the world. Factors known to cause road blockages and damage in rugged regions include flooding, mountainous debris, alluvial fan, road and drainage structure wash out, landslides and roadside slope failures. The situation is often exacerbated in developing countries where engineering, hydrological, geological and geotechnical information is frequently limited or unavailable. In many cases in under-developed regions only limited engineering assessments have been carried out prior to road construction (in geographically challenging locations from Ethiopia to Bhutan and all else in between) only a very few of the potential hazards are likely to have been identified during project feasibility study and design phases (Hearn & Massey, 2009). Generally post completion failure occurs frequently as a result of a lack of problem/criteria analysis.

Following any in-use (post-occupancy) road-failure/ road-collapse, technical engineering geological investigations, field investigation and topographic surveys are required to be carried out to determine both cause and effect using mechanisms such as field mapping, supplemented in places by trial pit investigation, road inventory, hydrological and hydraulic analysis, roadway planning, environmental assessment, and stability analysis (Khawlie, 1992). Effectively then, this becomes a

costly and timeous treatment of failure causes, rather than appropriate design-stage analysis of need (Hearn and Massey, 2009).

Although available material and labour are cheap in newly developing countries, infrastructure projects in these locations can be expensive. Often a major reason for the expense stems from the need to mitigate the problems of constructing essential infrastructure due to, not only a geographically challenging area, but also as a result of mitigation to address natural-disaster and, in many cases, man-made disaster stemming from national and international conflict and war (USAID, 2011).

Additional costs beyond the usual technical application of labour, plant and machinery in war-ravaged conflict zones can often relate to 'project de-mining' (clearance of mines and explosive devices), alongside related costs to address security, community development costs, specialist de-mining vehicle cost, as well as add-on expenses related to conflict-zone transport cost, fuel cost, accommodation, overloading, rock-cut, blasting, and hauling.

In addition, there are several behavioural factors; basically six of them that impact the design and specification decision-making process, namely: *ethics, values, personality, predilection for risk, potential for dissonance*, and *escalation of commitment* (Gibson et al. 2006). Some affect only certain aspects of the process, while others influence the entire process. However, each have an impact and therefore must be understood to fully appreciate and add-value to the decision-making process in organising new-build road projects, as well as retrospective-refit following failure, or as part of life-cycle road maintenance measures.

## 1.2 Road Construction in rough terrain – background problems

Developing new infrastructure in rough terrain and flood prone terrain, design/construction and maintenance personnel must be able to acknowledge, coordinate and manage a multitude of inter-related issues to address a range of techno-socio problems. There have been many issues examined by research studies; these are discussed in the introductory, general terms below.

According to Singh and Singh (2001, 686), the general causes of premature pavement failure in road infrastructure were:

- Faulty construction materials,
- Faulty construction and improper quality control during construction,
- Inadequate surface and subsurface drainage of road structure and the vicinity,
- Increased wheel load,
- Increased traffic volume,
- Settlement of foundation of embankment for fill materials,
- Environmental factors such as rain, soil erosion, high water table and frost action.

Mahamid (2013) stated that infrastructure projects faced problems due to lack of consideration of *risk*, where the main risks affecting time overrun in road construction projects (in Palestine, by way of example) were due to a lack of consideration of financial status of the contractors, payment delays by the owner, the political situation and political-segmentation of area, poor communication among construction parties, lack of equipment, plant-efficiency and high tender competition.

According to Kadyali and Lal (2003, 671), embankment settlement was another problem failure to be addressed by infrastructure practitioners due to a lack of identification of swampy or marshy ground (implying unstable ground composed of peat or soft clay with low shear strength); indeed designers must also recognise that often live-loads can be exacerbated by marsh deposits that may settle under their *own* weight.

Owolabi et al. ( 2014) highlighted that there were many factors that influenced *delay* in construction projects in newly developing regions, using Nigeria as an example; some of their identified factors included lack of funds to finance the project to completion, changes in drawings, lack of effective communication among the parties involved, lack of adequate information from consultants, slow decision making, contractor's insolvency, variations as well as project management problems such as mistakes and discrepancies in contract documents, equipment availability and failure, mistakes during construction, bad weather, fluctuation in prices of building materials, and, inappropriate overall organizational structures linking to the project and labour.

According to Kadyali and Lal (2003, 667), issues with construction and maintenance of roads (in India) resulted from inappropriate identification of physiography and, climate characteristics such as low rainfall in desert areas (sandy soils) resulting from either/or drought and then (in many cases, sequentially) heavy rainfall in clay causing water log.

According to Bhandary et al. (2003), landslide is a major problem when designing new highways and when re-constructing and maintaining existing highways in most mountainous zones of the world.

Figure 1: Keshim Fayzabad Road, May 2010, Drainage structure blocked with mountainous debris. Photo source: Keshim Fayzabad (2010)

Figure 1 opposite illustrates the issue of drainage structures blockages. Mountain debris blockage can in some cases exacerbate the problem of landslide.

Landslides cause road blockage and drainage structure washout.

The costs of landslide blockages increase exponentially (to the power of 2) with increases in blockage time related to access routes.

Kadyali and Lal (2003, 635) reported that, in Indian hilly regions particularly, landslides are certainly common problems; the natural conditions' disturbances cause slips, subsidence and land-slides resulting from cuts in hillsides for road formation. Included with 'cuts', the increase in frequency of landslides related to *forestry activities* has led to elevated disturbances on alluvial fans (particularly reported in areas throughout British Columbia) (Jordan et al. 2010). For whatever reason, landslide issues dominate pavement design; Bhandary et al. (2003), reported that 'Landslides are the most frequent natural disaster in Nepal. Scientific studies of

Nepalese landslides have been in progress for several years, but no significant achievement has been made to preventing landslides and mitigating disaster damage'.

A factor related to landslides is *rainfall*. One amongst many illustrative examples relates to the Philippines; after a week of heavy rains in 17 Feb 2006, a massive landslide covered a provincial village of Guinsaugon, tragically killed roughly half of the 2,500 residents (Naranjo 2007). No prior identification of risks had been undertaken. Similarly Sayers, Yuanyuan, Galloway, Penning-Rowsell, Fuxin, Kang, Yiwei and Quesne (2013) have also reported that, in areas with steep soil-covered slopes, *intense rainfall* can cause massive mudslides, which can move with such force as to wash away whole communities and landscapes below them.

Landslide generally is greatly increased by slope disturbance, and roads are often built in conjunction with agricultural or forestry activities contributing to landslides one to two times higher than in undisturbed forests' (Sidle, Ziegler, Negishi, Nik, Siew, and Turkelboom 2006). Indeed, compounding the issue, in much of rural Asia, upland roads are often built without adequate attention to engineering standards and as such are a frequent *cause* of landslides (Forbes and Broadhead 2011).

With regard to environmental issues, Kadyali and Lal (2003, 778), stated that highway traffic has earned the dubious distinction of being the *worst defilers* of the environment, creating a direct impact on social and community values, the environment and ecology; this is an ongoing issue in decision-making particularly in Kadvali's (2003) study of India.

The environment is (clearly) affected by rock blasting, too; the intensity of shock waves from explosives create ground vibration through the spread of seismic waves (EPD 1999). Blasting for 'cut' is a major issue. Hoek (2000) reported that rock cut leads to loss of lives and properties during road construction (particularly in areas where community-pressure-group input is at best nominal or at worst discounted); rock falls are a major hazard in rock cuts for highways and railways in mountainous terrain.

Jiminez (1972) finds embankment construction prone to talus/ scree material impact (impact from the deposits of broken rock fragments at the bottom of mountain slopes).

Figure 2: Cracks along the Pentalia road, July 2005. Source: Hadjigeorgiou, Kyriakou, Papanastasiou (2006)

Talus (or scree), disturbs construction procedures. According to Hadjigeorgiou, Kyriakou and Papanastasiou (2006), even newly constructed roads can be damaged by talus material. The Pantalia Road (Figure 2) illustrates this point.

Whilst discussion thus far has concentrated on newly-developing regions, developed regions too report pavement failure as a result of natural impact. International engineering company, AECOM (2010), reported road blockage in urban Hong Kong due to debris at the hillside along Cheung Tung Road, which resulted in severe flooding of the adjoining NLH-region and the highway; this highway, a critical

transport corridor to the Hong Kong International Airport, was temporarily closed for about 16 hours, resulting in knock-on international transportation delays.

Extending environmental evaluation, *freezing* is another issue when constructing roads. The Freeze Thaw/Frost Action phenomenon results in the occurrence of frost heaving, causing a reduction in the serviceability of the pavement, and ultimately to surface failure if left unattended (AASHTO 1993).

Another impact on both road access and stormwater drainage is the drainage of high water tables to lower levels of underground water (Johannessen 2008).

Reporting instances of water table drainage, the Base Conversion Development Authority (BCDA) (2003), reported that deep failure occurred on dikes as a result of rain/table erosion (Fig-3); an issue for decision-making in the Philippines with regard to road embankment for slope stability, bank erosion and pavement damage.

Figure 3: Dike deep failure, June 2003. Subic-Clark-Tarlac Expressway Project Mancatian in Pasig-Potrero river . Source: Base Conversion Development Authority (2003).

Geographical considerations remain ever-present. *Narrow gorges* present significant problems in road design, construction and maintenance. As the pressure group '*dangerousroads.org*' (2014) reports, maintenance of the road in the Taroko Gorge in Taiwan represents an important challenge to engineering geologists, with road

design required to include extra tunnels to be dug to make the road safer for vehicles, not least, since a major part of the design brief (in this area of exception beauty), required maintenance of vista-visibility for tourists and locals alike; in this case the cost to achieve this aesthetic essentiality, was significant in terms of capital cost to construct, and remains significant in terms of its life-cycle maintenance.

## 1.3 Solutions to mitigate problems – background design issues

A wide range of engineering measures and technical solutions exist to mitigate the problems discussed above and, not least, to coordinate and project-manage the multitude of inter-related design solutions into respective quality-system decision-making processes.

Project management of technical engineering design solutions need to cater for both the routine and the complex. By way of example the need to reduce collision on sharp bends is somewhat fundamental; Ray (1963) states that 'the minimum sight distance must be verified for every bend: this is particularly important in cuttings where the inside bank 'juts out' and hides the road. This sight distance imposes stringent conditions even for curves of small radius taken at a reduced speed. Bearing these points in mind, it is possible to improve the visibility by several methods', towards accident avoidance. Whilst such an approach is logical, design problems are compounded significantly by geographical site-restriction, especially in areas where access is required to navigate deep narrow mountain gorges (as illustrated in figure 4 below).

Retaining minimum site distances and incorporating these into a design solution is seldom straightforward in mountainous regions. Similarly solutions to reduce collisions with oncoming vehicles via a widening of carriageways (TRRL 1998) are somewhat impossible to process in narrow gorge mountain areas where there are deep mountains adjacent to key river courses, as shown in Figure 4 below.

Figure 4: Doshi-Bamyan Road, 24 Sep 2009. Photo source: Doshi-Bamyan photo folder (2009)

A deep mountain narrow gorge (such as those in the Doshi-Bamyan) creates add-on design problems to be considered when dealing with the need to find technical solutions to reduce bend collisions.

Preventing erosion in mountainous roads also requires extensive technical redress. The construction of roadside ditches presents a logical best-practice way forward. The ILO (2008) report finds that in mountainous terrain, it may be necessary to accept steeper gradients. In such cases, appropriate soil erosion measures should be considered such as ditch lining or scour checks.

In mountainous terrain, there may not be sufficient space for a headwall at the inlet side. In such situations a wing wall is installed only at the outlet of the culvert; recognising too, *drop inlet* construction on the high side of the culvert. (ILO 2008)

Figure 5: Keshim Fayzabad Road, 13 May 2010 drainage structure blocked with mountainous debris. Photo source: Keshim Fayzabad photo folder

Drop inlet installation on the high side of the outlet of the culvert in lieu of a wing wall requires fit for purpose consideration where flood water runs with mountain debris; as illustrated in the Keshim Fayzabad Road shown opposite in Figure 5.

In order to define and resolve problems concerning pavement design, construction, and performance, on-going fit-for-use technical solutions require constant assessment/reassessment (Hoppe 2004). In developed regions such as the United States of America, the USA Strategic Highway Research Program (SHRP) coordinates and analyses data from various parts of the country, with regional bodies such as The Minnesota Road Research Project (Mn/ROAD) providing localised data analyses and facilities for conducting detailed studies at particular locations.

However, there is no such data-base in newly developing regions (such as Afghanistan or Bangladesh which make up the case-study locations in the research conducted here). It is difficult for newly-developing countries to be proactive when

they do not have remote (site) sensing technology, nor indeed have any State or National authority to collate and analyse appropriate data.

Costs to realise appropriate infrastructure design remains an issue in developing regions, not least the *expenditure* to carry out *initial feasibility studies* alongside requisite 'benefit/cost' (B/C) ratio analyses. Developed nations have the means to instigate and subsequently recognise the return and merit in such early investigation; such as the adoption of benefit-cost ratio (BCR) by a leading engineering company (CH2M HILL 2011, V) who report that, for one particular project the total value of benefits, over the 25-year life-cycle, total more than $500 million, revealing a benefit-cost ratio (BCR) of 3.6. [(*far in excess of the 1.0 limit needed to indicate a significant benefit (at a 6% real discount rate*)]; such that merit results from implementing the project and justifies the capital-cost outlay for a sound technically fit-for-use built-asset. Generally, however, the motivation and means to implement such wide-ranging feasibility (and technical analysis) studies are unavailable to developing regions.

Compounding the (un)availability of financial resources to actually carry-out the early feasibility studies, is the lack of value management skill to conduct an extensive review of technical options in mountainous regions. Such feasibility assessments must consider drainage systems, not just for technical reasons, but also as a means to reduce life-cycle maintenance/repair costs through a mitigation of life-cycle water-damage (that can cause serious impact on both the road access and its strength) (Johannessen 2008). 'Good drainage needs to be taken into consideration at the early design stages in order to secure a long life for the road. With a well-

designed drainage system, future rehabilitation and maintenance works can be considerably reduced and thus limit the costs of keeping the road in a good condition' (Johannessen 2008). However the solution is difficult to enact where mountain debris is not measured at the outset.

A newly developing region's lack of resourcing to conduct value engineering is a drawback in the technical consideration of cold-weather options. To reduce road hazard due to frost-heave action, identification of frost-heave susceptibility requires to be done – factors contributing to frost heave are a frost-susceptible soil, lowering of air temperatures and a supply of water (Yoder and Witczak 1975). However, it is not always possible to identify these factors in mountainous areas due to their remote locations (Afghanistan presenting a case in point), unless the time and cost to do so are factored-in at the *beginning* of the process. Rather than making changes in the road construction after the certificate of completion at the post-occupancy stage, it is preferable to enact appropriate design at the outset; this is of course the least expensive option in the long-run. 'It is easier to change a pencil-line on a road-route plan than to move concrete' suggests the Association of State, Territory and Federal Roads and Traffic Authorities in Australia (Austroads 2002, 5).

Risk management, classifying and quantifying asset-threats, is a means to reduce risks (Nerija and Audrius 2012). Construction companies (*and local public-works-departments charged to create and maintain infrastructure and road routes*) who manage risk effectively and competently, enjoy financial savings across the life-cycle, greater productivity, improved success rates of new projects and, better

decision making. However, in developing countries risk management can be difficult to undertake as there are many external socio-cultural/political pressures to consider.

Despite the best of intentions, designers who seek fit-for-purpose solutions *without* all of the geographical/regional/socio-economic information are *unlikely* to produce best-fit solutions for road life-cycles. By way of illustration *theoretical* catch drains and spoil banks must be considered in terms of a specific location (fig 6).

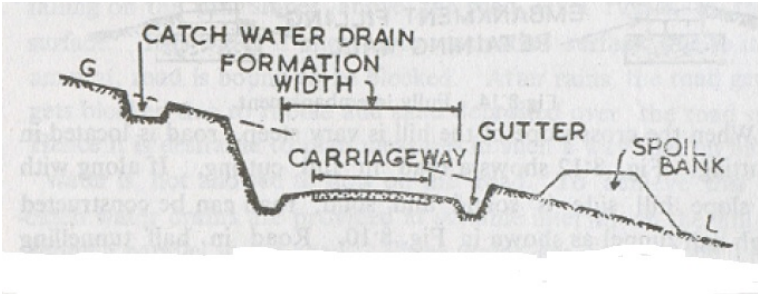


Figure 6: Proposed road template road passing through sloped hilly area section; sketch Singh and Singh (2001, 237)

To mitigate drainage issues in mountainous areas, Singh and Singh (2001, 237) installed catch drains and spoil banks. However, this solution cannot be successful where mountain debris (with a granite or slate geology) runs with flood water and completely blocks the catch-drain and gutter, causing road blockages as well as incurring huge expense.

Having touched briefly upon the range of (technical) problems that require mitigation the following section provides a background on the *processes* towards ensuring fit-for-purpose technical compliance.

## 1.4 General background/review of Quality Decision Making

An important factor to consider in mountainous road and infrastructure design is a means and method and processes to achieve fit-for-purpose technical compliance(s). Construction Quality-Management-Systems (QMS) provides a procedure for design and installation checks.

From a more generalist point of view 'Quality' may be defined as one of the components that contributes to 'value for money' for any client in road infrastructure projects (Flanagan and Tate 1997). Indeed to address 'quality' requires constant review and a way to do this within the industry is to seek continuing-improvement and recognition of so-called total-quality-management tools and techniques in the delivery of built assets. Vincent and Joel (1995) define 'total quality management' as: 'the integration of all functions and processes within an organization in order to achieve continuous improvement of the quality of goods and services. The goal is customer satisfaction'.

At the early stages in a development however, proposals to address the client's-brief must seek to adopt a quality decision making process to ensure that all factors have been covered adequately. To undertake the construction of new infrastructure for rough terrain and flood prone areas appropriate Quality Decision Making is argued here as essential.

According to Walker, Cone, McAuslane (2007, 1) Quality Decision Making can be described as a function of process-definition and skilled-application by qualified-personnel.

Walker's (2007) formula for quality decision making which applies equally to industry and agencies is stated as

Clear and well-defined processes

+ Consistent application

+ Talented, well-trained people

= **Good decision-making**

A decision, however, based on inadequate data will be a poor decision. A decision which addresses all customers' needs is a quality decision (Hess 2010).

The variables of decision making are important parameters in defining a quality decision. According to Kamruzzaman (2007, 3) 'People can change the variables of a decision process to achieve a good decision. But it is uncertain whether this change in the decision process will really change the decision making quality. Thus it is necessary to develop a methodology that can provide feedback of such changes toward the improvement of decision quality'.

It has been found that important decisions are often made by groups rather than by individuals and the quality of the decision is likely to be higher because of the combined wisdom of group members (Gallupe 1987; Podsakoff, Ahearne, MacKenzie and Scott 1997). Group members evaluate each other's thinking, so major errors are likely to be avoided, and decisions tend to be more creative solutions to the problem. However Yang (2010) argued that a single leader may make quicker decisions than a group. His argument is substantiated by Janis (1972), cited by Schafer and Crichlow (2010) who argued that in the case of the historic Bay of Pigs

incident, groupthink led to a very poor outcome. Again Janis (1982) provided the example of the Cuban Missile Crisis where, 'without groupthink, a workable outcome *was* achieved'.

Hoffberg and Corver (2006, 2) stated that 'a high quality decision comes with a warranty: a guarantee, not a guarantee of a certain outcome but a warranty that the process used to arrive at a choice was a good one. A set of steps and rules provide that assurance'.

With regard specifically to road construction, Deng, Jordan and Goodge (2012) stated that a quality decision can reduce road hazards by removing preventable crash producing elements (such as inappropriate intersection layouts, traffic signals, road layout) at the design stages, by mitigating the effects of remaining problems by including suitable crash-reducing elements (such as anti-skid surfacing, crash barriers, and road signs, speed hump, street lighting, line marking), and through road safety audits which provide a final and comprehensive safety check before a new road project or design scheme is built and put in use. Road safety audits can be conducted at various stages of a project such as at the feasibility stage, design stage or after the construction phase; they can add value or can determine the issues and offer alternative recommendations. In addition, road safety impact assessments, road safety audits and road safety network management can be integrated into the decision making process (Schermers, Kenjic, Moning and van der Drift 2010).

Quality decision making also requires safety impact assessment in the planning process alongside other information relevant to decision-making - which schemes

should be implemented and what could improve the quality of such decision-making (European Transport Safety Council (ETSC) 1997, 15).

Other aspects to consider for effective decision-making are improving the management and administrative culture; improving the decision making process and making improvements in legislation (Ministry of Transport et al. 2009; Schermers et al. 2009).

Another aspect to be considered for decision-making for infrastructure development is the capability and desires of the people who will implement the aid (tools/device) and use it (Brown 2005). Such people need tools; by using factual analysis, balanced with experience and intuition and increasing ability to review, challenge and change opinions and decisions, an organization could achieve success (ISO 9000 2005 and ISO 9004 2009).

Care and analysis make the process successful according to the Federal Highway Administration (FHWA, 1997); a process is essential for infrastructure projects to identify safety deficiencies otherwise agencies would be left vulnerable to litigation.
To enforce the process control, quality decisions consist of strict maintenance of some processes (RHB 2008). Donor agencies have stated that, when developing design strategy, policies, and executing actions, assessment and performance indicators must be used, because decisions cannot be taken without information (UNEP-DPCSD, 1995). Some other donor agencies have stated that the decision making process involves a series of commonly used data, statistics, and economic, social, and environmental indicators (UNEP, 1993; UNDP, 1998; World Bank, 1998;

WRI, 1998). Bettman (1998) argues that, in order to maximise quality decision making, two fundamental goals are needed: minimizing the experience of negative emotion while making the decision and, afterwards, maximising the ease of justification of a decision to oneself and to others.

## 1.5 Issues with Quality Decision Making

According to Keeney (1992) a decision situation may be a decision problem or a decision opportunity and a decision problem takes place when there is a need to do something about a circumstance which is found unsatisfactory in some way (Belton and Stewart 2002).

Issues impacting on quality for the Department of Transport and Regional Services in Australia, according to a Green Paper, were: a short-term focus, poor coordination of intermodal planning and funding, lack of cooperation between governments or with the private sector, poor integration of land use and transport planning, insufficient focus on new technology-based solutions, ad-hoc approaches to rail and port access investments (DOTARS 2002).

Another issue related to decision making is that decision makers can underestimate the costs, completion times and risks of the planned actions (Kahneman and Tversky1979), and this is extremely pertinent for design criteria to address the complex requirements of building in mountainous regions. By way of example, Chan (1997) indicated that slow decision making had contributed to delays in Hong Kong Road construction projects as well as poor site management and supervision,

unforeseen ground conditions, client-initiated variations and other variations of works (Mahamid 2013).

Alhomidan (2013) also identified slow decision making as a factor causing cost overrun in road construction projects in Saudi Arabia from contractors' viewpoints. The other factors were: internal administrative problems, payments delay, and poor communication among construction parties.

Related also to decision making has been the state of disrepair of highway systems especially around older cities (The Federal Highway Administration 2001). For example, as of December 2001, about 14% of highway bridges in the U.S. were considered structurally deficient, and another 14% were deemed functionally obsolete. This was due to failure to make ongoing operation decisions about capacity expansion, maintenance/rehabilitation, and regular maintenance.

According to Daley (2014) Australian governments have spent significant amounts on transport infrastructure over the last six years – about 1.1% of GDP, considerably higher than the average between 1987 and 2006 of around 0.8% yet there has been 'no noticeable economic lift as a result'. Poor decisions were cited as part of the cause.

Sabah (2012) carried out a study to identify the significant risks encountered in the Middle East & North Africa (MENA) region, specifically the relationship between the resources and infrastructures industry (RII) of relative frequency and RII of relative impact from different aspects using the Risk Mapping Matrix (RMM); slow

decision making was (again) identified as a risk. Risk was again an issue for Damart and Roy (2005) who carried out study on the 3rd Paris Airport construction project to differentiate between internal uncertainty, relating to the decision-making process, and external uncertainty, regarding the lack of knowledge about the consequences of a particular choice. They found that uncertainty can be reduced but not eliminated.

Al-Khalil and Al-Hazmi (1995) identified 56 main causes of delay in large Saudi Arabian building construction projects; one of the main causes of delay was the ambiguous relationships between subcontractors and the owner's time-consuming decision-making. Ambiguity and transparency were also issues for Short and Kopp (2005) who observed a lack of transparency in mega project decision-making on transport infrastructure projects on a national and European scale. They found that there were no traffic forecasts made or economic analyses carried out, and neither data nor costs were publicly available. So, lack of transparency in decision making was a significant issue.

Kasimu and Usman (2013) found, too, from their study of construction projects in Nigeria that most had experienced time and cost overrun which in turn had led to abandonment of some of the projects. The causes, they found, included time-consuming decision making.

One solution to ineffective decision making is training. The Chevron organization introduced more than 1,000 decision makers to the subject of decision quality in two-day workshops. Dozens of decision staff members took part in two-week ‘boot camps’, and then were subsequently educated while assisting in making important

real-world decisions. During the early stages, adoption of the practices was not compulsory for individual business units (Spetzler 2011). And the result of the training was that it played a vital role in assisting important decision making in the workplace. The need for training rings true for developed regions and is perhaps even more pertinent for newly developing countries such those identified for case-study by this research.

## 1.6 Case studies

This research project, through the use of two case studies, one in Afghanistan and one in Bangladesh, was designed to examine Project Management and Quality Decision Making towards improved Infrastructure design and construction in rough terrain and inclement environments.

Issues pertaining to road construction in Bangladesh specifically relate to the fact that two-thirds of Bangladesh is less than 5 meters above sea level, making it one of the most flood prone countries in the world. A pavement design standard has been set for all national and regional roads to be built above the highest flood level with Average Recurrence Interval (ARI) of 50 years, and feeder roads to be designed above normal flood levels (Siddiqui and Hossain 2006). However these standards have not been adequate enough to prevent large losses in road infrastructure during recent major floods in Bangladesh. For instance, road damage accounted for 15% of the total damage or about 0.7% of GDP during the 1998 flood (Islam and Mechler 2007).

This research project's primary data-gathering was designed to address the problems that had occurred on road construction projects – Bangladesh as mentioned briefly above, as well as in Afghanistan; recognising the need to mitigate technical issues, and address cost overruns, safety issues, and appropriate levels of quality.

## 1.7 Case study/review

Through the use of two case studies, (in Afghanistan and Bangladesh), the issues related to project management and quality decision making towards infrastructure design, construction and maintenance in rough terrain and flood prone plane shall be detailed.

This chapter highlighted that there are many specification choices and engineering methods available in the industry towards the identification and mitigation of design problems and issues. However, it is true that appropriate selection and mitigation of approaches always depend on context. So, the two case studies described in detail in subsequent results chapters sought to determine how the projects were managed and how their respective decisions had been made towards best-practice guidance.

Figure 7: Afghanistan mountainous road (8th April 2007), source: photo folders during construction phase of KFP, Aerial Photo during site visit

In this research project, an Afghani case-study complements the Bangladeshi case-study alluded to above.

Issues related to the Afghanistan case study pertained to the fact that it is a landlocked mountainous country where terrain is harsh and where there are different types of topography such as flat, rolling, mountainous areas to be managed. Figure 7 highlights the nature of a hill road in Afghanistan.

It is noted that in Afghanistan canals running close to valleyed areas are very important and play a significant role in the country's economy for agriculture, hydropower, and animal farming. Appropriate design-making for infrastructure provision and roads in extremely restrictive sites, was be very wary of any impact upon these water canals as this will make a huge impact on the economy as a whole.

The general terrain characteristics of the case-studies selected for analysis allow suitable discussion of the requirements for best-practice design guides in rough terrain and inclement environments.

Figure 8: Apron-Filling 5th April 2005, (sand bag placement) early Arial Khan Bridge works
source: SRNDP photo folders

Design and construction decision-making and technical requirements pertinent to Bangladesh are illustrated opposite. Figure 8 shows the early construction activities of the Arial Khan Bridge in a flood prone environment at the Bangali-SRNDP province

The design and construction of the roads selected for investigation are:

- in Bangladesh, a 'Southwest Road Network Development Project' (SRNDP) of road length 165km, and road building cost was US$210M; and,
- in Afghanistan, a 'Design Construction of Keshim Fayzabad Road' (DCKFP) of road length 103km, and road building cost was US$100M.

Both are significant road projects in newly developing countries and likely to play a vital role in the two countries' economies.

This research project recognises that there have long been problems with both design and construction of infrastructure in flood-prone and mountainous regions; the two projects selected for case-study exemplify the significant delays that can result from a lack of structured quality decision making in robust and harsh regions. This study was designed to evaluate project management and quality decision making towards improved life cycle infrastructure design and construction in rough terrain and inclement environments.

## 1.8 Conclusion

In conclusion this chapter has shown that there are many problems associated with road construction in rough terrain and flood prone terrains. Moreover, it has revealed that Quality Decision Making – when used to reduce these problems – can have problems of its own. These problems include insufficient focus on new technology, inappropriate risks management, uncertainty, contextual issues and procedures, safety and lack of decision-excellence. This research study was therefore designed to evaluate the *decision making* process undertaken in two projects in order to develop a set of *guidelines* for use in future similar road construction projects. This thesis comprised six chapters:

Chapter 1: provides the foundation for the research, giving a brief overview of the research topic including the significance of the research to the engineering industry. This presents the background of the research by providing an understanding of the context of the study,

Chapter 2: contains an analysis of the previous research undertaken on the topic and justification for this research study.

Chapter 3: discusses the methodology/ research design, highlighting the differences between qualitative and quantitative research methods and provides a justification for the research strategy and interview technique utilised specifically to target the objectives outlined by this research. This chapter ends with a discussion of the

methods of validation and ethical issues related to the qualitative research methodology used for this study.

Chapter 4: provides an analysis of the results of this research including the results of the interviews and document analysis conducted as part of primary data collection for this study. These were used to measure the variables identified as part of the secondary research outlined in Chapter 3 of this report. This chapter also shows the key factors identified as part of this research as influencing the decision process.

Chapter 5: provides a discussion of the results, how they relate to previous research undertaken and the implications of the results of this study.

Chapter 6: outlines the conclusions drawn from this research and provides recommendations (centred around a set of Guidelines developed by this researcher) for further research in key areas.

# LITERATURE REVIEW

## 2.10 Introduction

This chapter reviews the research and literature on the problems and issues connected with road design and construction in rough terrain and inclement environments and the impacts on the decision making process for road infrastructure development and its determinants. In particular, this literature review analysed studies related to ***decision-making*** that could add value to infrastructure planning, design, construction and maintenance through IT consideration along with different factors such as Decision Support System (DSS), Spatial Multi Criteria Evaluation (SMCE), Dynamic Decision Environment, Integer Linear Programming (ILP), Fuzzy Decision Making (FDM), Network Perception Model and Multi Objective character.

This literature review also analysed studies related to decision making on Top Management Characteristics, Top Management Team (TMT), Total Quality Management (TQM) as well as for Requirements Engineering (RE) context.

Besides that, this literature review analysed studies related to decision making on various industrial decisions considering the factors: high production logistic performance, joint production control and product quality, Fuzzy Cognitive Map (FCM).

This literature review analysed also studies related to Project Management and Quality Decision Making (QDM) performed considering different factors such as modelling of time, cost and quality, awareness, technical and social knowledge of managers, human bias, intuitions and errors, information quality, performance measurement, performance of human behaviour, critical thinking, risks, single leader decision, environmental effect, Ethical Decision Making EDM), Quality Management System (QMS), Integrated Quality Management System (IQMS) and others.

Finally the literature review specially analysed studies related to decision-making on civil engineering infrastructure and related engineering or technical fields which had taken into consideration different factors such as Environmental Impact Assessment (EIA), Structured Decision Making (SDM), Constructor engagement, Ethical Decision Making (EDM), Dynamic Multi Criteria Decision Making (DMCDM), Multi Criteria Analysis (MCA), Multi Objective Optimization on basis of Ratio Analysis (MOORA), Multistage Stochastic Model, Quality Control, Decision Making Support System (DMSS), Decision Support System (DSS), Decision Making on crisis and contextual challenge.

To perform quality *decision-making* in transport infrastructure, a study was carried out by Lukszo, Ferreira and Vrancken (2006) based on a number of cases, to evaluate how the solution methods were functioning in practice. In this study the multi-objective character of decision problems with a variety of benchmarks were taken into account. The study was based on computer-based simulation, where the different stages of simulation were suggested since optimization methods and simulation as

decision-supporting tools are important for many transport infrastructure companies around the world. The researchers found that decision making in transportation struggled to adjust to different types of conflicting criteria instantaneously and decision making had to take place at different stages, and this could be differentiated by geographical extent and time scale. The researchers also found that computer-based simulation performed an accumulative role and that computerized systems had reinforced the role of the lowest and most distributed level of personnel in the hierarchy of decision makers by applying different methods in amalgamation.

A similar study on IT software development was done by Shia and Costa (2014) to develop a network perception model to demonstrate the ability to control, service quality assessment and make decisions with regard to the provision of IT software service environments. The data collection was carried out using professionals in the field of improvement consisting of a project manager, a system analyst and software developer. In this study, lists of issues with the quality attributes were represented by Square model which had functionality, maintainability, usability, trustworthiness, proficiency and transportability. It was found that the communications between development teams were more harmonious through the use of this perception model, and it was also possible to forecast with more correctness the risks and delays in the delivery of its services.

Another study concerning IT was carried out on the decision making process in field technology for industrial process management by Koskinen (2000). The study used Decision-making and hermeneutical methodologies. The objective was to verify the multivariable decision-making models based on experience and evidence by means

of multiple-choice questionnaires, model and case process surveys, and by gathering information on field technology. The target group of the research model was made up of 50 decision-makers and end users from 20 different factories, and the response varied in percentage from 28% to 47%. The study also considered contributions from 13 key persons from these factories. The research found that the decision making support model was an exceptional tool in circumstances involving technological changes and development and decision databanks, constant learning, human and electronic information networks, and benchmarking.

A similar study on IT and FCM was carried out by Dweiri and Kablan (2005) on decision making, evaluating internal management efficiency using fuzzy logic to present an approach that employed fuzzy decision making (FDM) to combine these three measures (project cost, project time, and project quality) into one measure, namely the project management internal efficiency (PMIE); this would represent an overall estimate of how well the project was managed and executed. To analyse and assess the PMIE, a fuzzy decision making system was designed which was implemented using the MATLAB software. The researchers concluded that a FDM Expert System (FDMES) could assist in preserving the knowledge of experts.

A similar study on IT, where another type of model was developed by Ssemaluulu and Williams (2008), was carried out to identify the dependency of the decision making process on IT managers and the factors that prejudiced the decisions of IT managers in the flight simulation field. The research argued that the systems thinking or systems dynamics-based flight simulator approach could be applied to examine the effect of difference on IT decision-making. The researchers found that, although

System Dynamic (SD) tools tend to complicate the decision-making processes, it also offered a way of exploring the impact of change on decision-making over time.

Correspondingly a study on IT PC based software of an integer linear programming (ILP) based decision making framework to help system engineers in feature selection activity using feature modelling was carried out by Fajar, Nakanishi, Hisazumi, Fukuda (2010) for development of Agricultural Wireless Sensor Network Systems. This research collected the raw data using Field Server and conducted a case study to obtain an optimal arrangement within the specified cost and power utilization to satisfy farmers' requirements by increasing a field monitoring application from which the quality decision making framework delivers a dramatic way to derive an associate of the agricultural wireless sensor network (WSN) system. The study found that this *framework of decision-making* provides an optimal configuration within the specified cost and power consumption to satisfy farmers' requirements in developing a field monitoring application. The framework used a logical level features model and a physical level features model which considered different features such as temperature, soil properties and local environments.

Again, a study of IT to determine an efficient tool for making quality decisions from a large volume of data from mobile and wireless technology was carried out by Shankaranarayan, Ziad and Wang (2003) based on product information approach. The researchers carried out a literature review and developed an Information Product (IP) framework for data quality management which included a set of modeling techniques to compute data quality at the manufacturing stage. The demonstration was called an Information Product Map or IPMAP. In addition, the researchers

developed a Virtual Business Environment (VBE) to support dynamic decision-making and displayed how the IPMAP and data quality management could mount into the VBE. The study developed a framework which was specifically required in dynamic decision environments where decision-makers need to perform or react quickly to all decision-tasks such as patient management in medical hospitals. The developed framework from their study provided full support for managing data quality and implementing total data quality management.

Using the IT concept, Kamruzzaman (2007) conducted a different study designed to determine the strengths and weaknesses of decisions based on the list of conflicting (political boundary conflict) municipalities of Cordillera Administration Region (CAR) to sort out spatial conflicts in the Philippines. In this study a framework was developed to evaluate the decision quality and one resolved and one unresolved case were selected for this evaluation; the unresolved case was further examined to determine whether Spatial Multi Criteria Evaluation (SMCE) as a decision method will generate a better decision. The framework revealed that a method was worthy when it satisfied technical quality, organizational capacities, user satisfaction, and when there was enlarged collaboration in a group decision situation. The study described the importance of contextual challenges and the quality of one decision variable impacting on the quality of the other decisions. The researcher found from this aspect that the Spatial Multi Criteria Evaluation (SMCE) as a method can produce better quality decision techniques and can control the weaknesses of both resolved and unresolved cases.

Another IT study was carried out by Turban and Aronson (1998) on quality decision making with Hewlett Packard (HP) Quality Decision Management, a PC based software package for analysing manufacturing process and product quality to better understand how to profitably make complex products with short life cycles. The researchers found Hewlett Packard (HP) quality decision management was based on Ready-Made Decision Support Systems (DSS) and the system was used in the following application areas:

- **Incoming inspection:** check-up instructions display, vendor rating reports, control charts of fault rates, and vendor quality.
- **Product test:** manual and automatic on-line data gathering, test method display, statistical monitoring of defect levels, and decision support graphics and reports.
- **Statistical process and product monitoring:** on-line data gathering from incoming inspection, manufacturing process and test areas, statistical graphs and reports to monitor manufacturing process quality, relationship between product defect data, and defect cause data (in real-time environment).

The researchers concluded that Decision Support System (DSS) considered the basic tools of Management Resource Planning II (MRP II), Decision Support for Manufacturing, Risk Estimates at Banks, Intelligent Decision Support Systems, basically a menu which could respond promptly. This approach allowed engineers to configure data collection transactions, identify, report and graph formats, archive data, and execute system maintenance functions without programming experience. The system also provided data collection, validation, and storage and allowed analysis, sensitivity analysis, and simulation capabilities where engineers could statistically analyse the data and output the results in tabular or graphical format.

From the above studies on the IT sector, it was noticed that a few essential elements were considered in decision making such as geographical extent, time, cost, quality, data quality management, political issues, life cycle analysis, risks and tools (software). However, *not examined in these studies* were: uncertainty, client focus, Value Management/Value Engineering, Checklist Procedure, technical standard, manager's proficiency.

Other researchers have focussed on top management and *total quality management* in relation to *decision making*.

A study was carried out by Hambrick and Mason (1984) on the Decision Making Process to propose a model of how top management characteristics may affect decisions and to provide a foundation and stimulus for empirical research into the links between top managers and organizational outcomes. In this study, the researchers analysed the observable characteristics of top managers which were age, tenure in the organization, functional area of Organization (production, process, engineering and accounting) background, formal education, socioeconomic roots, and financial position. The study found that the firms with young managers were more inclined to peruse risky strategy and greater growth and variability in profitability than those firms with older managers. The research also found that the degree of experience of top managers related to production in their own field would positively associate with growth.

A similar sort of study to determine the impact of conflict in Top Management Teams (TMT) and setting of goals for the organization to enhance strategic decision-

making and organizational performance was carried out by Clerkin and Jones (2013). Two elements were examined - how the moderating variables could impact the quality of decision-making; what the effects were of two types of conflict using a model tested in another study by Amason and Sapienza (1997) who identified five moderating variables to frame their model: team size; cognitive conflict; affective conflict; openness. The researchers, Clerkin and Jones, found that the decisions made by Top Management Teams with regard to setting goals for their organizations were most important and the process was one which could be subject to conflict.

A historical study related to '*Presidential' decision making* on crisis management was carried out by Herek, Janis and Huth (1987) for Decision Making for International Crises during World War II. This study examined the assumption that during crises high-quality decision-making processes were linked with better crisis results than were malfunctioning decision-making processes. This study scrutinized a study carried out by Janis and Mann (1977), where 19 Presidential decisions were made during international crises and seven symptoms of malfunctioning decision making were found. The study results indicated that crisis effects had a tendency to have more aggressive effects on U.S. interests and were likely to escalate international conflict.

Another study on managerial decision making was carried out by Sabur (2013) to highlight the various uses of Total Quality Management (TQM) as a tool for managerial decision making from continuous input from owners/customers to keep organizations running smoothly. The major components of TQM which influenced the decision making were quality data, rewards for results, cooperation in teamwork,

secured jobs, fairness, unbiased payment, employees' ownership stake and others for customer satisfaction safety guiding principles, elimination of mistakes and defects, continuous development, employee empowerment. The method used for this study was a theoretical approach based on fundamental principle of desk study, analysis of related literature and existing stock of information. The researcher found the limitations of TQM were: incompatible business environment, high production cost, price escalation of products and prejudiced competition in the market. The study concluded that there should be proper market research to satisfy customers as well as managerial efficiency; strategic management techniques should be developed in order to operate well in an open market economy.

Other studies have investigated the environmental effects on decision making. A study financed by Fulbright Research Scholarship Grants was carried out by Paprika (2008) to evaluate the environmental effects on decision making methods. The participants were twenty top level managers: twelve were CEOs, Presidents, Vice Presidents or Chief financial officers while eight were founders and majority owners of their own enterprises. This research also focused on the role of sensitivity in strategic decision making. Paprika (2008) found that executives in a corporate setting have a tendency to view decision makers in a different way from entrepreneurs. Decision makers were found to have been given a certain amount of estimated resources to work with; they had a tendency to identify a problem in terms of an objective. On the other hand, entrepreneurial decision makers were less restrained by resource deficiencies.

Another aspect of quality decision making that has been investigated by Stashevsky and Elizur (2000) is the effect of Total Quality Management (TQM) on improvement efforts and individual performance within an organization.The data were drawn from 208 employees in three Israeli industrial organizations and three theoretical models were tested empirically by means of structural equation modelling using LISREL which is a statistical software package used in structural equation modelling. This study concluded that participation in Decision Making (PDM) is important for effective application of TQM in organizations and lack of participation of TQM is 'like a body without a soul'. There may have been different results if data from organizations in other countries had been analysed.

A similar sort of study was carried out by Kaluzny, McLaughlin and Simpson (1992) on Total Quality Management (TQM) concepts in public health organizations, a continuous organizational development process. The objective of this approach was to focus on customer satisfaction, problem identification, commitment building, and promoting open decision-making among workers. The method used for TQM was analytical tools, such as statistical charts, flow charts, and check sheets, to accumulate data about happenings within an organization. To facilitate communication and decision making, this approach used the process techniques, such as nominal groups, brainstorming, and consensus forming. Since the application of TQM in the public sector and in public health agencies in USA was limited, this study used the process to amalgamate TQM into public health agencies to develop the Model Standards Program and assessment methodology, the Assessment Protocol for Excellence in Public Health (APEX-PH), used for launching strategic directions for public health. The researchers developed guidelines for public health

organizations; these guidelines included redefining the management role, describing a common corporate culture, filtering the '***inaccurate functional role'*** of citizens, and the time required for setting rational estimates to complete a task or project.

Another study was carried out by Williams and Kennedy (2000) to develop a model for Decision Making. The researchers studied the effect of requirement changes on decision-making, taking into consideration decision-making behaviour, individual factors such as age, education, background, experience of managing change and characteristics of the organisation in which they operated and which might influence decision-making behaviour. The researchers concluded that the value of the model was very important in both theory building and in learning or training circumstances and stated that this model could provide a framework for building a framework of understanding on decision-making processes in Requirements Engineering (RE).

A similar focus on Requirements Engineering (RE) complex decision-making, was maintained by Alenljung (2008) in his study based on a decision situation framework which had been developed through an analysis of decision-making theories as well as decision support systems literature. The decision circumstances of RE decision-makers were analysed at a systems engineering company which was described in this research through literature review. The research found that Requirements Engineering (RE) decision-making can become significantly better through using RE decision support systems (REDSS) based on the definite needs of RE decision-makers as well as the actual standard human decision-making activities that take place in the RE decision processes such as social, environmental and other hidden activities; judgement and trade-off were also considered. The research found that

applying only one RE tool, made it difficult to justify the usefulness of the method; moreover the evaluator and the inventor of the method (and the foundations of the criteria) were one and the same person, leading to possible bias.

A corresponding research study was carried out by Kabbedijk, Wnuk, Regnell and Brinkkemper (2010) to identify the factors prejudicing the decision lead time and outcome. The case study was carried out at a large product software manufacturer and analysed seven possible relationships among decision characteristics statistically. To test all hypotheses statistically, a large Requirements Engineering decision log was used. The study found that decisions had been prejudiced by several factors which were time, cost, and quality. The researchers concluded that decision making activities should be cautiously refined in large scale Requirements Engineering processes in order to make efficient decisions.

From the above studies on Top Management Decision Making in different industries, it was noticed that top managers usually considered several essential elements in decision making such as socioeconomic issues, goal setting, price escalation, strategic management technique, intuition, PDM, guidelines (corporate culture, role and time), decision bias, social and environmental activities; however, it was also shown that many elements had not been considered such as decision making tools (software), political issues, religious issues, security issues, culture of countries, context sensitive approach.

Other researchers have focussed on high production logistic performance, joint production control and product quality in relation to decision making.

A study designed to evaluate an intelligent modelling system based on Fuzzy Cognitive Map (FCM) was carried out by Pang (2013) to assess the effect of fluctuating support scale of trained data (output data) by using FCM in various environments. This study developed a system to reduce the response time by processing the multivariate QC before they were transferred to quality managers. The final results showed that FCM methodology ensured better assurance of the appropriateness of product quality with intelligent modelling and decision making.

A research study, carried out by Schuh, Potente, Thomas and Zeller (2014), examined decision making within companies' production control departments in order to attain a high production logistic performance. The four tasks of the production control, order generation, order release, sequencing and capacity control were tested. The study found that the good decisions within production control required consideration of three questions: What do I want (aims)? what can I do (action alternatives)? what can happen (consequences)? This study identified four main characteristics of employee's decision making process: conformity goal, alternatives number (or within production orders), time expenditure to find out the next order and information about the outcomes**.** This study did not take into account the fact that many problems are initiated by misunderstandings, overload of alternatives and a lack of communication. However, this study did establish an approach which represented a new perspective of production control's configuration process with a high significance for practice.

Hajji, Gharbi and Pellerin (2012) also looked at quality decision making, in research into failure prone multiple-product manufacturing systems. This study developed a methodology considering joint production control and product quality specifications decision making in erroneous multiple-product manufacturing system. This study used a trial method based on simulation modelling where experiment design and response surface methodology were applied to find the parameters of best control policy and scanned dynamic stochastic context. The results showed that it was very challenging to anticipate without deep analysis and optimisation and the turnover under a joint production-quality control policy could escalate up to 7% compared to results from completely disconnected control and quality related design strategies.

Eweje, Turner and Muller (2012) carried out a research study on the decision-making for maximizing strategic value from mega projects in the oil and gas industry. This study used survey data from 69 managers of mega-projects in the oil and gas industry. Results showed that information feed to project managers significantly influenced the strategic value created by mega projects and the decisions made by project managers had a significant impact on the strategic value of the asset delivered. The result also showed some moderating effects of contextual factors that influenced project manager decision-making related to what they had perceived to be Senior Management drivers for their projects. Finally, the study found that four risk areas were significant to long-term value creation from mega projects in decision making: government relations; host community relations; contract management and procurement; and the influence of multi-location execution and the extent to which project managers feel in control. However, an effect was not found on decision making related to a project manager's experience.

From the above studies on decision making in the manufacturing industry, it was noticed that they used different elements in decision making process such as quality control, response time, production control (goal, action, consequence), product quality control, risks, information feed to managers, manager proficiency and competency.

Other researchers have focussed on *Project Management and Quality Decision Making (QDM)* taking into consideration different factors such as modelling of time, cost and quality, awareness of technical and social knowledge of managers, human bias, intuitions and errors, information quality, performance measurement, performance of human behaviour, critical thinking, risks, Quality Management System (QMS), Integrated Quality Management System (IQMS) in different fields in relation to decision making.

Dooley and Fryxell (1999) carried out a different kind of study on the strategic decision-making process from a sample of 86 strategic decision-making teams in U.S. hospitals. During data collection, 534 questionnaires were mailed and 365 were returned, giving a response rate of 68 percent. Of the respondents, 73 percent were executive officers such as chief financial or operating officers, 16 percent were either chiefs of staff or chiefs of a specific medical field (for instance, chiefs of surgery), and 11 percent were directors or vice presidents of nursing services. Two hospitals had no respondents other than the Chief Executive Officers (CEOs). These were dropped from the data sample, resulting in a final sample of 86 hospitals. At the sampled hospitals, the number of respondents ranged from 2 to 14, with an average

of 4.16. All variables were measured on a seven-point Likert-type scale and the study proposed two hypotheses which were: 'When levels of perceived loyalty are high, dissent during the strategic decision-making process will be positively related to decision quality. And when levels of perceived loyalty are low, dissent during the strategic decision-making process will be negatively related to decision quality'.

The researchers found that awareness within team competence reinforced the relationship between dissent and commitment for decision making.

A similar kind of study was carried out by Liberator and Johnson (2013). They designed a study for Decision Making on Project Management by modelling quality, time, and cost where quality was an important component of project management, but had no joint relationship with time and cost. This study developed a concept of quality function to model quality at the task level. Data were used from two case studies, a translation agency and a software development company, where the quality function was specified and integrated into a mathematical programming model that permitted quality to be unambiguously deliberated in project planning and scheduling. This study found that there were three fundamental dimensions (quality, time, and cost) at the task level and provided insights for project planning and scheduling that could be gained through improved understanding of the choices and trade-offs. The effect of parameter uncertainty (if any) on the model's results was not determined since the parameters of the quality function were expressed as crisp data; hence model formulation considered direct costs that were associated with each task, but did not consider any project indirect costs which could have addressed the overall administration of the project, including quality management.

Another study also set up to determine the most *effective factors* for quality decision making where decision failure had happened at any stage in the value creation process, and where there had been many implementation failures, was carried out by Bickel, Spetzler, Winter and Marca (2011) on behalf of Stanford Strategic Decision and Risk Management (SSDRM), a certificate program run by Strategic Decision Group (SDG) of Stanford University. This program established that the source for quality decision making comes from two academic fields: behavioral decision science and prescriptive decision science. SDG combined the arts and science of decision making along six elements as a chain. The researchers found that this chain comprised the following elements such as appropriate frame (clear purpose, conscious perspective and define scope), creative doable alternatives, meaningful reliable information, clear values and trade-offs, locally correct reasoning, and commitment to action. The researchers on behalf of SDG suggested that the Decision Makers should demand 100% quality in each element to achieve QDM.

A different study of the management planning process in order to develop effective grazing management strategies was carried out by Stuth, Conner, and Heitschmidt (2005). A comprehensive literature review was carried out for this study on management planning decision making on climatic forecasting. The decisions were made or discussed in this study about uncertainties in climate depending on the degree of understanding the manager possessed related to biological relationships and the amount of statistics that could be procured or secured to access market trends, weather personal characteristics.

The researchers found that quality decisions depended on the analytical skills of a manager; he/she needed to have strong technical knowledge as well as a functional social knowledge of his/her cultural environment.

Another study carried out by Harris (2012) aimed to determine the variables that could disrupt data-driven decision making such as time, big data, pattern recognition, human biases, intuitions and errors. The study was based on an extensive literature review of the following topics: Computability versus Complexity, Decision Needles in Data Haystacks, The Paradox of More Data, the Data-Decision Symphony, the Data that Supported the Decision, a Partial Defence of Intuition, and Data-Driven Decision Disrupters. The researcher found that, to get comparatively better operational quality data or information, organizations needed to make better business decisions in less time, using better data, and more varied sources and types of data, and information with more openness in data-driven decision making.

Quality information research was done by Popovic and Habjan (2012) to determine the effect of the relationship between information quality and information use on decision making culture. The study was a quantitative analysis carried out with data from two industries, the transportation industry and the financial/insurance industry from Slovenian medium and large organizations. This study's target population was Slovenian medium and large size companies from financial/insurance industry and transport industry as listed in the registry of Slovenian Agency of Public Records and Related Services at the time of data gathering. Questionnaires were distributed to senior managers estimated as having satisfactory knowledge about the quality of available information for decision-making and the use of information for decision-

making. Empirical data for this research were composed by means of paper and Web-based surveys. The researchers analyzed the gathered data using a form of Structural Equation Modelling (SEM). For the estimation of the model the study employed Structural Equation Models by Partial Least Squares (SEM-PLS). The study found a positive relationship between quality of information and use of information i.e. when uncertainties decreased in decision making, and organizations had an opportunity to rapidly react to business events, the decision making culture of these organizations was always enhanced. Harris also found that improving information quality had a stronger effect on information usage in organizations with a low level of decision making culture. A limitation of this research was found to be the cross-sectional nature of the data gathered and so it was suggested that future research designs should be tested experimentally and with longitudinal data.

To investigate the critical role of decision making based on performance measurement, Dhanpat (2007) carried out a study to enhance educator competence and ultimately school effectiveness to accountability as aspects of performance measurement. The main focus of this research study was the need for responsible decision-making, empowerment and successful application and independent participation of the Integrated Quality Management System (IQMS) in schools. In order to establish the engagement of educators in decision-making and their accountability pertaining to the execution of IQMS in schools, a structured questionnaire was used to collect data. In this research study thirty-one (31) items were developed in order to extract information on the engagement of educators at different post levels. The construct validity of the structured questionnaire was explored by means of consecutive first and second order factors. Dhanpat found that

group effort and decision making at all stages was key to successful implementation of systems which were equally appropriate to the successful implementation of performance management systems in schools. Thus, the researcher recommended that principals should be trained in such a manner that the leadership role of the principal could influence the effective performance of educators, and could be capable of implementing the education systems and change, including, managing performance management systems. The researcher concluded that decision-making and performance instrument accountability rotate around the hypotheses of democratic participation, authorization and responsible decision-making. Based on this hypothesis of having validity, high reliability could work as a source of executing the processes of IQMS effectively.

A similar study on management efficiency was carried out by Shoommuangpak (2011) to investigate the efficiency of management accounting implementation that affects decision making quality and performance, taking into account cost management productivity, participation of budget suitability, and segment report fairness in Thailand. A regression statistic technique was applied to analyse the data which was collected through questionnaires. A total of 566 firms were identified from the Thai-listed firms' database. The research showed that there was an influence on the relationship with both decision making quality and performance by the effectiveness of the management accounting implementation. This study also found that factors affecting the effectiveness were corporate strategy, top management support, and employee involvement.

A study on crises management to improve decision making through critical thinking support was carried out by Schraagen and Ven (2008); The study used 60 participants, 27 men and 33 women, aged 17 to 30 who were employed at Utrecht University; they were asked to act as crisis managers to establish how to use ground-breaking techniques to develop the quality decision making process in crisis response organizations. The researchers found that people who used tools and supporting data were more effective in their thinking. In addition, people who used tools for critical thinking were more successful in avoiding tunnel vision and information bias than people who were not using tools. The study also showed the disadvantages of using the tools, one being time delay because of colour coding, which could make difficulties when users were under time pressure in a crisis. It should be noted, though, that the research was not conducted with participants who had not been exposed to crisis management prior to the study.

Assessing the *thinking processes* in *decision-making* was carried out by Gidel, Gautier and Duchamp (2005). This study found, through examination of the use of a framework that the more substantial a framework is, the greater its effectiveness at the ***earlier stages of construction***.

Another similar study on a quality management framework for public management decision making was carried out by Yu, To and Lee (2012) supported by the Socio-cultural Development Research Association, Macau. The study examined a basic process-based model and then improved the model with the quality management principles for continuous improvement of the process. This study examined the effectiveness in the quality management system with proof of identity of concerned

factors from the literature. Doing an empirical analysis on the framework, this study identified eight factors: actual decision making approach, application of quality tools, customer focus, leadership, people involvement, development approach, mutually beneficial supplier organization and their internal results, which finally showed that leadership and customer focus were more important than the successful implementation of a previously projected quality management system.

Yang (2010) used a structured design method to compare two styles of group decision-making, building consensus and single leader decision-making. This study considered three common criteria for group decision-making: speed, team members' satisfaction with final decision and the quality of the final decision. The study used 59 Masters level students; each participant was randomly assigned into one team of six, nine teams of five, and two teams of four members. Yang (2010) found a single leader to be faster in decision making than groups. It was also found that, when there was more uncertainty in a decision, as represented by a smaller point spread between selections, teams had a tendency to speed up and decisions were of lower quality.

Howard (2007) carried out a study examining the treatment of very large and complex decision problems using modern computation to avoid common errors of thought. The study considered uncertainties, values, and preferences in a major structure that models the decision and incorporated technical, marketing, competitive, and environmental factors. The purpose of this study was to produce a formal procedure for the analysis of decision problems. Howard (2007) concluded that transparency was a great strength but also a threat to organizations that wanted to limit alternatives, control information, and hide preferences. The more open the

organization, either private or public, the more important it appeared to be to value the process of decision analysis which can help decision makers to consider different features such as uncertainty.

Another aspect of decision making, *intuition,* was carried out by Fields (2001) by means of a literature review and study of measures presently being used inside organizations in the USA. This research focussed on the relationship between intuitive thought, organization level and function. This research was done to determine the systematic use of intuitive skills and abilities in business organizations and the findings of this research supported the proposition that insight is a standard, probability-based occurrence when individuals deal with the information processing. Overall, the findings of this research created a strong case for using Organizational Engineering theory (Salton's theory) over the older psychological theories.

Based on psychological theories a different sort of study carried out by Rutten, Dorée and Halman (2014) explored the ability of an innovative psychological theory to discover how people make decisions based on narrative decision theory. In order to mitigate the costs, this study applied the theory to an empirical finding of existing research on R and D progress decisions. The study found a more detailed explanation about the influence on the decision making process and other management decisions by using the variables, the predictor variable (sunk cost) and the moderator variable (instruction in the sunk cost principle). This study also illustrated how the theory may help in explaining the findings of empirical research on management decisions.

From the above studies on Project Management and quality decision making in different fields, it was found that factors such as quality, cost, time and manager

skills (analytical, technical, social and cultural), openness of information and organization, participation in decision making, data quality, tools (decision making), risks, customer focus, leadership skills of manager, faster decision making skills, uncertainty, technical and social knowledge of decision theory were important. However, it was revealed that there were m*any elements not considered by top management* such as political issues, religious issues, security issues, culture of countries, context sensitive approach, LCCA, CBA, client focus, Value Management.

Other researchers have focussed on ***Civil Engineering Infrastructure*** and related engineering or technical fields taking into consideration different factors such as Environmental Impact Assessment (EIA), Contractor engagement, and other variables in different engineering fields in relation to decision making.

A study on decision making during a highway development project in the USA was carried out by Zhao, Sundararajan and Tseng (2004) with regard to uncertainty and its impact on decision making in highway expansion, operation, growth, and rehabilitation; a multistage stochastic model was used. The model was run on a 50-mile-long highway section; the researchers stated that the model could be stretched to manage longer circumstances such as a network of roads. Zhao, Sundararajan and Tseng found that the model made a fundamental and theoretical step towards optimal decision making in highway engineering. In this study, the researchers also developed a real-options methodology for best decision making in highway design, operation, rehabilitation, and expansion, which was incorporated in life-cycle analysis.

To develop a procedure for multi-objective optimization of multi-alternative decisions in road design and construction, Brauers, Zavadskas, Peldschus, Turskis (2008) carried out a study of a similar model. The researchers selected multi-objective optimization with discrete alternatives, called MOORA (Multi-Objective Optimization on basis of Ratio Analysis) after a rough overview of multi-objective decision support for evaluation of road design alternatives. The researchers used wide-ranging literature reviews, previous project data and a case study in Germany. From the case study the researchers inaugurated the theory of multi-objective optimization of road design alternatives and therefore the best road design alternative was established. The approach was found to be quite accurate for problems concerning large numbers of perspectives and objectives. Based on the study, the researchers suggested substitutions in a priority order and the best alternative selection could not be based on a single objective.

A similar study was carried out by Deluka, Karleuša, Dragičević (2013) to improve the decision-making process in the field of planning, design, maintenance and reconstruction of transport infrastructure. This study used Multi Criteria Analysis (MCA) method using a mathematical model since researchers believed that MCA would be supported by the decision makers to provide the quality of the decision making process for transport infrastructure in urban areas. This study also compared results of cost benefit analysis, and hypothetical relationships with the MCA method for road reconstruction and found the CBA method did not demonstrate any substantial differences during analysis and evaluation of two acceptable reconstruction alternatives. This study concluded that MCA in the decision support

systems could significantly add value to the quality of decision making in the field of transport infrastructure in urban areas.

A similar type of study, undertaken to analyse societal decisions involving complexity and conflicting objectives, was carried out by Vo, Chae and Olson (2002). The researchers demonstrated a case of urban infrastructure to explain the method. The perceptions, goals and preferences of three groups of personnel were analysed to predict their behaviours in the model. A composite cognitive map showing people who had a good understanding of the system was built on the mental models. Finally, a system dynamics model was set up on the composite cognitive map, integrating preferences of the three personnel groups. The researchers proposed a method that integrated Multi Criteria Decision Making (MCDM) into system dynamics modelling to deal with dynamic multiple criteria situations. Moreover, it was observed that Dynamic Multi Criteria Decision Making (DMCDM) can manage different lags in economic, social, economic and technical effects of a large scale system. Finally, the researchers concluded that DMCDM could help decision makers to avoid choosing options apparently effective in the short term, but not beneficial in the long term. So MCDM and DMCDM together could be a powerful tool for decision making in dynamic environments.

A similar study was done by Turskis, Zavadskas (2010) to select a potential supplier, the most appropriate and most applicable. Data were collected by interviewing and surveying several purchase managers of organizations in Lithuania. The selection criteria for supplier were Delivery Price, Financial Position, Production Specifications, Standards and Relevant Certificates, Commercial Strength, and the

Performance of supplier. The evaluation criteria were also based on the interests and goals of the stakeholders. The researchers found that the best method for selection of a supplier was a new Additive Ratio Assessment (ARAS) method.

Relatedly Zavadskas, Liias, Turskis (2008) assessed quality in bridge and road construction based on Multi-Attribute Decision-Making Methods. This study evaluated the capital spending decision support tools used in bridges and road quality management in an international and national practice context in three Baltic Countries (Lithuania, Latvia, and Estonia). This study utilized the multi-attribute analysis, strategic planning, and cost benefit analysis methodologies. The researchers found that cost benefit analysis and multi attribute analysis were the principal and most beneficial methodologies for decision-making in bridges and road quality management.

A different study was carried out by Aliza (2012) on ethical decision making (EDM) for project management (PM) in public sector projects in Malaysia where there had been ethical issues, conflict of interest, bid shopping, collusive tendering, bid cutting, dishonesty and payment biases during the project procurement process. A questionnaire survey was performed among the public officials (consultants) who had been involved in the procurement of Malaysian public sectors. To perform the study a panel was formed with experts who had skills in the area of project governance and project procurement combined with academics. This study measured the correlation and the influence of the criteria and indicators of Ethical Decision Making (EDM) and project governance (project criteria, organizational culture, contract award criteria, individual criteria, client's requirements, government

procedures and professional ethics). Based on the methodology, this study merged a project governance ethical decision making framework (PGEDM) with ethical decision making (EDM). This study found that PGEDM framework played an important role in supporting consistent, ethical decisions in the project procurement process in the public sector. It was also found that the outcomes provided advantages to the people involved in project procurement and to the public officials; thus they became more responsible in managing ethical issues in the future with transparency. However, the study did not consider the role of clients, in relation to unethical practice in project procurement in the public sector.

A different study carried out by Lingard, Pirzadeh, Blismas, Wakefield and Kleiner (2014) explored the link between timely contractor participation in project decision-making and the efficiency of health and safety risk control. The study also considered the involvement of contractors in communication networks, previously engaged at the beginning of construction. Twenty three cases were drawn from about 10 construction projects in Australia and New Zealand. The assessment used social network analysis. The study found a substantial difference in contractors' pre-construction degree certainty for cases based on high and low risk control criteria and delivered initial confirmation that contractors' understanding about construction procedures, materials, Work Health and Safety (WHS) risks, when combined into pre-construction decision-making could guarantee WHS benefits. The researchers stated that understanding these 'high order' technological risk controls was more possible when the construction contractor had a fundamental and active role in project communication networks before construction was launched. However, the sample size was rather small and therefore cannot be generalized. The researchers

recommended that construction contractors should be able to participate in the decision-making during the planning and design stages to expedite the agreement of technological (as opposed to behavioural) controls for WHS risk.

A different kind of study was carried out by Martin, Nichols, Eaton, Runge, Fackler, Lubow, Stith and Langtimm (2011) on structured decision making (SDM) as a proactive approach to dealing with Sea Level Rise (SLR) in Florida. The objective of this study was to find out the best decisions with regard to management objectives and understanding of the system. The study included computer scientists who were working on developing optimization methods. The results showed that SDM provided an effective framework for collaborative research, since the improvement and classification of each of the elements of the SDM process required different kinds of proficiency. It was recommended that the SDM framework be used for dealing with argumentative issues along with existing laws and regulations such as the National Environmental Policy Act (NEPA) to bring transparency (by stating the objectives explicitly) and consistency (by extending models based on the best available science) to the decision making process.

An engineering study was carried out by Zhou and Sheate (2011) to illuminate the decision-making hierarchy on Environmental Impact Assessment (EIA) application on China's expressway infrastructure. Environmental Impact Assessment (including project EIA and plan EIA, or strategic environmental impact assessment, SEA) has been widely applied in the expressway infrastructure planning discipline. The study showed that the key difficulties were the institutional and governance failure to provide the appropriate level of appraisal to the relevant scale of infrastructure and

decision making. The study recommended that the appropriate packaging of small EIA projects should stand under the application of SEA to the higher level PLEI programmes (including the small projects in order under the application of SEA to PLEI plans), which could build a more understandably tiered structure (level in hierarchy) than currently.

A similar study was carried out by Guillaume, Didier and Mathieu (2010) in France examining multi-criteria performance in decision making in project management. To carry out the case study, an aggregation tool called MACBETH was used to analyse the performance measures according to project managers' own performance interests. The case study demonstrated that using MACBETH, decision-makers could keep precise information rather than a mass of inappropriate details and information. However, the case study exhibited that the concrete measures of performance can be increased by the point of understanding of the decision-maker as well as during utilization of this method; improvement in the use of sensitivity analysis can be gained if the project has major scope and is adequately structured.

A study by Moreno and Mataix (2012) was designed to evaluate the feasibility of an Analytical Hierarchy Process (AHP) - model to assist Corporate Social Responsibility (CSR) decisions in wide-ranging infrastructure projects. The study was with a Spanish company called Red Electrica de Espana (REE). This research found that AHP tools must be included in a procedural framework to bring together stakeholder relationships where transparency and clear evidence are essential. The study concluded that multi-criteria techniques for decision-making practices might

play a significant role where the company had a significant social impact and where there was a determination to allow stakeholder participation.

The Environmental Protection Agency (EPA) (2003) carried out a study on the quality decision making of environmental cleaning professionals working on contaminated sites. This study used field and laboratory-based methods to match the selection criteria in the systematic planning process through a flow chart. The study found that dynamic field activities were legally competent at decreasing the time and cost of field work at contaminated sites for a comprehensive range of site activities by considerably increasing Quality Control (QC) as well as generating available real-time data that could be used to correct problems or to demonstrate another method of verifying fixed-laboratory data.

Heilman, Hatfield, Adkins, Porter, and Kurth (2004) undertook research on quality decision making in the field of agricultural land management and water quality management. The object of this study was to define a method for field scale decision making for water quality on Midwestern croplands, and to validate the method with a case study along with proper adjustments, where a similar method was applied on rangelands and irrigated areas. A model interface was established to identify the climate, soil, and topography of the field, and the possible circumstances of management for the alternative management systems. The study developed a methodology which considered six soil and slope groups, with a total of 66 combinations of management practices creating management systems for the Deep Loess Hills area of Harrison County, which were outlined and simulated based on formerly adjusted data from Deep Loess Research Station (DLRS). The study found

there were a number of challenges in developing tools (decision support systems) to make available information for improving decision making; the study found also that it was a challenge having DSS technology adopted in agricultural environments. However, the study concluded that a multi-objective decision support system (DSS) should be adopted to support conservation planning by the Natural Resources Conservation Service (NRCS) since greater scale attempts were underway to improve water quality decision making.

Correspondingly, work by Garfi and Marti (2011) concentrated upon decision-making criteria and indicators for water and sanitation projects in developing countries. The objective of their study was to resolve the needs of small communities. The study classified the factors into 4 main groups: social (e.g. local community participation, overcoming conflict discrimination); economic (e.g. low cost, employment of local staff) and environmental criteria (e.g. atmospheric emissions, water pollution); technical (e.g. local resources use, appropriate management) and technical criteria to be further counted in each specific type of project such as water supply (e.g. water needs, independent access), water treatment (e.g. constant resource availability, flexibility of use for different types of water) and basic sanitation projects (e.g. maximum number of people per system, effluent quality). The study found Multi Criteria Analysis (MCA) was a suitable decision-making tool that scored a limited number of options based on a set of evaluation criteria. However, the researcher found the main challenge in MCA was choosing the appropriate criteria and evaluation indicators to use for evaluation.

A similar study on Decision-Making Support System (DMSS) was carried out by Yossi, Baruch and Zohar (2012) to select an appropriate project manager according to his/her preceding performance. This study used the Mann–Whitney–Wilcoxon U test to examine the difference between the past performance of the managers where Project managers were ranked according to previous project rank and used a DMSS module by an Israeli IT company. The research concluded that the choice of input and outputs should be confirmed in longitudinal research studies and the DMSS module was a useful tool for selection of an appropriate project manager.

A study on the State Water Resources Control Board of Sacramento, California, was carried out by Vance (2005) on the function of science and engineering (technology) in decision-making at the water boards in executing and implementing federal and state laws, and water board plans and policies in order to confirm the distribution of water to meet the current and future needs of the people and environment of California. The researcher developed a framework of decision-making based on laws, management plans and policies that govern and direct the accountabilities and actions of the State and regional water boards. Data analysis of different applications of laws (Federal Clean Water Act, Porter-Cologne Water Quality Control Act); Water Quality Control Plans (Ocean Plan, Basin Plan); Water Quality Control Policies (State Implementation Policy, Anti-degradation, Impaired Waters, and Total Maximum Daily Load) and Measuring Water Quality were examined. From this study the researcher developed a set of guidelines which would allow the Boards to get critical scientific knowledge and statistics needed for decision-making with regard to design and clarification of field studies, engineering tests and analyses.

Other studies have investigated the contextual challenges of decision making. Goff (2011), for example, carried out a study in order to determine the challenges of decision making in various contexts. The researcher further investigated the decision-making trade-offs in key factors that contribute to success. The projects ranged from the Beijing Olympics Birds Nest event facility, to a major sub-Saharan highway, to a water purification plant in Bangladesh, to the tallest building in downtown Beijing. Many of the questions dealt with the challenges faced, and how they were overcome. In most cases, the researcher found that the greatest challenges were those of difficult contexts:

- Very long-distance supply chain for food, water, materials
- Poor telecommunications
- Inadequate electric power supply
- Lack of personal safety
- Potential for disease, sickness, or injury by predatory fauna
- Financial risks
- Schedule and cost risks, based on slow supply of new parts needed
- At least 3 to 5 different cultures, with language barriers, and a variety of customs
- Legal challenges

Analyzing the wide range of difficult contexts through project vital Charts and Periodic Table of International Project Management Association (IPMA) of Project Manager (PM) Competence Elements, Goff (2011) found that project management success and decisions made in challenging circumstances depended on personal behavioral styles and interpersonal skills of project Managers (PM); decisions were easier even when the difficulties increased.

To analyse different decision making methods in an organization, and discuss their consequences for quality management and systematic process, a different study was done by Akdere (2011). This study used a comprehensive survey with a large group of students who had registered in a decision-making course at graduate level in a large Midwestern University in the USA. A total of 71 students participated. The study analysed different decision-making processes including brainstorming, affinity diagramming, force-field analysis, flow charting, planning matrix, unilateral decision-making, consultative decision-making, voting decision-making, and consensus decision making. The researchers found important links between decision-making and a number of organizational settings for quality decision and quality management - organized planning, systematic planning, performance, and learning. The researcher further found that, in general, the decision making process necessitated both a systemic approach along with creative thinking, both of which are dynamic and imperative to attain quality and effective decisions.

With regard to decisions under risk conditions, a study was carried out by the National Research Council (NRC) (2001) through a selected committee by The Board on Manufacturing and Engineering Design. The study was done in order to:

- Identify the strengths and weaknesses of tools currently used in engineering design associated with decision making and issues of risk and values in the increasingly complex manufacturing climate.
- Discover approaches to decision making in other fields, such as operations research, economics, and management sciences, that deal with issues of risk and value. The study also examined the pertinence and legality of these

approaches for constructing comparatively better-quality decision making frameworks for engineering design that can methodically deal with probability, preferences, and risks.

- Prepare recommendations for future expansion, justification, and function of these tools in order to make improvements in design decision-making capability in a reasonable and consistent manner.

From analysis of the above mentioned steps, NRC (2001) found that Decision-making tools and decision theory were useful design aids for engineers operating with uncertainty related to the changing nature of world trade regulations and business operations in engineering design and manufacturing.

Another research study carried out by Zou, Liu, Liu and Guo (2010) examined uncertainty-based Decision Making in Civil Engineering including the factors of uncertainty, ambiguity, and incomplete information. The Interval Linear Mathematical Program (ILP) was used in this study where a risk function was demarcated to facilitate finding solutions which make best use of system return while decreasing system risks. The study proposed a risk explicit ILP (REILP) methodology to mitigate the limitations of existing ILP methods. A mathematical experiment on land-use decision making under total maximum daily load was performed to demonstrate the REILP methodology. The model results showed that the REILP approach was capable of competently discovering the interval uncertainty space and of generating an optimal decision front that directly duplicates the trade-off between decision risks and system return, allowing decision makers to make valuable decisions based on the risk-reward information.

Cram (1998) carried out a similar sort of study on environmental management decision-making processes to estimate indirect costs related with non-financial factors in investment decision processes from environmental improvement project datasets which were counted by a major U.S. corporation during 1993-1994. A model, 'Arctanit', with financial and non-financial decision data, was used to generate coefficients which were openly interpretable since prices in inner capital market and decision models should be estimated by including one financial measure along with one or more non-financial measures and where a direct explanation of coefficients scaling is exchanged by standard scaling of "probit" coefficients along with absolute physical measures of environmental impacts. The study found that the 'Arctanit' estimation model functioned better than similar probit and logit models. The study found too, that decision makers retained a significant value on achieving environmental progress that addressed publicly stated corporate environmental objectives observed from basic cost estimates, beyond the net present value (NPV) estimations. It was found also that ratio experiments were better adjusted and more powerful than Wald-based experiments in detecting statistically important relationships. The researcher introduced an alternative termed "Multivariate Pareto Analysis" that may have useful application in quality control and other decision-making fields.

From the above studies on civil and water engineering as well as related technical fields, it is clear that a number of elements are frequently used in decision making such as Environmental Impact Assessment (EIA), decision making tools (software), risks, high water table, rising sea level, quality control, Cost Benefit Analysis (CBA) and guidelines. There were other factors such as traffic growth, land price,

uncertainty, life cycle cost, multi-objective decision, data independency, cost, technical standard, specification, project governance, project procurement, quality, Occupational Health and Safety (OHS), technical experts, social impacts, time, laboratory data, climate, soil characteristics, topography, local staff, appropriate data analysis, telecommunication, financial risks, decision crisis, Net Present Value (NPV) and decision making (planning matrix, brainstorming, guideline, affinity diagramming). However, it seems there were a number of factors which had not been extensively considered - political issues, religious issues, security issues, culture of countries, context sensitive approach, LCCA, client focus, Value Management/Value Engineering, Checklist Procedure, Engineering Problems, specification (discussed at the tendering stage but not at the construction stage or detailed design stage), technical standard, manager's proficiency, costs, quality (however, not related to resource management) and time variables.

## 2.11 Conclusion

In conclusion, this analysis of the research studies on project management and decision making in *various fields* has highlighted the fact that decisions are made through consideration of time, cost, quality, data quality management, political issues, life cycle analysis, risks and tools (software) as well as appropriate data analysis, telecommunication, financial risks, decision crisis, Net Present Value (NPV).

*While the various studies have highlighted important findings, none have (been unearthed that) examined decision-making related to projects specifically carried out in mountainous terrain and flood prone terrain. This represents a gap in knowledge.*

Since infrastructure development is time consuming and costly, especially for highways in rugged mountainous terrain and flood prone terrain, there is a need to extend existing knowledge bases and identify the significant cost components, issues, risks, uncertainties for cost effective and long term financial, technical decisions at every stage in project levels; this would allow the industry to better design, construct and maintain cost-efficient highway infrastructure in inclement environments. This study then, examines the different factors impacting on decision making with regard to road infrastructure development in flood prone and mountainous terrain in order to minimise cost, risks, delay while, at the same time, maximising sustainability and financial viability.

# METHODOLOGY

## 3.1 Introduction

Methodology is the logical, theoretical analysis of the methods applied to a field of study, or the theoretical analysis of the body of methods and principles conjoined with a branch of understanding. It, typically, incorporates impressions such as paradigm, theoretical model, phases and quantitative or qualitative techniques (Irny and Rose 2005). Methodology, according to Burton (2002) is only a method which is nothing more than a listing of the information or data collection and information or data analysis methods used. It discovers the mysterious and answers unanswered questions or discovers what currently does not exist in current research (Goddard and Melville 2004), as well as define research as a systematized determination to attain new knowledge or interpretation (Redmen and Mory 2009). It includes the significant components of academic research such as design, setting, sample, validity, strategy and methodological limitations, and the data gathering and analysis procedures in a research (Burns and Grove 2003:488).

The purpose of this chapter is to describe the methods undertaken to conduct this research study. This chapter also defines the scope and limitations of the research design, and describes the procedure used in designing the mechanism and collecting the data to provide justification for the procedures used to analyse the data. Consideration is given to quantitative and qualitative research approaches. Then justification is given for the choice of methodology for this study, particularly for investigation of decision making related to rough terrain and inclement environments

infrastructure design. Aspects of the study such as selection of research methodology, objectives of research, the participants' profile, case study, data collection and recording, validity and ethical issues are also discussed. Fig-9 shows a somewhat *generic* summary of the methodology undertaken in this research, which forms the foundations for the project-specific method described later in *Figure-10*.

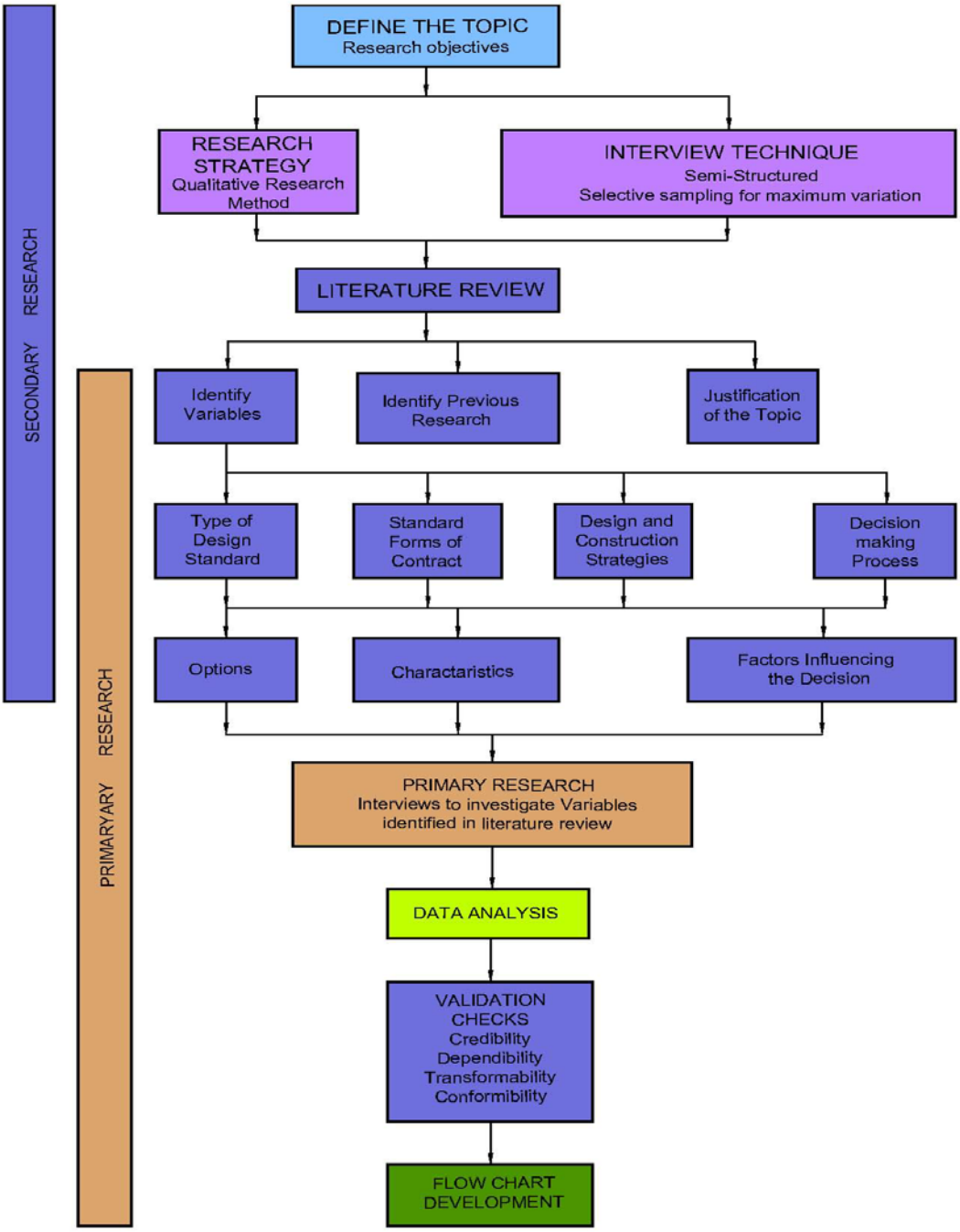


**Figure 9: Qualitative research approach**

## 3.2 Research objectives

The main aim of this study was to examine the decision-making processes for infrastructure design and construction in mountainous and flood plain environments in Bangladesh and Afghanistan.

Specifically the objectives were to:

- Identify the key budgetary variables considered in the quality management decision-making for two projects in the Hindukush/Ganges-Delta regions – Southwest Road Network Development Project (SRNDP) in Bangladesh and Design Construction of Keshim Fayzabad Road (DCKFP) in Afghanistan;
- Identify the *scheduling variables* which were considered in the quality management decision-making for each project;
- Identify the *risks and environmental variables* which were considered in the quality management decision-making for each project;
- Examine the impacts of the *budgetary*, *scheduling* and *cost* variables considered when making decisions for these two projects;
- Adopt and recommend for current highway design, construction and maintenance ***guideline procedures*** that provide compliance with existing standards, and also address the stages of projects in rough terrain and flood prone areas.

## 3.3 Research development

### 3.3.1 Research strategy

There were two major primary research strategies considered when approaching this study, these being qualitative or quantitative research. According to Creswell (2008)

the choice of which approach to use is dependent on the characteristics of the problem under scrutiny.

### 3.3.2 Qualitative research approach

The qualitative methodology is predominantly exploratory and text based to accumulate information or data focused on describing a phenomenon in a deep widespread manner concentrating on differences in quality, describing a problem or condition from the point of view of those experiencing it rather than differences in magnitude. This method necessitates less time during the planning phase; however, comparatively, it necessitates more during the analysis phase (Creswell 2003). Data are often collected through interviews.

Qualitative research can also be explained as a successful model that occurs in a natural setting that enables the researcher to develop a level of detail about actual experiences that can be extremely complicated (Creswell, 2003). The qualitative researcher illustrates what is seen, heard and understood or assumed. This must be seen, of course, in light of the researcher's circumstances, history, context and prior understanding or settlement. The researcher tries to develop a multifaceted picture of the problem or issue or questions by reporting multiple perspectives and identifying or discovering multiple factors, elements or issues involved (Creswell 2009, 175-6).

#### 3.3.2.1 Benefits of the qualitative approach

This approach has a tendency to be rich in narrative and explanation, and instead of providing an outcome, has a tendency to illustrate the process, and find out the implications through detailed clarifications that basically do not exist in quantitative studies (Filstead 1979).

Qualitative inquiry enhances individual understanding of 'otherness' for the goal which is, not only to explain its authenticity but also to understand it throughout in-depth studies of specific groups (Morales, 1995 cited in Velez 2008), where 'otherness' is embedded in the tradition's anthropology, sociology, human geography, cultural studies and social psychology (Atkinson and Delamont, 2006 cited in Velez 2008). Moreover, the research design is flexible (Brink and Wood 1998, 246; Burns and Grove 2003, 374-374). There is tolerance of ambiguity and contradictions, yet another strength of the qualitative research, since there is acknowledgement that social beings are different, and, therefore, cannot be understood in the absence of the context of the setting (Descombe 2003).

To emphasise the benefits of the qualitative approach Johnson and Onwuegbuzie (2004) highlighted the qualitative inquiry's strong points include the following:

- ✓ it is worthwhile for describing complex phenomena;
- ✓ it is usually gathered in naturalistic settings (known as naturalistic research or analysis (Taylor 1977);
- ✓ it is quick to respond to local conditions and the needs of those studied and those who are well-versed in the study;
- ✓ the words of the participants or interviewees contribute to further research into how and why incidents occur;
- ✓ it allows for the dynamic processes for the study (Stanfield 2006, 20);
- ✓ it acknowledges identification of new and untouched phenomena (Mack et al. 2005);
- ✓ it can provide a deeper comprehension of mechanisms (Benzand Newman 1998);

- ✓ it presents a holistic view of the occurrences under examination (Bogdan and Taylor 1975, Patton 1980);
- ✓ it has the capability to work together with the research subjects in their own language and on their own terms (Kirk and Miller1986).

This method also can deliver verbal evidence that may sometimes be converted into numerical form (Ben-Eliyahu 2013) and might expose information that would not be acknowledged through pre-determined survey questions. There is the opportunity for alternative explanations. The data and the analysis are grounded. Under qualitative research, the researcher is usually involved closely with the unit of analysis. And this leads to a clearer understanding of phenomena, providing broad conclusions with sound credibility (Descombe 2003). Qualitative approaches also have the advantages of flexibility, in-depth analysis, and the potential to observe a variety of features of a social situation (Babbie 1986) and more in-depth information or data on a few cases (Cormack 1991) and hence be responsible for a holistic view of the phenomena under examination (Bogdan and Taylor 1975, Patton 1980). Qualitative research is advocated as the best approach for discovery investigation and exploring a new era, developing assumptions (Miles and Huberman 1994) and does deliver a depth and richness of data or information (Merriam 1988).

#### 3.3.2.2 Limitations of the qualitative research approach

Although there have been substantial amounts of research carried out by using qualitative research, it does have some limitations. According to Tashakkori and Teddlie (1998) qualitative methodology is incapable of taking into account a comprehensive range of information or data in its analyses. It cannot simplify to the general population (Polit and Hungler 1991, 645; Liouka 2007). It might go away

from the original or deep-stated objectives of the research in reply to the shifting nature of the situations (Cassell and Symon1994). This approach has limitations related to external validity and reliability, because matters are scrutinized or tested in their natural setting and encounter a fewer controlling elements as compared with quantitative research circumstances (Sandelowski1986; Wiersma 2000, 211). Another drawback is emotional involvement may accompany qualitative interactions and interviewees may feel too exposed during or after interview sessions. Hence, it is important for the researcher to be aware of emotional vulnerabilities and maintain an ethical approach through following a proper interview protocol (Gall et al. 2003)

### 3.3.3 Quantitative Research approach

Quantitative research methodology is defined by Leedy and Ormrod (2001, 14) as the general approach the researcher takes in carrying out the research project'. Quantitative research engages in gathering data so that information can be quantified and subjected to numerical treatment in order to support or counter alternate knowledge claims' (Creswell 2003, 153). Creswell (2002) emphasizes that quantitative research was initiated in the physical sciences, mainly in chemistry and physics. Thus the researcher uses mathematical models as the methodology of data analysis. Three historical styles pertaining to quantitative research include research design, test and measurement procedures, and statistical analysis. Additionally, the researcher employs inquiry methods to ensure alignment with statistical data collection methodology. In conclusion, quantitative assumptions consider reality, experience, and conditions as quantifiable and measurable. If something is measured or calculated, it can be validated and be generalizable when data are demonstrated from fairly large random samples (Gall, Gall and Borg 2003).

#### 3.3.3.1 Benefits of the quantitative approach

In quantitative research, the main focus point is the topic being studied or revealed; data are usually objective as the researcher is not usually engaged with the matter or subjects being studied. Thus this methodology is believed to decrease the possibility of people's responses or activities being affected or influenced by the researcher (Gall, Gall and Borg, 2003). The quantitative approach can function in a number of groups, and can allow for comparison (Ben-Eliyahu 2013). Quantitative studies do have power in that they generate answers (if done properly) that are concrete (Ratnesar and Mackenzie 2006). The approach illustrates an experience by collecting quantitative (mathematical) data that are analysed using calculation based methods such as statistics (Aliaga and Gunderson, 2002). Quantitative approach usually attains high levels of consistency of congregated data due to controlled observations, laboratory experiments, mass surveys, clarification or other forms of research management (Balsley 1970). According to Johnson and Onwuegbuzie (2004, 19), the data gathering process is fairly rapid; data are comparatively precise and mathematical; it allows for generalizability.

#### 3.3.3.2 Limitations of quantitative approach

Because of the complexity of human understanding it is difficult to rule out or manage all the variables (Burns 2000). Quantitative research often produces predictable and insignificant findings of little consequence due to the constraint on, and the confines of, variables (Burns 2000). These research designs also have a tendency to generate only proved or unproven results, with very little room for grey areas and uncertainty (Shuttle 2008). Bamberger, Rugh and Mabry (2012, 255) stated that this methodology makes it difficult to recognize new and untouched or

unaffected phenomena. Winter (2000) highlighted that quantitative researchers try to disengage themselves as much as possible from the research procedure which leads to the statement that facts are factual and identical for all people at all times (Burns 2000); they only focus on presenting observed special effects (interpreted by researchers) of a program or a problem or condition (Creswell 2008). Their mechanistic philosophies have a tendency to eliminate concepts of freedom, choice and moral responsibility (Burns 2000). It lacks control over data quality (Saunders, 2009). Finally, it cannot take into account people's unique ability to clarify their experiences, construct their own implications and act on these (Burns 2000) and it creates complexities in organizational research, because organizations use a holistic view of people and their environment, according to Briones and Cecchini (1991).

### 3.3.4 Reason for choosing qualitative methodology

Qualitative Research describes knowledge (awareness, understanding) in its natural setting (Abusabha and Woelfel 2003). Qualitative research, largely defined, means 'any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification' (Strauss and Corbin 1990, 17); it uses the characteristics of the setting as the source of data, where the researcher undertakes to identify, explain and clarify the settings while maintaining 'empathic neutrality' (Strauss and Corbin 1990, 55). Qualitative research data are explanatory and incorporate communicative language and the 'presence of voice in the text' (Eisner 1991, 36) and enables the production of research reports which are typically dynamic with detail and with the clear perceptions of interviewees' experiences of the world; in other words, the data may be 'epistemologically in harmony with the researcher's experience' (Stake 1978, 5). Qualitative research is more concerned with

the procedure rather than the conclusion (Munhall and Boyd 1993). It also gathers knowledge from 'why' questions, and uses methodologies such as ethnography, case studies, participant statement and questioning. This particular research was configured around the use of two case studies incorporating interviews. Case studies can be used in quantitative or qualitative research, but in qualitative research the researcher studies 'cases' in their real life situation using several foundations of data gathering (Johnston 2010, 188).

This methodology allows researchers to emphasise/weight comprehensive range(s) of evidence in its analyses (Tashakkori and Teddlie 1998); their reactions, frustrations, moods and so on, may become data in their own right (Flick 2002). Some researchers consider that research is prejudiced by the values held by the researcher as well as by the theories, hypotheses or the framework that the researcher is implementing in his or her particular circumstances (Tashakkori and Teddlie 1998). However, qualitative investigation may be thought of as subjective and that social environments are personal examples produced by individual explanations that are not generalizable (Gall, Gall and Borg, 2003); these viewpoints are embedded in constructivism rather than positivism. Qualitative researchers believe in in-depth data gathering (Sechrest and Sidani 1995).

Researchers use qualitative method study cases in their natural settings and attempt to make common sense of, or to clarify, events in terms of the perspectives of the study participants. To qualitative researchers, the world is 'shifting, changing, and dynamic' (Filstead 1979 cited in Velez 2008). Qualitative research methods were used for this study because they are holistic and seek to comprehend an entire

complex picture which cannot be done with a few disconnected variables and linear cause-effect relationships (Forman et al. 2008, 765).

Johnston (2010, 188) stated that qualitative research is based on the hypothesis that reality is socially constructed and variables are multifaceted and complicated to measure, so qualitative research tries to find contextual issues and explanation. So, using this methodology, this study ensured that social, political, religious issues as well as risks and environmental issues could be examined for quality decision making by eliciting the perspectives of carefully selected participants.

## 3.4 Action Research

This study benefited from the use of *Action Research*. The term 'action research' was first used by Kurt Lewin in the 1940s with a special focus on social action. It is a sophisticated research methodology looking at the changes which take place 'within every day, natural contexts rather than within controlled settings' (Cousin 2009, 150). It can be defined as 'a term which is applied to projects in which practitioners seek to effect transformations in their own practices' (Brown and Dowling 2001, 152). Kember (2000) also describes action research as being reflective, systematic, and cyclical. In its design, methods, and realization, it consciously and deliberately sets out to improve, enhance, and realize practice through actions informed, but not constrained, by research and theory. Elliott (2000, 209) stated that it is a process in which practitioners 'gather evidence about their practices and critique assumptions, beliefs and values embedded in them'. McNiff (2002, 7) states that action research involves becoming aware of the principles that drive us in our work: we need to be clear about both what we are doing and why we are doing it.

This study introduced action research methodology because it is flexible and adaptive, allowing changes during or after the research study based on receiving feedback. The first stage focussed on the evaluation of the project management and quality decision making variables for infrastructure design and construction in rough terrain and flood prone terrain related specifically to two projects; then a set of guidelines was developed. In the second stage of the Action Research, the Interviewees were interviewed once again to provide their feedback on the guidelines. The researcher then revisited the guidelines and incorporated the feedback.

## 3.5 Case Study approach

The Action Research incorporated two case studies. According to Yin (1984, 23) the case study research method is 'an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used'. A case study is an exceptional way of identifying any natural happening which stays alive in a set of data (Yin 1984); case study helps to give detailed explanation, both of the procedure and outcome of an observable fact through complete statement, reconstruction and analysis of the cases under exploration (Tellis 1997). According to Walsham (1993, 14), 'case studies provide the main vehicle for research in the interpretive tradition'. The case study strategy has been argued to be predominantly advantageous for practice-based issues and problems where the understanding of the researcher is significant and the context of action is important (Lee 1989 and Galliers 1991).

The case study method is well-suited to this study because of its capability to answer the research questions appropriately along with context, 'the case study is preferred in examining contemporary events but when the relevant behaviours cannot be manipulated' (Yin 2003, 7).

Regardless of these benefits, case studies also have disadvantages. Yin (1984) discusses three types of disagreements against case study research. First, case studies are often accused of lack of uniformity. Yin (1984, 21) notes that 'too many times, the case study investigator has been sloppy, and has allowed equivocal evidence or biased views to influence the direction of the findings and conclusions'. Second, case studies make available very little foundation for scientific generalization since they exercise a small number of subjects, some carried out with only one subject. The question frequently raised is 'How can you generalize from a single case' (Yin 1984, 21). Third, case studies can be time-consuming and are often too long, difficult to perform and bring into being an enormous amount of documentation (Yin 1984).

Nevertheless, case study was used in this study because it allowed the researcher to collect in-depth rich data on a phenomenon and to provide insights into the topics of interest – the decision making practices of personnel involved with two road construction projects.

## 3.6 Case Studies

Case examples from Afghanistan and Bangladesh were used in this study -Southwest Road Network Development project (SRNDP) in Bangladesh and the Keshim

Fayzabad Road Project in Afghanistan to examine the issues related to decision making such as engineering problems, risks, uncertainties, environmental issues and other variables linked to decision making in new-build design specification as well as the rehabilitation of existing roads in these mountain and flood prone areas where roads are often severely impassable. Another issue to consider in Afghanistan was the fact that it represents a conflict-zone(/war-zone). In Bangladesh flooding is a major problem; two-thirds of Bangladesh is less than 5 meters above sea level, making it one of the most flood prone countries in the world.

Data for these case studies were collected through interviews with selected participants and document analysis.

Figure 10 illustrates the way in which the case study was used for this research.

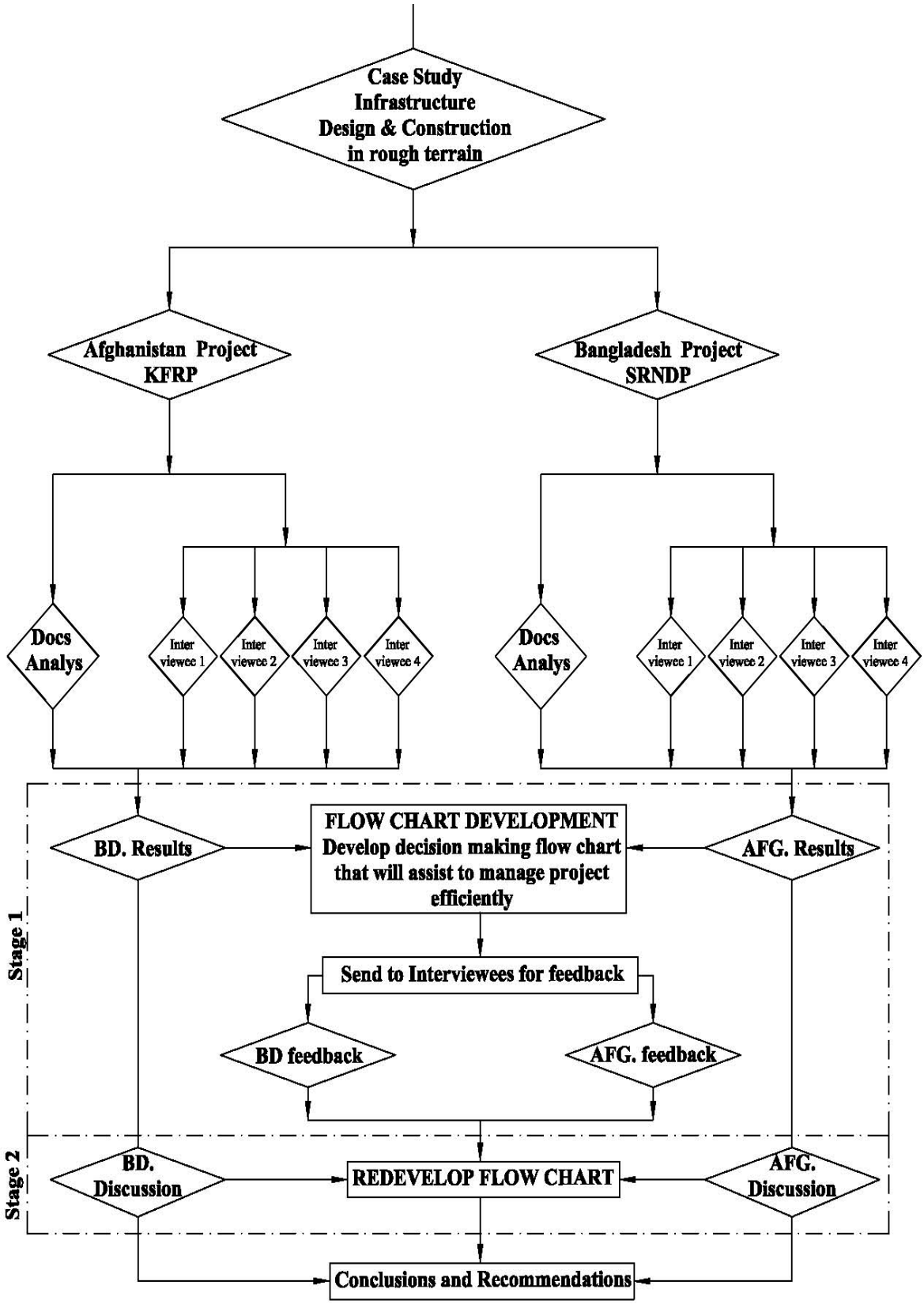


**Figure 10: Construction of this study**

## 3.7 Interview technique

Interviews were conducted for data collection for this research. The term 'Interviewing' has been defined by Johnston (2010, 189) as the procedure of gathering comprehensive confirmation or proof, and suggestions about a research question from an interviewee or participant, and what might be structured or unstructured.

This study used a qualitative interview technique since questions can elicit rich, full stories and the information or evidence needed for a study. They can make it clear to the respondent when they need more examples or explanations (Emans 1986).

Another advantage of qualitative interviewing is that participants can draw a picture of what happened on a specific occasion, tell their viewpoint of such occasion, as well as give other social cues such as voice, intonation, body language etc. (Weiss 1994)

In a qualitative interview, good questions should be open-ended (e.g. require more than a yes/no answer), unprejudiced, thoughtful, reflective and reasonable (Britten 1999). It is typically best to start with questions that participants or interviewees can answer straightforwardly and then carry on to more challenging or sensitive topics (Britten 1999). To ensure that the interview is as effective as possible researchers must hold a series of skills and techniques to ensure that wide-ranging and demonstrative data are collected during the interview session (Hammersley 1995). Structured interviews are more appropriate to quantitative research studies because they depend on c1osed questions. Unstructured interviews allow for more flexible

communication between the researcher and respondent/interviewees; asking open ended questions encourages respondents to go into detail (Marvasti 2010, 424). Marvasti (2010, 426) suggests that the unstructured arrangement does not principally mean that anything goes; the process requires that researchers be more perceptive and purposeful about the genuineness they are jointly producing with the interview participant.

According to Hill, Knox, Thompson, Williams, Hess and Ladany (2005) there are several advantages of phone interviews which include (1) they are cost-effective and human resources can be efficiently used (e.g. they reduce the need for travel, thereby broadening the net); (2) they possibly reduce complications of in-person interviews (e.g. researchers can take detailed notes of an interview without making interviewees feel embarrassed, response unfairness might be reduced in the absence of facial expressions and the privacy allowed by the phone may enable interviewees to be more open in their reactions.

## 3.8 Interview participants

Creswell (2007) discusses the significance of choosing suitable candidates or interviewees for interviews in such a way that the researcher should take advantage of one of the various types of sampling strategies such as criterion based sampling or critical case sampling (among many others) in order to achieve qualified candidates that will provide the most pragmatic information to the study. Creswell also suggests the importance of getting participants who will be willing to openly and honestly share information, evidence or 'their story' (Marvasti 2010, 133). It might be easier

to organize the interviews with interviewees in a comfortable environment where the interviewees do not feel embarrassed to share information or knowledge.

## 3.9 Interview protocol

Kvale (1996, 13) highlighted 'there is no common procedure for interview research. Interview research . . . if well carried out, can become an art'. In this study, an email statement was sent to participants following initial contact, prior to interviews, further detailing the purpose of the study and providing an outline of questions to be asked.

## 3.10 Profile of participants

For this study, eight staff members who had been involved in the two projects - Design and Construction of Southwest Road Network Development Project in Bangladesh and Keshim Fayzabad Road in Afghanistan were interviewed.

Interviewees were interviewed by phone and Skype to gather information which would help address the research objectives.

In this study, while the interview style was semi-structured, a question guide was used (in Appendix A) to ensure that adequate information was collected, with open ended questions formatted to encourage participants to elaborate and explain their answers and as a guide to the wide-ranging topics to be covered.

All interview participants had been involved with engineering design and construction, procurement or contract management within their respective

engineering companies. The Interviewees chosen from the SRNDP and KFP projects in Bangladesh and Afghanistan had a substantial track record of work experience in similar fields as well as having worked for both projects in decision making roles. The Interviewees had significant length of work experience in project management for design and construction of road infrastructure; they had also had several years' experience in QDM and had post-graduate qualifications with certified professional engineering. It was assumed that this selection of Interviewees, with their varying experience and qualifications, could provide insightful data on the Quality Decision Making and Project Management of the SRNDP and KFP.

***Interviewees for SRNDP in Bangladesh were***:

Interviewee 1 is a Registered Professional Engineer, currently working with multinational consulting engineering company, at the time of this study; he was working as Team Leader/Resident Engineer at Bari Zambia Limited for upgrading of Mansa – Luwing (M3) Road (175 Km) in Zambia.

Interviewee 2 is an Experienced Civil Engineer, currently working with a multinational consulting engineering company. He was working as Senior Highway Design Engineer at HIFAB-BCL-JV for Urban Governance and Infrastructure Improvement Project (UGIP-3) in Bangladesh at the time of this study.

Interviewee 3 is a Registered Professional Engineer, currently working with a multinational consulting engineering company; he was working as a Resident Engineer cum Construction Manager at Contract: CSTB 2140/2, HRRIIP in Papua New Gunnie at the time of this study.

Interviewee 4 is a Registered Professional Engineer, currently working with a multinational consulting engineering company; he was working as Team Leader at M4 Highway Reconstruction in Azerbaijan at the time of this study.

***Interviewees for DCKFP in Afghanistan were***:

Interviewee 1 is a Senior Hydrologist with a postgraduate qualification and experience in Hydraulic infrastructure design and construction, supervision, management, procurement, maintenance. He is an experienced consultant in Agricultural Structure and, at the time of this study, was working as a Hydrologist with Ghana Commercial Agricultural Project (GCAP) with Agriconsulting Europe S. A, in West Africa.

Interviewee 2 is a Professional Engineer with a postgraduate qualification, currently working with a multinational consulting engineering company. He was working as Team Leader/Residence Engineer at Bari Zambia Ltd. for upgrading of Mbala - Nakonde Road Project (172 Km) for Highway Reconstruction in Zambia.

Interviewee 3 is a Registered Professional Engineer with a postgraduate qualification, currently working with a multinational consulting engineering company in the US. He was working, at the time of this study, at CH2M Hill in Qatar and working as a Senior Engineer/QA/QC lead in northern Virginia offices working in North East US.

Interviewee 4 is an experienced registered professional Civil Engineer, currently working with BCL Associates Ltd.. He had experience in road surveys and land disputes. He was working as Highway Design Engineer for Baharak to Eshkashim Road Feasibility Project in Afghanistan at the time of this study.

## 3.11 Document Analysis

This case study also integrated document analysis. A document is any substance that gives information about the investigated phenomenon and exists independently of the researcher's actions. It is normally produced for definite principles other than those of the research but it can be used by the researcher for purposes of concern with acquisition of knowledge e.g. letters, newspapers, reports, diaries and websites (Corbetta 2003). Yin (2003, 87) emphasized that 'for case studies, the most important use of documents is to corroborate and augment evidence from other sources'. Corbetta (2003) identified a number of advantages of analysis of documents over other research methods:

- It is a non-reactive method where the information given in a document is not subject to possible alteration as a result of the communication between the researcher and the respondent e.g. as in interviews;
- It helps the researcher to study the matter according to what went on in the past;
- It is a cost-effective method as the information has already been manufactured (Denscombe 1998).

Document analysis is valuable for accumulating qualitative data. Document analysis is a valid research strategy with considerable merit as a methodology for policy assessment and reform. Due to the wide variation in documents, some minor

modifications may be needed when applying the methodology to other types of document sources. Sources of documents can be:

- Public records
- The media
- Research Journal
- Case Study
- Visual documents

However, documents may have some limitations or restrictions in terms of the correctness and fullness of the data (Patton 2002). Data require to be examined and to be explained in order to encourage and accelerate meaning, gain understanding, and develop knowledge and awareness (Corbin and Strauss 2008, Rapley 2007, cited in Bowen 2009); this is the reason organisational documents were gathered in this study. The main purpose of this document analysis was to increase knowledge and understanding of the aims of this study. Identification and investigation of the key budgetary, scheduling and risk variables to facilitate decision making in quality assurance were also carried out.

Documents analysed were sourced from research journals, World Bank (WB), Asian Development Banks (ADB), The United States Agency for International Development (USAID). In this study documents that related to the projects in Bangladesh and Afghanistan and that were available online were analysed with permission of the Project's lead engineers for academic research only.

## 3.12 Data Recording

Tape recordings provide evidence of what the informant has said. Such evidence or data is communicable to others besides the researcher. Tape recordings are long-lasting; the verbal signals do not change whether one listens to them straightaway after recording or after three months or anytime in the future. One may listen to data in the tapes frequently without any damage or loss of data. Fetterman (1989, 81) and Pontin (2000) stated, all interviews should be tape recorded and transliterated verbatim subsequently, as this defends against unfairness and provides a long-lasting record of what was and was not said. However, unless the informant is a public figure who is very used to being recorded, the very existence of the recorder during the interview may often prove threatening to the informant because his/her voice may be recognizable on the tapes.

This research used tape recorder (iPad and laptop to record data) after gaining permission from the Interviewees. In this case detailed notes were also taken throughout the interview.

Interviews were conducted using telephone and Skype in the Interviewees' current work locations since all Interviewees were, at the time of the study, in different countries such as USA, Zambia, Afghanistan, Bangladesh, Azerbaijan, Papua New Gunnie, and Nepal.

## 3.13 Data Analysis

One of the strengths of qualitative research is the acknowledgement and reaction that data must always be appreciated in relation to the background of their construction

(Murphy, Dingwall, Greatbatch, Parker and Watson 2010). Data analysis in qualitative research refers to the organization of knowledge, categorisation and justification of the data or information (Creswell 2007). This study utilised three stages:

1. Coding the data by detecting and decreasing key segments and assigning these segments a name;
2. Cataloguing these codes to form themes; then
3. Explaining, clarifying and displaying the data to draw conclusions.

Information obtained from this analysis may be categorised as follows (Creswell 2007):

- Information the researcher anticipated finding before the study;
- Information that the researcher did not presume to find before the study; or
- Information that is theoretically remarkable or seldom found among researchers, participants or audiences.

## 3.14 Data Validity

The validity of qualitative research can be evaluated by investigating methodological uniformity, in particular study design and the research process such as the quality of data sources, sampling strategy and data gathering and analysis procedures (Forman et al. 2008, 768). According to Patten (2004, 71), 'validity is more important than reliability'; however reliability does need to be consistent where reliability communicates the uniformity of the data gathering (Wallen and Fraenkel 2001). A methodical approach to analysing data should be established and rigour such as triangulation and reflexivity may also be used to guarantee validity.

In this study, Interviewee answers were cross checked with each other and data or information from the Interviewees were cross checked with each other and data from the responses were cross checked with analysis of the Interviewees' (employed in case study projects) data. Interviewees' data were also used as a comparison against results from the interviews which also provided some overall background for the study. Another means of ensuring study validity was the use of quotations during the course of the result discussions, which allow the reader to determine the quality of work for themselves. Verbatim quotations are used in this study to help the reader assess the integrity and reliability of data presented.

## 3.15 Ethics

Ethics may be expressed as a method of ethical philosophies that are recognized by specific groups or individuals (Robbins 2009, 39). When carrying out research, ethics relates to aspects such as the morality of the researcher, methodologies used and the ability of the researcher not to overgeneralise findings or draw comprehensive conclusions. Because qualitative research necessitates intrusive data collection, ethical issues should constantly be considered prior to carrying out primary research. The nature of the research necessitates the interviewer building an understanding with participants. This can only be constructed on robust ethical foundations. While ethical questions may arise at every stage of qualitative research the key issues generally arise during the interview stage, during the primary data gathering phase. When information acquired is often of a personal nature or professionally sensitive it must be dealt with at a high level of confidentiality and respect. Given the nature of this study, ethical issues focussed on informed consent and confidentiality.

## 3.16 Anonymity

Anonymity is used to describe situations where the Interviewee's name is unknown. The important idea here is that a person be non-identifiable, unreachable, or untraceable. Anonymity is seen as a technique, or a way of realizing, certain other values, such as privacy, or freedom (Wallace 1999, Nissenbaum 1999 and Matthews 2010). So, it is essential that information be collected in such a way that anonymity can be guaranteed. Interviewees in this study were assured that they would remain anonymous.

## 3.17 Confidentiality

Confidentiality means avoiding the acknowledgment of comments, in reports or presentations, to recognized participants (Lewis, 2003: 67). Sharing information about an Interviewee with others for purposes other than research, is unethical (Kumar 1999). So, Interviewees involved in this study were assured that the source of their information collected in this study would remain confidential.

## 3.18 Voluntary participation

Voluntary participation means that participants in a study are free from coercion. Participants are free to withdraw their participation at any time without negatively impacting on their involvement in future services. Interviewees were assured in this study that they had the right to leave the study at any time if they so wished.

## 3.19 Conclusion

This chapter described quantitative and qualitative research methods, including the benefits and limitations of each method. In this chapter it was explained that

qualitative research methods were chosen for this study because tools such as unstructured interviews provide data with a greater richness than quantitative methods could have. This chapter also described Action Research and justified the use of the Case study approach and interviews and document analysis for collection of data.

The next chapter presents the results from this study through interviews and document analysis.

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# RESULTS

## 4.1 Introduction

This study collected and analysed responses from Interviewees and also conducted a document analysis. Firstly this chapter presents the analysis of the ***documents*** related to the Bangladesh project and from the Afghanistan project; and, secondly presents the ***analysis of the responses*** from the Bangladesh project Interviewees and the Afghanistan project Interviewees.

## 4.2 Document Analysis Bangladesh

For the Bangladesh Project, documents were collected from the web-resources : Southwest Road Network Development Project (ADB LOAN NO.1708-BAN (SF), http://www.rhd.gov.bd/RHDNews/ViewDetail.asp?vCompID=55, and from project documentation including drawings, letters, internal memos, variation orders, revised BoQ, tender evaluation, inception report, Completion-Defect Liability Certificate, Completion-Certificate, Addendum-SRNDP and Tender Documents.

During the document analysis for SRNDP, it was revealed that the majority of documents were associated with the construction phase; these included the project organization chart, monthly progress report, and Quality Assurance and Quality Control plan, submitted by the contractor as well as all memos and correspondence among client, contractor and consultants. Other construction related documents included the project manual folder where the position descriptions for all major positions such as clients, contractor and consultants representatives such as Chief

Engineer, Executive Engineer, Sub-division Engineer, and other executive positions of contractors and consultants as well as the completion report and the Project Performance Monitoring and Evaluation (PPME) report, Project completion report for Poverty reduction, Environmental Management Monitoring Plan and Resettlement report. All these documents were produced in detail with photographs. The progress report showed most of the details about resources and schedule. The project Bills-of-Quantities (***BoQ***) with variations was also included. There was a folder with details of all laboratory tests about soil and material for road pavements. There were five contracts named as Contract No. 1: Dhaka - Mawa (31.1 km), Contract No. 2: Mawa - Bhanga (22.8 km) including Arial Khan Bridge (450 m), Contract No. 3: Bhanga - Bhatiapara (38.0 km), Contract No. 4: Bhatiapara - Mollahat (42.6 km) including Gopalganj Bypass (10 Km), and Contract No. 5: Mollahat - Noapara (31.0 km); since SRNDP was 165 km it was divided into five contracts and each folder contained basically similar sorts of documents except for contract 2 which had additional information on the major bridge called Arial Khan Bridge. There were also documents relating to staff training. During the construction period, all the documents displayed information about the activities for construction and design of the road project, and details of contract variations with respective bill numbers; no information was revealed with regard to measurement tools for resource planning with regard to cost, quality and time, or with regard to ranking, sorting or choosing from among alternatives. From the design documentation - drawings, Hydraulic and Hydrology analysis Environmental Management Monitoring Plan, Project ToR, Land acquisition and Resettlement plan, Soil and material report which included site investigations, source of available material, bore logs, text results, and recommendations with regard to tests and

observations executed for the road, it was revealed that significant amounts of land had been acquired and resettlements had been carried out. Documents concerning these aspects included topographic survey, invoices, correspondence about field survey and designer of consultants. It was found that the surveyor used total station equipment for surveying (easting and northing and height) and a level machine had been used for level/height control on Bench Mark or Temporary Bench Mark. For soil and material, approximately forty nine different tests and analyses were carried out; in addition 3 to 5 test samples with pictures were collected for laboratory tests.

With regard to environmental matters, an Environmental Management Action Plan provided details of monitoring of environmental variables and contractors' obligations with respect to the environment. Evidence of the use of any alternative analysis, cost benefit analysis, life Cycle Cost Analysis for pavement, Road Safety Audit, Value Engineering and final check list was sought. Only a checklist for the Environmental Management Plan (EMP) was found; it had been prepared for the construction phase as an annexure called checklist of the EMMP guidelines for the construction related activities of the SRNDP where the factors arising from construction activities such as dust, air pollution, noise and their impact on the environment and mitigation requirements were listed. Also included were documents recording soil and material tests with a checklist as well as a quality control manual and a test brief for soil and materials for road pavements for the construction phase only. The Contract documents prepared for bidding and tendering included the engineer's estimates for five contracts with sufficient detail to complete the construction work and meet the service delivery requirements. The completion report showed that each contract had contract variations. The Contract basically

included the bidding procedure, Requirements and Conditions of contract and contract forms, with detailed contract drawings, Plan and Profiles, Road Cross section, Intersection details, Survey data with traverse adjustment and Standard drawings such as pavement thickness detail, typical details of guard post, edge kerb and drain at super elevated curved areas, super elevation and plan transition details, schedule for road side slope, typical signage and line marking plan. The construction drawings were also checked and it was found that all drawings had been prepared in dwg formats with detailed plan and profiles, road cross sections, all major intersection details and there were many standard drawings with pavement thickness detail, road side kerbs, with road side drainages, chainage of rigid and flexible pavements. Pavement marking and road signs such as regulatory, warning, directional signs and a typical drawing for all side roads with drainage detail, superelevation with transition details had been prepared based on AASHTO. The locations of drainage culverts and bridges had also been marked on plan drawings. The drawings examined for the roads and bridges were tender drawings as there were no Ascon drawings (As-constructed drawings) on which all the changes and modifications had been marked by the field engineer during construction with modified dimensions or sketches, finally signed and approved by the contractor and consultants with stamp for record. Although there were details on the tender drawing, without the Ascon drawings, it was difficult to assess the changes or modifications. In addition, there were drainage structure documents which included information on bridges, culverts, road side drainage with different sizes and shapes. It was also observed that the culverts were basically Reinforced Cement Concrete (RCC) and Bridges were prestressed Bridge with Girder and RCC deck slabs with wing wall, diaphragm, footing detail, pile length with pile caps and pier caps details including

reinforming detail. Hydrological analysis, hydraulic analysis and load analysis for the bridges had been conducted but there was no evidence of LCCA having been undertaken. Nor was there any evidence found of a context- sensitive design approach having been used for road, bridges, pavement, risks and environments. Hence, it was impossible to evaluate how the designer handled design matters. In addition, there were no detailed memos reporting deviations from actual standard (usually found in projects).

It can be concluded that, although there was a significant amount of detailed documentation, there was no background information (e.g. design review comments, field investigation information, design memos for every stage, feasibility study phase notes, review comments for each phase) provided or available for construction managers/team leaders in order that they could conduct analysis on costs to make cost effective decisions.

## 4.3 Document Analysis Afghanistan

Documents for Keshim Fayzabad Road Project (KFP) were collected from both USAID web: Design and Reconstruction of the Keshim - Fayzabad Road (103 Km), and from project documents related to Design Criteria, Traffic Study, Topographic Survey, Correspondence, Hydrology and Hydraulic Analysis, Geotechnical Investigation, Maps, Reports, 30% Preliminary Design, 60% Detail Design, 100% Rev Final, Pavement Design, Bid Docs, Road Video, Project Photo and miscellaneous.

During the document analysis for KFP, it was revealed that the majority of documents were associated with the construction phase; these included the project organization chart, monthly progress report, and Quality Assurance and Quality Control plan, submitted by the contractor as well as all memos and correspondence among client, contractor and consultants. There were plans called demining plan, work plan, and Federal Project (FP) 03 technical specification. Photographs were included in the monthly progress report. The progress report detailed matters about resources and schedule. However, there were no controlling measures or alternative method or tools found to have been used by the construction managers/Resident Engineer to show how these changes had impacted on the rest of the month's allocation of resources. The project Bills-of-Quantities ***(BoQ)*** also included the variations named as Mod. There were details also of all laboratory tests about soil and material for road pavements, Request for a Task Order Modification of Task Order (RFTOM) 04, TSP meeting, USAID issues folder, Request for a Task Order Proposal of Task Order (RFTOP) 04. The project also had details about the Construction Camp. There were also details of staff training and workshops carried out during the construction period. The details concerning staffing showed that a significant amount of staff had been hired from overseas – the USA, India, the Philippines. Apart from that it was revealed KFP was designed in three stages, 30% design, 70% design and 90% design in the same way as feasibility design, draft final and final design and Value Engineering had been done in two stages, 30% and 70%. It was noted, too, that there had been no final check list documents apart from a checklist for soil and material prepared for the construction phase. On the other hand, it was found that there were other detailed documents such as main report of the project, design drawings, Hydraulic and Hydrology analysis, Project ToR,

Geotechnical report including investigation and flexible Pavement design report. Further documents included topographic survey, Aerial Survey, invoices, correspondence between field surveyor and the consultant's designer. It was revealed that a design review had been carried out on top of the aerial survey because the physical survey had not been sufficient compared with 200m band (100m each side). Bid documents included Vol 1 - Bid Documents, Vol 2 - Road Works, Vol 3 - Bridge Works, Vol 4 - Signing and Stripping, Vol 5 – Geotechnical, Vol 6 - Road Right of Way, Vol 7 - Road Cross Sections, Vol 8 - Geotechnical Report, there were also Standard drawings such as pavement thickness detail, typical details of masonry wall, edge kerb and drain at super elevated curved area, super elevation and plan transition details and schedule for road side slope. The construction drawings were also checked and it was found that all drawings had been prepared in dwg formats with detailed plan and profiles, road cross sections, all major intersection details; there had also been many standard drawings with details of pavement thickness, road side kerbs, with road side drainage, chainage detail for rigid and flexible pavement sections. It was revealed that this project had prepared signage and a line marking plan not found in SRNDP and a typical drawing for all side roads with drainage detail, superelevation with transition details prepared based on AASHTO. There were other details such as road side drainage, cut and fill slope, drainage culverts. In addition, there was information for Drainage structure such as bridges, culverts, road side drainages with different size and shapes (there had been 24 bridges and 450 culverts designed; however nine bridges and 600 culverts had been finally constructed). It was also observed that the culverts and bridges had been basically Reinforced Cement Concrete with all details with wing wall, diaphragm, footing detail, pier column length with pier caps including reinforcing detail

prepared at the design review stage. Overall the information was quite detailed; however, it was revealed that a substantial amount of work had been done preparing a new set of design plans and rejecting the early design details during the design review phase. In addition it was revealed that the project had required modifications/variations during the construction phase.

No details were found related to LCCA or Cost benefit analysis including road, bridges, pavement, risks and environments so it was difficult to assess how the designer dealt with any major issues during the design phase.

So, it can be concluded for both projects that no LCCA, Cost Benefit analysis, Checklist procedures, risks and hazard analysis with appropriate audit, design memos or Ascon drawings were used. Although Value Engineering was done for KFP, it had not been carried out for SRNDP during the final design stage. Appropriate Environmental Impact Analysis and Poverty analysis had been carried out for SRNDP, but not for KFP during the design and construction phases. It was discovered that both projects had a significant amount of contract variations.

Besides document analysis for both SRNDP and KFP, interview data was collected and analysed from staff who had worked on both these projects.

## 4.4 Interview Results from Bangladeshi Interviewees

Table 1 presents the highlights of the results from the interviews with staff involved in the Southwest Road Network Development Project (SRNDP) in Bangladesh.

**Table 1: Results from Research Interviews in Bangladesh**

| Q1_BD What was your position in this company at the time of SRNDP in Bangladesh? | | | |
|---|---|---|---|
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Planning Engineer | Highway Design Engineer | Residence Engineer | Principal Engineer Road design section |
| Q2_BD How long had you worked for this company at the time SRNDP was under design and construction? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| 13 yrs at the time of SRNDP | Worked for 13 years | 20 yrs at the time of SRNDP | at that time 16yrs with this company |
| Q3_BD What are your qualifications? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Bachelor of Science in Civil Engineering and PEng | Bachelor of Science in Civil Engineering from BUET since 1983 | Bachelor of Science in Civil Engineering | B. Sc in Civil Engineering |
| Q4_BD How much experience have you had in quality decision making? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| 5 yrs with SRNDP | 15 years in QDM | 25 yrs in QDM | Since 1975 (39 yrs) |
| Q5_BD How would you define quality decision making? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| When decision according to ToR of contract, policy, design principle, timely manner and shouldn't deviate from all above; can say QDM for construction and supervision | Decision making based on few criteria first is cost, then safety, quality as well as time schedule and unit rate and during construction maintenance | QDM is a concept where you can get thing better and durable product | The main activity of the company /management staff and it ruled construction. For design; to select the best from few alternatives |
| Q6_BD How would you define quality decision making with regard to design and construction? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |

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| QDM in design is on ToR in design from Client to consultants in timely manner<br>QDM in construction; according to ToR given by client in contract, will be follow specification, Standard, Experience in timely manner | I have provided examples and defined as above | QDM for design and construction very important, in design you should correct deployment, documentation, in construction; there are lots of problem what is unknown and when will be done with quality and timely manner can be called QDM in field. | Design; to make design successful from alternatives both economically and technically, appropriate to context, satisfy the requirements of client<br>Construction; appropriate work method, machinery, trained workforce, planning and programming and its sequential, follow work program, quality material and progress should be monitored properly, where types of decision will make then can call QDM |
| Q7_BD | What elements do you consider important for effective quality decision making with regard to the design and construction of the project of SRNDP? | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| ToR in design from Client, specification, Standard, Experience in timely manner;<br>Contracts with technical spec, drawings, Work program (showing progress, issues, resources) | Risk factor, Sight distance, resettlement (housing, market, religious structure), locality, environmental issue.<br>What we designed, we followed in construction and if any issue raised, we resolved by redesign | In design: better design, better standard practices for design drawings, document within time and construction considered budget and time and quality of final product was the main element in QDM | Design; context, Environmental, alternative alignment to choose right one, survey, Hand H, river modeling, geometric design, LA plan, aesthetic view of structure, Road safety aspect, Economic viability<br>Construction: Work program of contractor (workforce, machinery, materials), weather, unsuitable material |

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| | | | during planning and programming, diversion, Traffic management, safety, hazard |
| Q8_BD | What legislation and standards did your company comply with when implementing this construction project? Were there any difficulties complying with these standards during SRNDP in Bangladesh? If so, what were they? | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| There was Highway manual as well as AASHTO standard for design and for construction there were country guidelines for construction as well as AASHTO<br>Yes, we encountered some difficulties when we applied the AASHTO spec since it was developed for a different country and context. So in SRNDP, some location materials were not just standard, we changed parameter and considered as per available material on site, e.g. filler material (x,y,z) but not matching with local material, so we changed to local material | Firstly, there were clear guidelines from Client and donor agency. Secondly, our company is ISO certified so we followed that requirement.<br>The technical standard used was TRRL<br>Not any difficulties faced using SRNDP<br>Yes, there were many difficulties faced in the project:<br>Land crises, political pressure, religious issue (graveyard, mosque, temple) | For consultancy purpose, RHD standard and for construction used FIDIC 4 and for technical document preparation was AASHTO, ACI, ASTM<br>Yes, some of the material like local brick and brick chips were used; as the brick didn't comply with any foreign standard, we used local RHD standard while using local material and Bangladesh Building Code for building material for Office Building Construction | ECNEC (Executive agency of Govt.) approved the project, so,GoB Statutory and legislation policy were followed.<br>The technical standard we used was international standard (AASHTO, BS, IRC)standard as well as Standard of RHD Bangladesh<br>Not any difficulties faced in using SRNDP in design and documentation process |
| Q9_BD | Did you conduct a Cost-Benefit-Analysis (CBA) as part of the quality decision making during this project? If not, why not? | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Yes, CBA was done; in SRNDP | Yes, we did during feasibility | We didn't do any CBA during this | Of course it was done, |

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| Project Benefit Analysis was done for construction;<br>CBA was definitely done in design,<br>I believe it was done | study - conducted by a transport economist using HDM software; in design we also did CBA for particular cases: intersection design, relocation | project as it is not common practice and we don't have a background in such activities | It was requirement from Client and donor;<br>A Transport economist carried it out |
| Q10_BD | Did you conduct an Analysis of Uncertainty (AU) as part of the quality decision making during this project? If not, why not? | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Yes, lots of uncertainty, e.g. Pavement design based on selected material but during construction, material was not available, so there was uncertainty; this sort of AU was considered and alternatives considered | Yes, AU was considered; changed from flexible pavement to rigid pavement | No, we didn't also do AU for SRNDP; this is not a practice in Bangladesh although I think it is very important | Yes, this 163 Km road and National Road category |
| Q11_BD | Did you conduct a Checklist Procedure as part of the quality decision making during this project? If not, why not? | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Yes, there was checklist procedure in construction by flow chart in QA report and followed in SRNDP | There was no written checklist doc but we follow the procedure to complete the project,<br>This is due to lack or our knowledge. | Yes, we did, there was checklist procedure in construction in QA plan and followed in SRNDP | Yes, in every stage from design, implementation we did, |
| Q12_BD | How would you define Engineering Problems? How were problems mitigated during the design phase? How were problems mitigated during the construction phase? | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| There were EP, ex; soft soil, and settlement due to | There are many EP; soft soil, bank erosion, | The issue in engineering design also socio | Ex; this road passes through flood prone area, two of them |

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| soft soil and used PVD (prefabricated Vertical Drain), use different alternative since too expensive, we use normal sand fill, and check differential settlement for first layer for 1 year with preloading and use alternative of PVD and check rate of settlement and change asphalt surface since asphalt can't allow differential settlement to DBST after 5 yrs again asphalt surface will be back, we did since alternative had provision based on Analysis of Uncertainty from alternative | pavement. settlement due to soft soil, landsliding,<br>Special treatment consider during design like; pavement. settlement<br>During construction Embankment washout so, realign the Arial khan bridge approach | economic issue in socio economic context<br>Ex; it was mitigated by collecting proper field data and analysis, those data effectively that way we mitigated design problems<br>In construction; all issue can't be resolve in design and there had lots of problem, so normally did with what problem and mitigated with standard practice on that time, ex; when design project, there was cross road at bridge approach and designed as grade intersection but during construction, we found it was not at level crossing and we did underpass at bridge approach another example was during construction after project award we had to make bypass road and it was 9.7 km was going through marshy land, with water body and soft ground with organic soil, so it was another problems and during design | were major where erosion and scouring, marshy land, high water table,<br>Road hazard, risk, material scarcity, utilization of existing alignment<br>This is the problem and in specification it was mentioned how it will be mitigated<br>The documents were prepared by experienced contract engineer and contractor was international experience contractor, So, there was no problem for mitigation |

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| | | where showed borrow pits in field it was organic pits, then we used dredged material from river 1.5 km away from site. It most were overlooked in design | |
| Q13_BD How would you define Context-sensitive Design approach? Was this approach used for this project? If so how? If not, why not? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| the Term was new to Interviewee, As explain to what it is and interview replied; Designer rendered the design based on his judgment, ToR, Standard and guidelines, they did the right approach what they need during design but for pavement material it is always uncertain and that's why put few alternative and will be confirmed during construction as per site situation and availability | Can't define but put an example: People sentiments, culture, history, social, Env.<br>Yes, this approach used<br>Meet and consult with people or leader | It is a very good idea, we had different Env, topographic, political issue, socio economic issue or the issue on context can be used,<br>We used, used experts people and they analysis and incorporated | As mentioned, this road passes through low lying area, couple river crossing, high water table this was the context for this project, So, design should be done or to be done considering appropriate measure, Note this is national asset of country and will be direct use of its user, Context is very important<br>Yes, this approach used |
| Q14_BD How do you think resources with regard to time could be more efficiently managed? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| the resources can be manpower, material and equipment for projects, so if local resources could be used for projects, will be cost and time saving, Based on | our main resources are manpower and tools, prepare CPM considering both contractor resources and program and ours, | Since we have had always limited resources with regard to budget, time and so we need to optimization of cost and time to | During preparation of document we made provision of use local manpower, equipment to make economy and use foreign expert to |

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| material, manpower skill project should consider the approaches so that it can locally managed | could be better manage however to be updated with reality | get better quality product by keeping skilled workforce with management, optimization of equipment since equipment always there but not properly programmed | get better quality in project<br>So, contractor should make work program showing time gap for each stage when and where material, equipment and manpower can be managed. So, work should not stop |
| Q15_BD How do you think resources with regard to quality could be better managed? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Interviewee believe like so; Use resources from local if they have right education and competent.<br>Competent and competency is different, competent people can deliver quality under competency .circumstances, So take TL from foreign expert, competent can receive his expertise advise and implement, this way can maintain better quality with budget | Provided examples and finally articulate that if we use quality resources and quality tools (software), could be better managed | Same way as discussed earlier | To achieving quality, contractor should make work program, otherwise quality control can't and if there were an experienced quality control engineer form contractor and quality assurance engineer from consultant engaged for a context, then better quality could be achieved |
| Q16_BD How do you think resources with regard to budget be better managed? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| As discussed earlier that resources with regard to quality and budget together better managed | Provided examples and finally articulate that if we use quality resources and quality tools although initial | Same way as discussed earlier | Contractor must prepare cash flow program based on FIDIC showing resource with payment requirement, where |

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| | cost will be high but in long run can be better managed with regard to budget | | both contractor and client are in that, So, if resources plan properly and competent, budget could be better managed |
| Q17_BD What kind of design and construct standard- form- of contract did you use for this project? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| our contract was Time base contract for consultancy and for Contractor was International Contract Bidding (ICB) and selection of contract was Quality Cost Selection Base (QCSB) method but most of donor chose QCB time base contract don't consider financial for consultancy since Consultant should select through high performance not cost but for construction it will QCSB | For consultants it was quality and cost base contract but during construction, the contract between client and contractor and it was FIDIC methodology | There was some sort of contract but at this moment can't remember, sorry for that | Both design and construction was under FIDIC contract<br>Selection of contractor was Prequalification like short list prepared from qualified contractor and those contractor offer their bids and after that financial basis their bid accepted<br>For consultants shortlisted from both technical and financial criteria |
| Q18_BD What kind of contract did your company use for the SRNDP? To what extent did the schedule form part of the contract documents? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Interviewee said his consultants received TB-QCBS from RHD dept.<br>Yes, Donor agency(WB, ADB,) adopt FIDIC form and schedule form is TB-QCB/QCBS, | Same as discussed like time base contract<br>Not known | For consultancy, company used RHD contract and construction, it was FIDIC 4, with general, particular condition of contract and tech spec (AASHTO, ACI, ASTM, BS | Yes, we prepare contract for technical and financial basis based on FIDIC as we made JV with JOC-NA<br>Schedule is mostly for contractor, this |

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| This project was funded by ADB | | and local Std)<br>The contract includes (drawings, contract agreement, tech spec, BoQ) was part of contract docs | schedule had clause that contractor must follow as part of contract document and consultants engaged on behalf of client and as per schedule time consultants engaged for schedule period<br>This is FIDIC condition of contract, which is general condition of contract, another is particular condition of contract that is base of context of project, these are main docs beside, Tech. Spec. and drawings |
| Q19_BD Who was responsible for producing and actioning the schedule? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Team Leader (Project Lead) he was Japanese Expert but I was assisting him to action | Team Leader (Project Lead) | When project awarded it was Team Leader (Project Lead) from consultant | Contract Specialist but under Team leader (Manager of the project). consulting company in design prepared this schedule |
| Q20_BD How were the estimating, planning components of the contract and the Bill of Quantities monitored after construction work started? Were there deviations to the contract found? If so, what were they? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Before Construction started contract had three parts, contractor was awarded by contract, bill of quantities and | During construction there was monthly meeting with contractor, consultants and | After awarding the contract, contractor submitted construction plan with S-curve, Pert | During construction contractor raise concern if any to consultants and it verified by respective officer |

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| bill of quantities figured out project cost<br>After construction started consultant was responsible to planning and monitoring BoQ and based on that Designed reviewed since some of items considered not required and some then were required for project what contractor sorted out, we prepare estimate by increase decrease qty as per review to minimize cost overrun<br>There was contingency allowed 10% for variation in construction and adjusted accordingly | client. From that meeting it was mentioned about progress and items details and also showed the reason of delay and what action took and will be taken.<br>During construction it varied ; during design soft soil qty was included but during construction it was more than estimated | and CPM and every month we had meeting with contractor, consultant and client<br>Where progress were monitored and checked any deficiency like manpower shortage, equipment shortage, material shortage and we notified contactor about the specific matter what was affecting contract<br>Yes, we found deviation like slow progress, resource mobilization and notified, actually in BD had very skilled shortage in manpower and management and hard to relocate in local area and lots way contract were deviated | and approved. Sometime need approval from client and NOC from donor.<br>There was variation, during construction contractor can or will face difficulties for such kind of big project. It normally covered in contact about uncertainty,<br>Additional material, quantity, items for environment, request form locals. There is restriction in contract either increase or decrease , if within limit one sort of action if exceed another action such way monitored<br>There is another Item in contract called provisional sump and price escalation when project more than 1 or 1.5 yrs |
| Q21_BD How were the environmental variables monitored? To what extent did they adhere to the contract? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| We did very well; Env Specialist was in design and construction. EIA and EMP and according to EMP we did compliance and every month contractor include | EMP was prepared and contractor prepared EAP following EMP and we monitored during construction | Env engr. Prepared Env. checklist and included in EIA and EMP, every month it include in progress report and monitored accordingly and | Asian development Bank very keen and conservative for this issue. Env. Engineer prepared plan to monitor<br>The plan was part of contract and |

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| progress report<br>Accordingly to Env regulation of Bangladesh, we did monitoring camp, working sites, HIV awareness, Public nuisance etc was monitored | EMP and EAP was part of contract document | submitted to concern authority EIA and EMP included in contract doc | finally special report prepared to ADB and client had his own wing to monitor the issue |
| Q22_BD How were the human resources monitored? To what extent did they adhere to the contract? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Normally, All major projects use local manpower and experts, there were two international contractor worked for SRNDP, all position, RE, BE, DTL, ME except SRE and TL from overseas.<br>Form Progress report it showed the picture about HR<br>From start to end point 36 month, we maintained this level | As I mentioned that HR already in monthly progress report (HR contractor, consultant, consultants) and monitored<br>It was predefined in contract during contract documents preparation. | Contractor prepared progress report with person name and monitored every forth nightly<br>During Contract preparation it was included , | During construction there was monthly meeting with contractor, consultants and client. From that meeting it was mentioned about manpower, material, equipment, and progress and items details and also showed the reason of delay and what action took and will be taken. This was monitored by consultants, if they found unskilled or semiskilled manpower, not adequate, not appropriate, not good quality material and then consultant warned the contractor<br>It was predefined in contract during contract docs preparation. |
| Q23_BD How were the material/equipment resources monitored? To what extent did they adhere to the contract? | | | |

| Interviewee 1 | Interviewee 2 | Interviewee 3 | Interviewee 4 |
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| Every monthly progress report providing picture of our construction and consultant sites, how project progress about HR, material and equipment were monitoring<br>Yes it was adhere to contract even after end of contract defect liability period, it was monitored and was part of contract | It is similar that monthly progress report monitored<br>As discussed it was included in contract during documentation | Every forth nightly we monitored from start of project the ideal equipment, working equipment, stake down equipment and major equipment (batching, asphalt, concrete mix plant) reported accordingly<br>it was included in contract during documentation | in Tech Spec. it was mentioned about material, equipment (mostly imported)that contractor will prepared work program (man-hour, machine, materials) part of contract requirement and this was reviewed daily, monthly basis<br>As discussed it was included in contract during documentation |
| Q24_BD What standards did you follow for the design and construction of the SRNDP? Were there any difficulties following the standards? If so, what were they? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Design; we followed AASHTO,<br>Construction; Spec was developed and specified<br>RHD standard (not covered full Spec), So AASHTO, ASTM used to borrow few clause<br>Yes, we can't copy for a particular case, AASHTO build for wide range of world, In BD context; we need to change some parameter, So we amended as per BD prospect. | TRRL for design and ASTM, AASHTO in construction.<br>Not faced difficulties | As told; technical is AASHTO, ASTM and for construction FIDIC 4,<br>Yes faced difficulties, like material testing and grading was added to spec but in field was not match<br>Some property strength, parameter was not matched but we had expert and material engr. Who resolved by trial and error and test basis and got approved from | AASHTO, BS, IRC were used as technical standard,<br>For contract was FIDIC<br>Not faced difficulties |

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| | | authority | |
| Q25_BD Are there other standards that could have been satisfactorily followed for this road design and construction project? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| For concrete design BS, ACI for concrete mix design, for Asphalt mix used good manual American Asphalt mix design manual<br>Used the standard what will satisfy the job, used that standard | For Bridge Design used like BS, LRFD | Yes, we used other standard, like Bangladesh Building code, for preparation of building at site of Client and sometime we didn't get some items in ASTM then used RHD standard for local material | AS discussed earlier |
| Q26_BD How would you define risk? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Very good question,<br>There are lot of risk when construction started, Project was designed based on parameter, available material, guidelines lodged the design and design accepted<br>When construction; use variation, that sort of risk should be considered<br>First risk identification, then risk assessment and<br>done risk mitigation, also added contingency for risk mitigation and prepare the design manual | Can define like political, delay associate (cost and technical staff), Road side hazard, Noise, children crossing, level crossing | In terms of time risk associated, like prolonged weather,<br>Cyclone, flooding, typhoon, flooding others | Can define like, if project after completion can't achieve the certain benefit EIRR (economic internal rate of return) can be called financial risk. This for all aspect like in design and construction, ultimately use of road and ultimate return of the project ex; design traffic, forecast traffic provided |

| Q27_BD How were risks identified during the design and construction phases? Were there any difficulties identifying these risks? If so, what were they? If you did not identify risks, why not? | | | |
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| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Based on above discussion risk identified in design and construction<br>Added example like if moisture content high, will be crack, So, Spec should prepare very skilled manner (don't limit like minimum and maximum) it actually big gap, this the risk to be reviewed and rewrite the spec during construction | As discuss earlier the risk how identified,<br>Yes difficulties, like grave yard, religious structure, very rapid change of ground feature specially like Bangladesh where population is high, long gap between design and construction<br>Since it was not properly marked or any wall or boundary not identified during survey | Some risk identified during design but some was not as the road was in flood prone zone, hard to assess without in situation<br>Yes difficulties, as told some of them identified but some you can't like heave rainfall, flash flood, cyclone | Transport economist analysis project from different scenario (Traffic, structure, maintenance with and without etc) what is cost and what is out come<br>He also considered uncertainty like unsuitable material, hazard and Risk found from RSA, during opening affect from other road and users<br>From RSA all technical risk identified |
| Q28_BD How were risks mitigated during the design and construction phases? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| During design, and dwg preparation, there may some parameter missing or wrong, what need checked properly before issue design also need to check during design review stage as well because drawing is language of engineering<br>Proverb in local: "Construction always need the progress and to claim the permit but does not need the | Realign the road, sometime provide toe wall or retaining wall | Mitigation was done by extending contract and separated or sub divided the contract as small contract | Pre-feasibility stage RSA did and mitigate,<br>As per design docs guide it was mitigated |

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| quality" not ignoring the quality since they are international contractor but said the view of contractor,<br>So, quality control and quantity control checked. | | | |
| Q29_BD Did you conduct an LCCA as part of the quality decision making during this project? If not, why not? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Can't explain about the matter | So, Interviewee know that it was not done,<br>It is not mentioned in project to be done | We didn't do<br>We are not aware but it was good to do both in design and construction | Yes we did, WB developed a manual, that was checked,<br>It depends on quality of consultants for this country. It was the criteria from Client |
| Q30_BD What regional development plans did the design development process for this project follow? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| We have only centrally plan what is controlled by RHD and planning commission, So, no development plans and development process, We have only unique plan like 5 yrs plan | Govt. Follow 5 yrs plan, it was definitely on that plan, for the main objective was to connect another port | Actually we had road master plan in Bangladesh, as per the plan it was followed , I'm not aware of that this was any regional plan | There is plan for Nepal, India, and Bhutan like east corridor, southeast corridor; So, SRNDP was part of Southwest corridor to connect to boarder |
| Q31_BD How would you define value-management and value-engineering? Was it used? If yes, at what stage was the value management or value engineering implemented? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Very very good question, Defined " | Not clear idea about VM/VE, | Yes, some value add on top of any | VE is that to find a economical and |

| | | | |
|---|---|---|---|
| when project have skilled and quality design and implemented by skilled quality resources" can be value engineering<br>Yes used, "Client gave to same consultants not to bid, because design consultant can pick the matter nicely than newly engaged"<br>Since they select design and construct same, it cost time saving | Possibly not, it not in contract, | act,<br>Not used, since no one aware of it,<br>I know personally may be not 100%, yes it is good to do but no one do in our country, | timely solution without compromising quality of project can be called<br>Since we used some alternative alignment, bridge aesthetic so it was covered,<br>During design stage it was covered but in construction always applied when any variation, alternative or issue raised |
| Q32_BD If not, what other quality decision making method was used? Was it adequate, in your opinion? Why/why not? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Yes, used | We did only internal with other team like bridge, Hand H, Env. Highway, resettlement,<br>This is only in design | Yes, VE is required but no one did at that time | it was used |
| Q33_BD Did you conduct value-management/value-engineering as part of the management decision making process for the SRNDP? Why/why not? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Yes, Implementing agency change the QCBS proposal when other contractor coming with very low rate that 90% technical and 10% financial also clause that who is design consultants they have the better | This term not familiar in our country but not was done in that level | I'm not aware but I don't believe they do,<br>Actually this not a process, who is doing management process, they are not expert or lack of awareness and knowledge | There was not specific or formal action but just compares of economic variations it was done but no formal process like RSA was done but not included |

| | | | |
|---|---|---|---|
| marks for design review, According to they have considered quality and value the engineering<br>Since the project cost was US$210M and consultancy is nothing in respect of that and who is technically sound and qualified will be the part of construction | | | |
| Q34_BD How would you improve future management decision making for future projects? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| it is a continuous process, So, professional should do continual professional development, As an engineer you may know the technical matter but you may not know about timely manner. So any problems come either design or construction doesn't keep for long for better decision. Decision what you provide early that will optimize cost and time. May be decision may not strong but timely manner because your work encourage the construction to finish on time<br>So, Everyone makes decisions on timely | actually, from this session, I learnt new terms like LCCA, AU, VE, Checklist<br>So, if you include in future project definitely improve future project<br>Every stage form Management to implement we have unskilled manpower, so if we improve the quality, can improve future project | My advice, our people should be better educated with modern tools and technology and management people should be improve technical and management capability<br>On job training from company, Uni should take and add courses and employee should consider as part of CPD | What I can say, proper identification and checklist procedure and quality resources, coordination among divisions/sections with encouraging attitude, |

| | | | |
|---|---|---|---|
| manner/action jobs | | | |

## 4.5 ANALYSIS - BANGLADESH

The analysis of the responses from the four Interviewees from Bangladesh is now presented.

### 4.5.1 Demographics of Interviewees (questions 1-4)

Interviewees were firstly asked about their experience and qualifications. The Interviewees explained that local personnel such as themselves had been engaged during the design and construction phases of the Southwest Road Network Development Project in Bangladesh because they had adequate experience and qualifications. All the Interviewees selected for this study had qualifications such as B.Sc (Hons) in Civil engineering and two of the Interviewees (1 and 4) were registered professional engineers (PEng) in road design and construction industry and had, in addition, experience with small to large scale projects in infrastructure design, main road geometric design and construction, supervision, management, procurement, maintenance with client, consultants and contractors with experience from different countries. Interviewee 1 had had experience in Zambia, Sudan, Bangladesh and Botswana; Interviewee 2, from Afghanistan, Bangladesh, Botswana; Interviewee 3 from Papua New Gunnie, Iraq, Qatar, Bangladesh and the Philippines, India, Afghanistan and Interviewee 4 from Azerbaijan, Bangladesh, Botswana, Afghanistan, India, Iraq. All the Interviewees had senior positions during this project (principal engineer; senior design engineer; construction manager and planning engineer) and had contributed to the decision making process. Figure 1 shows how

long each Interviewee had been involved with Quality Decision Making (QDM) as part of his/her professional experience.

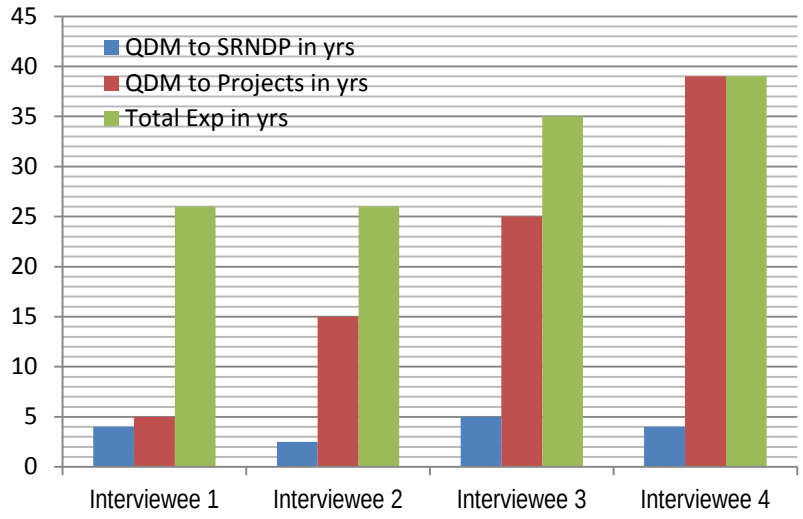


**Figure 11: Visualization of SRNDP Interviewees' Experience in QDM**

The Interviewees had worked for at least thirteen years each with the company including the time SRNDP was under design and construction; they had also had several years' experience in QDM from other projects with this company and with other companies. It was assumed that this selection of Interviewees, with their varying experience and qualifications, could provide insightful data on the Quality Decision Making and Project Management of the SRNDP.

### 4.5.2 Understanding about quality decision making in SRNDP (questions 5-7)

A group of questions was asked to establish how Interviewees defined QDM and how QDM was undertaken in this project. Interviewee 1 defined QDM as when the Terms of Reference (ToR) of the contract and a country's policies are complied with. Interviewee 2 replied in more detail stating that QDM is when consideration is given

during construction of cost, then safety and quality as well as time schedule and unit rate. Interviewee 3 stated that, from the design perspective, there should be employment of appropriate personnel, correct documentation to perform or stabilize quality product; in the construction of this project, on the other hand, he said there had been many problems related to quality and time during implementation of the construction work because of unknowns such as climate conditions e.g. flash floods. Interviewee 4's response had a different focus; for QDM to be successful from the design perspective the requirements of the client should be met, he stated. In addition, he stated that appropriate work method, machinery, trained workforce, planning and programming and sequential follow up work program, quality of materials and progress should be monitored properly.

It seems from the responses from Interviewees 1, 3 and 4 that they believed the concept of QDM was similar to Quality Management. However Interviewee 2 explained that cost, quality, schedule and safety are factors of QDM.

When asked about elements important for QDM on this project, Interviewee 1 stated QDM should always consider Terms of Reference (ToR) of contract, policy and design principles; Interviewee 2 said risk factors, site distance, resettlement housing, market, and religious structure, locality and environmental issues were considered. With regard to design, Interviewee 3 said appropriate design, appropriate technical standard for design drawings, contract documents were considered along with schedule, the construction budget and quality of final product. Interviewee 4 said, also with regard to design, that important elements to consider were environmental issues, appropriate selection of road alignment from alternative alignment study,

topographic survey, hydraulic and hydrology for structure design, river modelling, geometric design, Land Acquisition (LA) plan, aesthetic view of structure, road safety aspects; he added that a feasibility study should be undertaken. With regard to the construction phase, Interviewee 4 stated that issues which were considered in QDM included work program of contractor (workforce, machinery, and materials), weather, suitability of materials during planning and programming, traffic management (including diversion or road and bridge design), safety and hazards. The differences in responses could be due to the differing responsibilities and professional expertise of Interviewees in their own field.

It is clear that the Interviewees considered many aspects of QDM, highlighting the need for consideration of cost, quality, time, weather, suitability of material, work program, road safety aspects, resettlement (housing, market, and religious structure), locality, environmental issues during design and construction – largely according to their own areas of work.

### 4.5.3 Quality decision making in Legislation and standard (questions 8, 24 and 25)

In answer to questions about the legislation and standards adhered to in the project, all Interviewees stated that the American Association of State Highway and Transportation Officials (AASHTO) and Roads and Highways Department (RHD) were used for road geometry design, pavement design, pavement material and laboratory testing and road drainage structures; Interviewee 2 added that the Transport and Road Research Laboratory (TRRL) standard was used initially for geometry design before AASHTO; he stated, furthermore, that their design team of

consultants had been engaged for the same client for another major project in Bangladesh, the Jamuna Multipurpose Bridge project (a bridge 4.8 km long with almost 2km bridge approach each side) where they used TRRL. Interviewee 3, the Construction Manager, explained that the local standard (RHD) did not cover all technical matters related to design and construction and that was the reason AASHTO had been used to cover all aspects.

In addition, Interviewee 1, the principal engineer of the highway section, advised that the Executive Committee of the National Economic Council (ECNEC), Bangladesh's highest authority for approving the development of projects, had approved this project.

Interviewees were thus aware of the AASHTO and RHD standards and importantly the areas which the local standard, Roads and Highways Department standard (RHD), did not address.

With regard to any difficulties complying with technical standards, Interviewee 1 stated that some difficulties had been encountered when AASHTO had been applied, particularly with regard to the preparation of technical specifications, since the standard had been developed for the USA context. So, during the SRNDP, according to Interviewees 1 and 3, some materials as specified in AASHTO could not be complied with as the local material properties did not match the specification e.g. filler material, brick chips as lower base for pavement. Interviewee 1 added that, although the specified material with similar properties could have been brought in from India or some other country to conform to AASHTO standard for SNDRP, this

would have been costly in terms of finance and time. Instead of bringing in materials the specification was changed so that local materials could be used and approval for their use was got from the RHD. Interviewee 2 said he had not faced any difficulties complying with the technical standards required for geometry design; however, he did state that there had been other problems such as resettlement issues (e.g. land acquisition), political pressure (local representatives did not consent to land acquisition during this road construction in a few locations), religious issues (e.g. having to design around many graveyards, mosques and temples). Interviewee 3 stated that some of the construction material, such as local brick and brick chips, were used; as the brick had not complied with any foreign standard as pavement construction material, they had used local RHD standard and the Bangladesh Building Code for building materials for the construction of Office Buildings. Interviewee 4, on the other hand, stated he had not faced any difficulties during the design and documentation process. When asked about any other standards which had been satisfactorily used, Interviewees 1 and 3 said RHD standard for technical specifications and ASTM for laboratory testing and road construction material had been used; however, Interviewee 2 said TRRL for geometry design was initially used and, finally, AASHTO and ASTM for geometry design and material testing; Interviewee 4 said British Standard (BS) and Indian Road Congress (IRC) had been used during the design and documentation period since IRC had been developed based on the same context and weather as Bangladesh's. Finally, Interviewees 1 and 3 agreed that in SRNDP there were different technical standards used for different types of difficulties; the specification had been modified during the design review and after award of contract for construction because of lack of availability of

recommended materials and the desire to keep unit rates of the established BoQ realistic to run the work programme smoothly.

### 4.5.4 Quality decision making in economy of project (questions 9-11 and 13)

Interviewees were also asked about their understanding of the road infrastructure implementation process and project management; in answer to questions about Cost-Benefit-Analysis (CBA), Interviewees 1, 2 and 4 clearly stated that CBA had been conducted and, according to Interviewee 2, had been carried out by a transport economist at the feasibility stage. Interviewee 3, however, said that CBA had not been carried out during this project because it was not common practice in Bangladesh and the project management team did not have a background in such activities. The difference in responses as to whether CBA had been undertaken or not, could have been because of the lack of project report records or documented checklist procedures; the lack of certainty as to whether or not CBA had been undertaken could also have been due to the fact that it had been conducted during the feasibility stage and not in the detailed design stage.

When asked about Analysis of Uncertainty (AU), Interviewees 1, 2 and 4 said that AU had been done; Interviewee 2 provided an example saying that, during the design phase, they had found issues with building asphalt pavement in the market area; so they then considered and used rigid pavement. But Interviewee 3 reported that, although he thought AU was important, it had not been undertaken for SRNDP as this is not a practice in Bangladesh. The difference in responses as to whether AU had been undertaken or not could have been because of lack of project records or proper checklist procedures in the detailed design stage as with the conduct of CBA.

With regard to a Checklist Procedure (CP), Interviewees 1, 3, and 4 agreed that this procedure had been carried out during the construction stage but Interviewee 2 said there was no written checklist for them to follow to complete the project due to their lack of knowledge. The difference in responses as to whether Checklist Procedure had been undertaken or not could have been again because of lack of records or proper checklist procedures in the detailed design stage as with the conduct of AU, EP, CBA. In addition, interviewees' responses may have differed due to their differing exposures to certain phases of the project e.g. design, construction and maintenance; function of choice – according to their perspectives related to the work for which they were responsible.

When asked to define 'Context-Sensitive Design approach' (CSD), Interviewees 1, 2 and 3 stated that they could not define CSD but agreed this procedure had been carried out and provided a few examples from their own field; Interviewee 1 said the designer had designed the road using his own judgement on material use such as flexible pavement and its thickness as well as providing alternative pavement structure designs; Interviewee 2 also said CSD had been considered including people's sentiments, cultures, history, social and environmental context; Interviewee 3 added that political issues and socio economic issues (poverty, land constraints, resettlement) had been considered, too; Interviewee 4 stated the CSD approach had been considered e.g. a couple of high tidal river crossings, high water table, material uncertainty context were all considered.

Although one interviewee stated CSD had been used, in fact the items he had considered were only partially CSD (which needs examination of design consistency,

design aesthetics, safety, environmental impact, capital cost, LCCA, mobility and reliability).

### 4.5.5 Quality decision making in engineering design and construction (question 12)

The Interviewees were able to provide examples of engineering problems which had to be considered in SRDNP. Interviewee 1 stated there had been problems with soft soil and settlement due to soft soil and issues with embankments due to soft soil and settlement; the contractor had offered to install prefabricated Vertical Drains (PVD) but this method was considered to be too expensive and sophisticated for this project. In addition to soft soil and settlement, Interviewee 2 identified bank erosion, pavement settlement due to soft soil, landslides; Interviewee 3 said problems he had encountered included land acquisition which had impacted on the agriculture conducted in the construction area. Interviewee 4 said the road (a section of SRNDP) passed through a flood-prone region where the issues included a couple of river crossings which were very current-related and had caused erosion and scouring; in addition a section of road had also passed through marshy land, with high water table. Although some major engineering problems were cited, none of the Interviewees knew of a checklist procedure for identification of engineering problems.

When asked about mitigation of engineering problems during the design and construction phases, Interviewee 1 acknowledged there had been engineering problems, e.g. settlement due to soft soil and design proposed PVD but alternatives had been used since PVD as quoted by the contractor was too expensive and no one

had experience of PVD at the time SRNDP was under construction. According to Interviewee 1, that was the reason why normal sand fill method was used, and differential settlement was checked for first layer for 1 year with preloading and rate of settlement; in addition the asphalt surface had been changed to DBST since asphalt cannot allow differential settlement to Double Bituminous Surface Treatment (DBST), and after 5 years it was proposed that asphalt surface would be laid as actually proposed in the contract. He also stated that they had made provision for an alternative based on Analysis of Uncertainty. Interviewee 2 said there had been engineering problems during construction like road embankment washed out in various locations and road alignment not realigning with the Arial Khan river bridge approaches during construction due to the river's high tide. Interviewee 3 said there had been many problems. For example, a cross road at the bridge approach and at a grade intersection had been designed but, during construction, it was found not to be at level-crossing (road and rail cross at same level) and an underpass at the bridge approach was constructed. Another example given by Interviewee 3 was during construction; after the project had been awarded, a bypass road had to be made and it went 9.7 km through marshy land, with water body and soft ground with organic soil. In addition, during design where design reports showed borrow pits in field there were actually organic pits; then dredged material from the river 1.5 km away from the site had to be used. These issues had been overlooked during the design phase. Interviewee 4 said he had not worked in the road construction phase and had therefore not encountered any engineering problems; the contract documents had been prepared by an experienced contract engineer; again the data showed that personnel had not worked with a specific checklist during design and construction phases.

### 4.5.6 Understanding about project resource management with regard to time, cost and quality (questions 14-16)

Three questions were asked about Project Management in quality decision making, with regard to the SRNDP schedule. Interviewee 1 stated that, if local resources (manpower, material and equipment for projects) had been used for this project, there would have been cost and time savings; Interviewees 2, 3 and 4 stated that, if skilled manpower and more specific tools had been used, the project would have been better managed. Interviewee 2 specifically mentioned that it would have been useful to have utilised various software programs for road design and drafting and Critical Path Method.

When asked about resources with regard to quality, Interviewee 1 stated that the Team Leader had been recruited from overseas because it was believed he had the competency to produce a quality project. However, Interviewee 2 focussed on resources stating that, if quality resources and quality tools (software) had been used, they would have enabled a better managed project. Interviewee 3 also believed that skilled management and properly programmed equipment would have led to better quality. Interviewee 4 added that, if an experienced quality control engineer and a quality assurance engineer had been supplied by the contractor and consultant respectively, better quality could have been achieved.

When asked about resources with regard to the SRNDP budget and time, Interviewee 1 stated that, if the project leader had been competent, the budget would have been better managed. Interviewee 2 said using quality resources and quality tools

(software), although initially costly, would have helped the budget in the long run. Interviewee 3 said keeping a skilled workforce and skilled management would have helped optimize the use of the equipment; then the budget would have been better managed; as it was, the equipment was always there but not properly programmed. However, Interviewee 4 emphasised that the contractor must prepare a cash flow program based on FIDIC showing resources with payment requirements from both contractor and client.

Finally, it can be concluded that resources could have been better managed with regard to budget, quality and time with the inclusion of some important elements which were local resources, tools (software), skilled resources with skilled management, work program as well as skilled quality control engineer from contractor, and skilled quality assurance engineer from consultants and a cash flow program.

### 4.5.7 Quality decision making with regard to contract (questions 17-19)

Interviewees were also asked about contractual issues in quality decision making during the project under design and construction. Interviewee 1 stated that, for consultancy, a time-based contract was used and for the contractor an International Contract Bidding (ICB) was used. The method used for selection of contract was Quality Cost Selection Base (QCSB). Interviewees 2, 3 and 4 stated that a quality and cost based contract for consultancy was used during construction and the contract was between client and contractor and the contract approach had been FIDIC. In conclusion, Interviewees stated both design and construction had been

under a FIDIC contract as per Asian Development Bank (ADB) guidelines since the donor was ADB.

When asked about schedule form, all four Interviewees stated that the schedule form was already part of the contract document. This could have been the reason that Interviewees had not been aware of contractual issues.

When asked about producing and actioning the schedule, all Interviewees said that was the Team Leader's responsibility.

### 4.5.8 Quality decision making in project management (question 20)

With regard to monitoring of the estimating and planning components of the contract and the Bill of Quantities after construction work had started, Interviewee 1 said that, before construction had started, the contract had three parts; first, contractor was awarded the contract; second, bill of quantities was reviewed and third, from the review of bill of quantities, the project cost was estimated. After construction had started the consultant was responsible for planning and monitoring BoQ and as part of this process, the design also had been reviewed since some of the items considered in BoQ had not been required and some new items had been requested by the contractor. Following this review, the consultants prepared a revised estimate. Ten percent contingency was allowed for variation in construction and adjusted accordingly. Interviewee 2 said, during construction, there was a monthly meeting among contractor, consultants and client. There had been a progress report which had explained the reason for the delay and what action had been taken and would be

taken. Field personnel subsequently had monitored the action. Interviewees 2 and 3 responded similarly, adding that, after awarding the contract, the contractor had submitted the construction plan with S-curve, Pert and CPM. However, Interviewee 4 said, during construction, the contractor had raised concerns with the consultants and issues had been verified by the engineers of the consultants and approved; sometimes approval had been needed from the client and a No Objection Certificate (NOC) from the donor agency.

It can be concluded that Interviewees had monitored the planning components and BoQ through a work plan, a monthly progress meeting among client, consultants and contractor, and had got approval from clients and donor agency for any variation of contract.

When asked about contract variation, all Interviewees stated there had been deviations and that there was a 10% contingency allowed for variation in construction. The deviations were due to more than the estimated soft soil quantities being required; they were, according to Interviewee 1, slow progress, scarcity of local materials, resource mobilization, sourcing skilled manpower and management to relocate to a local area and the effect of climate and the marshland with organic soil. However, Interviewee 4 said the contract normally covered uncertainty, additional materials, quantity and items for environments, requests from local people as well as restrictions related to either increase or decrease of contract items and quantities; Interviewee 4 also stated there had been another item in the contract called provisional sum and price escalation to cover the extension of the project of more than 1 or 1.5 years.

It seems therefore that the contract drawings were not correct e.g. quantity of soil to be removed was less than it was actually found to be; for the construction stage, due to design changes, incorrect river modelling had remained in the contract.

### 4.5.9 Quality decision making with regard to environmental issues in SRNDP (question 21)

When asked about how environmental variables had been monitored, Interviewee 1 said an Environmental Specialist, who had been employed in design and construction, had conducted an Environmental Impact Assessment and had prepared an Environmental Management Plan (EMP); according to the EMP, monitoring had been undertaken of camp, work sites, HIV awareness and public nuisance according to the environmental regulations of Bangladesh. Interviewee 2 added that the contractor had prepared an Environmental Action Plan (EAP) which had been thereafter monitored during construction. In addition, according to Interviewee 3, the environmental engineer had prepared a checklist that included an Environmental Impact Assessment (EIA) which had been prepared from the EMP. The Checklist had been included in the progress report every month and the actions designated in the EMP had been monitored accordingly by the consultants and submitted to the Clients. According to Interviewee 4, the project, with regard to the ADB guidelines, had been checked also by the Asian Development Bank (ADB).

Hence, it is clear that due regard was paid to environmental issues by consultants, client and donor agency; all elements had been included in the EAP.

### 4.5.10 Quality decision making with regard to resource management (questions 22-23)

When asked about human resource management all Interviewees agreed that there had been a monthly progress report; in addition Interviewee 4 stated that, during construction, if they found unskilled or semi-skilled manpower to be inadequate and/or inappropriate or materials lacking quality, the consultant warned the contractor. Nonetheless, no one mentioned the use of any tools (software) like Microsoft project or similar sorts of packages to monitor the resources, slip of schedule; that would be why Interviewee 3 stated in an earlier response that resources had always been there but not properly managed and had been misused.

When asked about monitoring of material/equipment, all Interviewees stated that every fortnight they (Interviewees) had monitored, from the start of the project, the idle equipment, working equipment, stake down equipment and major equipment (batching, asphalt, concrete mix plant), had reported on it and had taken appropriate action.

Although monitoring of human resources, materials and equipment had been carried out, there was still schedule slippage. Inefficient management of resources on site was implied by the interviewees.

### 4.5.11 Quality decision making with regard to risks in SRNDP (questions 26-28)

Interviewees were also asked for their definition of risk; they provided examples of what they had faced in design and construction during SRNDP. Interviewee 1 said

that, when a project requires a contract variation during construction, after accepting the design or award of contract, major risks may arise with respect to construction. Interviewee 2 stated risks can be defined as political, delay associated (cost and technical staff), road side hazards, noise, children crossing, level crossing (road and rail cross at same level), Interviewee 3 defined risk in terms of time associated with prolonged weather (rainy season), cyclone, flooding, typhoon. Interviewee 4 stated risks as financial risks; when a project cannot achieve the certain benefit after its completion such as EIRR (economic internal rate of return), which linked to other aspects such as design and construction, ultimate use of road and ultimate return of the project (design traffic, forecast traffic).

When asked about risks identification during the design and construction phase, Interviewee 1 reported that, during the design phase, risks identified were availability of construction materials, pavement design and other design parameters. Interviewee 2 stated that, during the design phase, a few factors were identified such as risk associated with ongoing politics, delays associated with cost and technical staff, road side hazard, noise, children crossing, and level crossing for rail with road. Interview 3 stated that, during design, risks were identified but not accurately and hence problems occurred during construction. Interviewee 4 stated that, during the feasibility study when the Transport Economist analysed the project from different scenarios with regard to cost and outcomes (traffic, structure, and maintenance), risks were identified. All the Interviewees reported that there had been difficulties identifying risk. Interviewee 1 explained that there was a big time gap between design and construction phases, and hence many uncertainties arose related to land value, topographic features, price increases, and policy changes. Interviewee 2 said

that another reason for the difficulty in identifying risk was the rapid change in features, e.g. grave yards, religious structures (mosque, temple, and others) where the population density was very high. There were of course some risks that could not be easily identified such as heavy rainfall, flash flood, cyclone (Interviewee 3) and Interviewee 4 stated unsuitable materials, hazards (power poles, graveyards, mosque); however, Interviewees did not mention an appropriate process of risk identification for such kinds of project. So, it can be concluded that there had been a lack of awareness of the need for risk identification.

When asked about risk mitigation during the design and construction phase, Interviewee 1 said, during the design review of design drawings, risks encountered were mitigated by readjusting/modifying the design during the design review stage. Interviewee 2 said they had realigned the road and provided toe wall or retaining wall to mitigate risks from sliding, visual issues for high embankments. Interviewee 3 stated that risks had been mitigated by extending the contract and sub dividing the awarded contract (divided road section by couple of segments) as a small contract. A Feasibility Stage Road Safety Audit (RSA) was reported by Interviewee 4 as being a mitigation measure which had been used.

Although many risks had been identified, no procedural measures seem to have been used to identify and mitigate risk; no checklist was mentioned. RSA was not conducted at the final design stage; it is likely therefore that quality was not assured.

### 4.5.12 LCCA (question 29)

Interviewees were also asked about the role of Life Cycle Cost Analysis (LCCA) as a part of quality decision making in the Southwest Road Network Development Project

(SRNDP); HDM software had been used and CBA at the feasibility phase to determine the Net Present Value, Internal RR, ERR, BCR or Payback period as well as possibly LCCA but LCCA had not been conducted at the final design stage because it was not mandatory.

### 4.5.13 Quality decision making in regional planning (question 30)

Interviewees were also asked about regional development plan in order to assess what they knew about efficient placement of infrastructure and zoning for the sustainable growth of a region and region-wide environmental, social, and economic issues. Interviewee 1 stated Bangladesh had only a central plan controlled by RHD and the Planning Commission. This plan was a Government 5 year plan, according to Interviewees 2, 3 and 4. Hence, it can be concluded that Bangladesh had only one central plan and no regional plans.

### 4.5.14 VM/VE (questions 31-34)

Interviewees were also asked to define Value Management/Value Engineering and how it had been undertaken. Interviewee 1 said that, when a project has a quality design and it is implemented by skilled quality resources, that is Value Engineering. Interviewee 3 said VM/VE was when value was added to something and Interviewee 4 stated that VE is about finding an economic and timely solution without compromising quality of a project and he said that it had been applied in the construction phase. The other Interviewees could not define VE, possibly because it is not common practice in Bangladesh.

When asked about their views on future management decision making for future projects, Interviewee 1 stated it is a continuous process and professionals should undertake continual professional development, as engineers may know about technical matters but may not know about project scheduling. Interviewee 2 stated that improving the quality of management through training programmes or on the job training, could improve future projects. Interviewee 3 agreed that training in modern tools (software) and modern technology, training in technical and management fields with on-the job company training would be useful; Universities should develop courses and employees should consider Continual Professional Development (CPD); Interviewee 4 said there needed to be a proper identification and checklist procedure and quality resources, coordination among divisions/sections with encouraging attitude.

It can be concluded, from the gathered data from the Interviewees, that quality decision making for future management decision making for future projects can be done by appropriate training in technical and administration areas for Project Management.

The results from the ***Bangladesh project*** showed that there was lack of consideration given to risks identification and mitigation; many issues were overlooked during the design phase such as underpass, analysis of existing bridge capacity.

## 4.6 Interview Results from Afghanistan Interviewees

This next section of the results chapter presents the responses and the analysis of the data collected from the Interviewees with regard to the Design Construction Project for Keshim Fayzabad Road (DCKFP) in ***Afghanistan*** (see Table 2)

**Table 2: Results from Research Interviews from Afghanistan**

| Q1_Afg What was your position in this company at the time of KFP in Afghanistan? | | | |
|---|---|---|---|
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Senior Hydrologist | Soil and Material Engineer | Transportation Sector Lead (US$1.4B USAID funded Program) | Highway Design Engineer |
| Q2_Afg How long had you worked for this company at the time KFP was under design and construction? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Worked for 2 years period during project under construction | Worked for 1 year period during the project under construction, left due to urgent personal issue | Worked for 2.5 years period during design review and construction | Worked for last 3 years and engaged in KFP for 1 year |
| Q3_Afg What are your qualifications? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| M. Sc in Water resource Engineering, recently completed MIE in rural development | Masters in Transportation Engineering | Masters in Civil Infrastructure and Professional Engineer in USA | BSc in Civil Engg, MBA and PEng |
| Q4_Afg How much experience have you had in quality decision making? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Had experience in QDM in couple of projects but not for | More than 10 years' experience in QDM | 34 years Professional Experience but 20 | About 14 years in QDM |

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| KFP | | years engaged in QDM | |
| Q5_Afg How would you define quality decision making? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Decision results economy, optimize benefit, environment, sustainability, construction friendly | When Design Specification, Quality control plan and filed run same call QDM | This is based on quality design, cost, the impact of environment to balance all these requirement to project which make everybody happy | When standard, design drawings, specification, BoQ properly follow in construction can be said QDM |
| Q6_Afg How would you define quality decision making with regard to design and construction? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Inclusive design, appropriate to locality, adoptability to pupils, design based on standard, economical, what will serve the purpose and resources are adequate to build | As mentioned early that Design Specification, Quality control plan and filed run same call QDM for design and construction | The design should meet contractual requirements at the same time it should minimize the cost, impact of environment and serve purpose of the project, the main purpose of road project is accessibility than mobility | if Standard, design dwg, spec, BoQ match with construction then we can say QDM in design and construction |
| Q7_Afg What elements do you consider important for effective quality decision making with regard to the design and construction of the project of KFP? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Suitability to environment, effectiveness, benefits to people, adoptability, Operation and maintenance, kind of structure suitable to environment considered for hydrological | Specification, Quality control plan<br>implement both | Safety for user, accessibility, Environmental Impact, Cost<br>Factors will be in both design and construct | Cost, quality, time and variation order, risk factor, environmental factors normally considered in design and construction |

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| structures | | | |
| Q8_Afg | What legislation and standards did your company comply with when implementing this construction project? Were there any difficulties complying with these standards during KFP in Afghanistan? If so, what were they? | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| The consultant and got project from USAID and USAID had norm to follow and Afghan Standard, Federal Financial Rule (FAR) during construction. Especially Afghan Road Standard and AASHTO.<br>Didn't face any difficulties but comparatively expensive location wise | ISO standard and mentioned not know more than that<br>Didn't face any difficulties | Federal Highway (FH)Instruction since USAID is FH agency<br>USAID adopted AASHTO as standard for Highway<br>Of course there were difficulties like technical resources, technical hands, remoteness of site, security, | Since Consultants worked under USAID, there was a guideline to follow as per agency<br>Followed AASHTO standard, there was Afghan standard which not enough<br>Of course there was difficulties since AASHTO is not for Afg but we mitigated to discuss with MoPW<br>Problems like side slopes of rock cut which associate huge cost and time as well |
| Q9_Afg | Did you conduct a Cost-Benefit-Analysis (CBA) as part of the quality decision making during this project? If not, why not? | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| It was considered for this project | This was done early in design stage | Yes, CBA conducted when he started during design review | It was done by Transport Economist |
| Q10_Afg | Did you conduct an Analysis of Uncertainty (AU) as part of the quality decision making during this project? If not, why not? | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| It was done and it is part of design and | it was conducted since it was a | AU was not conducted by him | AU was considered like |

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| implementation process | warfront job | but So far remember 15% of contingency was since everything uncertain in Afghanistan for uncertainty and can't quantify exactly for | snowfall, equipment, material, worker strike, damage, conflict and so on |
| Q11_Afg Did you conduct a Checklist Procedure as part of the quality decision making during this project? If not, why not? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Yes, and it was approved from different layer of decision making | Checklist procedure was conducted | Yes, it was conducted and mentioned myself since I worked with him to conduct | Yes, it was considered during construction project |
| Q12_Afg How would you define Engineering Problems? How were problems mitigated during the design phase? How were problems mitigated during the construction phase? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| The unforeseen Problems and solve at first hand and allocated fund for it but still lot of problems when implemented, for KFP unpredictable hydrology was main problem, like unprecedented flood, soil characteristics was different than design and in some places to get proper road alignment, furthermore some social problem like relocation, protest.<br>There was no problem in Design phase | Fixing of alignment, material selection, consider specification can say Engineering Problem<br>After survey we have to see what problem and mitigate in design phase (source of material, availability of material, climatic condition)<br>During construction where didn't match with design then redesigned as per requirement | The lack of sufficient information, competent people and technology<br>Visit site quite often, check the plan and updated accordingly, to mitigate the technical issue hired from overseas,<br>They hired very competent Sub-contractor (construction company)who had previously experience in that country, had lots of equipment and technical people, | Different people have different answer and as a highway engineer what are problem encountered can be define EP<br>During site visit and survey encountered problems like landslides, debris, Talus material structure washout, rock fall, unsuitable material, Alluvial fans, rock avalanche etc and design and note how to solve<br>As per the design drawing and note |

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| Re construction mitigation - The major problem was inadequate study of geology and hydrology (No time series of flood data for design even not 10 years, So, Landslide, debris flow)<br>Problems were mitigated through variation order, mean; budget variance, for social addressing community program to help the local people and finally change the structure design, e.g; size was small so the shape and size was revised | | they were familiar with culture, availability of material | or guide it was mitigated during construction phase |
| Q13_Afg How would you define Context-sensitive Design approach? Was this approach used for this project? If so how? If not, why not? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| user friendly approach; consider total context like physical setting, culture, local harmony, everything considered in design to maximize the benefit to people<br>This approach was used in the project | efficient design with regard to time can be called Context sensitive design approach,<br>This approach was used<br>For example normally used bitumen 80/100 grade but climatic condition we used 60/70 grade bitumen | Although it was not mentioned but it was always part of design and FH requirement, EA to balance context sensitive design. Although Afghanistan have accessibility than mobility<br>So, it will no impact to environment, cultural, historical sites, Although this site have more historical or cultural issue, huge river to protect | Afg is country with plane, rolling and mountainous terrain and the designer who has experience to design in Afghanistan or similar sort of countries, used CSDA. |

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| | | dumping of dart in main stream of river<br>Had company community leader who met with the community leaders | |
| Q14_Afg How do you think resources with regard to time could be more efficiently managed? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Effective Work plan, Standard | This is a very, very important issue for projects. For example, we have had 6 months very very cold; we can't do any construction, so, resource and time should be appropriately managed | In Afghanistan, no one value time as much we do in east, Although raise concern, this is only point out. Competent resources and schedule is important, should not slip without any important reason, then no cost overrun,<br>During war lots of experts, expert labour were killed; there was a gap of 20 yrs; that's why project brought in experts from different countries | If we can make a good work program and follow accordingly in weekly and monthly basis, can be better managed with regard to time |
| Q15_Afg How do you think resources with regard to quality could be better managed? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Increase the resources (although chances of misuses but used AASHTO std in Afg) better the quality like quality control standard plan, schedule, strict supervision and monitoring, progress | When we select resources make sure they are appropriate to the project; time needs to be considered so project can be better managed | For quality, you have to have good system to check works that can be done by qualified inspectors both in design and construction, material selection. Some tools can | If we have experienced manpower, good condition of equipment and material, will get better quality |

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| monitoring or road work | | also be used in projects using software to manage the quality | |
| Q16_Afg How do you think resources with regard to budget could be better managed? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| What you allocate for the project at the time like synchronize, contract management, auditing, financial management, rules and regulation have to be considered | Everything should be in budget, if budget fails, everything fails, so management needs to check budget and ensure resources are within budget | Budget is most important for Roadway projects; normally only 6% to 10% designed in Afg, but the construction takes a greater % So ensure material, staff, equipment, all are available as per schedule; but you should be more conservative about these | During weekly, monthly progress meeting contractor, consultant, client, about material, equipment, workforce, if it is discussed and actioned |
| Q17_Afg What kind of design and construct standard- form- of contract did you use for this project? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Since project from USAID to Consultants an indefinite quantity contract was used.<br>When Consultants hired Subcon, International Contract Bidding (ICB) was used. | Since this project was funded by US government, used FP03 contract | it was used AASHTO design standard, used FIDIC contract methodology | USAID provided Federal highway contract like FP03 for design and for construction and also used FIDIC for construction. |
| Q18_Afg What kind of contract did your company use for the KFP? To what extent did the schedule form part of the contract documents? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Consultants therefore used International contract Bidding (ICB) to hire | FIDIC<br>Based on FIDIC rule it was part of contract document | FIDIC<br>Schedule is main part of contract doc, so it was added, this one of | Company used same as I said, FP03 for design and FIDIC for construction |

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| Subcon based on FIDIC, FP03 for design spec.<br>It was part of contract documents | | the three pillars of contract | Schedule already in contract document |
| Q19_Afg Who was responsible for producing and actioning the schedule? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Task Order Manager for KFP | Consultants (Task Order Manager) | Contractor submitted TO manager and finally verified by myself | Task Order Manager for KFP |
| Q20_Afg How were the estimating, planning components of the contract and the Bill of Quantities monitored after construction work started? Were there deviations to the contract found? If so, what were they? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Initially KFP design and estimated by Consultants, Consultants had project offices both field and central both monitored the work (Step by Step process design, planning, construct and monitored)<br>On Hydrology, there were some deviations because significant no of culverts needed to be added and some of them were to be resized, road side drainage structure were added<br>Also deviation for road alignment to accommodate the local conditions<br>This is due to Alluvial fan, debris, alignment passes | At first design then estimate and based on design, it BoQ; construction started based on BoQ<br>So it deviated from contract<br>At construction it may change and they made variations from originals according to site condition, situation, uncertainty, | BoQ was built during design and any change less than 15% will be same rate and more than 15% rate will be change<br>During review lots of Bridges changed to culverts and huge cost saving; no more issues or deviations from contract | At beginning of construction start, we reviewed field and we decided and every month had progress meeting and reported; we discussed accordingly and if shortage we discussed as well<br>Of course there was deviation and project had contingency 10 to 15% but it was within 10%<br>For example rock blasting was considered but practically exceeded the estimated quantity; furthermore, design considered a few bridges but |

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| through the futile was not seriously taken during design analysis | | | practically culverts were used instead |
| Q21_Afg How were the environmental variables monitored? To what extent did they adhere to the contract? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| It was monitored to road alignment as environmental safeguard, eg rock blasting not haphazard basis or random basis; little impact on the environment, EMP was there and it was part of contract doc. | There was environmental section and it was monitored by company personnel<br>Since it generated cost and was part of BoQ, the contract was adhered to | For this project the most important thing was river. Only allow certain area where cavity without interrupt river course, other than that nothing allowed dumping in river.<br>It was 100% in contract requirement, it was mentioned in Environmental docs | The Environmental manager monitored the site, for example rock blasting where we disposed of rock; cannot dispose of rock in it river as per document provided during design<br>The environmental management plan was added to contract document |
| Q22_Afg How were the human resources monitored? To what extent did they adhere to the contract? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Consultants did HR management for the project and its subcontractor hired labour and equipment and used local manpower during construction; all these activities were maintained by Consultants and sent to USAID as part of contract mentioned earlier | There was HR department to deploy or employ and have method and policy there and that way monitored<br>Since a project always has resignation, join, terminate, a clause is there HR in the contract | There was schedule and contactor was loaded with staff, labour, machinery cost and it was followed<br>an inspector checked resources in the field with the schedule<br>It was already part of contract | there was a group of people - experts, workers HR - who monitored<br>Same way as discussed that during design and experienced HR items were added to contract |
| Q23_Afg How were the material/equipment resources monitored? To what extent did they adhere to the contract? | | | |

| Interviewee 1 | Interviewee 2 | Interviewee 3 | Interviewee 4 |
|---|---|---|---|
| Subcon (Korean Contractor) was selected through ICB contract were responsible for material and equipment for KFP<br>Consultants was monitored and quality controlled | There is monthly progress report that reflect how material used, how much import and also have list of equipment and we monitored every monthly meeting<br>This was already in contract doc. based on project requirement | What was said in early question that it was added in schedule<br>Created to satellite two site camp, equipment was three, staff was there, monitored what material needed. This all monitored as per schedule<br>This is fully the contract requirement | It also same things, material engineer monitored every week, every month, progress meeting and submitted material and equipment detail like good condition or availability<br>As mentioned, discussed that during design and added to contract |
| Q24_Afg What standards did you follow for the design and construction of the KFP? Were there any difficulties following the standards? If so, what were they? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Main Afg Standard and AASHTO followed in Highway design<br>There was not many difficulties carrying out works, the only difficulty was the social factor | Mainly followed AASHTO and ASTM and BS in some extent<br>There were difficulties; that's why we followed BS and ASTM | Design standard was AASHTO and for construction was FIDIC<br>There were not many difficulties as much what we should have since contractor was experienced since contractor was pre experienced to work | Design standard was AASHTO and Afg standard, for construction was ASTM for testing.<br>Of course difficulties,<br>AASHTO, ASTM for civilized country, but Afg is poor country<br>For example like 80kph speed need 230m radius but in field not possible, huge cutting material and cost involved also time factor |
| Q25_Afg Are there other standards that could have been satisfactorily followed for | | | |

| this road design and construction project? | | | |
|---|---|---|---|
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| No other standard was used but advised that based on topography, IRC or Pakistan Std could have been used and it could have been more appropriate as it would have been more economical for that context since AASHTO was expensive for that Project and it takes more resources | As mentioned BS and ASTM<br>Another was Afg local standard prepared by Afg Govt. (MoPW) which was partially used | There is another standard from Afg. Govt (MoPW) which was partially used but that is not a comprehensive standard, so AASHTO was used | Afg. Standard was used |
| Q26_Afg How would you define risk? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| uncertainty of project, risk can be technical, political, social with regard to cost, delay project, cost overrun | Risk is always risk like climate, timeframe, conflict | the probability of unknown; there were some unknowns in this project like geotechnical, security, utility, geology | Risk means probability of uncertainty for anything |
| Q27_Afg How were risks identified during the design and construction phases? Were there any difficulties identifying these risks? If so, what were they? If you did not identify risks, why not? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Risk are inherent to any project<br>Not specifically identified but risks came to our knowledge; few methods were used to identify risk; project was scheduled to finish in two years but took more than 4 | When we did the design, risk was already considered, eg. including flash flood<br>No difficulties, I mean, when it in construction we reschedule the work<br>Risk may not have | During design phase limited survey information, we corrected during design review and in construction<br>During construction it was mitigated by redesigning, | We did field visits, took photos, video and decided where rock fall, need blasting, so on, decided the risk factor<br>What was mentioned in design documents was checked and |

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| years because risk not identified properly that's why it was delayed<br>There were social, political and technical risks, unforeseen activities encountered during construction | been properly identified during the design | surveying.<br>No difficulties to identified but hydrology was in risk no data, no information, geologic model or study of that area | if any changes needed, they were discussed with MoPW and higher authority |
| Q28_Afg How were risks mitigated during the design and construction phases? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| As mentioned design revised and time delayed, cost increased, project delayed | As mentioned reschedule, variation | During design I was not there; during design risks were not identified; however, Consultants took on this design<br>We mitigated by wide range of survey, realignment, balance cut/fill<br>Geological risks were mitigated by an expert geologist<br>Security risks were minimal as we expected<br>hydrology was at risk and mitigated using redesign, use tools | During design provided Risk Management plan<br>According to RMP, during construction it was followed and mitigated |
| Q29_Afg Did you conduct an LCCA as part of the quality decision making during this project? If not, why not? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| It was not used his part since he was not responsible for that but finally mentioned that so far he knows not | We didn't do<br>Because it was another part of project, it was only assigned for design and construction | I don't know exactly during design whether did.<br>Probably not<br>It is difficult to do | We didn't follow that because huge shortage of data, expatriate and problematic zone it is difficult to do |

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| done<br>It based CBA only and in addition Strategic Regional Planning | But agreed that could better | in Afg because no historical data because there is not a strong construction industry, it always conflict, war and price inflated, lack of sufficient information, maintenance cost or Govt has no proper system to do this | |
| Q30_Afg What regional development plans did the design development process for this project follow? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| As discussed earlier that it was outreach program, it was inclusive development program approach of Afghan govt. to access the road to rural setting | There was master plan from Afghan govt. already there, according to it followed | This road was part of national network of Afg | MoPW had regional development plan; they supplied to us like KFP is National road, so we considered in design period, the parameters and designed accordingly |
| Q31_Afg How would you define value-management and value-engineering? Was it used? If yes, at what stage was the value management or value engineering implemented? | | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| Process used to test possible economic design to know whether too expensive or under design or appropriately design<br>It was used design phase but not done in construction phase | There may be but he didn't but he did quality control<br>May be done at design stage | This is an independent review the design by another set of eyes to come up alternative way to do same thing. like KFP Design was in Afg and Consultants sent to US another satellite office for comments | It means like some value added, we had design and sent to third party to review and add value.<br>It was used in KFP<br>Normally, we do 100% design stage but for KFP we did in 70% stage |

| Q32_Afg | If not, what other quality decision making method was used? Was it adequate, in your opinion? Why/why not? | | |
|---|---|---|---|
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| It was considered in design phase only | It used,<br>Yes adequate and end of design stage | VE was used, from explanation it noted did for all project and part of requirement | Not relevant |
| Q33_Afg | Did you conduct value-management/value-engineering as part of the management decision making process for the KFP? Why/why not? | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| He don't know, but since it was conducted so was part of Management decision making | He was not and not sure | During construction it was, He did and get approval from different level from the position above or below him and from client too | Yes, our transport lead discussed with upper management and MoPW and took action accordingly |
| Q34_Afg | How would you improve future management decision making for future projects? | | |
| **Interviewee 1** | **Interviewee 2** | **Interviewee 3** | **Interviewee 4** |
| As discussed that future decision making should be based on value engineering, CBA, LCCA and should also follow cost sensitive procedure, top of that stakeholder participants, other program should be in design and construct so that owner ship billing comes to them | We know when designing, some sort of problem there, at the time of construction, some deficiency, so if we learn from this project then we can better managed in next project<br>Also explained that if there is good management and experienced personnel for that context then can be better decision making | in Afg, my recommendation is, was and will be<br>Make sure you collect all information during design (geologic, hydraulic, topographic, material, equipment, technical expert), Survey will bit more normally what you need since no GIS or Geological survey maps to select better route<br>Ensure security | For future project we must consider few things;<br>CBR, LCCA, AU, Checklist,<br>We also need to consider time but in Afg. It is difficult because security is problem, snow fall but these associates cost |

## 4.7 ANALYSIS - AFGHANISTAN

The analysis of the responses from the four Interviewees from Afghanistan is now presented.

### 4.7.1 Demographics of Interviewees (questions 1-4)

For the Design and Construction of Keshim Fayzabad Road Project in Afghanistan (**KFP**), many foreign experts had been engaged. All the Interviewees selected for this study had considerable experience in the field and good educational qualifications such as B.Sc (Hons) in Civil engineering and post graduate qualification Masters; in addition Interviewee 4 had a Master of Business Administration (MBA) and all of the Interviewees were professional engineers (PEng) in road design and construction and were experienced also in infrastructure design and construction, supervision, management, procurement, maintenance from small scale to massive billion dollar projects with client, contractor and consultants in a variety of countries - Interviewee 1 in India, Nepal, Afghanistan, West Africa and Sweden; Interviewee 2 in Bangladesh, Afghanistan, Saudi Arabia and Zambia; Interviewee 3 in the USA, Afghanistan, Qatar; Interviewee 4 in Azerbaijan, Bangladesh, Afghanistan. All the Interviewees held senior positions during KFP (Senior Hydrologist, Transport Sector Lead, Soil and Material Engineer and Senior Highway Design engineer) and had participated in the decision making process. Figure 2 shows how long each Interviewee had been involved with Quality Decision Making (QDM) as part of his professional experience.

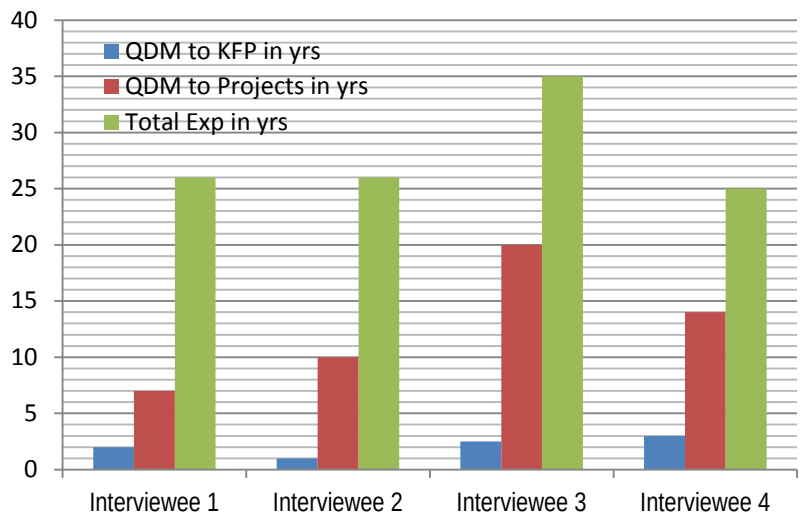


**Figure 12: Visualization of KFP Interviewees' Experience in QDM**

All the Interviewees had worked for at least one year on KFP but had had several years' experience in QDM from other projects.

### 4.7.2 Understanding about quality decision making in KFP (questions 5-7)

Interviewees were asked to define QDM and how QDM was undertaken in this project. Interviewees 1 and 3 defined QDM as the cost effectiveness of the project, optimizing benefits, considering environmental sustainability during the design and construction phase. However, Interviewees 2 and 4 defined QDM as being management of technical specifications, BoQ, Quality control plans so the project process runs well. Although all the Interviewees could define QDM, they did not agree on how QDM had been carried out. The responses from Interviewees 2 and 4 varied, possibly because they believed QDM was similar to Quality Management.

When asked what elements were considered in QDM, responses again differed. Interviewees 1, 3 and 4 stated that QDM was carried out by considering elements

such as cost, quality, time, risk factors, environmental impacts and benefits to people, operations and maintenance whereas Interviewee 2 stated QDM was considering specification and quality control planning so that the construction work programme could run smoothly. It is clear that the Interviewees considered many aspects of QDM – largely according to their area of work.

### 4.7.3 Quality decision making with regard to legislation and standards (questions 8, 24 and 25)

In answer to questions about the legislation and standards adhered to in the project, all Interviewees stated that the project used the American Association of State Highway and Transportation Officials (AASHTO) for road geometry design, pavement design, material and laboratory tests and road drainage structures. Even though there is an Afghan standard, it was not used as it does not cover all technical matters; AASHTO was therefore used as the technical standard for design and construction; however there had been difficulties complying with AASHTO, according to Interviewee 1, as it was comparatively expensive due to the broad range of factors that had to be considered (e.g. material, size of structure, construction methodology). Interviewee 2, on the other hand, stated he had not faced any difficulties, possibly because he had not been involved in QDM; however, he (Interviewee 2) stated there had been a few difficulties in KFP e.g. the technical specification did not specify local material quality. Interviewee 3 stated that the difficulties complying with the AASHTO standard were due to lack of technical resources locally; they had had to use different methods of construction practice; they had had to consider the remoteness of the site (to bring in equipment and appropriate technical labour) and the local security issues (e.g. removing mines,

being aware of Taliban presence, inappropriate assistance from locals). Interviewee 4 added that there would have been problems like side slopes of rock cut associated with huge cost and time if AASHTO had been used because AASHTO requires a higher radius with superelevation for geometric design than other standards. Although Interviewee 2 said there had been no difficulties with the technical standard (AASHTO), and the technical specification had been prepared based on AASHTO, the material properties for pavement had not directly matched.

It seems, with regard to standards, that foreign standards are not always appropriate for developing countries as they do not take into account local context and topography and climate sets and also they are associated with additional costs and time.

### 4.7.4 Quality decision making related to project budget (questions 9-11 and 13)

Interviewees were also asked about their understanding of the road infrastructure implementation process (design and construction) and how project management had been undertaken.

In answer to questions about Cost-Benefit-Analysis (CBA), all the Interviewees stated that CBA had been conducted and, in addition, Interviewees 2 and 4 stated that CBA was done at the feasibility stage and done by a transport economist; Interviewee 3 said specifically that he had carried out a CBA during the design review after award of contract but he believed that it had not been properly analysed because he had encountered issues such as inaccuracies in drainage structure design

(e.g. size, location and type) and there had been missing information in relation to the road design and construction for the topographic survey.

When asked about Analysis of Uncertainty (AU), all the Interviewees, except Interviewee 3, reported that AU had been conducted during the design and implementation process. Interviewee 3 explained that he had not conducted AU as there was 15% contingency because everything is uncertain in Afghanistan. He added that KFP had been designed in detail by the consultant (India office) in Afghanistan and they had reviewed the design for construction from central office (USA) and he had observed during review of the design that a few issues had not been properly considered such as drainage structure sizes and numbers of structures, extent of topographic survey.

Interviewee 2 added that the location was a warfront and so not properly analysed; however there had been enough contingency to mitigate any issues. Interviewee 4 provided examples of elements taken into account in the AU such as snowfall, equipment, materials, worker strikes, damage and conflict. So it can be concluded that the difference in responses as to whether AU had been undertaken or not, could have been because there had been no records or checklist about uncertainty identification and mitigation.

However, all Interviewees stated that a Checklist Procedure (CP) had been conducted but not in the design phase. Interviewee 2 stated that there had been a written CP prepared for the soil and material laboratory; this CP was developed for construction only, and had been given approval by different levels of decision making personnel;

Interviewee 3 explained that, even though CP had been prepared by him, it had not been used for this project because it had been too late to apply it to this project. So, it can be concluded that no written CP had been used during the design phase of KFP.

When asked about Context-Sensitive Design approach (CSD), Interviewee 1 stated that CSD is a user friendly approach as it considers total context like physical setting of project, culture and local issues in the design stage to maximize the benefits. Interviewee 2 said that the approach had resulted in an efficient design with regard to context of the project design. Interviewee 3 was the only Interviewee to state it had always been part of design and a Federal Highway (FH) requirement; Environmental Analysis was also carried out, he said to balance the context sensitive design. Although no documentation on CSD could be found by the researcher there may have been documentation. It seems, therefore, that, although all the Interviewees claimed that CSD had been undertaken in compliance with FH, there had been no actual checklist procedure.

### 4.7.5 Quality decision making: KFP engineering problems (question 12)

All Interviewees stated that they had faced engineering problems on the KFP. Interviewee 1 said he had encountered unpredictable hydrology like unprecedented floods, soil characteristics, different from the design, and difficulty getting proper road alignment; furthermore some social problems like relocation structure and resettlement of housing, protests from local people were also encountered. Interviewee 2 stated he had faced fixing of alignment, material selection, lack of availability of materials, six months of unfavourable conditions due to snow. Interviewee 3 mentioned some different problems e.g. lack of sufficient design

information and data, lack of competent people and lack of equipment. Interviewee 4 stated that he had encountered engineering problems like landslides, mountain debris flow, talus materials, structure wash out, rock fall, unsuitable material, alluvial fans, rock avalanche.

In relation to mitigation of engineering problems during the design and construction, Interviewees 1 and 2 said problems had been mitigated through variation orders; through budget variance, for social issues; through addressing community programs to help the local people and, finally, through changes to the structure design, e.g. size and shape were revised to accommodate the practical needs of the project. Interviewee 3 stated he had visited the site quite often, checked the plan and updated accordingly; to mitigate the technical issues experts from overseas had been hired as well as a very competent sub-contractor. Interviewee 4 stated that, during site visits and the survey and design stages, he had encountered engineering problems, and design drawings had been prepared with notes/instructions to provide guidance as to how the engineering problems could be mitigated during the construction phase.

Although some major engineering problems were cited, none of the Interviewees mentioned a checklist procedure for identification of engineering problems. So, it can be concluded that Interviewees had listed problems during site visits and during the design phase as and when they had encountered them.

### 4.7.6 Understandings of project resource management with regard to time, cost and quality (questions 14-16)

Interviewees were also asked about Project Management and quality decision making with regard to time management of KFP. Interviewee 1 said effective work plan and an appropriate technical standard had been the major elements for decision making in the project. Interviewee 2 said QDM is a very important issue for any project especially in Afghanistan as there are six months of very, very cold weather when construction work cannot be carried out. Thus, he said, all uncertainty should be determined for effective management of resources with regard to time. Interviewee 3 said clients and executive agencies do not value time as much as in the USA. In Afghanistan clients raise concerns about time but, according to him, this was only a formality. So, competent personnel and schedule were important, Interviewee 3 said, to control cost overrun. He added that, as many experts had been killed during wars, there was a loss of 20 years' expertise. That was why the project manager had to bring in experts from different countries to manage resources in order to finish on time; Interviewee 4 emphasised the importance of a good work programme, monitored on a weekly basis, to better manage KFP projects. Therefore the important elements needed to manage the KFP project with regard to schedule had been a time effective work plan, compliance with an appropriate technical standard, sound management skills , skilled resources such as field labour, operator and supervisor, along with good equipment.

In order to maintain the quality of KFP, the Interviewees reported they had used a variety of measures – increased resources (although there was a chance of misuse of resources, because of overconfidence), a quality control plan, schedule, strict

supervision, including monitoring progress (Interviewee 1). Other measures were mentioned for future projects: Interviewee 2 stated that selected resources needed to be appropriate for the project and the schedule needed to be considered so the project could be well managed; Interviewee 3 stated that a good system for checking work by qualified inspectors who were competent to select materials and other resources both in design and construction was needed. Some tools (software) can also be used in projects to manage the quality. Interviewee 4 stated there has to be experienced manpower, good condition of equipment and material, to get better quality in future projects.

When asked about the requirements for keeping to the budget of KFP, there were differing responses: synchronization of contract management, auditing, sound financial management, code of conduct /rules and regulations of clients of the project (Interviewee 1) skilled management (Interviewee 2), ensuring availability of material, staff, equipment to manage the budget (Interviewee 3) and monitoring the work program with quality material and trained workforce with good equipment (Interviewee 4). Therefore the important elements needed to manage the KFP project with regard to budget had been a time effective work plan, compliance with an appropriate contract management, sound management skills, appropriately managed ToR, skilled resources such as trained workforce with good equipment, skilled QC engineer.

### 4.7.7 Quality decision making related to contract (questions 17-19)

Interviewees were asked about contractual issues in quality decision making during the project under design and construction, particularly the standard form of contract. All the Interviewees said that, during the design of the KFP, a Federal Highway

contract (FP03) and construction contract had used both FH and FIDIC. Schedule form was already part of the contract document according to all the Interviewees except Interviewee 3 who stated that schedule form was one of the three pillars of the contract, and a large contingency of 10 to 15 percent had been included. It seems that not all the Interviewees were aware of contractual issues or the method in which the contract documents had been prepared.

With regard to producing and actioning of schedule, the results showed that the Task Order Manager (26 different projects were implemented under Afghanistan Infrastructure Rehabilitation Program, each project called a Task and each Task had a Manager; all managers finally reported to the Sector Lead. There were two sectors: Power and Road; each Sector Lead reported to the Chief of Party). Interviewees 1, 2 and 4 said that the Manager had been responsible for producing and actioning the schedule; Interviewee 3 added that he had verified the schedule after the Manager had produced the schedule.

### 4.7.8 Quality decision making in relation to project management (question 20)

When asked about the estimating, planning components of the contract monitored after construction work had started, Interviewee 1 stated that the consultant, with offices both in the field and in Kabul, had monitored the work through each stage - process design, planning, construction; after award of contract, the factors monitored had been based on estimated items and quantities, according to Interviewee 2; the BoQ had been developed during the design and construction stages – if there was any change for a BoQ item less than 15% from the original estimate, the unit rate

remained at the same rate and if more than 15%, the rate changed (Interviewee 3). Interviewee 4 stated that, at the beginning of construction, the Design department had reviewed the contract design in relation to field conditions and had revised the design as required; every month there had been a progress meeting and details of any shortages of construction material and equipment with explanations for the delay and what action had been taken and would be taken, were provided; any security issues (bearing in mind Afghanistan was in a war zone and mine explosion issues were a constant reminder of that) and weather conditions had also been reported.

So, it can be concluded that Interviewees had monitored the planning components and BoQ through a work plan, monthly progress meeting among client, consultants and contractor, and had carried out variations as per the conditions of the contract when required.

According to Interviewees 1, 3 and 4 there had been deviations concerning hydraulic and hydrological data and hydraulic structure design - a significant number of culverts had needed to be added or resized, road side drainage structures had needed to be added and a number of proposed bridges had had to be reduced and replaced by culverts (the design had proposed 24 bridges and after review it had been considered only eight were required with the remaining ones being replaced by culverts); rock blasting, rock draping. There had also been deviations for road alignment to accommodate the local conditions due to alluvial fan, debris, as well as alignment passes as attempts to keep fans from mounting but they had been futile. Interview 2 stated there also had been deviations in pavement materials and equipment to make them appropriate for site conditions.

So, it can be concluded from the Interviewees' responses that, after award of the contract, the contractor had established BoQ, had finalized project costs related to BoQ, had prepared a work program as per contract with resources (manpower, material, equipment) and had called a monthly progress meeting to monitor shortage of resources, time delays and make recommendations. There had been 15% variation adjustment as per contract clause/sub clause.

### 4.7.9 Decision making in relation to environmental issues (question 21)

Each Interviewee stated that an Environmental Management Plan (EMP) had been included in the contract and had been followed during construction. The river was an important element of the EMP. Interviewees 2, 3 and 4 all stated that the river course could not be interrupted (e.g. by disposing of rock). Interviewee 1 said environmental issues (water pollution, air pollution, dust) had been monitored and environmental safeguards had been followed e.g. rock blasting material or haulages were not disposed of or dumped haphazardly on river banks, only at allowed road edges with little impact on the environment.

When asked about how the contract had been adhered to, Interviewees 1, 2, 4 said they did not know how parts of the plan had been implemented.

So, it can be concluded from these results that no major issues had been revealed except the environmental issues surrounding the river banks; however, there seems to

have been no proper environmental assessment, identification or checklist for environmental issues.

### 4.7.10 Quality decision making in relation to resource management (questions 22-23)

When asked about human resource management, Interviewee 1 said the consultant had had HR management for the project and his subcontractor had hired labour and equipment locally; all these activities (road design, construction, investigation, security) had been maintained or monitored by the consultant. Interviewee 2 said there had been a monthly progress report including information on material, labour, condition of equipment and any shortages. Interviewee 3 said a schedule had been prepared and included information on staff, labour, machinery costs by contractor; this schedule had been followed. Interviewee 4 said that the material engineer had monitored the material and equipment issues every week and every month at the progress meeting and had submitted material and equipment and labour details such as condition of equipment, availability, shortages.

Every two weeks from the start of the project, the Interviewees stated, they had monitored the resources through progress meetings with progress reports including condition of the equipment, stake down equipment and major equipment such as crasher, batching, asphalt, concrete mix plant.

However, the Interviewee from Bangladesh added that, although resources had always been available, they had not been properly managed or had been misused. All the Interviewees stated that HR and material/equipment had been part of the

contract, but they had no knowledge of any further details. Hence they had no knowledge of Condition of Contract part 3 which referred to the general conditions of contracts, particular conditions of contracts and contract form.

### 4.7.11 Quality decision making in relation to risks (questions 26-28)

Interviewees were also asked about their understanding of risk and how risks had been mitigated during design and construction and how they had conducted QDM with regard to risk. Firstly Interviewees included the following elements in Decision Making focussing on risks - uncertainty of project, risk can be technical, political, social with regard to cost, delay project, cost overrun (Interviewee 1); climate, timeframe, conflict (Interviewee 2); the probability of unknown elements e.g. geological (granite, slate, limestone), security, utility, geology (Interviewee 3); probability of uncertainty for anything (Interviewee 4). About risks identification, all the Interviewees stated that risks (e.g. flash flood) had been considered during the design phase. Interviewee 4 added that he had undertaken field visits, had taken photos and videos and had consequently assessed the risk factors e.g. where rock fall needed blasting. None of the Interviewees mentioned a check list procedure for risk identification.

With regard to mitigation of risks, all Interviewees stated they had redesigned, rescheduled, resurveyed, realigned the road and carried out other variations as required; these, of course, caused time delay and cost increases. Interviewee 3 said security risks had been minimal compared with other areas in Afghanistan and Interviewee 4 said that, during design, risk issues had been added into the report and/

or into design drawings. Again it seems there was a lack of written checklist procedure and no mention was made about a Road Safety Audit (RSA).

### 4.7.12 LCCA (question 29)

Life Cycle Cost Analysis (LCCA) was not considered for the KFP. According to the Interviewees this was because there was no historical data in Afghanistan to enable an LCCA to be carried out; in addition, many experts and engineers who had expertise in pavement construction, maintenance, rehabilitation with data records including having knowledge of LCCA had been killed during past wars and because of inflation it was not the right time to conduct LCCA.

### 4.7.13 Quality decision making in regional planning (question 30)

In order to understand how Interviewees had determined the most efficient placement of infrastructure and zoning for the sustainable growth of a region (environmentally, socially and economically), they were also asked about the Regional Development Plan. Interviewees 1, 2, 3, and 4 responded that the Ministry of Public Works Afghanistan (MoPW) had stated that, as KFP was a National road, National road criteria ought to be followed; Afghanistan has only one standard plan (and no regional plans) although the country has 34 provinces. Interviewee 3 added that the standard Plan had been initiated by the Afghan Government to provide access to rural areas. Although initially a dirt road in the centre of Badakhshan, it was finally designed as a national road network to connect Fayzabad, one of the reasons being that Badakhshan had the highest maternal mortality rate before development of KFP. The construction of the road cut travelling time from 8 to 1.5 hours.

### 4.7.14 VM/VE (questions 31-34)

Interviewees were also asked for definitions of VM/VE; Interviewees 1, 3 and 4 defined VM/VE as an independent review in order to develop an alternative way to do the same activity; all Interviewees stated, apart from Interviewee 2 (who had no knowledge of VM/VE) that VM/VE had been used at the design stage.

Interviewees were also asked if VM/VE had been used as part of the management decision making process; Interviewees 1 and 2 both stated that they did not know if it had been used; however, Interviewees 3 and 4 articulated that they had used it with approval from different levels of top management and from the client as well. With regard to recommendations for future management decision making for future projects, Interviewee 1 said future decision making should be based on value engineering, CBA, LCCA and should also follow context sensitive procedure, stakeholder participation, and other programs in infrastructure design and construction so that there would be fewer issues with regard to cost, quality and schedule. Interviewee 2 said that the lessons learnt (such as uncertainty, material scarcity, and security) during design and construction in KFP in Afghanistan could be applied to future projects in order to better manage them. Interviewee 3 stated that organizations should ensure all information is collected during the design stage (geological: granite, slate, limestone; hydraulic: catchment, discharge, slope; topographic: permanent features, religious structures and material, equipment, expert technical staff availability); he added that a survey and investigation for infrastructure should be conducted since there is no GIS or Geological survey maps to help select the most appropriate route; security should be considered also. Interviewee 4 stated CBR, LCCA, AU, context sensitive procedure, Checklist and

stakeholder participation should also be considered. Time, he added, should be considered, too, even though this is difficult due to security problems and snow falls.

The results from the ***Afghanistan project*** show that lack of consideration had been given to risks identification and mitigation; engineering problems had not been properly identified and mitigated during the design stage and a new set of engineering drawings had had to be prepared during the design review stage; overlooked during the design stage had been appropriate investigation of hydraulic structures and management of environmental issues.

## 4.8 Second Stage of Action Research

As a result of the data received from the Interviewees, a set of Guidelines was developed (see Figure 13). As the second part of this Action Research, feedback on these Guidelines was sought from the Interviewees.

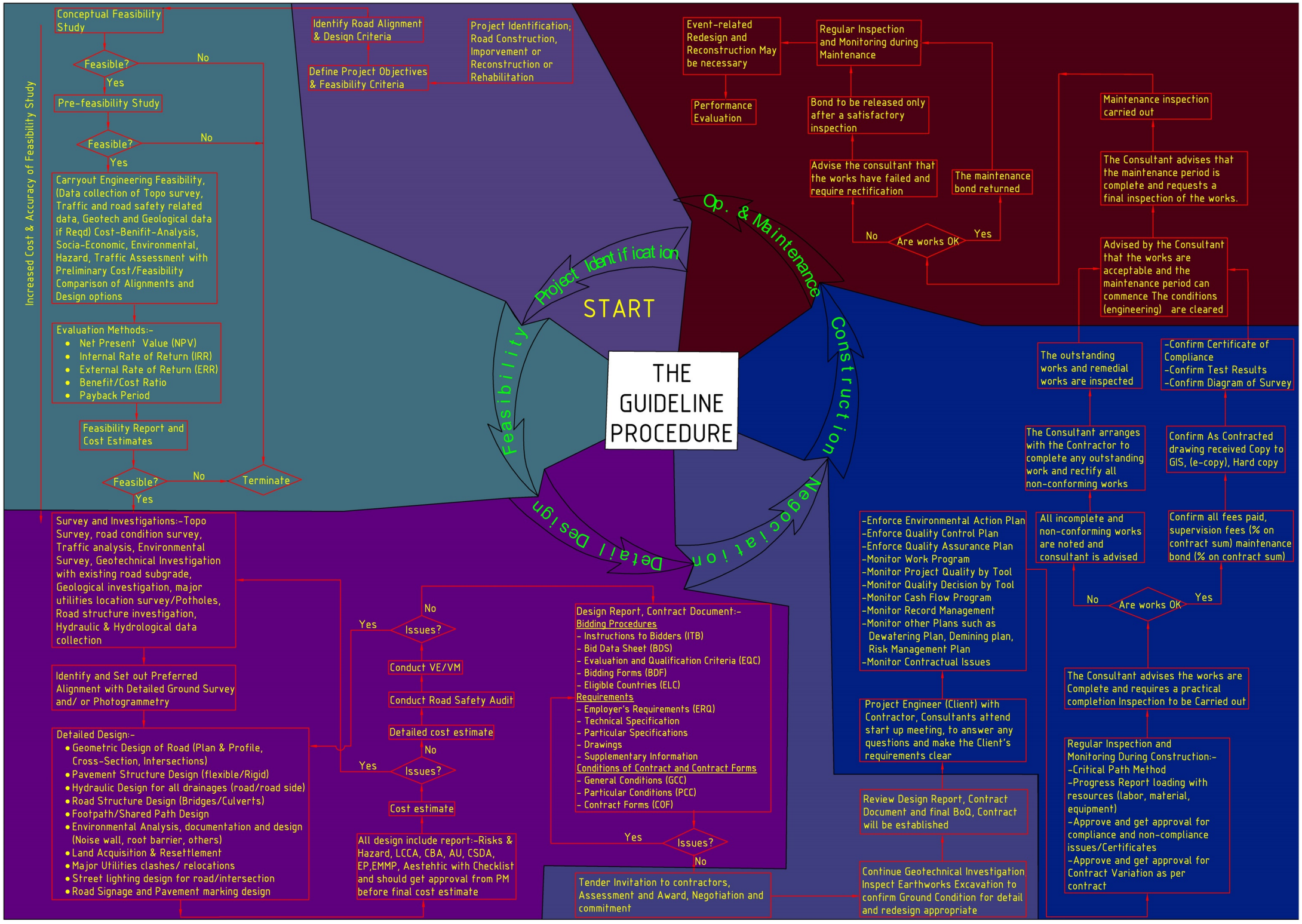


**Figure 13: The Guideline Procedure (before interview)**

## 4.9 Second Stage Analysis – Bangladesh

This section presents the responses from the Bangladeshi Interviewees after viewing the developed guidelines.

### 4.9.1 Project identification (Bangladesh)

No Interviewees made any comment for this stage.

### 4.9.2 Feasibility (Bangladesh)

Interviewee 1 suggested that, in order to provide more essential details for the practitioner, **feasibility documents should be verified and adopted.**

Interviewee 2 stated that a **Topographic Survey, Traffic Count with crash data and Geotechnical Investigation should be carried out at the feasibility stage.**

### 4.9.3 Detailed design and bidding document (Bangladesh)

Interviewee 1 also emphasised that **Value Engineering/ Value Management** will definitely add benefit by finding a cost effective engineering design; the Designer should be proactive selecting the design approach/ standards/ principles of the design works according to ToR. In addition, value management could be looked at after completion of bidding documents.

Interviewee 4 suggested the Design phase heading should be **Detailed design and bidding document;** he pointed out that the design review and final BOQ are part of the tender document. So, the confirmatory geo-tech investigations can be included in

BOQ, which can be done during execution of the work and necessary design modifications resulting from these investigations can also be done at that stage.

### 4.9.4 Tendering and Award of contract (Bangladesh)

Interviewee 1 suggested that in the Tender Process- '**Specific Procurement Notice (SPN)' could be included.**

Interviewee 3 stated that a Pre-bid meeting could be held at the Tendering and Construction phase; since as many misconceptions can become apparent at that stage among bidders, client, contractor and consultant.

Interviewee 3 suggested that a Performance Bank Guarantee at the Tender stage be verified when awarding Bid and contract agreement.

Interviewee 4 suggested the phase heading should be **Tendering and Award of contract** instead of negotiation since the flow chart had 'continue confirmatory investigations for detail and redesign' and 'review of design report, contract document and final BOQ' and 'contract will be established', he (Interviewee 4) suggested that it shall be better to term "tendering and Award of contract' in place of negotiation,

### 4.9.5 Construction (Bangladesh)

Interviewee 3 suggested Bar Chart, S-Curve, CPM, equipment and manpower mobilization including supply plan of construction materials and Cash flow chart should be part of construction work; Interviewee 3 also suggested EMP Approval

and Periodic Monitoring be adopted as works approval by RFI and field measurement procedure are important elements of this flow chart.

### 4.9.6 Operation and Maintenance (Bangladesh)

No Interviewees made any comment for this stage.

## 4.10 Second Stage Analysis – Afghanistan

This section presents the responses from the Afghanistan Interviewees.

### 4.10.1 Project Identification (Afghanistan)

Interviewee 2 said that he had studied the whole guideline and did not have anything further to contribute. He was happy with it as it was.

### 4.10.2 Feasibility (Afghanistan)

When Interviewees were asked to comment on the proposed guideline procedure with regard to Feasibility stage Interviewee 1 commented that sometimes a project is not feasible but due to the strategic importance of the government or agency the project is taken up for implementation. This, he believed, occurred more often in developing countries because of political pressure. He, therefore, requested that this kind of **uncertainty in selection should be reflected in the chart.**

Interviewee 4 said that IRR is important. The client can decide whether this project is feasible or not on the basis of IRR. Cost benefit is also important. If project is costly, he added, there is no benefit; then the project will not be feasible. So, IRR and Cost benefit ratio are important, and should be included in the Guidelines.

### 4.10.3 Detail design and bidding document (Afghanistan)

Interviewee 4 commented on the Design phase; he suggested consideration of Risk and Hazard, LCCA, CBA, AU, CSDA, EP, EMMP and checklist. His reasoning was that these tools are necessary for successful completion of the project. He also requested consideration be given to a Checklist procedure as it is important for quality work.

### 4.10.4 Tendering and award of contract (Afghanistan)

No Interviewees made any comment for this stage.

### 4.10.5 Construction (Afghanistan)

No Interviewees made any comment for this stage.

### 4.10.6 Operation and maintenance (Afghanistan)

No Interviewees made any comment for this stage.

In conclusion this second stage of the Action Research presented the feedback from the four Interviewees with regard to the researcher-developed set of Guidelines.

## 4.11 Conclusion

This chapter presented the results and analysis of the responses gathered in both stage one and stage two of this Action Research. The main findings are that there was a lack of consideration revealed during the execution and design of both projects of Quality Decision Making; there were difficulties complying with technical

standards, a lack of a system to determine accuracy and safety on the project and a lack of identification and mitigation of Engineering Problems in SRNDP and KFP. In addition, there was a lack of monitoring of environmental issues and documentation, identification and mitigation of risk, CP, AU, LCCA in QDM, VM/VE.

In the next chapter, a discussion of the results and their implications are presented.

# DISCUSSION

## 5.1 Introduction

This chapter firstly discusses the implications of the results of the first stage of this study which was designed to examine quality management decision-making for two projects, one in Bangladesh and another in Afghanistan; specifically the study was set-up to examine quality decision-making for road design and construction projects in rough terrain and inclement environments. This chapter secondly discusses the implications from the second, iterative stage – incorporation of additional, validity feedback after the guidelines had been developed.

## 5.2 Discussion about Bangladesh issues

### 5.2.1 Effect of lack of employee understanding of quality decision-making

Quality decision-making can have a serious impact on people in the community where a project takes place. Therefore, it is important that infrastructure industries have policies and procedures to support and inform fair, sound and consistent decision-making.

Interview questions in the first quarter of this study were posed to determine the QDM in road infrastructure design and construction in a Bangladeshi project. Responses from Interviewees showed that most of the staff understood the concept of Quality Decision Making (QDM) and QDM appropriate to their level.

However, there was some lack of understanding of the impacts of some of their decisions. The study showed, for example, that there was a lack of consideration given to alternative routes/diversion routes that would normally be required during construction. As a result, there were significant impacts [previously exemplified by a bridge collapse that could not handle the additional capacity required for the highway being re-constructed (see Figure 9, chapter one)].

Figure 14: Underpass construction (Km 16+545, SRNDP overlooked at the design stage. Source: SRNDP project folder (May 2005)

Another fact that was revealed in this case-study was that Value-Engineering was not implemented (until *after* construction had commenced); this led subsequently to a design scope change, increased costs and time. In addition, the study showed that the specification was allowed to change during construction as the materials could not be found in the areas designated and therefore had to be brought in from borrow-pits, 1.5 km away from the location by dredging, resulting again in increased costs and time. It was shown, too, that on-site resources were re-distributed when an unforeseen problem arose; namely cross-roads at the bridge approach and at a grade intersection that had been designed but, during construction was found not at level, necessitating construction of a wide culvert underpass as shown in Figure 14 above.

This type of design scope change was compounded by situations leading to an increase in project costs (according to the Interviewees) by a lack of *monitoring* at the design and construction stages despite periodic Progress-*Reports*; requiring critical paths work-flows adjustments well after occurrences and well beyond *'reasonable'* timely mitigation measures.

### 5.2.2 Effect of compliance with foreign technical standards

International technical standards may be used either directly or by a process of explicitly (in the contract documents) modifying a foreign standard to suit local conditions. In the case of the Bangladeshi project, AASHTO was considered as the technical standard for the geometry design, pavement design and laboratory tests; however, (local ambiguities with the American standards resulted in) problems encountered such as inconsistencies in the properties of *local* material with the (US) standard, scarcity of material and other climatic, geographical, technological issues; therefore, '*other*' technical standards were deemed more appropriate and used, such as TRRL, ASTM, BS, ACI, IRC, BNBC and this lack of uniformity led to significant impacts. Some materials, according to some standards, required to be sourced from diverse locations causing increases in costs, compounded by variations in staff-skill dictated by *different* standards' training needs. Hiring staff who *did* have the requisite skill-sets, from other locations/countries, resulted in increased costs; moreover there was a time element when staff were not immediately available. In essence, the study revealed that the mix-and-match approach with staff members not necessarily having the knowledge/expertise across *all* the (plethora of) standards being applied, increased project time as each standard had a different time allowance/compliance factor for respective stages.

In addition, some of the construction materials, such as local brick and brick chips, were used; as the (locally available and used) brick had not complied with any foreign standard (AASHTO) with regard to pavement construction material, decision-makers adopted in-turn *local* RHD standards and sought material compliances with these RHD standards to supplement the *other* standards adopted (Figures 15 and 16 illustrate decisions-made by stakeholders to use brick chips as pavement materials proved excessively timeous.)


**Figure 15:** Local brick chips stake yard used for pavement structure as lower base at Cont 3 in SRNDP. Source: SRNDP project folder (June 2004)

**Figure 16:** Local brick chips used for pavement structure as lower base at Cont 3 in SRNDP. Source: SRNDP project folder (June 2004)

Even though there has been development of national Bangladeshi standards along the line of the international standards, the national standards had not been fully adopted by this project because of the current perceived ambiguities related to technical content; governmental regulations or industry-specific requirements caused by fundamental climatic, geographical, technological factors.

In addition there are implications with regard to the technical barriers that can arise when different (internationally diverse/qualified) groups seek to apply their (internationally perceived interpretations and) differing knowledge of standards come together to work on a major road construction project; namely it was found that negative impacts occurred as a result of instances where: staff have different skill sets, staff require more time to familiarise themselves with different technical standards, technical-language barriers (different standards using different terminology) and procedures are different for the same items of design and construction work.

### 5.2.3 Effect of lack of CBA, AU, CP, CSD on the budget and safety of the project

Infrastructure projects have increased rapidly in recent years, especially over the last decade. Infrastructure decision-making based on rigorous cost–benefit is (typically) required to ensure the highest economic and social benefits to a nation over the long term and to ensure transparency at all stages of the decision making process within companies. This study showed that there was, in this Bangladeshi project, no alternative analysis; no CBA analysis undertaken prior to the detail design stage to justify go-ahead relative to other options. Since an appropriate alternative alignment study with CBA had not been undertaken, the bridges approaches had to be realigned during construction as they had been washed away by a high tide (in lieu of dam/infrastructure &/or water retention as a pre-cursor to the go-ahead to the road); this led to increased project cost and time delay to mitigate such scoping changes.

**Figure 17:** Washout of newly constructed guide banks (Arial Khan Bridge) at Contract-3 in SRNDP

*source: photo folders during construction phase (June 2004)*

Typically local-authority development planning legislation requires C/B analysis to be undertaken to determine the benefits for the local economy and environment; the findings from SRNDP showed that no CBA had been undertaken; therefore, the project could not ensure that it had achieved its objectives e.g. the most economic and safe roadway that necessarily complements the full range of existing and planned infrastructure projects and adds value collectively to regional development. Precedent exists internationally for this type of study prior to go-ahead. A Cost-benefit analysis is included in European projects as it is a useful instrument aiding decision making on investments in road safety. A study carried out by SWOV, The Institute for Road Safety Research, Netherlands, (December 2011) showed that in European projects, C/BAs have been used for various separate measures in Road (Safety) Audits, such as:

- Specific measures for vulnerable road users (TRL, 2001).
- Intelligent vehicle systems (Baum et al., 2008);
- As well as: Measures against driving under the influence of drugs (Veisten et al., 2011); Measures against drunk driving; An eye test when the driver's

licence is renewed (Vlakveld et al., 2005); Extra police enforcement for speed, alcohol and seat belts (Elvik, 2001);

Essentially, Cost Benefit Analysis (CBA) has been considered a principle methodology in supporting decision-making in bridges and road go-ahead as a fore-runner to quality management across the majority of international infrastructure projects (Zavadskas, Liias, Turskis 2008).

However, in SRNDP, proper QDM had not been done in relation to a necessary compliment to an overall regional C/B-analysis.

Uncertainty analysis (AU) investigates the uncertainty of variables that are used in decision-making problems in which observations and models represent the knowledge base. The responses of the Interviewees as to whether or not AU had been undertaken on this project depended upon subjective perception of the definition of uncertainty analysis. It may be that past experiences were evoked to consider uncertainties (and in many cases aligned to perceived risk and technical mitigation of such) but not properly. As a result, there were significant impacts from not analysing the uncertainty.

Many changes took place between the design and construction phases and estimated cost was higher than the estimated contract price as a result of the changes. Due to the time difference of 2 to 3 years between the design and the construction phases, the topography had changed leading to the necessity to re-design and consider additional structures (in one case the discovery of recent graveyards).

It was shown from the study also that climate issues were difficult to predict although a issues relating to expected climatic-variation such as the seasons were considered. Because of the long delays, the costs (to address topography changes over the lag time between design & geotech survey and construction) rose higher than estimated. As mentioned above, 'borrow-pits' for construction material were found not to be in the allocated areas; this led to increased costs as materials had to be brought from another areas. Also, (again as alluded to above) because of the long (lead-time/lag-time) delays, the stakeholder/practitioner-experts nominated for the construction phase of the project relinquished their positions to take up other positions elsewhere. Finding other experts at the construction phase took extra time and delayed the project progress and increased costs.

Social and political problems made explicit in Bangladesh by localised and national '***hartals***' (designated days when no traffic or activity is allowed in the area as a result of labour strikes or collective actions) delayed project progress too. Results showed that there was lack of communication between government agencies (Agricultural Department, Resettlement Department, the Water Development Board, Environment and Roads and Highways), causing delays in land acquisition. This implicitly lead to contract variation, construction delay, inconsistencies, e.g. a hazard may not be re-located, and subsequently increases in (potential) land values.

Inadequate consideration of the uncertainties embodied in the technical methods considered initially for the embankment construction, led to settling of the embankment necessitating (re)monitoring of the settlement (differential settlement) which had not been previously factored in.

Similar findings were revealed from an *uncertainties-analysis* point of view that traffic demand, land price, and highway deterioration, as well as their interdependence were important for decision making in (typical international) highway development, operation, expansion, and rehabilitation (Tseng 2004). In addition, uncertainty analysis was found to be an essential component of decision making for Project Management (Liberator (2013). Indeed Schraagen and Ven (2008) and the National Research Council (2001) both have recommended the importance of having a focus on uncertainty and unreliability associated with incoming information.

Another important procedure for project management is the *Checklist Procedure*. *Checklist Procedure (CP*) is an important tool in project management. The checklist provides the project manager/leader with guidance on *what* to take into account, to support the sustainability of the projects. A checklist is a type of informational job aid used to reduce failure by compensating for potential limits of human memory and attention. It helps to ensure consistency and completeness in carrying out a task. Responses from Interviewees showed there were few checklists used in the construction stage and one Interviewee stated that they followed procedure to complete the project *without* any recorded checklist. The study showed, generally, that there was a lack of consideration given to Checklist Procedure; this had resulted in significant impacts. Again it was not clear whether all matters pertaining to the project had been appropriately incorporated or considered, and there were also many changes in design during the design review, specification and variation of contract,

increasing cost and time delay. Not using CP implies that there was not full compliance with the quality assurance or quality control process.

Once again precedence for international projects suggest that Checklists were found to be one of the important analytical tools for Total Quality Management (TQM) in the study by Kaluzny, McLaughlin and Simpson (1992), towards construction quality systems. Some elements had been checked; nevertheless the CP did not seem to be fully comprehensive.

Yet another procedure that can be utilised in the design phase of projects is *Context Sensitive Design (CSD*); this is an approach that provides the flexibility to encourage independent designs tailored to particular situations. *CSD* seeks to produce a design that combines good engineering practice in harmony with the natural and built environment, and meets the required constraints and parameters for the project. To quote the US Federal Highway Administration (FHWA, undated), a major agency of the U.S. Department of Transportation, *Context Sensitive Design* asks questions about the necessity and reason of the transportation project, and then in the same way discourses safety, mobility and the preservation of scenic, aesthetic, historic, environmental, and other community values. Context Sensitive Design encompasses a collaborative, interdisciplinary methodology in which citizens are part of the design team. Responses from Interviewees were that CSD as such was not used but they recognised it as best-practice for future local infrastructure development. It might be argued that the consequences of not using CSD were significant: there was loss of consistency of design (a safety issue), which could possibly lead to reduction in the life of infrastructure, possible increases in whole of life costs (e.g. maintenance cost, vehicle operating costs), increases in capital costs; without CSD, the design, too,

would not be able to be based on significant crash history at particular locations – risk factors would therefore not be discovered and would affect the construction phase. In addition, cost effective design could not be ensured as they followed merely procedural standards; in addition designers were not fully informed and could only design based on their own experience. Physical manifestation found that there was an increase in risks and safety issues, since the bridge approaches changed during construction, meaning tying had to be done with a freshly built road adding a sharp curve just after the bridge.

Although outcomes were different, the *Context sensitive approaches* were considered by Goff (2011) to be a principal part of decision making in various contexts on major sub-Saharan highways, water purification plants and tall buildings (Goff, 2011); similarly Context sensitive approaches were considered as principal elements for decision-making by Ralf, John and Rodney (2012) to maximize strategic value on mega projects in the oil and gas industry and to determine the risk for long term value creation in mega projects.

### 5.2.4 Effect of lack of identification and mitigation of engineering problem in project

Engineering problems were discussed at length (alongside the somewhat unstructured approach to respective technical mitigation) by the interviewees during the interview session highlighting, for example, the need to mitigate soft soil and

settlement due to soft soil, using geo-grids and the like as illustrated in Fig18 & 19.

**Figure 18:** Installing Geo-grid due to soft soil during embankment construction at Contract-3 in SRNDP, Source: SRNDP project folder (January 2004)

Although some major engineering problems were cited, none of the Interviewees knew of a checklist procedure for identification of *engineering problems*; as a result, during construction, Interviewees found that they needed to check the differential settlement issue for first layer for 1 year with preloading and the rate of settlement; due to the settlement issue the asphalt surface had to be changed to Double Bituminous Surface Treatment (DBST); the schedule also needed to be changed to incorporate checks in 5 years' time. The case-study showed that there was a lack of consideration given to engineering problems that would normally be required during the design phase e.g. the impact of heavy vehicles being diverted to detour because there had been no proper river modelling. There were other significant impacts; as engineering problems had not been identified, the proposed Bridge (Arial Khan Bridge) approaches had to be realigned during the construction phase thus increasing project cost and time delay. As mentioned the borrow pits had not been accurately identified thus necessitating the use of dredged material from the river 1.5 km away from the site. Again this added to costs and time.

As the capacity of the existing bridge had not been properly assessed it collapsed as seen in Figure 20 below. The new bridge (Arial Khan Bridge) had to tie with the newly constructed alignment, so a sharp curve just after the bridge had to be added; this increased the risks and safety issues of using this road.

It was shown, too, that the Specification had to be changed as the construction materials were not soucred from the immediate vacinity. This situation, according to the Interviewees, was a result of lack of awareness of Value Engineering at the design stage. However, at the construction stage, the principal engineer agreed and gave consent to the Construction Manager to *retrospectively* carry out a (Main contractor instigated) VE; this resulted in increasing the project costs, not allowing for potential savings. This led to contract variation and thus construction delay. In addition, because of the changes, which could not be aligned with AASHTO (as a current rehabilitation project by the government also did not align with AASHTO), and the doubling up of some construction activities (e.g. Client, RHD, was building major/minor culverts and some road side structures on the alignment of SRNDP) the allocation of funds was uncertain due to different funds during SRNDP design stage. Different funding was being used by the same client for the same road section; one amount of funding was for implementation of existing section of the road and the other amount of funding was for fully new design and construction. Since the Client, RHD, had not designed the alignment, few of the structures had been considered in the SRNDP. Therefore, unnecessary drainage structures, kinks in alignment and unusual horizontal and vertical curves had been constructed which finally increased cost and time and inconsistencies with the alignment geometry standard.

A major issue was that the construction alignment did not match with the proposed design due to the coordinates and control points not matching with the contract plan; the control points had shifted a few meters on each side, so a few sections of road had to be redesigned and this again led to increased cost and time.

Even though the consultants had established a Bench Mark (BM) every 3 km, during construction it was observed that periodic BMs were missing, and those which were there did not match the supplied coordinates; according to the Interviewees this had occurred because the surveyor had not carried out a (commonly expected) closed traverse and hence during construction had found survey errors which had led to resurveying and readjustment increasing time and cost.

**Figure 19:** Road embankment failure due to soft soil at Cont 5 in SRNDP. Source: SRNDP project folder (February 2005)

**Figure 20:** Bridge collapse due to improper selection of diversion road at Cont 2 in SRNDP. Source: SRNDP project folder (May 2003)

Figure 19 above shows the embankment settlement due to soft soil during construction; Figure 20 above shows the existing bridge collapse because of the lack of identification of engineering problems with knock-on increased costs and time.

### 5.2.5 Effect of lack of resources management on project with regard to time, quality and budget

As a prelude to this sub-chapter's primary results discussion, it is deemed worthwhile to re-establish the importance of quality cost and time in the construction industry in general as a pre-cursor to subsequent discussion of case-study analysis. Thus it can be argued that internationally the clients of the construction industry are primarily concerned with quality, time and cost and yet the majority of construction projects are procured on the basis of only two of these parameters, namely time and cost (Bennett and Grice, 1990). This is understandable, since the majority of project management control systems highlight time and cost, and overlook the relative importance of quality (Hughes and Williams, 1991). It is argued by Herbsman and Ellis (1991) that the major failings in traditional approaches to project delivery have been extensive delays in the planned schedules, cost overruns, serious problems in quality, and an increase in the number of claims and litigation associated with construction projects. In order to plan and manage a successful project, the three parameters of time, cost and quality should be considered. Hughes and Williams (1991), in arguing for the consideration of these three factors in attaining the client's objectives, propose that these factors are the three points of a triangle and that neglecting one factor will have a corresponding detrimental effect upon the other two. In support of this, Lansley (1993) argued strongly for the importance of studying the behavioral aspects of management in attempting to address the problems facing the construction industry, i.e. that it is the issue of the 'human factor' involved in construction projects that needs to be addressed. Rwelamila and Hall (1995) further argue that little evidence exists of projects where these three factors have been balanced and there is a need to embrace time, cost and quality management.

One of the purposes of this study was to explore how time, cost and quality management on road construction projects in Bangladesh are perceived by those involved in project teams. The concept of managing construction projects is deeply embedded in the *traditional* construction procurement system. Ireland (1983) links with Rwelamila above and argues that time, cost and quality are the principal feasible objectives of the client in any construction project. The implications for time, cost and quality are now discussed in relation to SRNDP.

**Time:** Timely completion of a construction project is frequently seen as a major criterion of project success by clients, contractors and consultants alike. Newcombe et al. (1990) noted that there has been universal criticism of the failure of the construction industry to deliver projects in a timely way. NEDO (1983) stated that a disciplined management effort is needed to complete a construction project on time, and that this concerted management effort will help to control both costs and quality. This is tantamount to saying that the client's objectives can be achieved through a management effort that recognizes the interdependence of time, cost and quality.

This study showed that there was a lack of consideration given to time with regard to resources that would normally be required during design and construction. As a result, there were significant impacts such as inappropriate measures to mitigate prolonged weather such as cyclone, typhoon, flash flood, which caused delay and increased costs in relation to staff and appropriate resources and equipment, alongside as mentioned previously the other social and political problems such as 'hartals' – that delayed project progress.

Furthermore, the use of labour (traditionally used in this region for what might be called heavy-squad substructure activities) rather than plant and equipment caused further delays and contract variations as the time scale was not planned to accommodate the increase in (or extensive use of) labour. Another impact involved quality as the labour could not match equipment for certain tasks e.g. concreting. It was also difficult to manage the quality because the man hours had been fixed but due to the contract extension; when new staff were hired they needed time to adjust to the project.

**Cost:** Clients have been increasingly concerned with the overall profitability of projects and the accountability of projects generally. Cost overruns, in association with project delays, are frequently identified as one of the principal factors leading to the high cost of construction (Charles and Andrew 1990). Research to date has tended to focus on the technical aspects of managing costs on construction projects in the attainment of client objectives. There was little evidence found for the consideration of organizational, social and political problems in order that the project team could meet the client's needs in terms of cost (Hendrickson and Au 1989). However, in SRNDP there were many impacts relating to this lack of consideration for cost with regard to resources. Another consequence of hiring more labour rather than equipment was contract variation as proper costing had not been carried out with regard to such resources (and the weighting towards labour rather than machine). This in turn had led to considerable delays exemplified by a dependency on the country-specific resource of labour, leading to impact as a result of increased costs due to improper planning stage estimation of costs/and method times.

### 5.2.6 Effect of lack of understanding of contractual issues and documentation in project

The contract document is one of the most important documents for execution of a successful construction project. There are several types of construction contracts used in the industry. Construction contract types define the disbursement to be made and other specific terms, like duration, quality, and specifications. Procurement and contract records are important because they serve as an audit trail of how the process was carried out. However, from the Interviewees' responses it appeared that the value engineering attempts *during construction phase* rather than assist with progression simply lead to contact variation dispute claims, despite agreed Sub clauses in the (FIDIC 13.2) standard form of contract that: the contractor may, at the time, submit to the Engineer a written proposal which (in the contractor's opinion) will, if adopted, (i) accelerate the completion, (ii) reduce the cost to the Employer of executing, maintaining or operating the works (iii) improve the efficiency of value the Employer of the completed works or (iv) otherwise be of benefit to the Employer. Theoretically such proposals shall be prepared at the cost of the contractor and shall include the items in Sub-clause 13.3 [Variation Procedure]. The contractor found some major issues during road construction that had not been properly designed; these led to increased project costs associated with time.

In addition, there was a considerable time gap between design and construction of SRNDP project; on the other hand, price escalation should be considered in contract as per FIDIC 13.7. However, SRNDP time gaps were greater than the contract, so there was a problem, compounded by the fact that there was Interviewee perception of contract inclusions for HR, environmental issues, and resources where all

Interviewees replied that FIDIC Sub clause 1.5 Priority of Documents include (i) schedules and any other documents forming part of the contract and schedule means the documents entitled schedules, completed by the contractor and submitted with the letter of Tender, as included in the contract; such a document may include the Bill of quantities, data, lists and schedule of rates/prices. Due to inexperience with Contract documents, there were changes to contract clauses which resulted in increased costs and time.

Furthermore, material property and selection did not match with contract specification; this led to increased costs as the technical specification was changed and the contractor would have used current market prices. A case in point was the cross road at the proposed bridge approach in which the designer had designed it as a grade intersection but, during construction, Interviewees found it was not at a level crossing and they had to construct an underpass at the bridge approach with additional structure, resulting in contract variation. Also during construction, after award of the project, a bypass road had had to be made - 9.7 km going through marshy land, with water body and soft ground with organic soil. Another problem was that, during design where borrow pits in field were shown, they were actually organic pits; dredged material from river 1.5 km away from site had to be used.

In addition to (mis)estimated earth quantities during the design stage (resulting in contract variation), the Project needed to reinstate bridges and make alternative detours, resulting again in additional work, slips in time scheduling and increased cost despite the fact that Interviewees mentioned that they checked settlements

periodically across the three year design to construction stages to create alternative embankments

It can be concluded in this case that engineers' estimates were not correct during the design stage, making it very difficult to produce a good contract execution and indeed time blow-outs increased contract prices and stemmed from a lack of management skills, lack of employee skills, an Interviews' perception of a lack of integrity among some consultants that also impacted on the contract document and changed the bill of quantities, thus adding cost and time. Issues identified previously by Aliza (2012), who argued that the contractual issues such as conflict of interest, bid shopping, collusive tendering, bid cutting, dishonesty and the payment biases have been challenges for Ethical Decision Making (EDM) for Project Management in many international public sector projects.

### 5.2.7 Effect of lack of risk identification and mitigation in project

A hazard is defined as 'any feature that could cause significant personal injury' that is otherwise operated in an appropriate manner and in accordance with warnings or advisory information (New York Design Manual Chapter 10, 2003). Hazards aplenty were identified in the Bangladeshi case-study and these are discussed and illustrated below.

**Figure 21:** Casting of Deck Slab for proposed Arial Khan Bridge at Cont2 in SRNDP, Source: SRNDP project folder (January 2005)

**Figure 22:** Casting of Deck Slab span for proposed Arial Khan Bridge at Cont2 in SRNDP , Source: SRNDP project folder (January 2005)

**Figure 23:** Lifting of Steel casing of pile for Arial Khan Bridge at Cont2 in SRNDP, Source: SRNDP project folder (October 2001)

**Figure 24:** Pre-stressing of girders for Arial Khan Bridge at Cont2 in SRNDP, Source: SRNDP project folder (June 2004)

The figures above (Figures 21, 22, 23 and 24) collected from case-study SRNDP's photo folders during the construction phase, show issues related to contravention of quality systems installations and illustrate concerns raised by the primary data respondents

In SRNDP the Interviewees responded to questions concerning risks from their professional positions. They stated they encountered risks related to political issues,

noise from construction works, prolonged bad weather, cyclone, flooding, typhoon, religious issues (mosque, temples, and grave yards) without proper risk identification and mitigation. The consequences of the lack of risk identification were that there had to be changes to the pavement signage and line markings during construction and BoQ item changes leading to increased costs and time. The underpass was overlooked; some existing power poles had to be relocated during construction, increasing cost and time delay; some shops and markets were not identified during the design stage and had to be subsequently relocated during construction, plus some RCC box culverts had had to be created during construction because graveyards had been found in the middle of the carriageway – these changes, too, increased project cost and time delay; as did, other issues which had not been identified at the design stage including unsafe vertical shifts between main carriageway and hard shoulder remained and were *not* rectified due to the huge cost of the contract variations.

### 5.2.8 Effect of lack of understanding of LCCA on SRNDP

Life Cycle Cost Analysis (LCCA) was *lacking* in the case-study albeit that LCCA is deemed an an essential part of Cost Benefit Analysis, according to the Department of Transport (DOT) (2007). The analysis enables total whole-cost comparison (somewhat in perpetuity) of competing design alternatives with equivalent benefits. LCCA accounts for significant costs to the sponsoring agency, owner, operator of the facility, and the roadway user that will occur throughout analysis of alternatives (DOT-California 2013). Relevant costs include initial construction (including project support), future maintenance and rehabilitation, and user costs (time and vehicle costs). The LCCA analytical process helps to identify the lowest cost alternative. It is pivotal to the asset management process as an input to the evaluation of alternatives

via Economic Appraisal, Financial Appraisal, Value Management, Risk Management and Demand Management. Therefore, the consideration of Life Cycle analysis is an important element of QDM. Whilst a multitude of researchers (Kucerova and Lestyanszka 2013; Serenkov and Ramanchak 2000; Turban and Aronson 1999 and Zhao, Sundararajan, and Tseng 2004) consider that Life Cycle analysis should be an element of quality decision-making (QDM); in SRNDP LCCA did not occur, neither within the early cost estimation process, nor as part of a value-engineering/ value-management exercise.

### 5.2.9 Effect of lack of understanding of value-management/ value engineering and its implementation

Three employees among four stated VE was not considered although one employee said they had carried it out (*somewhat inappropriately*) in the construction stage; certainly, it had not been carried out in the design stage. As a result, there were significant impacts. As Value engineering had not been adopted before the construction had started, changes (*had to be and*) were made resulting in contract variations which had led to increased costs and time. Indeed SRNDP could not ensure the lowest cost alternative and could not make a comparison of competing design alternatives, nor, it was revealed, did SRNDP stakeholders seek to ensure (in any structured transparent way) that the lowest cost alternative was chosen.

In conclusion, this Bangladeshi case-study found that engineering problems had not been properly identified; construction items and quantities had had to be modified leading to contract variations. It was also found that there were delay, increased cost impacts due to inappropriate identification and (lack of) mitigation of risk; other

impacts were inconsistency complying with AASHTO slippage of work programmes. Whilst environmental issues were managed by donor agency, clients, contractor and consultants, ***risks*** were neither identified appropriately nor mitigated.

## 5.3 Afghanistan

### 5.3.1 Effect of lack of employee understanding of quality decision making

Interview questions in the first half of this study were posed to determine the quality decision making (QDM) in road infrastructure design and construction in an ***Afghanistan*** project. Responses from Interviewees showed what management staff understood the objectives of Quality Decision Making and the implications of making sound decisions.

The study showed, however, that there was a lack of consideration given (with the quality decision making process) to alternative routes/alignment. As a result, there were significant impacts. Illustrated by figures 25 and 26 which show the extent to which inappropriate routing resulted in mud flow at a particular section of road and the talus formations between the base and the river; these routes unfortunately lead to blocked communication and vehicle movement and required continuous maintenance as the highway was being re-constructed.

**Figure 25:** Road blockage due to mud flow in DCKFP, Source: KFP project folder (April 2007)

**Figure 26:** Road alignment passes through river, Deep Mountain with Talus formed in DCKFP, Source: KFP project folder (April 2007)

It was revealed in this ***Afghan*** study that preliminary design documentation had been done and a contractor had been engaged for construction; the contractor determined several discrepancies in this preliminary design documentation; hence the consultants decided to conduct detailed design prior to further construction i.e. investigation, analysis, and an appropriate context sensitive approach.

This led to changes which would have resulted in increased costs and time; the study showed that, as a result, the specification required necessary change during construction as the (previously planned) resources could not be found due to remoteness of site and security, geological and geotechnical issues such as rock cut, side slopes, horizontal and vertical curves. This resulted in increased costs and time again.

Most worryingly for the workers and managers on-site were concerns over security, leading to closures of the site on numerous occasions, resulting from explosions heard from surrounding areas and reports of tragedy, injury and fatality. This situation according to the Interviewees stopped construction activities and closed the

Camp resulting in (understandably) a slippage of schedule and increased costs during the design and construction phases. This extent to which such risks may have been mitigated or at the very least anticipated and factored into processes were a key line of questioning towards seeking ways to address contract variation, construction delay, and inconsistent construction practices.

### 5.3.2 Effect of compliance with foreign technical standards

As in the Bangladeshi case-study described above, *'international'* technical standards were key to work progression. Interview questions of this study were asked to determine the difficulties employees may have encountered complying with technical standards. Responses from Interviewees showed AASHTO was used as the technical standard for geometry, pavement and laboratory tests; however, Interviewees encountered problems such as inconsistent properties of materials, scarcity of materials and climatic, geographical, technological issues and therefore they depended on other technical standards such as interestinbgly the Philippine Standard, as well as guides such as the TRRL, ASTM, BS, ACI, LRFD and MoPW. Using so many technical standards resulted in compliance difficulties from lack of availability of materials, manpower, the latest technology and expert knowledge.

### 5.3.3 Effect of lack of CBA, AU, CP, CSD on economy and safety of project

Infrastructure projects have increased rapidly in recent years, especially over the last decade and many international projects readily incorporate cost/benefit-analysis (CBA) into respective decision making processes. This Afghan study, on the other hand, showed that there was a lack of consideration given to *best route selection*

from alternative routes that would (normally) be required during feasibility towards CBA. As a result, there were significant impacts: a number of drainage structures had to be adjusted to realign during construction, since during construction and review, it was found that there had been improper selection of structures such as bridges and culverts (e.g. size was small so the shape and size had had to be revised); the total number of bridges required had been planned/designed/proposed to be 24; this number was subsequently reduced to 8 and replaced by box culverts, thus it was suggested that such a major variation to addressing the overarching scope may have been, as argued by the respondents, 'better' anticipated.

Uncertainty analysis investigates the uncertainty of variables that are used in decision-making problems in which observations and models represent the knowledge base. In other words, uncertainty analysis aims to make a technical contribution to decision-making through the quantification of uncertainties in the relevant variables. In relation to this study it was found that uncertainty had *not* been factored in to decision making. As a result, there were significant impacts: as there was a large time gap between the design and construction stages, many estimated costs for changes had been lower than contract price; fixing of alignment, material selection, availability of material, climate condition, problems related to insufficient design information, lack of competent people and technology also increased cost and time. It was shown, too, that climate issues (snow fall, flash flood, debris flow, mud flow) also impacted negatively on the project's schedule, even though they *had* been considered to a certain extent in the planned work method-statement(s).

In addition, as experts were reluctant to work for such projects in Afghani conflict-zones, professional consultant remuneration had to be commensurate. Furthermore, as a result of lack of communication between government agencies (agricultural, resettlement, Water Corporation, Environment and MoPW), social and political problems such as protests, explosions, threats on the life of stakeholders and users also contributed greatly to delays and increased costs; such is the nature of infrastructure development in areas of extreme-political flux.

Checklist Procedure (CP) is another important tool in project management. The checklist provides project managers/leaders with guidance on what to take into account to support the sustainability of their projects. Responses from Interviewees showed there was no CP in the design stages although a few checklists had been used in the construction stage. As a result, there were significant impacts as installation 'stop-points' and materials' compliance checks occurred in an ad-hoc unstructured way. For example, it was not clear whether all necessary details had been appropriately incorporated or considered, nor was the (usual) quality management system checks recorded in a structured way; certainly there had been many changes in the design during the design review, specification and variation of contract which had increased costs and time.

Many engineering problems had been encountered during the implementation stage, increasing project costs which may have been avoided if a CP had been used.

*Context sensitive design (CSD)* is an approach that provides the flexibility to encourage independent designs tailored to particular situations. CSD seeks to

produce a design that combines good engineering practice in harmony with the natural and built environment, and meets the required constraints and parameters for the project. The study showed that there was a lack of consideration given to Context Sensitive Design Approaches that would normally be required during design. Hence, there was loss of consistency (a safety issue), increased capital cost and environmental impact from (excess levels of) talus and scree.

Although CSD was undertaken, as stated by the Interviewees, it is likely that it was only partially conducted, *recalling generally that Goff (2012) and others argue that cost effective decision making cannot be achieved without conducting a comprehensive CSD analysis*; it is tacitly acknowledged that there was loss of consistency of design (and knock-on negative safety issues), reduction in the life of infrastructure, less than appropriate whole of life cost consideration (with the implication of future increased maintenance and thus increased vehicle operating costs based on significant crash history), higher capital costs and design variations through the construction phase.

### 5.3.4 Effect of lack of identification and mitigation of engineering problem in project

As there was, according to the Interviewees, lack of consideration of engineering problems (a less than structured attempt to address an unpredictable hydrology) construction-stage re-design of hydraulic structures had to be undertaken, increasing costs and time. It was difficult to achieve correct road alignment due to soil characteristics being represented incorrectly in the design. Furthermore, social problems, religious problems such as population resettlement, newly established

gravesites and perceived mosque-site infringement and subsequent protests from local residents demanding rerouting in geographically restricted topography delayed the project and increased costs.

**Figure 27:** Road alignment passes through river and mountain where talus forms in DCKFP, Source: KFP project folder (April 2007)

**Figure 28:** Road passes through Deep Mountain/ river in DCKFP, Source: KFP project folder (April 2007)

Figures 27 and 28 show the engineering problems like rock cut, sight distance and appropriate road widening issues as per AASHTO; the photos reflect the issues such as landslides, mountain debris flow, talus materials, structure wash out, rock fall, unsuitable material, alluvial fans, rock avalanche encountered during construction and readjustment of alignment which led to increased cost and time.

There was a wide range of survey and geological problems requiring redesign and resurveying to mitigate the issues during construction; this in turn led to increased cost and time and financial risks.

During construction and review, it was found that improper early design-stage selection of road augmentation such as bridges and culverts, required ongoing review and changes to the structural design working drawings resulting in many revisions to

accommodate sizes that were too small so the shape and size capacities were revised, as well as somewhat over-specifications in some areas, such as notably, as mentioned, the total number of bridges initially considered was 24, with this number reduced to 8 and the remainder replaced by box culverts.

The confirmation of clearances from land-mines and incendiary devices and explosives left over from war, was essentially determined every day before prestart of work; this led to additional costs as the extent of the daily load of mine removal and demining plans had not been envisaged. Frequent site visits had, therefore, been required and a chopper, additional security forces, vehicles and night hold planning had had to be considered for these visits leading once again to increased costs and time; indeed since local experts had not been available to carry out the project tasks or to mitigate the technical issues, experts from overseas had had to be hired, and resultantly during the construction review it was found that a complete set of construction drawings had to be fully revised and re-prepared again within a short time.

This required an increase in employees resulting in increased costs, since extensive inaccuracies were found in the original drawings (probably because they had been prepared quickly) by the contractor. Adjustments to these drawings again resulted in increased costs from contract variation, construction delay.

### 5.3.5 Effect of lack of resources management on project with regard to time, quality and budget

As shown in SRNDP, Bangladesh, and as highlighted again above by different researchers, time, cost and quality are the principal objectives of the client in any

construction project. Furthermore, it is claimed that time, cost and quality are incorporated in the management of construction projects. This study showed that in fact a time-cost bias existed (recalling that Harris (2012) found that human biases, intuitions and errors were important elements in time effectiveness related to decision-making).

**Time:** The Afghani study showed that there was a lack of consideration given to time with regard to resources that would normally be required during design and construction. As a result, there were significant impacts. Inappropriate measures were taken to mitigate prolonged difficult weather conditions such as snowfall, cold, flash flood. These conditions caused delay and increased costs in relation to staff and appropriate resources and equipment. The uncertainties pertaining to the building site being an warfront zone and ongoing conflict zone from Taliban activities, necessitating regular demining activities also unsurpisingly delayed project progress.

Furthermore the use of labour (and reliance on old fashioned 'heavy-squad' labourers) rather than plant and equipment caused further delays and contract variations as the time scale was not planned to accommodate the intensity of labour subsequently used throughout the work-breakdown method(s). Interviewees stated that often the local residents pleaded for such manual labour since post-conflict previous occupations were no longer available. Another impact involved quality as again unsurprisingly the manual labour adopted could not match plant/equipment for certain tasks e.g. concreting. It was also difficult to manage the quality because the man hours had been fixed but due to the contract extension, when new staff were hired they needed time to adjust to the project.

**Cost:** The study showed that there was a lack of consideration given to cost with regard to resources that would normally be required during design and construction. One consequence was contract variation as proper costing had not been carried out with regard to resources. This in turn led to considerable delays – depending on the country from which the resources had to be sourced. Table 3 from the study's document analysis shows the estimated versus the final costs for SRNDP. The final cost was at least $34m more than the estimated cost.

**Table 3: The estimated versus the final cost for SRNDP in Bangladesh**

| SRNDP | |
|---|---|
| Project Commencement | February 1 |
| Actual completion date | February 4 |
| Final completion date | May 5 |
| Road construction estimated cost | $210m |
| Road construction final cost | $244m |

Furthermore, the designer believed that hiring experts 'from overseas', delayed the design schedule as others sought to re-establish their respective worth, increasing time and cost.

Another impact was increased costs due to improper estimation of costs and variations in contract. Furthermore, the designer believed that hiring experts 'from overseas', delayed the design schedule as others sought to re-establish their respective worth, increasing time and cost. Other issues which resulted in delays were scarcity of construction materials and remoteness of project as well as difficult

weather conditions such as snowfall, cold, flash floods and debris. In addition, the project was clearly delayed due to the security issues pertaining to the war and the social and political problems such as protests and threats to personnel; the delays impacted on the costs.

**Quality:** The study revealed that there was a lack of quality with regard to resources that would normally be required during design and construction. As a result, due to the hiring of local manual labour (argued to reduce poverty through a minimisation of a reliance on mechanical equipment), quality was compromised and delays were incurred. Increased site-maintenance costs were incurred as a result of ongoing landslip and road blockages and, not least a scarcity of good construction materials able to be delivered to a very remote project site; these issues impacted also on quality. Interviewees believed that inappropriate management (supply-chain inefficiencies and material ordering deficiences) also influenced the project negatively. Interviewees also believed that Quality Control engineers and Quality assurance engineers' skills (or lack thereof in an adhoc approach to compliance checking) impacted negatively on the project.

### 5.3.6 Effect of lack of understanding of contractual issues and documentation in KFP

As mentioned in the previous discussion a contract is a key element of a procurement system and a necessary tool used for contract agreement which includes a letter of acceptance, a letter of tender, specification, drawings, schedules. The study showed that the contractor found major inappropriate design drawings that were not in compliance with clauses seeking confirmation of contract documentation; the main

drawback of a large *15% contingency figure was the lack of motivation to control and monitor costs and variations to technical work activities* in any structured traditional way. Interviewees explained there were large time gaps between the design and construction phases of the KFP project. Price escalation was considered in the contract as per FIDIC 13.7; albeit that insufficient clause recognition was provided *for materials fluctuations* in the FIDIC based contract, and that this in turn affected negatively supply-chain relationships and the delivery of materials to site.

So the project management team had had to go through the contract frequently with the contract engineers; contract variations had to be carried out, increasing costs and time. The costs, however, incurred although very high in relative on-site variations, were not as high as those of SRNDP since KFP had this very large contingency fund of 15% instilled into the contract documents. Furthermore, Interviewees also explained that material property and selection did not match with contract specification; this led to changes in technical specification. However, again the "overall project" came in under budget (see Table 4 KFP)

**Table 4: The estimated versus the final cost for KFP in Afghanistan**

| KFP | |
|---|---|
| Project commencement | January 7 |
| Actual completion date | December 8 |
| Final completion date | December 10 |
| Total estimated cost | $104m |
| Total final cost | $104m |

Engineering problems also resulted from lack of geological data - landslides, mountain debris flow, talus materials, structure wash out, rock fall, unsuitable material, alluvial fans, rock avalanche, leading to increased costs and time. With as mentioned design issues that had been overlooked at the early stages – such as number of culverts, roadside drainage and a lack of hydraulic data. Finally, it can be concluded that there had been many contractual issues simply swallowed up by the large contingency which allowed a (somewhat false and resultantly less efficient) appearance of meeting budgets

### 5.3.7 Effects of lack of monitoring and management of environmental issues in KFP

Environmental issues in Afghanistan predate the political turmoil of the past few decades. Forests and wetlands have been depleted by centuries of grazing and framing, practices which have only increased with modern population growth. In Afghanistan, environmental conservation and economic concerns are not at odds; with 80% of the population dependent on herding or farming, the welfare of the environment is critical to the economic welfare of the people (Post-Conflict Environmental Assessment: Afghanistan. United Nations Environment Programme, 2003). In 2007, the World Health Organization released a report (related to a country-by-country data showing the impact of environmental factors on health) ranking Afghanistan as the lowest among non-African nations in deaths from environmental hazards (World Health Organization, 2007).

Concentration of land utilisation in this case finds that the land becomes less productive, threatening the livelihood of the rural population and floods that are

washing the agricultural lands and destroying rural dwellings. Loss of vegetation also creates a higher risk of floods, which not only endangers the people, but causes soil erosion and decreases the amount of land available for agriculture.

This case-study showed that there was a lack of consideration given to environmental assessment, monitoring or checklist for environmental issues that would normally be required during design and construction. As a result, there were impacts. This development was able to utilise very few agricultural lands, nominal arable land was acquired for road boundary. Although infrastructure development will create positive impacts on the economy, farmers are apt to lose their fertile land. Secondly, Afghanistan still has no legal tool for environmental management (no Environmental Management Monitoring Plan); this could potentially lead to environmental damage. Only the river course had been considered as part of any structured environmental impact assessment; while rock dumping had been carried out on the river banks it did not disturb the environment or the river itself. However, as construction rock blasting had been carried out, this did lead to vibrations or (small earthquake effects) that had not been measured.

Reviewing this case study in the light of secondary research it is remembered that Howard (2007) and Cram (1998) found that consideration of environmental issues is valuable and leads to environmental improvements. Garfi and Marti (2011) and Deluka, Karleuša, Dragičević (2013) also considered environmental factors in complex decision-making (the latter in water and sanitation projects in developing countries) and found them to be useful to their overall projects. Zhou and Sheate

(2011), too, found that an Environmental Impact Assessment (EIA) was an important decision making element in China's expressway infrastructure project.

Therefore, although an EMMP seems to be a valuable tool, KFP at the time of this project had not included one in their decision making.

### 5.3.8 Effect of lack of risks identification and mitigation in KFP

In the KFP case-study the infrastructure employees assessed risks subjectively from their professional position(s); they stated risks to be related to politics, and the environment including mud flow, flooding, snowfall, debris flow, rock fall, talus material, alluvial fan. Furthermore, risk mitigation did not in any structured way seek to address the fragile local political environment, the conflict zone, war-impact and terrorist (Taliban) threats and attacks on the construction camp, daily removal of the daily occurrence of land-mines and explosives (although de-mining had been carried out in advance of past mines) in the construction area.

The effect of this was there were financial risks, delays associated with cost and lack of expertise. An implicit risk (without appropriate mitigation) in Afghanistan included not allowing for an appropriate time gap between finishing the detailed design and the start of the construction project. The impact of this was project variations and time overruns. Furthermore, risk mitigation did not in any structured way seek to address the fragile local political environment, the conflict zone, war-impact and terrorist (Taliban) threats and attacks on the construction camp, land-mines and explosives in the construction area; no explicit mitigation measures were taken to address workforce-availability risk related to

discouraged/demotivated/disenfranchised labour/experts effectiveness on this project. Indeed it was argued (after the certificate of practical completion) that 15% to 30% additional costs had been generated to ensure safety during site visits and data collection; this had resulted in delays and increased design review costs, since besides, topographic surveys being undertaken in normal conditions, this warfront conflict zone, required additional security increasing costs.

There was no final Road Safety Audit on final design, and during design review substantial design changes had had to be made for the road drainage structures increasing costs, to manage mountain debris flow, Talus materials, rock fall, unsuitable material, alluvial fans which had not been determined properly; during construction readjusted alignments had to be carried out, so BoQ item changes had led to increased cost and time (even to the extent that local resident activity had not been factored into the design route; shops and markets had not been identified during the design stage and had to be relocated during construction).

### 5.3.9 Effect of lack of understanding of LCCA on KFP

As discussed earlier in SRNDP the LCCA analytical process helps to identify the lowest cost alternative. It is pivotal to the asset management process as an input to the evaluation of alternatives via Economic Appraisal, Financial Appraisal, Value Management, Risk Management and Demand Management. However, LCCA was not done for KFP since during the war(s) there was no skill base to do so (tragically many engineers and experts were killed throughout the preceding conflicts). The study showed that there was a lack of consideration given to Life Cycle Cost Analysis. As a result, there were significant impacts. The lowest whole-cost

alternative was not assessed; comparison could not be made among the competing design alternatives with equivalent benefits in order to make the best decisions with regard to the project's life, including maintenance costs (beyond the initial capital cost).

In conclusion, the main findings for KFP were lack of consideration of topographic survey, hydraulic data and environmental issues. The impacts, as in SRDNP, included inconsistencies complying with AASHTO, slippage of work program increased costs, delays. VM/ VE was conducted in an ad-hoc way by the donor agency, clients and consultants didn't involve local practitioner's knowledge. Importantly it should be noted the zone was a warfront and that together with severe weather conditions led to much contract variations and delays. Generally it was found that, whilst all stakeholders knew the harsh socio-economic and topographical conditions there was almost no attempt to identification explicitly, categorise and mitigation the risks.

## 5.4 Conclusion

In conclusion, this chapter has shown that the results from this study are in alignment with several other studies. In addition, this study has presented findings not previously found in other studies. There were many impacts from the results found from this study. These included lack of employee understanding of resources management, risks and safety, environmental issues, contractual issues, technical problems in Quality Decision Making for road infrastructure design and construction in rough terrain and inclement environments.

# CONCLUSIONS AND RECOMMENDATIONS

## 5.5 Introduction

The purpose of this study was to examine Project Management and Quality Decision Making towards improved life cycle infrastructure design and construction in rough terrain and inclement environments in order to improve the various stages of decision making at the explicit phases of road infrastructure such as design, construction and ongoing maintenance (the project had a certain length of defect liability) by examining two road construction projects, one in Afghanistan and one in Bangladesh.

The major objectives of this study were to identify the key budgetary, scheduling, risk, contractual, environmental variables considered in the quality management decision making for each project. In addition, the impacts of the budgetary, scheduling and risk variables on decision making were examined for these two projects. This study reviewed the existing research and literature on the problems and issues connected with road design and construction in rough terrain and inclement environments and the impacts on the decision making process for road infrastructure development and its determinants.

This research used the case study method and the data were acquired from selected personnel within the organisations.

This research was designed based on qualitative methodology, specifically a case study incorporating individual interviews and document analysis. The rich data provided by the Interviewees and from the document analysis justified this choice of research methodology. Moreover, it enabled Action Research to be conducted giving the opportunity for Interviewees to provide follow up feedback to the guidelines developed by the researcher.

The results relating to SRNDP (in Bangladesh) showed that there were substantial engineering problems faced during construction: bank erosion, pavement settlement due to soft soil, landslides as well as road alignment being required through a flood-prone region where the issues included a couple of river crossings which were very tidal and had caused erosion and scouring. It was also shown that, while there were resources, they had been mismanaged. Hence, it can be concluded that there was a lack of risk identification and mitigation, ineffective resource management and mismanagement of contracts.

With regard to KFP (Afghanistan case-study), results showed that uncertainties had not been properly analysed as there was a (broad-brush) 15% contingency given at the outset, which masked any attempt to mitigate risk in a structured way to address uncertainties related to the hydrology e.g. unprecedented floods, soil characteristics and socio-economic-/political-flux issues. There were many significant engineering problems; for example, in the KFP there were disposal issues from rock cutting and blasting impacting on the environment, and there were, moreover, substantial security issues and different cultural, political, religious issues and climate issues. It can be concluded therefore that in KFP there was ineffective resource management,

inappropriate contract documentation and a lack of appropriate risk management for the high number of uncertainties pertaining to this project. These issues had led to significantly increased costs and delays.

## 5.6 Implications

This study demonstrated that there had been many difficulties throughout the two projects (not least anxiety and protest generated by political, religious, cultural and man-made conflict issues). Projects like SRNDP and KFP had many engineering problems which had led to unprecedented damage to roads, exacerbated congestion and traffic delays as well as reduced access. Increased traffic volumes with heavy vehicles had had environmental effects, Moreover, there had been increased risks due to inappropriate design, and the lack of identification and consideration of engineering problems, environmental issues and inappropriateness of resources had led to more maintenance work being required. Additionally, because of the tight economic times resulting in the tightening of road agency budgets, staff numbers had had to be reduced.

A set of Guidelines is clearly required in order that all aspects of infrastructure construction could be taken into account; the section that follows presents such an explicit guide generated iteratively from research conducted here.

## 5.7 Recommendations

From the results of the *first stage* of this study a set of Guidelines was developed (see Figure 13). The *second stage* of the Action Research sought an iterative enhancement via the subsequent views of the Interviewees on the original set of

Guidelines towards a best-practice revised developed Guide (Figure 29). Recommendations are offered here in order to improve decision-making in future road infrastructure projects.

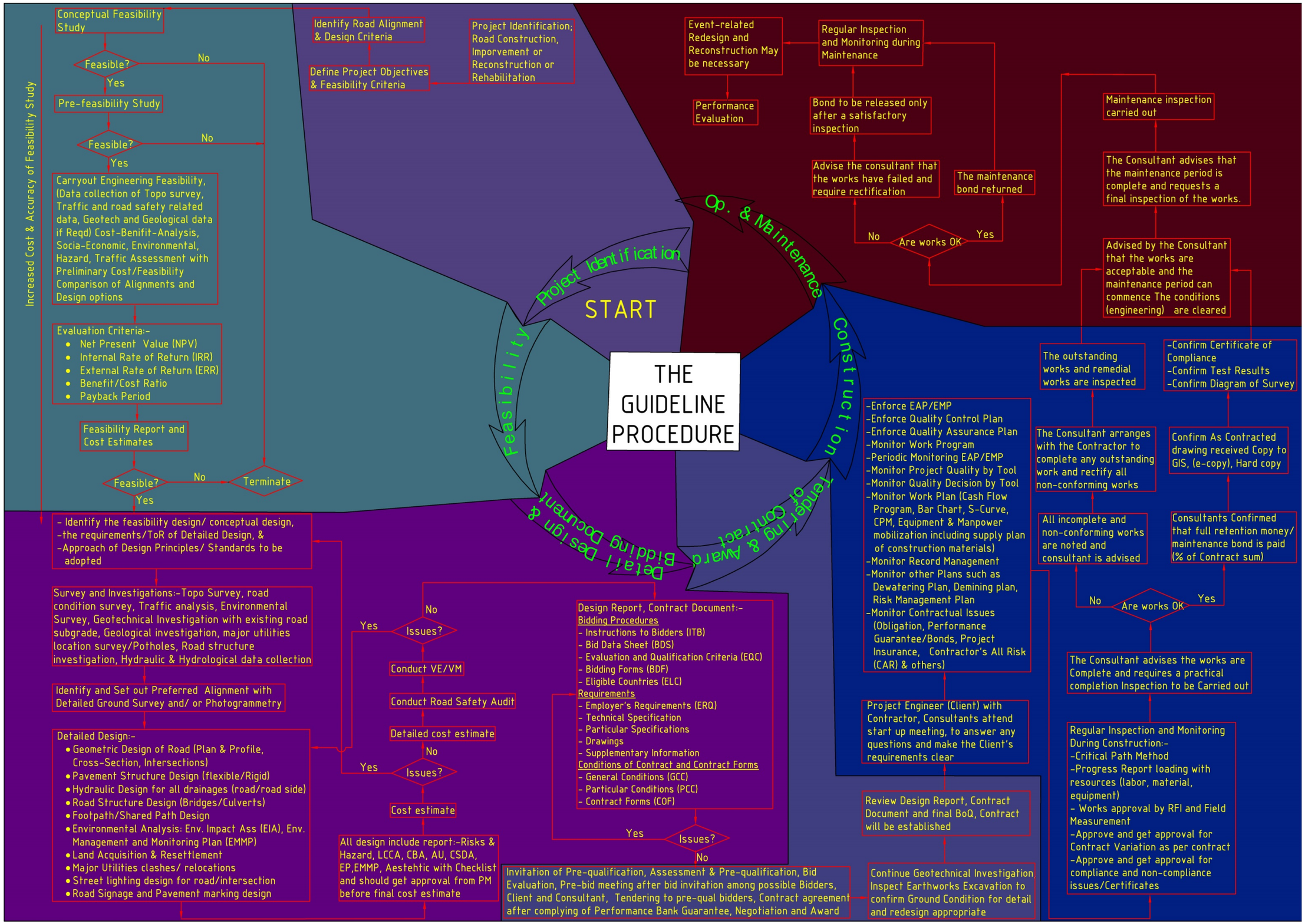




**Figure 29:The Guideline Procedure (incorporating feedback from Interviewees)**

Recommendation 1:

- The Guidelines (Figure 29), developed by the researcher, should be used for future projects by the two organisations examined in this study.
- Project engineers should adopt the local technical standards wherever possible during feasibility stage as well as detail design stage.

If appropriate local technical standards are not available, Project engineers shall liaise with client to adapt the local standards by selecting appropriate local techniques and competencies rather than borrowing from foreign standards which are difficult to apply.

Recommendation 2:

Road safety risks should be identified from road safety auditing during feasibility stage, concept Design stage, detailed design stage, Pre-opening stage and Operation, and be mitigated by a Risk management plan.

It is essential to conduct RSA at the Design stage.

Recommendation 3:

Engineering problems should be identified and mitigated through check list procedure during detailed design and design review in the Tendering and Award phases.

They should be listed and approved by the Design Manager and again verified during the whole process before completion of final design and mitigated where necessary as per checklist.

Recommendation 4:

Value Engineering/Value Management should be carried out and incorporated during the detailed design stage.

Recommendation 5:

Appropriate tools (software) should be supplied to designer, drafters and project manager by clients, contractors, consultants to their personnel during design and tendering, construction and maintenance stage.

These tools are crucial for major infrastructure development e.g. advanced geometric design facilities, LCCA, project quality control and work program that will assist project managers to make decisions with regard to cost, quality and schedule.

Recommendation 6:

- CBA should be considered at all stages in the developed guidelines, especially at the detailed design stage;
- CSD should be considered at the detailed design stages;
- AU should be considered at all stages in the developed guidelines, especially at the detailed design stage;
- CP should be considered at all stages in the developed guidelines, especially at the detailed design stage.

Recommendation 7:

LCCA should be run and recorded at the detailed planning/design stage.

LCCA is pivotal to the asset management process as an input to the evaluation of alternatives via Economic Appraisal, Financial Appraisal, Value Management, Risk Management and Demand Management. Therefore, this study recommends it should be considered at the detailed design stage.

Recommendation 8:

This study recommends contract documentation structures such that:

- There is a Detailed Design and Design Review in Tendering and Contract Award phase; Contract Engineer should check all checklists before finalizing the documents and prior to writing the clauses. BoQ should also be verified simultaneously with the detailed design.
- At the Construction phase, the Project Manager should consider all the aspects prior to decision making.

In addition, training should be organized by contract engineer for project managers engaged in document preparation so that they are aware of, and knowledgeable about, critical points.

Recommendation 9:

Contract documents should be reviewed carefully by Design Manager/Construction Manager during design review in Tendering and Award and construction phases should be modified if necessary before signing.

Recommendation 10:

Decisions should be made promptly at each stage in the decision making process.

Recommendation 11:

Uncertainty should be considered in the tender selection and evaluation stages, since in developing countries, the political pressure supersedes all the evaluation criteria during feasibility stage rather than strategic importance to the government or agency.

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Recommendation 12:

Appropriate design method should be considered for hydraulic structure design during detailed design stage.

The selection methods for Hydraulic and Hydrology design as well as its calculation have significant impact on cost for road infrastructure development.

Recommendation 13:

Local standards (such as the Afghan MoPW) should consider EMMP for current and future infrastructure development at the detailed design stage and implement it during the construction stage.

Recommendation 14:

Knowledgeable managers with appropriate local resources knowledge utilised with quality tools (software), work programming as well as skilled quality control and knowledgeable quality assurance engineers, an cash flow programming based on FIDIC should be considered for better management of road projects with regard to time, quality and budget.

Recommendation 15:

Agencies should consider reasonable funding and strategic planning (5 years or 10 years) of current and future maintenance of infrastructures.

Although there are infrastructure projects being built, there are no programme details or future maintenance details or schedules currently held by agencies.

Recommendation 16:

Clients should select skilled team (contractor/ consultants) who can run LCCA.

Recommendation 17:

Decisions should be made during the project identification, feasibility or detailed design stage with regard to duplication of funding.

Client should determine the duplication of funding and reallocate the funds whenever funding has been allocated from different sources for a single project; the financial and development plan should be changed to avoid conflicts among planning, design and risks management departments.

Recommendation 18:

A Manager/Leader should have the authority to make decisions.

It has been observed that team decision-making can be slower than individual leader decision making.

Recommendation 19:

This study recommends that

- Uncertainties or risks should be especially considered such as religious risks like graveyards, mosques or temple;
- Social and political problems such as 'hartals' should be considered as they delay project progress.

Recommendation 20:

Good record keeping should be established by both contractors and employer's agents or engineers for all stages.

Recommendation 21:

It is recommended that university courses and on the job training be provided for management/decision making staff – this recommendation relates to question 34 of responses table 1, interviewee 3.

In addition praise should be timely and specific to the individual's performance. Positive reinforcement should be ongoing and frequent to address the demotivation aspects of working in conflict zones.

Recommendation 22:

Continual Professional Development (CPD) should be part of project management in areas of political/topographical flux; staff should be encouraged to update their technical and management skills through in-house training programmes offered by design teams and client's representatives.

Recommendation 23:

Geologic, hydraulic, topographic, material, equipment, technical expert surveys should be considered and related explicitly and specifically to context and location of infrastructure projects.

The 23 recommendations above alongside the developed detailed checklist and guide (presented in Figure 29) for quality decision-making towards improved infrastructure design and construction in rough terrain and inclement environments, is deemed appropriate for utilisation to the betterment of future projects.

# REFERENCES


- A. Hajji, A. Gharbi and R. Pellerin 2012, "Joint production control and product quality decision making in a failure prone multiple-product manufacturing system." *International Journal of Production Research* 50 (13): 3661-3672.
- Abusabha, R. and Woelfel, M.L. 2003. "Qualitative vs. Quantitative Methods: Two Opposites that Make a Perfect Match." *Journal of the American Dietetic Association* 103 (5): 566-575.
- Akdere, Mesut. 2011. "An Analysis of Decision-Making Process in Organizations: Implications for Quality Management and Systematic Practice." *Total Quality Management & Business Excellence* 22 (12): 1317-1330.
- Alenljung, Beatrice. 2008. "Envisioning a Future Decision Support System for Requirements Engineering –A Holistic and Human-centred Perspective", *Linköping Studies in Science and Technology Dissertation No. 1155*, Department of Computer and Information Science, SE-581 83 Linköping, Sweden, Linköping, 2008.
- Aliza Abu Hassim. 2012. *Project Governance: Ethical Decision Making In Project Procurement In The Malaysian Public Sectors.* Queensland University of Technology School of Civil Engineering and Built Environment Science and Engineering Faculty (SEF).
- American Association of State and Highway and Transportation Officials (AASHTO), (2004).

- Ana Moreno and Carlos Mataix 2012. The analytic hierarchy process to support decision-making processes in infrastructure projects with social impact, Department of Organization, Business Administration and Statistics, School of Industrial Engineering, Madrid Polytechnic University, Madrid, Spain, http://www.tandfonline.com/loi/ctqm20.
- Asian Development Bank (ADB) 2005. Southwest Road Network Development Project (SRNDP), (ADBLOANNO.1708 – BAN(SF), http://www.rhd.gov.bd/RHDNews/ViewDetail.asp?vCompID=55.
- Atkinson, P., and Delamont, S. 2006. "In the roiling smoke: Qualitative inquiry and contested fields." *International Journal of Qualitative Studies in Education*. 19(6): 747-755.
- Ben-Eliyahu A. 2013. On Methods: What's the difference between qualitative and quantitative approaches?. http://chronicle.umbmentoring.org/on-methods-whats-the-difference-between-qualitative-and-quantitative-approaches/.
- Bennett, J. and Grice, T. 1990. *Procurement systems for building. In: Brandon, P. (ed) Quantity Surveying Techniques*: New Directions, Blackwell Scientific Publications, Oxford.
- Bickel J. E., Spetzler C., Winter H., and Marca P. 2011. *Decision Quality: The Art and Science of Good Decision-Making.* Stanford Strategic Decision and Risk Management Certificate Program, Stanford Center for Professional Development, Strategic Decision Group (SDG), Stanford, 5th Edition.
- Billy, TW, WM To, and Peter KC Lee. 2012. "Quality Management Framework for Public Management Decision Making." *Management Decision* 50 (3): 420-438. ISO 9000 Series · ISO 9001 · Performance ·

Process-based Quality Management System · Public Management Decision Making.

- Bogdan, R. and Taylor, S.J. 1975. *Introduction to Qualitative Research Methods. A Phenomenological Approach to the Social Sciences*, Wiley, Toronto.
- Brauers, W. K. M., Zavadskas, E. K., Peldschus, F., Turskis, Z. 2008. "Multi-Objective Optimization of Road Design Alternatives with an Application of the Moora Method." *The 25th International Symposium on Automation and Robotics in Construction, Institute of Internet and Intelligent Technologies, Vilnius Gediminas Technical University, Vilnius, Lithuania.*
- Briones, T.L., and Cecchini, D. 1991. *Nursing versus medical research*. Heart Lung, 20(2): 206–207.
- Britten N. 1999. *Qualitative interviews in healthcare. In Pope C, Mays N (eds) Qualitative research in health care. 2nd ed*: 11–19. London: BMJ Book.
- Brown R. 2005. "Rational Choice and Judgment Decision Analysis for the Decider". *New Jersey, John Wiley and Sons Inc.*
- Brown, A. and P. Dowling 2001. *Doing research/reading research: A mode of interrogation for teaching.* London: Routledge Falmer.
- Brown, A. and Dowling, P. 2001. "Doing Research/Reading Research: A Mode of Interrogation for Teaching." *Doing research/reading research: a mode of interrogation for teaching*.
- Bryman, A 1988. *Quantity and Quality in Social Research.* London, Routledge

- Bullen, F.2003. "Design and Construction of Low-Cost, Low-Volume Roads in Australia." Transportation Research Record: *Journal of the Transportation Research Board*1819 (1):173-79.
- Burns, R 2000. *Introduction to Research Methods*, London, Sage
- Cassell, C., and Symon, G. 1994. *Qualitative research in work contexts*. In C. Cassell, and G. Symon (Eds.), Qualitative methods in organizational research: 1-13. Thousand Oaks, CA: Sage Publications.
- CH2MHILL and TRANS-LINK 2011. *Burnaby Mountain Gondola Transit Business Case Report.*
- Charles, T.J. and Andrew, M.A. 1990. "Predictors of cost-overrun rates." *Journal of Construction Engineering and Management.* ASCE, 116, 548–552.
- Clerkin, T. A., and Jones, K. J.2013. "A Study of Conflict in Top Management Decision Making: The Impact of Contribution Motive", *The Coastal Business Journal*, 12 (1): 2163-9280.
- Corbetta, P. 2003. *Social Research Theory, Methods and Techniques.* London: SAGE Publications.
- Creswell 2009. *Research design: qualitative, quantitative, and mixed methods approaches.* Sage Publications.
- Creswell, J. 2003. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches.* Thousand Oaks, California: Sage Publications.
- Creswell, J.W. 2003. Research design: qualitative, quantitative, and mixed method approaches. SAGE.
- Deluka, A., Karleuša, K., Dragičević, D. 2013. "Review of multi-criteria-analysis methods application in decision making about transport

infrastructure", UDK 625.711.1.001.8: 519.8, GRAĐEVINAR 652013) 7, 619-63.

- Denscombe, M. 1998. *The Good Research Guide for Small-Scale Research Projects*. Buckingham, Open University Press.
- Denzin, N. K. and Lincoln, Y. S. (Eds.) 2000. *Handbook of qualitative research* (2nd edition: 189-213). Thousand Oaks, CA: Sage.
- Department of Transport and Regional Services (DOTARS) (2002), Australian Government Department Report, http://www.infrastructure.gov.au/department/annual_report/2001_2002/P2.aspx
- Dhanpat, Kamlawathee. 2009. "Decision-Making and Accountability as Aspects of the Integrated Quality Management System (Iqms)."
- Donald Peter Cram 1998. *Implicit Price Estimation: Measuring the Impact of Non-financial Factors in Environmental Management Decision-Making*. American Accounting Association Annual Meeting.
- Dooley, Robert S, and Gerald E Fryxell. 1999. "Attaining Decision Quality and Commitment from Dissent: The Moderating Effects of Loyalty and Competence in Strategic Decision-Making Teams." *Academy of Management Journal* 42 (4): 389-402.
- Dweiri, FT, and MM Kablan. 2006. "Using Fuzzy Decision Making for the Evaluation of the Project Management Internal Efficiency." *Decision Support Systems* 42 (2): 712-726.
- Eli Mina 2000. "The complete Handbook of Business Meetings. AMACOM 2000." *Cited from BCCPAC, Decision-Making in PACs, DPACs, and School Planning Councils, Leadership Manual, Tab 9: Page 2.*

- Elliott, J. 2000. *Towards a synoptic vision of educational change in advanced industrial societies.* In H. Altricher and J. Elliott Images of educational change. Buckingham: Open University Press.
- Emans, Ben 198). *Interviewen; theorie, technieken training*. Groningen: Wolters-Noordhoff.
- EPA 2003. "Using Dynamic Field Activities for On-Site Decision Making: A Guide for Project Managers". *Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency (EPA).* Washington, DC 20460, OSWER No. 9200.1-40, EPA/540/R-03/002.
- Eweje J, Tuner R., and Muller R. 2012. "Maximizing strategic value from megaprojects: the influence of information-feed on decision-making by the project manager." *International Journal of Project Management* 30: 639–651
- Fajar, M., Nakanishi, T. Hisazumi, K., Fukuda A. 2010. "A Decision Making Framework for Developing Agricultural Wireless Sensor Network Systems", *International Conference*, Department of Advanced Information Technology, Graduate School of Information Science and Electrical Engineering, Kyushu University, 744 Motooka, Nishi-ku, Fukuoka 819-0395, JAPAN.
- Fetterman, D.M. 1989. Ethnography Step by Step, London, Sage.
- FIDIC 2006. *Contract for Construction – General Conditions.* Multilateral Development Bank (MDB) Harmonized Edition.
- Fields, A. F. 2001. "A Study of Intuition in Decision-Making Using Organizational Engineering Methodology", Graduate School of Business and Entrepreneurship of Nova South-eastern University.

- Filstead, W. J. 1979. *Qualitative methods - a needed perspective in evaluation research. In Cook, T. D. and Reichardt, C. S. (eds).* Qualitative and Quantitative Methods in Evaluation Research: 33-48. London: Sage.
- Filstead, W. J. 1979. Qualitative methods: A needed perspective in evaluation research. In T. D. Cook & C. S. Reichardt (Eds.), *Qualitative and quantitative methods in evaluation research* Beverly Hills, CA: Sage.
- Flanagan, R. and Tate, B. 1997. *Cost Control in Building Design.* Blackwell Science, Oxford
- Gall, M., Gall, J., and Borg, W. 2003. Educational Research. Boston: Pearson Education, Inc.
- Galliers, R.D. 1991. *"Choosing Appropriate Information Systems Research Approaches: A Revised Taxonomy*," in: Information Systems Research: Contemporary Approaches & Emergent Traditions, Nissen, H-E, Klein, H.K. and Hirschheim, R. (Eds.): 327-346, The Netherlands: Elsevier Science Publishers B.V.
- Garfi, Marianna, Ferrer-martí, Laia, 2011. "Decision Making; Developing Countries; Sanitation; Water Supply, Water science and technology" : a journal of the International Association, *Water Pollution Research*, Vol.64 (1): 83-101
- Gidel, T, R Gautier, and R Duchamp. 2005. "Decision-Making Framework Methodology: An Original Approach to Project Risk Management in New Product Design." *Journal of Engineering Design* 16 (1): 1-23.
- Goddard, W and Melville, S. 2004. *Research Methodology: An Introduction. Lansdowne:* Juta and Company Ltd.

- Goddard, W. and Melville, S. 2004. Research Methodology: An Introduction. Lansdowne: Juta and Company Ltd
- GOFF S. A. 2011. *Project Management Success and Decision-Making Under Difficult Contexts*. American Society for the Advancement of Project Management (ASAPM) and International Project Management Association (IPMA).
- Guillaume M., Didier G., and Matthieu L. 2010. "Multi-criteria performance analysis for decision making in project management." *International Journal of Project Management* 29: 1057–1069.
- Hadad, Yossi, Baruch Keren, and Zohar Laslo. 2013. "A Decision-Making Support System Module for Project Manager Selection According to Past Performance." *International Journal of Project Management* 31 (4): 532-541.
- Hambrick, Donald C, and Phyllis A Mason. 1984. "Upper Echelons: The Organization as a Reflection of Its Top Managers." *Academy of management review* 9 (2): 193-206.
- Hammersley M, Atkinson P. 1995. *Ethnography: principles in practice*. 2nd ed. London: Routledge.
- Harris J. 2012. *"Decision-Driven Data Management"* A Strategy for Better Decisions with Better Data, White Paper, SAS Institute Inc. World Headquarters.
- Hartmann, T., Fischer, M., and Haymaker. J. 2009. "Implementing information systems with project teams using ethnographic-action research." *Advanced Engineering Informatics,* 23(1): 57–67.
- Hearn, G.; Hunt, T.; Aubert, J.; Howell, J. (2008). "Landslide impacts on the road network of Lao PDR and the feasibility of implementing a slope

management programme**."** *South East Asia Community Access Programme (SEACAP).*

- Hearn, GJ.and CI Massey. 2009."Engineering Geology in the Management of Roadside Slope Failures: Contributions to Best Practice from Bhutan and Ethiopia". *Quarterly Journal of Engineering Geology and Hydrogeology*42(4): 511.
- Heilman, Philip, Jerry L Hatfield, Martin Adkins, Jeffrey Porter, and Russell Kurth. 2004. "Field Scale Multi objective Decision Making: A Case Study From Western Iowa", Journal of The American Water Resources Association (JAWRA).
- Helen Lingard, Payam Pirzadeh, Nick Blismas, Ron Wakefield and Brian Kleiner 2014. "Exploring the link between early constructor involvement in project decision-making and the efficacy of health and safety risk control." *Construction Management and EconomicsJournal.*32 (9): 918-931.
- Herbsman, Z. and Ellis, R.D. 1991. *The cost / time / quality integrated bidding system, an innovation in contract administration.* In: Bezelega, A. and Brandon, P. (eds).
- Herek, Gregory M, Irving L Janis, and Paul Huth. 1987. "Decision Making During International Crises Is Quality of Process Related to Outcome?" *Journal of Conflict Resolution* 31 (2): 203-226.
- Hill, C. E., Knox, S., Thompson, B. J., Williams, E. N., Hess, S. A., and Ladany, N. 2005. "Consensual qualitative research: An update." *Journal of Counseling Psychology* 52: 196-205.

- Hoffberg, K. and Korver, C. 2006. Leadership and Decision making at www.decision-quality.com.
- Hoppe E. J. 2004. "*FROST ACTION CONSIDERATIONS IN ROADWAY CONSTRUCTION*." Virginia Transportation Research Council, Charlottesville, Virginia, USA.
- Howard, Ronald A. 2007. "The Foundations of Decision Analysis Revisited." *Advances in decision analysis: From foundations to applications*: 32-56. Cambridge University Press, Hardback.
- Hughes, T. and Williams, T. 1991. Quality Assurance. BSP Professional Books, Oxford.
- ILO 2008. *Building Rural Road* Chapter 7-Drainage, International Labour Organization (ILO), Asia and the Pacific, ISBN 9789221209775.
- Ireland, V. 1983. *The Role of Managerial Actions in the Cost Time and Quality Performance of High Rise Commercial Building Projects*. Unpublished PhD Thesis, University of Sydney, Sydney.
- Irny, S.I. and Rose, A.A. 2005. "Designing a Strategic Information Systems Planning Methodology for Malaysian Institutes of Higher Learning (isp-ipta)." Issues in Information System 4 (1).
- J. D. Nichols, M. J. Eaton, M. C. Runge, P. L. Fackler, B. C. Lubow, B. M. Stith and C. A. Langtimm 2011. "Structured Decision Making as a Proactive Approach to Dealing with Sea Level Rise in Florida." *Climatic Change* 107 (1-2): 185-202.
- Johannessen B. 2008. *Building rural roads –Drainage.* International Labour Organization; ILO Regional Office for Asia and the Pacific; ILO ASIST Asia Pacific road construction / rural public works / labour intensive employment /

rural employment / poverty alleviation 10.05.6, 466. ISBN: 9789221209775; 9789221209782 (web pdf), Bangkok: ILO.

- Johnston, J. 2010. Qualitative research methods. *Radiologic Technology* 82 (2): 188-189. EBSCO Host.
- Kabbedijk, Jaap, Krzysztof Wnuk, Bjorn Regnell, and Sjaak Brinkkemper. 2010. "What Decision Characteristics Influence Decision Making in Market-Driven Large-Scale Software Product Line Development?" *Hildesheimer Informatik-Berichte*: 42-53.
- Kadyali, L.R. Lal, N. B. 2003. "Principles and Practices of Highway Engineering (including Expressways and Airport Engineering)." Khanna Publishers, Delhi – 6. (Fourth Edition)
- Kamruzzaman, M. 2007. "Enhancing the quality of Decision Making? Introducing Spatial Multi Criteria Evaluation (SMCE) for boundary conflict resolution in Philippines", *International Institute For Geo-Information science and Earth Observation Enschede, The Netherlands, April, 2007*
- Kay E J, Blinkhorn A S. 1996. "A qualitative investigation of factors governing dentists' treatment philosophies." *Br Dent J* 180: 171–176.
- Kember, D. 2000. *Action learning and action research: Improving the quality of teaching and learning*. London, UK: Routledge.
- Khawlie, MR, and R. A'war.1992. "Terrain Evaluation for Assessment of Highways in the Mountainous Eastern Mediterranean of Lebanon". *Bulletin of Engineering Geology and the Environment*46 (1): 71-78.
- Koskinen, P. 2010. *Decision-making process on field technology for process management", University of Oulu, Faculty of Technology.* Department of Electrical Engineering.

- Kvale, S. 1996. *Interviews: An introduction to qualitative research.* Thousand Okas, CA: Sage.
- Kvale, S. and Brinkmann, S. 2009. *Interviews: Learning the Craft of Qualitative Research Interviewing.* Los Angeles, Calif., Sage.
- Lansley, P. 1993. "Towards improved managerial effectiveness. In: Proceedings of the CIB W-65 International Symposium on Organization and Management of Construction." *Journal of Construction Engineering and Management* 671–679.
- Lav, A.H. 200. "Method for Balancing Cut-Fill and Minimizing the Amount of Earthwork in the Geometric Design of Highways". *Journal of transportation engineering* 129: 564.
- Lee, A.S. 1989. 'A Scientific Methodology for MIS Case Studies,' MIS Quarterly, 13(1): 32-50.
- Leedy, P. and Ormrod, J. 2001. "*Practical research: Planning and design* (7th ed.)." Upper Saddle River, NJ.
- Liberatore, M. J, and Johnson B. P. 2013. "Dept. Of Manage. And Oper., Villanova Univ., Villanova, Pa, USA." *Engineering Management, IEEE Transactions on* 60 (3): 518-528.
- Lukszo, Z., Ferreira, L., and Vrancken, J. 2006. *"Decision making in transport infrastructures"* IEEE International Conference on Systems, Man, and Cybernetics, Taipei, Taiwan.
- Mark Schafer, Scott Crichlow 2010. *Groupthink Versus High-Quality Decision Making In International Relations.*
- Marshall C, Rossman GB. 1995. *Designing qualitative research.* Second edition. Thousand Oaks, California: Sage Publications.

- Marvasti, A. 2010. Interviews and Interviewing. *International Encyclopaedia of Education*: 424-429.
- Masterman, J.W.E. 1992. *An Introduction to Building Procurement Systems*. E and FNSpon, London.
- Matthews, S, 2010, 'Anonymity and the Social Self,' American Philosophical Quarterly, 47: 351-363.
- May K M. 1991. "Interview techniques in qualitative research: concerns and challenges. *In* Morse J M (ed)." *Qualitative nursing research:* 187–201. Newbury Park: Sage Publications.
- McNiff 2002. Action research for professional development: Concise advice for new action researchers. http://www.jeanmcniff.com/booklet1.html
- Michael, B. Jim, R. and Linda, M 2012. "Real World Evaluation, working under budget, time, data and political Constraints." Sage Publications, Inc. (Second Edition)
- Miles, M.B. and Huberman, A. M. 1994. *Qualitative Data Analysis: An Expanded Sourcebook*, London: Sage.
- Munhall PL and Boyd CO. 1993. *Nursing research: a qualitative perspective*. Second edition. New York: National League for Nursing Press.
- National Economic Development Office (N.E.D.O.) 1983. *Faster Building for Industry.* National Economic Development Office. London: the Stationery Office.
- Newcombe, R., Langford, D. and Fellows. 1990. Construction Management 2. Mitchell, London.

- Newman, I. and Benz, C. R. 1998. *Qualitative-quantitative research methodology: Exploring the interactive continuum,* Carbondale: Southern Illinois University Press.
- Nissenbaum, H. 1999. 'The Meaning of Anonymity in an Information Age,' The Information Society, 15: 141-144.
- NRC. 2001. *Theoretical Foundations for Decision Making in Engineering Design.* National Research Council (NRC), Division on Engineering and Physical Sciences, Board on Manufacturing and Engineering Design, National Academy Press, Washington, D.C.
- Onwuegbuzie, A., and Leech, N. 2005. "On becoming a pragmatic researcher: The importance of combining quantitative and qualitative research methodologies." *International Journal of Social Research Methodology* 8 (5): 375-387.
- P. A. Bowen, K. A. Hall, P. J. Edwards, and P. G. Pearl 2002. "Perception of Time, Cost and Quality Management on Building Project." *The Australian Journal of Construction Economics and Building:* 2 (2).E. and F.N. Spon Ltd. London.
- Pang, J. 2013. "Intelligent Modelling and Decision Making for Product Quality of Manufacturing System Based on Fuzzy Cognitive Map." *International Journal of Computer Science Issues (IJCSI)* 10 (1).
- Paprika, Zita Zoltay. 2008. "Analysis and Intuition in Strategic Decision Making: The Case of California" *CDM* .
- Polit, D., and Hungler, B. 1991. *Nursing research: Principles and methods.* New York: JB Lippincott.

- Polkinghorne, D. E. 2005. "Language and meaning: Data collection in qualitative research." *Journal of Counseling Psychology* 52: 137-145.
- Pontin D. 2000. Interviews. In Cormack D F S (ed) The research process in nursing. 4th ed: 289-298. Oxford: Blackwell Science.
- Popovič, Aleš, and Andreja Habjan. 2012. "Exploring the Impact of Decision Making Culture on the Information Quality–Information Use Relationship: An Empirical Investigation of Two Industries." *Issues in Informing Science & Information Technology, Volume 9 (2012)* 9: 125.
- Ratnesar, N., and Mackenzie, J. 2006. "The quantitative-qualitative distinction and the null hypothesis significance testing procedure." *Journal of Philosophy of Education 40*(4): 501-509.
- RAY J. L. 1963. "Forest roads in the tropics – I." *an International Review of Forestry and Forest Products. FAO - The Food and Agriculture Organization (FAO)*, *Unasylva*69 (17): FAO corporate document Repository.
- Redman, L. V and Mory, A. V. H. 2009. *The Romance of Research*, Baltimore: The Williams and Wilkins Co.
- Redman, L. V and Mory, A. V. H. 2009. *"The Romance of Research. Baltimore."* The Williamsand Wilkins Co.
- Reichardt, C.S. and Cook, T.D. 1979. "Qualitative and Quantitative Methods in Evaluation Research." London: SAGE.
- Rutten M., Dorée G., and Halman J. 2014. "Exploring the value of a novel decision-making theory in understanding R&D progress decisions." Journal of Quality Management 51(1): 184-199.

- Rwelamila, P.D. and Hall, K.A. 1995. "Total Systems Intervention: an integrated approach to time, cost and quality management." Construction Management and Economics. 13: 235–241.
- Sabur, M. A., "Total Quality Management as a Tool for Decision Making", *Asian Business Review, Volume 3, (Issue 6), ISSN 2304-2613 (Print); ISSN 2305-8730 (Online), Number 4, 2013.*
- Schraagen, Jan Maarten, and J Van de Ven. 2008. "Improving Decision Making in Crisis Response through Critical Thinking Support." *Journal of Cognitive Engineering and Decision Making* 2 (4): 311-327.
- Schuh, G., Potente, T., Thomas, C., and Zeller P. 2014. "Improving Decision Making within Production Control", *Laboratory for Machine Tools and Production Engineering (WZL)*, International Conference on Industrial Engineering and Operations Management, Bali, Indonesia.
- Schwandt, T. A. 2000. *Three epistemological stances for qualitative inquiry: Interpretivism, hermeneutics and social constructivism*. In N. K. Denzin and Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed.189-214). Thousand Oaks, CA: Sage.
- SD-LTAP. 2000. "Gravel Roads-Maintenance and Design Manual-South Dakota local Transportation Assistance Program (SD LTAP)-U.S". *Department of Transportation-Federal Highway Administration.*
- Sechrest, L., and Sidani, S. 1995. Quantitative and qualitative methods: Is there an alternative? *Evaluation and Program Planning, 18*(1): 77-87.
- Seidman, I 1998. *"Technique isn't everything, but it is a lot. In Interviewing as qualitative research: A guide for researchers in education and the social sciences."* New York, NY: Teachers College Press.

- Shankaranarayan, Ganesan, MostafaZiad, and Richard Y Wang. 2003. "Managing Data Quality in Dynamic Decision Environments: An Information Product Approach." *Journal of Database Management (JDM)* 14 (4): 14-32.
- Shia, C. S., Costa, I. 2014. "Perception system to assist in decision making and monitoring of quality of software development in Information Technology environments", *American Journal of Engineering Research (AJER)* 3 (3): 251-263, E-ISSN: 2320-0847 P-ISSN: 2320-0936
- Shoommuangpak, Porntip. 2011. "Effectiveness of Management Accounting Implementation, Decision Making Quality and Performance: An Empirical Study *of Thai-Listed Firms." International Journal of Business Strategy 11 (1). ISSN: 1553-9563.*
- Shuy RW. 2003. *In-person versus telephone interviewing.* In: Holstein JA and Gubrium JF (eds) *Inside Interviewing*: 175–193. New Lenses, New Concerns. Thousand Oaks, CA: Sage.
- Singh, G. Singh, J. 2001. "Highway Engineering" Standard Publishers, Delhi. (Third Edition)
- Ssemaluulu, Paul, and Ddembe Williams. 2008. "Use of "Flight Simulator" for Training It Managers in Investment Decision Making." *Strengthening the Role of ICT in Development*: 144.
- Stanfield II, J. 2006. "The possible restorative justice functions of qualitative research." *International Journal of Qualitative studies in Education*. 19 (6): 723-727.
- Stashevsky, Shmuel, and DovElizur. 2000. "The Effect of Quality Management and Participation in Decision-Making on Individual Performance." *Journal of Quality Management* 5 (1): 53-65.

- Stuth JW. ConnerJR. and Heitschmidt RK. 1991. "The Decision-Making Environment and Planning Paradigm." *Grazing management: an ecological perspective. Edited by RK Heitschmidt and JR Stuth. Timber Press, Portland, Oreg*: 201-223.
- Susmita D. Mainul H. Zahirul HK. Sohel M. Manjur A. Nandan M. Kiran P. 2010. "The Incremental Cost of Limiting Future Inland Monsoon Flood Damage" Climate Proofing Infrastructure in Bangladesh. *Policy Research Working Paper 5469.* The World Bank Development Research Group, Environment and Energy Team.
- Tashakkori, A., and Teddlie, C. 1998. *"Mixed methodology: Combining qualitative and quantitative approaches."* Vol. 46. (L. Bickman, and D. Rog, Eds.) Thousand Oaks, CA: SAGE.
- TrentacosteM. 1997. "FHWA Study Tour for ROAD SAFETY AUDITS." Part 1, Federal Highway Administration, U.S. Department of Transportation.
- TRRL Overseas Unit 1997. *"Principles of low cost road engineering in mountainous regions, with special reference to the Nepal Himalaya."* Overseas Road Note 16. Crowthorne: Berkshire, RG45 6AU.
- Turban, E. Aronson, J. E. 1998. *Decision Support Systems and Intelligent Systems.* 5th Edition, Prentice-Hall.
- TURSKIS, Z. ZAVADSKAS, E.K. 2010. "A Novel Method for Multiple Criteria Analysis: Grey Additive Ratio Assessment (ARAS-G) Method". Vilnius Gediminas Technical University, Sauletekio al. 11, LT-10223 Vilnius, Lithuania. 21 (4): 597–610.

- United States Agency for International Development (USAID) 2010.*Design and Reconstruction of the Keshim - Fayzabad Road (103 Km)*, Afghanistan Infrastructure Rehabilitation Program (AIRP) fund by USAID, https://www.irp-af.com/?pname=open&id=424&type=html&c=5,
- United States Agency for International Development (USAID). (2007~2011).“Afghanistan Infrastructure and Rehabilitation Program”. *The Louis Berger Group Inc. / Black and Veatch Special Projects Corp. Joint Venture (LBG/B&V).*
- Vance, W. A. 2005. “Role of Science and Engineering in Decision-Making within the State and Regional Water Boards.” State Water Resources Control Board, Sacramento, CA 95812.
- Vance, William A. 2005. *Role of Science and Engineering in Decision-Making within the State and Regional Water Boards*: State Water Resources Control Board.
- Velez, A. M. 2008. Evaluating Research Methods: *Assumptions, Strengths, and Weaknesses of Three Educational Research Paradigm. http://www.unco.edu/ae-extra/2008/9/velez.html*
- Vincent, K.O. and Joel, E.R. 1995. *“Principles of Total Quality.”*Kogan Page, London.
- Vlakveld W., Wesemann P., Devillers E., Elvik R., Veisten K. 2005. ‘Detailed cost-benefit analysis of potential impairment countermeasures: research in the framework of the European research programme IMMORTAL’, SWOV Institute for Road Safety Research, Leidschendam.
- Vo, Chae and Olson 2002. “Information Technology and Decision Making.” *International Journal* (DOI:10.1142/S0219622002000166. 01, 269).

- Walker S., Cone M., McAuslane N. 2007. "Quality Decision-Making: Procedures and practices in drug development and the regulatory review" *CMR International, Institute for Regulatory Science*.
- Wallace, K. A. 1999. 'Anonymity,' Ethics and Information Technology 1: 23-35.
- Walsh, K. 2003. "Qualitative Research: Advancing the Science and Practice of Hospitality." Cornell Hotel and Restaurant Quarterly. 44 (12): 66-75.
- Walsham, G. 199). *Interpreting Information Systems in Organizations*. Chichester: Wiley and Sons, New York, USA.
- Weiss, R. S. 1994. *"Learning from strangers, the art and method of qualitative interview studies."* New York, NY.
- Weiss, R. S. 1994. *Learning from strangers, the art and method of qualitative interview studies.* New York, NY: Free Press.
- Williams, Ddembe, and Michael Kennedy. 2000. "Towards a Model of Decision-Making for Systems Requirements Engineering Process Management" *International System Dynamics 2000 Conference, Bergen, Norway*.
- Yang, Maria C. 2010. "Consensus and Single Leader Decision-Making in Teams Using Structured Design Methods." *Design Studies* 31 (4): 345-362.Department of Mechanical Engineering and the Engineering Systems Division, Massachusetts Institute of Technology, 77 Massachusetts Avenue, 3-449B Cambridge, MA 02139, USA.
- Yin, R. 1994. *Case study research: Design and methods* (Second Edition.). Beverly Hills, CA: Sage Publishing.

- Yin, R. K. 2003. *Case study research: Design and methods (third ed.).* Newbury Park: Sage Publications.
- Yin, R., and Moore, G., 1987. "The use of advanced technologies in special education." *Journal of Learning Disabilities, 20* (1): 60.
- Yin, R.K. 1984. *Case Study Research: Design and Methods*. Beverly Hills, Calif: Sage Publications.
- Yoder E. J. and Witczak M. W. 1975. "Principles of Pavement Design." *A Wiley Interscience Publication*, Jon Willy and Sons, Inc. New York, Chichster, Brisbane, Toronto, Second Edition: 186.
- Zavadskas, E. K., Liias, R., Turskis, Z.2008. "Multi-Attribute Decision-Making Methods for Assessment of Quality in Bridges and Road Construction: State-Of-The-Art Surveys." *Baltic Journal of Road and Bridge Engineering*. 3 (3): 152-160.
- Zhao, T., Sundararajan S. K., and Tseng, C. 2004. "Highway Development Decision-Making under Uncertainty: A Real Options Approach." *Journal of Infrastructure Systems*, 10 (1): 23–32.
- Zhou, K.-Y., and Sheate, W. R. 2011. "Case studies: Application of SEA in provincial level expressway infrastructure network planning in China - Current existing problems." *Environmental Impact Assessment Review* 31: 521-537.
- Zou, Rui, Yong Liu, Lei Liu, and Huaicheng Guo. 2009. "Reilp Approach for Uncertainty-Based Decision Making in Civil Engineering." *Journal of computing in civil engineering* 24 (4): 357-364.

# APPENDIX A

## Interview Questions

# INTERVIEW QUESTIONS

**Table 5: Interview Questions for Bangladesh;**

| | |
|---|---|
| Q1_BD | What was your position in this company at the time of SRNDP in Bangladesh? |
| Q2_BD | How long had you worked for this company at the time SRNDP was under design and construction? |
| Q3_BD | What are your qualifications? |
| Q4_BD | How much experience have you had in quality decision making? |
| Q5_BD | How would you define quality decision making? |
| Q6_BD | How would you define quality decision making with regard to design and construction? |
| Q7_BD | What elements do you consider important for effective quality decision making with regard to the design and construction of the project of SRNDP? |
| Q8_BD | What legislation and standards did your company comply with when implementing this construction project? Were there any difficulties complying with these standards during SRNDP in Bangladesh? If so, what were they? |
| Q9_BD | Did you conduct a Cost-Benefit-Analysis (CBA) as part of the quality decision making during this project? If not, why not? |
| Q10_BD | Did you conduct an Analysis of Uncertainty (AU) as part of the quality decision making during this project? If not, why not? |
| Q11_BD | Did you conduct a Checklist Procedure as part of the quality decision making during this project? If not, why not? |

| | |
|---|---|
| Q12_BD | How would you define Engineering Problems? How were problems mitigated during the design phase? How were problems mitigated during the construction phase? |
| Q13_BD | How would you define Context-sensitive Design approach? Was this approach used for this project? If so how? If not, why not? |
| Q14_BD | How do you think resources with regard to time could be more efficiently managed? |
| Q15_BD | How do you think resources with regard to quality could be better managed? |
| Q16_BD | How do you think resources with regard to budget be better managed? |
| Q17_BD | What kind of design and construct standard- form- of contract did you use for this project? |
| Q18_BD | What kind of contract did your company use for the SRNDP? To what extent did the schedule form part of the contract documents? |
| Q19_BD | Who was responsible for producing and actioning the schedule? |
| Q20_BD | How were the estimating, planning components of the contract and the Bill of Quantities monitored after construction work started? Were there deviations to the contract found? If so, what were they? |
| Q21_BD | How were the environmental variables monitored? To what extent did they adhere to the contract? |
| Q22_BD | How were the human resources monitored? To what extent did they adhere to the contract? |
| Q23_BD | How were the materials/equipment resources monitored? To what extent did they adhere to the contract? |
| Q24_BD | What standards did you follow for the design and construction of the SRNDP? Were there any difficulties following the standards? If so, |

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| | what were they? |
| Q25_BD | Are there other standards that could have been satisfactorily followed for this road design and construction project? |
| Q26_BD | How would you define risk? |
| Q27_BD | How were risks identified during the design and construction phases? Were there any difficulties identifying these risks? If so, what were they? If you did not identify risks, why not? |
| Q28_BD | How were risks mitigated during the design and construction phases? |
| Q29_BD | Did you conduct an LCCA as part of the quality decision making during this project? If not, why not? |
| Q30_BD | What regional development plans did the design development process for this project follow? |
| Q31_BD | How would you define value-management and value-engineering? Was it used? If yes, at what stage was the value management or value engineering implemented? |
| Q32_BD | If not, what other quality decision making method was used? Was it adequate, in your opinion? Why/why not? |
| Q33_BD | Did you conduct value-management/value-engineering as part of the management decision making process for the SRNDP? Why/why not? |
| Q34_BD | How would you improve future management decision making for future projects? |

**Table 6: Interview Questions for Afghanistan;**

| | |
|---|---|
| Q1_Afg | What was your position in this company at the time of KFP in Afghanistan? |
| Q2_Afg | How long had you worked for this company at the time KFP was under design and construction? |
| Q3_Afg | What are your qualifications? |
| Q4_Afg | How much experience have you had in quality decision making? |
| Q5_Afg | How would you define quality decision making? |
| Q6_Afg | How would you define quality decision making with regard to design and construction? |
| Q7_Afg | What elements do you consider important for effective quality decision making with regard to the design and construction of the project of KFP? |
| Q8_Afg | What legislation and standards did your company comply with when implementing this construction project? Were there any difficulties complying with these standards during KFP in Afghanistan? If so, what were they? |
| Q9_Afg | Did you conduct a Cost-Benefit-Analysis (CBA) as part of the quality decision making during this project? If not, why not? |
| Q10_Afg | Did you conduct an Analysis of Uncertainty (AU) as part of the quality decision making during this project? If not, why not? |
| Q11_Afg | Did you conduct a Checklist Procedure as part of the quality decision making during this project? If not, why not? |
| Q12_Afg | How would you define Engineering Problems? How were problems mitigated during the design phase? How were problems mitigated during |

| | |
|---|---|
| | the construction phase? |
| Q13_Afg | How would you define Context-sensitive Design approach? Was this approach used for this project? If so how? If not, why not? |
| Q14_Afg | How do you think resources with regard to time could be more efficiently managed? |
| Q15_Afg | How do you think resources with regard to quality could be better managed? |
| Q16_Afg | How do you think resources with regard to budget could be better managed? |
| Q17_Afg | What kind of design and construct standard- form- of contract did you use for this project? |
| Q18_Afg | What kind of contract did your company use for the KFP? To what extent did the schedule form part of the contract documents? |
| Q19_Afg | Who was responsible for producing and actioning the schedule? |
| Q20_Afg | How were the estimating, planning components of the contract and the Bill of Quantities monitored after construction work started? Were there deviations to the contract found? If so, what were they? |
| Q21_Afg | How were the environmental variables monitored? To what extent did they adhere to the contract? |
| Q22_Afg | How were the human resources monitored? To what extent did they adhere to the contract? |
| Q23_Afg | How were the materials/equipment resources monitored? To what extent did they adhere to the contract? |
| Q24_Afg | What standards did you follow for the design and construction of the KFP? Were there any difficulties following the standards? If so, what were they? |

| | |
|---|---|
| Q25_Afg | Are there other standards that could have been satisfactorily followed for this road design and construction project? |
| Q26_Afg | How would you define risk? |
| Q27_Afg | How were risks identified during the design and construction phases? Were there any difficulties identifying these risks? If so, what were they? If you did not identify risks, why not? |
| Q28_Afg | How were risks mitigated during the design and construction phases? |
| Q29_Afg | Did you conduct an LCCA as part of the quality decision making during this project? If not, why not? |
| Q30_Afg | What regional development plans did the design development process for this project follow? |
| Q31_Afg | How would you define value-management and value-engineering? Was it used? If yes, at what stage was the value management or value engineering implemented? |
| Q32_Afg | If not, what other quality decision making method was used? Was it adequate, in your opinion? Why/why not? |
| Q33_Afg | Did you conduct value-management/value-engineering as part of the management decision making process for the KFP? Why/why not? |
| Q34_Afg | How would you improve future management decision making for future projects? |