Managing the adoption of new technology by groundwater development companies in arid regions

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Abstract

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In the last decade, water exploration companies in arid regions of the world, particularly in the Kingdom of Saudi Arabia, have experienced business uncertainty resulting from the impact of climate change on their operations. The combination of declining water resources and increasing water demands presents a significant challenge to business sustainability. In response to this changing environment, drilling companies have sought solutions through the adoption of new technologies to improve productivity and efficiencies. However, companies in this water sector have traditionally been slow to adopt new technology. My own company offers drilling technology to firms in this water sector, and we have observed a reticence to implement new technology. The objective of this DBA thesis is to develop an actionable framework for the adoption of new technology by groundwater development companies in arid regions; and to make use of the framework in one technology adoption project.

The research draws from the academic literature related to the management of technology adoption to support an action research design conducted with the participation of six water drilling companies in the Kingdom of Saudi Arabia. The research design was organized in two stages. In stage 1; important themes from the literature of technology adoption informed engagement with the management of six leading drilling companies. Qualitative interviews were conducted with management from a range of functions within companies, to understand their current operational performance and experience of adopting new drilling technology. A thematic analysis of the interviews was used to build an actionable framework for the management of adopting new technology in this context. In the second stage of the research design, the actionable framework model was used by one of the companies in order to create and execute a plan to implement new drilling technology. This thesis reports the development of the plan and presents an evaluation of its implementation.

The thesis concludes with future implications for drilling companies, my own technology company, my own management practice as well as reflections on my own DBA “journey”.

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Chapter 1: Introduction

1.1 Project background

In a global technology and skills-based economy the performance of water drilling companies depends upon adopting new technology and ensuring that all their employees possess current and up to date knowledge and skills. Adoption of new technology is a critical decision for business growth, productivity competitiveness, and even sustainability. The adoption of new technology is acknowledged to be a significant management challenge (Roy & Raymond, 2008). For example, not only must drilling companies identify the most suitable technology, but they must educate their staff at the lowest possible cost while choosing the opportune time for adoption. Thus, many companies are now considering adopting new feasible technologies and employing specialized training programs for their employees to sustain in the most competitive business market.

Technology adoption can be defined as the process that starts with the firms becoming aware of the technology, evaluating potential competitive the benefits and finally integrating it within their operations (Montalvo,2008). Therefore, a firm will only choose to adopt new technology and training process if it is certain that doing so will provide greater benefits than the previous technology and generating more advanced services for the customer. Identifying the most appropriate implementation time for both the company and the technical staff employees is important to ensure that technical staff may also be benefited from the availability of an opportunity to learn in an appropriate manner at a higher pace.

The adoption of new technology is also becoming a key issue in public and policy arenas. This research study on technology adoption by drilling companies may also inform efforts of policy makers seeking to assist firms to foster technology adoption process, as such adoption presents a demanding management challenge. The obstacles to adoption of new technology are numerous and still limitedly understood (Wehn and Montalvo, 2014). First, the adoption decision concerning technology may depends upon several determinants that are context-specific and initiated mutually (Montalvo 2008). Secondly, the costs and rewards of new technology adoption are distributed unevenly among the stake holders including management, drilling staff, customers, and policy makers and may have conflicting objectives.

This multifaceted challenge brings in significant challenges for those who aim for higher efficiency at the company as well as the sectoral level. In addition to in-house company regulations, interaction with local regulatory authorities is a distinctive trait of most new technologies in the water sector. Water resources management is an inherently political process, whose hazards have not been recognized sufficiently in the water resources and environmental literature (Mollinga, 2008). The adoption of new technologies requires the involvement of various actors within the value chain network. Technology and drilling companies' management and technical staff must possess adequate technical and organizational capabilities. It may be difficult to overcome the lack of professional

knowledge of those companies' managers, who do not necessarily have aligned objectives. This can influence adoption choices and may even disrupt adoption process efficiencies.

This research addresses the management challenges in adopting new technologies for groundwater drilling companies that are seeking to improve their competitiveness. The research generates additional actionable knowledge for technology adoption, through a qualitative case study methodology. The research engages with six water companies which are assessing new drilling technologies in the Arabian Peninsula. I have been working with these companies for some time, in relation to a new drilling technology I have invented, which brings significant changes to the cementing of water wells and has been approved by the Ministry of Water of Saudi Arabia which is the country's only regulatory authority.

I am a researcher and a consultant with 25 years' experience in ground water exploration and development in arid regions around the globe. I have several publications at an international level. I have my own water resources consulting company in Canada and I have worked with different organizations and multinationals in the Middle East and abroad. I have explored all the major aquifer systems while working in close cooperation with government agencies, including the Saudi Ministry of Water, the United States Core of Engineers, Bureau de Recherché Geologies' et Manières (BRGM) France, Harza Engineering, the United States Geological Mission, Aramco, Nestle and other major private sector organizations.

While on consulting assignments, I have encountered many ground water exploration and management challenges concerning organizational performances and efficiencies in productivity and well cementing operations. This is how I invented my own technology to resolve deep water well drilling and completion issues. This new technology not only assists in the cementing of wells with higher cement bonding strengths, but it also provides higher production with the same energy input and pumping systems. This is the reason why the Saudi Ministry of Water approved this technology and incorporated it into new deep well specifications, to safeguard productivity and well efficiencies in the future. This technology policy change may influence drilling companies in adopting new technologies to safeguard their own business interests in the water sector.

Deep water well cementing operations are challenges due to their complexity. It is difficult to imagine drilling and completing water wells without proper cementation operations. The placement of neat cement slurry, with no contamination from drilling mud, is necessary to improve the quality of cementing jobs. Newly developed innovative shoe and collar technologies are proving far superior to existing technologies, by increasing cement bonding strengths and well life (Sahi, 2018).

Introducing technological change into a company presents multiple challenges to leadership and drilling management. While working with six drilling companies, I have found a persistent and troubling gap between the inherent value of the technology and a company's organizational ability to acquire, adopt and integrate the technology into their company environment. During my research, both the leadership and drilling management had difficulties in closing this gap. As a researcher, I identified challenges to implementing new technologies, including resistance to change and other company issues. I noted that

drilling managers from one company, who were responsible for managing technology adoption processes, had their own skills and technical knowledge severely scrutinized. Two other companies did not have enough drilling infrastructures required for the new technology adoption process. Other companies were not prepared to receive the new technologies due to shortages of drilling workers. Although technology adoption processes varied from company to company in terms of cultural issues, the availability of proper drilling infrastructures and trained drilling workforce were serious hurdles for some companies.

I concluded there were not just knowledge gaps associated with the adoption of new technologies, but also management challenges. This allowed me to set down the aims of this research, to explore these challenges and find solutions for one of these companies.

This chapter explores groundwater scarcity issues in operational contexts, technology adoption in the groundwater sector, technology policy in Saudi Arabia, an introduction to Company A, the research objectives and concluding remarks.

1.2 Operational context of research - Water scarcity issues in arid regions

There were increasing pressures on water resources over the latter part of the last century, due to growing competition between divergent interests, and there has been a growing awareness that these resources are scarce and overexploited. It is now recognized that water is an intricate part of nature and is more than just a resource for developed and developing countries. This is especially true for countries with arid landscapes.

Saudi Arabia is amongst the most arid countries in the Middle East but has a tremendous hydro-geological potential. The country hosts numerous fossil water aquifers created during the last ice age. These ancient fossil waters exist mostly in the central, eastern and northern regions and mostly within the sedimentary sequence. At present, Riyadh's water requirements are partially fulfilled by existing aquifer systems, while the remainder comes from the city of Jubail's sea-water desalination avenues. For the former, the Minjure aquifer has been the major water supply source for Riyadh. The Minjure aquifer, from the late Triassic age, is exploited through ground water wells, which are variable in depth. It is suggested that unless more innovative research procedures are applied to developing and extracting ground water, managing water demands in cities will become more difficult. Sustainable water utilization goals will become less manageable, while exploration for new ground water resources continues in arid regions.

The key environmental challenge is short water supply. This is because an aquifer's natural recharge is almost negligible due to rain scarcity. As a result, the only way is to increase desalinated water production, which is enormously expensive and causes massive environmental pollution. Thus, the salient goal of groundwater resource management has long been improvement of the resource. My argument is that problems are not primarily caused by water shortages, but by the increasing demands of population growth, industrialization and over-exploitation of resources.

There is extensive and theoretically diverse management and exploration literature concerning ground water resources (Driscoll, 1986; Helwig, 1985; GrIgg, 1996; Ponce, 2006), but it is inconclusive Since the last decade there has been work on the role of innovative well development procedures and managerial intentionality in managing ground water resources and achieving sustainability in arid regions (Al-Ibrahim, 1991; Ponce,2006; Hamilton,2012). Indeed, this literature focuses more on resource selection and water consumption, rather than improving the resource itself. The context of my research revolves around innovative well development procedures, which not only improve the resource's efficiency, but also extend its life. Early tests show that the technology can be used with existing pumping equipment, without additional costs. This alone is a step towards sustainable development. My experiences suggest that a technological solution to the drilling of deep-water wells is necessary, but enough practices of technology adoption are not well developed in this sector. In addressing these management challenges, this research aims to resolve groundwater management and sustainability issues, through efficiency improvements.

Innovative well development procedures and cementing technologies will play dynamic roles in groundwater exploration and developments in the future, specifically in the water policy sector. This is particularly significant in the Middle East, where aquifers are deep and continuously depleted with little sign of replenishment. Though this research demonstrates that deep groundwater resources can be developed more economically and efficiently, in a wide range of settings, more research insights are required. Development techniques for wells need to be developed to cope with diminishing ground water resources in the Kingdom of Saudi Arabia (KSA). Groundwater exists in arid regions in the form of non-renewable resources. This is largely due to the scarcity of surface water from little or no rainfall in these regions; the Arabian Peninsula is no exception.

The fundamental goal of water resource management is to economically harness the resource without depletion, while simultaneously laying out sustainable extraction plans and incorporating new technology adoption processes.

This may sound simple in theory, but it is very complex in practice, especially in countries like Saudi Arabia where demand outstrips supply. In such cases, the government has made very difficult decisions outlining key water policies and procedures through inter-disciplinary approaches, in accordance with the country's water demands and existing ground water reserves. Saudi Arabian groundwater resources originated from the last ice age through prehistoric fossil waters, encapsulated in deep aquifers in vast networks all over the Arabian Peninsula. Thanks to the country's population expansion and immense water demands, once resources are drained, it will be impossible to support cities with enough desalinated sea water (Al-Ibrahim, 1991).

The main aquifer used in this research is called the Minjure aquifer. It is one of the largest and most significant aquifers in terms of its historical and contemporary value. The aquifer was formed during the late Triassic period and is mainly composed of sandstone and shale sediments. It has supplied water to Riyadh for over a half a century (Beaumont, 1977). However, there may not be enough water left for future generations; therefore, the

government has implemented harsh controls and halted extraction of water from the Minjure aquifer without prior approval from the Ministry of Water. Still, government oversight and controls are only one part of the solution as new technological advancements, economical explorations and management techniques must be applied to new and old water wells, to safeguard future generations (Al Ibrahim, 1991).

This research will engage with six companies exploring the Minjure aquifer in areas where new wells are being drilled or have been drilled recently, employing the technology and innovative development procedures in the east of the basement complex of the Arabian Shield in sedimentary deposits. Information from existing wells and outcrops, from a leading groundwater exploration company (ADCO) database, confirms that related strata and the Minjure dip gently around one degree, from east to north-east. ADCO has developed a comprehensive database of water resources in the KSA. The strata largely consist of Cretaceous and late Triassic formations. The Minjure aquifer is composed of course and well cemented sandstone of the upper Triassic era. The mean porosity is quite high. It predominantly consists of sandstone and shale beds of various thicknesses, which creates serious issues for well completion, well development and screen installations, in relation to geophysical log results. The drilling companies, which do not have the ability to make such adjustments in accordance with the geophysical logs and actual drill string's length, well completion, developments and screen settings, will have an impact on their due diligence from any new technology (Todd, 1980).

1.3 Technology adoption in the ground water sector

The ground water sector has always been relatively reluctant in developing and adopting new technologies. However, with the development of water quality standards and increasing awareness of ground water scarcity, it has become a burning issue in the 21st century (John, 2013). New and innovative technology procedures in groundwater resources have begun to impact the groundwater resources management sector (Sahi, 2018). This technology improves efficiency and has reduced carbon footprints thanks to energy reductions and well life extension. Thus, in principle new technology could be a solution for improving both environmental and operational performances.

In previous research, I argued that the use of new technology in resource development has increased the production, and life expectancy to a great extent, making managerial decision-making processes more reliable and cost effective in meeting the ever-growing demand for water and other socio economic challenges such as population growth and industrialization in arid regions such as Saudi Arabia (Sahi, 1997). This research argued that groundwater sector companies needed to increase their capacity to address strategic challenges through new technology adoption processes, to improve groundwater sustainability. Groundwater companies should always be looking to adopt leading-edge technologies and innovative solutions from research, thereby raising their absorptive capacity through a sense of urgency and positive strategies. Incentives must promote new technology solutions through the support of ground water authorities. Incentives motivate companies to improve their technology base and adapt to new technologies. But it remains a difficult issue. However, the importance of groundwater sustainability in the context of

climate change implies a role for new technologies among those responsible for making the policy decisions (Taniguchi and Hiyama, 2014).

The management of water resources in Saudi Arabia differs from other countries, because of its arid climate. As explained above, the country relies heavily on groundwater and desalination processes. However, the country has oil wealth, therefore supplying water is nominal in cost. For Riyadh, almost 50% of water comes from desalination and the remainder comes from groundwater aquifers. Despite massive investments in the water sector, substantial inequalities still prevail due to institutional capacities and regulatory issues. However, the future of the water sector looks good. It has great potential for development and growth. It is expected to draw huge investments in the coming decades for both desalination and groundwater drilling areas. The government is taking constructive steps in improving the water sector's regulatory framework. This will pave the way for the privatization of the water and desalination sectors. In moving towards privatization, the government will reassess water tariffs to develop a national plan to attract foreign investments to this sector (Brown,1972; Gleick,2000; Brzozowski, 2007).

Currently, the most important water requirement is raising domestic water capacity to cope with growing populations and industry demands. With an average population growth rate of 2.5%, the Saudi government faces tremendous challenges in providing reliable water supplies in the coming decades. Government policy must expand desalination capacities to safeguard depleting aquifers. Water strategies in the agriculture sector include conservation and technology improvements in irrigation and water resource development. The agriculture sector is the largest water consumer, but it has very low productivity. At present, water consumption is more than ten times the renewable ground water resource. The adjustment is being done through fossil water, which is critical because the country's water demands must be balanced between renewable and non-renewable water resources.

1.4 Technology policies in Saudi Arabia

In 2002, the technology policy for the water sector in Saudi Arabia was approved by the Council of Ministers. Their aim was to develop technologies for the development and support of socio-economic programs, through both local and external means. The importance of a water technology program evolved from water's role in the country's development. It is based on input from all stakeholders including government agencies and industry. The Ministry of Water looks after water resources and is responsible for the supervision of all water sector policies and regulatory controls. The Ministry's main role is setting up mechanisms, instruments and programs to manage water resources and water delivery services, in a sustainable manner. These programs include the development of water resources, geological and hydrological studies, well drilling, the reuse of wastewater and the construction of dams to provide water for municipal, agriculture and industrial use. Encouraging self-reliance and supporting local water technology industries should contribute to employment opportunities and economic performance. My argument is that this is the right time for groundwater exploration companies working in Saudi Arabia to challenge efficiency targets and provide investment for technological solutions. This will

allow companies to deliver better value for customers and meet production targets. Companies can then contribute to the national policy of the country.

This research indicates that the organizations which have embraced new technologies have the biggest impact on efficiency gains and overall performance. It is up to these companies to manage their businesses and determine how to achieve set targets and objectives. Whether to invest in new technology and by how much is decided by the individual water company. There is a perception within the groundwater industry that technology does not necessarily have to be cutting edge. Technology must suit the purpose, but with changing times, infrastructural developments and continuous population growth, the water industry needs to rely on technologies, ideas, processes and systems. Groundwater companies need to embrace, absorb and utilize new technologies to provide reliable water supplies, maintain higher productivity and cut down the on harmful carbon footprints. Capturing and embracing new technology will lead to improved operations, capital investments and performance efficiencies.

The KSA's new technology policy seeks to improve the health of the water sector, by providing innovative solutions to meet water scarcity issues. These indicators may also guide regulatory authorities to monitor inputs and outputs, together with economic and environmental measures to understand water scarcity challenges. New technology transfer will provide additional opportunities to tackle water scarcity, productivity and building technological expertise in the water sector. New technologies must be strengthened through effective changes and adapting to local environments.

My argument is that new innovative technologies may generate extra business and higher revenues in special areas of exploration. Having new technological expertise leads to improvements in the application of new technologies, in terms of efficiencies, dealing with climate change effects and continuously improving operations. The new technology may not meet all water demand challenges, but it can be significant in building visionary strategies to deal with water resource management issues. This research shows that new technologies are at the helm of competitive strategies for any successful company. My experience with drilling companies suggests that companies which reengineer their business processes, by adopting new technologies, gain critical sustainable and competitive advantages in the marketplace.

However, the implementation initiative determines the success of the whole implementation process. New technologies must transfer know-how and core knowledge. This requires specialists who must build additional infrastructures involving people and training. Incorporating in-house or on the job training are key components of the implementation process. Companies and employees who build their own systems are more innovative in developing solutions later, as they have the expertise to provide efficient services (Heath and Heath, 2010). Developing new protocols and standards regulatory authority could play an important role in this area by erasing and replacing existing ones. Whilst both technologies and organizations are malleable and contingent, a degree of continuity is required if the technological adoption process is to be successful. Stakeholders are crucial in identifying unexpected problems and finding solutions. Working cultures can

also be affected by implementation processes. However, employees must be convinced of the benefits of inter worker-relationships and improvements in the working environment. Cost is a fundamental factor with new technology adoption and implementation processes. The company needs to prioritize and make decisions to accept and implement the new technology based on viable, essential and beneficial operations.

Other challenges may include security concerns; cultural issues can emerge as technology adoption processes may vary between countries (Bansemir *et al.,* 2012). In the KSA, security is not a big issue, but, personnel training and shortages of trained workers are real challenges in new technology adoption. Training processes are not only time-consuming, they are cumbersome due to shortages of skilled and self-oriented personnel. My experience suggests that drilling companies need to build long-term viable strategies to cope with these issues and mitigate uncertainties in the future. The need for adoption of new technology is widely recognized, but unfortunately, conventional wisdom does not offer much advice on how to embrace new technology (Jelinek and Schoonh, 1990).

Managing change, especially in relation to new technology, poses serious challenges. Companies are traditionally built for stability, but in turbulent times they need to adapt to maintain their competitive edge. My argument is they should call upon extraordinary technology talent, which needs to be updated on a continuous basis in any way required under the technology policy of KSA. Companies need to stay focused on the future, while managing the present. This demands continuous change and efficiency. I believe that once company management plans to embrace new technology, the focus should be on how to blend these entities, so that core advantages are captured, and pitfalls avoided.

1.5 Company A

This research involves six ground water companies. Technology adoption practices in this sector are explored using examples from all six. However, one of the firms (Company A) was interested in developing new practices, following an action research methodology. This sub-section introduces the company and outlines its challenges.

Company A is a leading Saudi groundwater exploration business in the Arabian Peninsula. It was established in 1958 as a water well drilling company. Since its formation, the company has grown and diversified into numerous other areas including geophysical investigations, supply of pumping systems, operating and maintaining deep water wells and the provision of recreation facilities. For water well drilling, pumping system installations, maintenance, recreation facilities, pipelines and accessories, the company has led projects all over the Arabian Peninsula; however, this is no longer the case. Over the years, the company has simply failed to add new technologies, which had been their biggest strength in the past. Due to a lack of new technologies and other internal challenges, Company A's growth drastically slowed down in the last decade. Revenues dropped from $82 million to less than $10 million. Similarly, their market image and customer base have shrunk proportionately.

The company wanted to regain its lost business through the strategic introduction of the latest technologies. This was considered visionary for a drilling business when oil prices were dropping, and the country needed better equipped companies to execute water projects. The leadership felt the company's adoption processes were lacking. Finally, the company decided to adopt new technologies and train the workforce to reclaim market share and make the company profitable again.

1.6 The research objective

My company invented a new technology for groundwater drilling and Company A decided to implement this technology. Their motivation was to improve their existing market position and future business prospects through new technology adoption. My experience suggested that it was not simply an absence of new technology, but also a lack of robust processes for integrating such technology into existing operations. The objective of this DBA thesis is to develop an actionable framework for the adoption of new technology by groundwater development companies in arid regions (based upon interviews with six drilling companies); and to make use of the framework in one technology adoption project with Company A. The research questions guiding this action inquiry are:

a) what actionable framework can be used to support the management technology adoption and its associated challenges?

b) how can this framework can be actually implemented within a water-drilling firm? and

c) what can be learnt from this implementation experience and its evaluation?

The rest of the thesis is structured as follows.

The next chapter is a review of the literature concerning the management of technology adoption and its implementation process.

Chapter Three covers the research design and explains the participation of ground water companies, particularly Company A in the action inquiry methodology.

Chapter Four presents the research findings and analysis. The output of the analysis is an actionable framework for technology adoption.

Chapter Five narrates a discussion with Company A, concerning the use of the actionable framework for adopting new drilling technology and reports on an external evaluation of the operation; the new technology required by KSA drilling regulations.

Chapter Six reflects on the action research with Company A (chapters 5 and 6) and argues for the implications for drilling companies in the groundwater sector, my technology company and my professional practice.

Finally, Chapter Seven concludes the thesis with reflections on my scholar-practitioner “journey” during this thesis project and the DBA program.

1.7 The research Importance

This research is of crucial importance for countries in the Middle East and Africa (MENA)area, it is the home to 12 of the world's 17 most water stressed countries `in the world. The whole region is extremely hot and dry with minimal rainfall. Water supplies are low, and the demands are now growing, pushing the countries into extreme stress. Climatic changes are adding fuel to the fire. World Bank confers that with continuous population growth this region may experience huge socio-economic losses that can vary around 6-14% of GDP by 2050 (Hofste et al, 2019). Water scarcity is just one dimension of water security. Like any other challenge, water scarcity outlook depends upon how new technology is being adopted and integrated by the management in the water sector firms. At present prevailing water scarcity situation, the water supplies may worsen due to fast depleting water resources in the Arabian Peninsula and may continue to further deteriorate due to limited renewable freshwater resources and rising of demands of fresh water due to population growth, socio- economic development and climatic changes. This situation may aggravate the other sectors as their performance may be increasingly dependent on the availability and management of water. World Bank report further adds that it is the time to move beyond the conventional approach to managing water, for instance by fostering new technologies into the drilling firms that contribute with their services to increasing sustainability in management of water sector.

1.8 Concluding remarks

This research study will be initiated by a thorough review of the literature, to provide the researcher with a deep understanding of the existing body of knowledge concerning the management of new technology adoption. This will be followed by in-depth interviews with the company management to acquire original data on how they manage the introduction of new technologies. An analysis of these data will allow the development of an actionable framework for technology adoption, which will be used in a project with Company A.

This chapter has introduced the issues addressed in the research project exploring ground water scarcity in the drilling business, technology and its importance, adoption issues, organizational issues, workers' skills and related challenges. It has also introduced Company A and its work-based problems. It is important to emphasize that, even though this research is based on the Arabian Peninsula, it may be relevant to companies operating in any arid climate but that needs to be explored by future researchers in those companies' contexts.

Chapter 2: Literature Review

2.1 Introduction

A review of the literature is essential for a research project. Without one, it is not possible to understand the research project, what has been discovered, how the research was conducted and what core issues were resolved (Hart, 1998). Beile emphasized that, "a substantive, thorough and sophisticated literature review is a precondition for doing substantive, thorough and sophisticated research" (Boole and Beile, 2005). A researcher cannot conduct significant research without first understanding the relevant literature. Without prior understanding of the literature, a researcher can be seriously disadvantaged. A comprehensive literature review can help the researcher understand research frontiers and gain enormous expertise in the field. Additionally, acquired insights and knowledge lead to better designed studies and helps acquire significant results underpinning the research (Roberts, 2010). Acquiring knowledge and skills is crucial in gaining comprehensive understandings of research analysis and its synthesis in the area of specialization. Therefore, a thorough literature review is essential feature and foundation of any successful academic research (Levy and Ellis, 2006). Literature reviews are pursued for different reasons; it provides a theoretical background of relevant research, it provides a research depth on the chosen topic, it critiques the literature to enhance its usefulness, and it derives answers to practical questions. In general, literature reviews are found in the introduction of an article or in the early part of an academic thesis (Okoli and Schabram, 2010).

Fink argues that literature reviews must be conducted systematically, using a methodological approach (Fink, 2005). Meanwhile, Rousseau calls for a structured approach consisting of a "comprehensive accumulation, transparent analysis and reflective interpretation of all empirical studies pertinent to a specific question" (Rousseau *et al.,* 2008). However, Kwan argues that a literature review in the introduction to scholarly research, must be considered a vital part of an academic thesis. Its structure can be different to the research article, but its outline stays like published research (Kwan, 2006). Hart explains more clearly how literature reviews play vital roles in the pursuit of academic research: not only does the review synthesize knowledge a researcher needs, but it also supports a researcher's rigorous research ability; moreover, the review justifies future research and makes the researcher an expert in that particular area (Hart, 1999). Constructing a high-quality literature review is challenging, particularly for the topic of groundwater, as it is infrequently mentioned in the literature. The review should cover all relevant literature on the topic, and not be confined to one methodology, one set of journals or regions (Galliers, 1992).

A good literature review becomes the basis of methodological and practitioner sophistication, thereby increasing the usefulness and quality of subsequent research (Oliveira and Martins, 2011). This research will help me acquire detailed thorough knowledge to summarize, analyze and criticize my research area. "The challenges of having

groundwater development companies adopting new technology in arid regions," so that my onward research discussion can be facilitated in a precise manner.

This literature review is divided into seven sections and consists of an introduction, planning for technology change, technology adoption processes and technology adoption methods, technology adoption challenges including organizational and implementation challenges, leadership roles and assessment.

2.2 Planning for technological change

In the developed world, intellectual progress is a fact of life, when compared to developing nations. Technology is the result of human intellect (Edosomwam, 1989). Since knowledge creation is expressive, with limited resources and the final product or services may or may not be that beneficial, technology must be carefully changed in an organizational set-up (Frick, 2015). The products or services must be evaluated in terms of immediate and long-term goals. To maximize benefits and minimize resources, planning and control procedures must be established so that technological methods can estimate resource requirements for project management and result evaluation (Galliers, 1992). Management is a critical factor in planning new technology adoption and utilization for groundwater development (Pisano, 2015). Organizational miscalculations and indifferent accomplishments can severely affect technological capabilities in continuing operations. Also, it is not easy for any organization to undertake several projects at the same time. So, the plan must be to go for a product or service with great potential benefit and a high probability of success. A good plan is worth more than a road map; it provides the organization with strategic directions, initiates anticipation and sets the blueprint for goals and achievement (Hart, 1999). It is a communication device in achieving objectives, with minimal resources. Goals are the manifestation of plans and standards are introduced to measure the results of a plan. The planning process for technological changes are quite sensitive to external and internal factors. External planning factors include existing technology, new technology, competition, client requirements and political pressures (Galliers, 1992). The adoption of new technology can have severe impact on plans. Molding an organization and developing capability requires time and forward planning. Failure to anticipate technological changes can hurt the business badly (Burgleman *et al.,* 2001).

Taking technical initiatives not only provide an immediate advantage, but they raise the business image which can be easily marketed in the future. However, change is relatively unpredictable and frequently radical (Betz, 1998). Management must be aware of the factors affecting change and must incorporate flexibility within planning mechanisms (Ulwick, 2015). This means a plan must remain open to modification or change, if set proposals have not been achieved. It is more logical that a simple, well formulated plan, with shorter operational times, has a higher success expectancy. Planning for reliable technology change is the first step towards improving organizational viability (Hamilton and Ives, 1992). Planning for a technology change is an envisioning process that forecasts the possible future. The vision sets the direction and timeframe of future planning, with explicit assumptions concerning outside business environments. This leads to goal planning and strategizing in terms of facilities and the procurement of relevant technologies.

It is recognized that technological advancements, tools and techniques have benefited humans in performing complex operations (Betz, 1998). In the latter part of the previous century, technological innovations were key driving forces behind improvements in industry, in terms of raising productivity and quality of life. It is heartening that the groundwater sector has always been relatively low in literature as well as developing new technologies but with the development of water quality standards and increasing awareness concerning scarcity of ground water due to population growth has made it the most burning issue of this precious resource at global scale in the 21st century (Solomon, 2010). In the past, technology development and management literature has been fragmented, but since the 1970s, considerable literature has been generated in this area.

Technology management and adoption are directed towards three broad areas (Roman, 1980): behavioral, economic, and operational approaches. The behavioral approach stresses the personal problems emerging in technology management and adoption processes. Economic approaches stress resource allocations. The third approach focuses on the operational or functional aspects (Doss, 2006). Much of the published literature, in the last three decades, has stressed new methodologies to deal with decision-making processes because economic techniques have become highly sophisticated (Besley *et al.*, 1993). These economic approaches compensate for the fact that researchers use cross sectional data to address problems that are inherently dynamic.

Key managerial issues concern how to improve functionality of the decision-making process. Practitioners make decisions on the adoption of technology packages to improve operational efficiencies (Doss, 2006). In any technological change adoption process, there are elements of risk and uncertainty, but practitioners have to assess the ability of their own organizations in achieving anticipated progress, while lessening risk and uncertainty. For groundwater industries, a more vigorous pace is often required to attain and maintain the market position of the company. The bolder the attempt to transcend limits of existing knowledge and applications, the greater the risk and uncertainty (Lichtenthaler and Lichtenthaler, 2010). In a highly competitive world, companies that have instituted effective systems are in better positions to provide services and goods to the market (Edosomwan, 1989). Similarly, groundwater exploration organizations that embrace new developments, procedures, tools and techniques have the potential to achieve breakthroughs in exploring and developing groundwater resources, at regional and global levels. Groundwater is undoubtedly our most precious resource; it is the only commodity whose cost has increased over time. However, understanding of its origins, flows and recharge mechanisms remains in the nineteenth century, (Bisson and Lehr, 2004).

It is ironic that this scientific anachronism has facilitated a global-scale shortage of available fresh water supplies in comparison to gas, oil and other minerals. The latest groundwater exploration and development techniques have emerged from 21st century technologies and geological concepts from the gas, oil, and mineral exploration industries. Since knowledge creation can be expensive in a limited resource environment, it is critical to understand technology and innovative procedures. Knowhow and technology services must be evaluated in terms of immediate and long-term goals and gains. Technologically induced change has already become an integral part of societal structure, across the world.

If the past is a reliable indicator of the future, technological change processes will continue to move at a much higher pace.

Such environments can generate operational challenges for those micro-level decision-makers, while simultaneously handling macro-aspects of technology assessment issues, environmental impacts, constraints and competition (Stoneman, 2001a). Introducing a technology is critical, however, its benefits and shortcomings should be anticipated before adoption. New and innovative technology procedures in groundwater resource development, have already impacted the groundwater resources management sector (Bisson and Lehr, 2004). These procedures have not only improved efficiency, but they have also reduced carbon footprints due to energy reduction (Bozeman, 2007). Thus, these procedures are successful in improving a resource's core production performance (Bozeman *et al.,* 2015).

In previous research, I argued that the use of new technology in resource development, has increased production and life expectancy to over 30% (Sahi, 1997). Technology makes managerial decision-making processes more reliable and cost-effective. This helps meet the ever-growing demands for water and other socio-economic challenges, from population growth and industrialization in arid regions such as Saudi Arabia. It is obvious the groundwater sector needs to build capacity to address strategic challenges, including water treatment processes, to improve ground water sustainability (Barlow, 2013). Groundwater companies must now change their strategies to cope with new capacity building challenges and adopt new leading-edge technologies and innovative solutions from research, thereby raising their absorptive capacities through a sense of urgency (Kotter, 2007) and net positive strategy (Steiman, 2013). Porter's "generic strategies" concept is a widely used framework to classify competitive strategies. Companies performing industry wide differentiation, look for more sustainable competitive advantage in different segments of industry. They offer efficient services that are better than competitors. Porter suggests that technology strategy is a powerful tool in pursuing generic strategies (Porter, 1985), however a company's strategy is expressed by the services it presents to customers (Burgelman *et al.,* 2001). One way to integrate a company's technology and services strategy is to dismantle services into constituent technologies and gauge the relative strengths of individual technologies, compared to competitors. Technology is expressed as an added value to the client (Prahalad, 1990).

The adoption of a new technology depends on existing technology know-how, to gain advantage over competitors. Technological change is one of the most critical forces affecting a company's competitive edge. Research suggests companies find it difficult to respond to such changes. Integrating technology and strategies should be a dynamic process, therefore the company needs to understand the dynamics of the new technology (Santos and Williamson, 2015). In every situation, there will be opportunities to act before a crisis takes over. Transforming organizations through standard procedures is not only ineffective but dangerous. What is required is a strategic renewal approach to harness new technology and proactively transform the organization. Strategic renewal can open new eras of technology innovation, leading to successful change processes (Binns *et al.,* 2014). However, research has confirmed there are no set strategies, policies, practices and

decision-making processes that lead to successful management of ground water technology and services companies. This is because no single company has a monopoly on managerial excellence (Burgelman and Rosenbloom, 1989). This may be why the best run companies make mistakes and other less regarded companies can perform at much higher efficiencies, due to better leadership and technology mixes. This is how companies demonstrate a strong business focus, through setting priorities and patterns of behavior that are consistently reinforced by management. Companies with vision balance a well-defined business focus, to undertake technological changes and avoid stagnation (Amit and Zott, 2012).

From a practitioner's standpoint, I argue a practical critique of this research and I suggest it is more essential, particularly in turbulent times, and when the future is obscure. Companies should seek technology and service strategies that reinforce strong leadership. Therefore, companies must seek and exploit rapid technological shifts in relation to technological competitive developments. Failing to exploit emerging opportunities can lead to costly stagnation. A company must realize that its current technology strategy is not working and needs to change (Porter and Lee, 2013). Technological progress is a key force, enhancing groundwater industry growth. It enables greater outputs from limited input resources. There is consensus among researchers that a 90% increase in labor output in the groundwater industry can be attributed to the adoption of new technologies (McLaughlin *et al.,* 1999). Technological changes and progress are not, however, phenomenon that stand alone; they are driven by effective human resources and management systems. In turn, technological change improves productivity and wellbeing of the company, through enhanced benefits (Kumar and Pan sari, 2015).

The adoption of useful technology and associated management processes can achieve enormous strategic, operational and organizational objectives. New innovative development procedures have proven that an extra 30% water production can be achieved from new water wells, without extra costs (Sahi, 1997). Incentives are needed to improve water technology bases through strategic planning and exploiting support from groundwater authorities to harness new technology applications (Kotter, 2012). The use of incentives remains a difficult issue (Pink, 2009). However, the role of groundwater, in the context of climate change, can lead to greater recognition of new technologies by those making policy decisions for municipal, agricultural and industrial water requirements (Taniguchi and Hiyama, 2014).

2.3 Technology adoption process

Drilling firms in groundwater sector have always been slow in adopting new technologies due to unfavorable business and economic conditions. The adoption of water sector technologies can be expected to occur under set conditions in the firms (Montalvo, 2008). At the same time, it may be recalled that the adopting firms may have to deploy or modernize infrastructural facilities to integrate the technology effectively. However, drilling firms attach mixed importance to these factors. The ground water regulations by the regulatory authorities may act as an industry level barrier to their adoption (Lopez and Montalvo,2015). Appropriation of returns is a source of uncertainty for any new

technology. The underinvestment risk is sizeable in drilling water sector due to the technological specificity assets (Spiller, 1993). Industry level policies explain why groundwater drilling firms may experience a gap in the adoption of new technologies, but concreate understanding is necessary at firm level adoption choices; so, that all sectors might be able to benefit from new technologies use (Bresnahan and Trajtenberg, 1995).

The benefits of new technology can only be achieved when new innovative technological procedures are used (Genoski, 2001). Adoption processes must move forward from organizational decisions at different levels emerging from the assumptions of having uncertain benefits in relation to uncertain adoption costs. Understanding the issues affecting this selection is critical for the organization and the supplier or technological developer (Stoneman, 2001b). The new technology which often evolves as a jump or a single event usually goes through at a slower pace concerning its diffusion process. The diffusion process, and not the technology innovation, ultimately reflects the rate of change of productivity and economic gains. Unless the technology is fully diffused across the organization, it may not add much (Davies, 1979). Diffusion processes are considered cumulative acts of individual decisions that gauges the benefits of adoption against costs. Although the final decision is taken by management, the supplier does have the capacity to influence the costs and benefits to a great extant through his decisions (Gandal *et al.,* 2000).

The core point about such decision-making is that it is not about adopting or not adopting, but between adopting now or later (Pisano, 2015). The significance is due to the benefits and costs ratio. Generally, the benefits of adopting a new technology or procedures are continuous benefits, which come throughout the life of the technology (Besley *et al.,* 1993). However, costs relating to training and learning are initially incurred and are difficult to recoup (Rosenberg, 1972). There may be additional ongoing fees, but in general they are significantly less than initial costs (Geroski, 2000). So, the adopter assesses fixed costs against anticipated benefits, but in real terms, the major fixed costs will be lost once the technology is adopted (Stoneman, 2001). This means decisions are made based on huge benefits less cumulative costs. Once this step is taken, the costs are sunk and if the decision is still needed to abandon in the favor of losing the benefits original cost will not be possible to be recovered.

In another sense, there is a possibility that new technology benefits are calculated under uncertainty, if reduced considering this factor before sinking the adoption costs, may lead to adoption delay (Luque, 2002). Many researchers suggest that when users are plotted against time of a new technology or invention, the resultant curve is S-shaped. This phenomenon has been observed by Mansfield, when looking at innovation diffusion in different industries (Mansfield, 1968). It is reasonable to imagine adoption processes moving at a slower pace initially but accelerating with increased adopters and slowing down when saturation levels are reached (Mansfield, 1968).

Both the key adoption process models present the dispersion in adoption times, incorporating it in two different ways; adopting heterogeneity or adopting learning. The heterogeneity model is based on different values placed by individuals on innovation

processes (Pisano, 2015). The variation of values placed on new technology is close to normal, whereas the technology cost is constant or decreases over time. So, individuals or organizations only adopt technology when the valuation or benefits are much higher than the cost of the new technology (Edosomwan, 1989).

The other model is epidemic, which has been commonly used in marketing and sociological areas (Strang and Soule, 1998). Clients in this model not only have identical selection criteria, but costs remain constant over time. However, not all clients are informed about the technology at the same time (Betz, 1998). Each client learns about new innovations from others, ultimately generating an S-shaped curve, over the time of the saturation point for the diffusion rate. These models have been used because of their simplicity and transparency. However, new research by Stoneman points out that new technology adoption is another type of investment under uncertainty and can therefore be evaluated through a framework of real options (Stoneman, 2000).

New technologies, pending investment decisions, can be characterized by three core factors: uncertainty regarding future benefits, irreversibility that generates sinking costs and the possibility of delay (Stoneman, 2000). The key advantage to the real options approach is that these features can be explicitly incorporated into the decision-making process of the adopter. So, the real option process model is like a call option in adopting new technology, without constraints concerning time (Stephanon, 1981). The main implication is to adopt technology in one scenario, when benefits are outweighed by costs. Otherwise wait until the opportunity of adoption becomes economically viable (Dixit and Pindycle, 1994). However, there are other factors which affect adoption rates in addition to uncertainty factors (Luque, 1998). These include demand, clients at hand and their commitments, organizational capacity and staff skills (Davies, 1979). Empirical research from the computing technology sector has confirmed the significance of these factors in adopting new technologies (Caselle and Coleman, 2001). Rosenberg argued that having a slow rate of diffusion could be due to poor initial technology performances and supplier behavior at initial stages. Lowering costs and improving performance over time leads to strong acceptance (Rosenberg, 1972). Finally, the adoption of new technology, especially in the water sector is influenced by regulatory activities. Environmental factors can affect adoption processes, because they can prohibit or require the use of technologies or innovation processes to enhance productivity (Wayne and Shadbegian, 1998).

2.4 Technology adoption methods

In this era of rapid technological change and information explosions, the problem of locating information, disseminating valuable information and incorporating information to enhance productivity, is becoming difficult if not overwhelming (Galliers, 1992). There are issues in determining what is known about a subject especially in the water sector when it comes to choosing and utilizing the information. In fact, there is a problem in maintaining reservoirs of usable information and technical knowledge (Farhoomand, 1992). The other issue is that knowledge of new technologies can present new capabilities and applications. This is the root cause of problems regarding awareness of what has already happened and new innovations and technologies coming up.

Technology adoption methods are critical parts of the technology transfer process, as technology is viewed as an essential production input (Galliers, 1987). However, attempting to establish a universal procedure or process for technology diffusion is not realistic. Designing a sequence of operations and structures is critical for any selected technology. Delineation of issues is also significantly important in managing technology transfer activities and its applications (Roman, 1980). The relevant information must be adopted according to existing needs. Evaluations of existing technologies and requirements are important to visualize the direct technological applicability and modifications, if needed.

Market research is important in influencing a technology's potential (Boudreau *et al.,* 2001). Technology transfer methods can be direct and apparent, or the transfer method can be indirect, slow and opaque. Technology can be transferred in full or piecemeal. Technology may be delivered as knowledge or as a service development. Researchers believe that perception-based approaches, taken up by adopter organizations, are more beneficial when compared to non-adopter organizations (Kuan, 2001). There are numerous methods for technology adoption or diffusion. Some have been explicitly designed to accelerate technology diffusion, other methods are of less importance because technology transfer or diffusion methods are not direct, nor immediately actionable. However, most methods are subject to change in terms of applicability and usefulness (Hamilton and Ives, 1992). Some of the more important include regulatory authorities, the professional literature, professional meetings, consulting, licensing, academic institutions and joint ventures and consortiums.

2.4.1 Regulatory authorities

Regulatory authorities provide invaluable information and are reservoirs for data and information (Bansemir *et al.,* 2015). For example, in the U.S., the government is perhaps the largest single information source in the world. Every agency holds extensive literature relating to its operations (Oliveira and Martins, 2011). Relevant technological information can be easily taken from various agencies which act as control collections and dispersing facilities. The US federal government is also the largest supporter of research and development (Edosomwan, 1989). The volume of research projects run by U.S. government agencies is staggering and the results of these studies are available for general dissemination, if no security issues are involved (Gray and Shadbegian, 1998). Although this information is available at a cost, its diffusion has been poor (Burgleman *et al.,* 2001).

The other difficulty is the utilization of public funds to generate knowledge or technologies which are not freely provided for commercial activity (Roman, 1980). This is the case with most government agencies. However, there are exceptions; when knowledge is developed by public organizations under government control. This knowledge can be utilized for other products or services under legal contract requirements, because governments do not have legal control.

2.4.2 The professional literature

Professional journals, technical books and trade magazines are good information sources. Although, the literature plays a dynamic role in facilitating technology transfer or diffusion, it has advantages and disadvantages (Bower and Christensen, 2007). Often the information is old (Betz, 1998). Books can often take longer to publish than professional journals. For most cases, information is not clear and may lack applicability because of time (Burgelman and Rosenbloom, 1989). Additionally, there are other issues such as proprietary rights. However, it is always possible to bridge the gap, from old to new technology, or from one technology to another (Hamilton and Ives, 1992).

The other problem is the volume of literature to review and the pressures to publish in academic journals. Other issues include, the sheer volume of information, information diversity, information fragmentation, the poor concentration of information in key sources, and the poor quality of information (Oliveira and Martins, 2011). Similarly, much of the professional literature originates from developed nations, and its use in developing nations is questionable. Moreover, information storage and access, presents financial, physical, and technical problems, and for developing nations, language issues and lack of access are key issues.

2.4.3 Professional meetings

Professional meetings create viable technology transfer or diffusion opportunities at national and international levels, as professionals attend meetings to exchange information and benefit from each other's experiences. At international conferences, global representation is increased, and a broad information exchange occurs (Luque, 2002). Additionally, professional meetings generate invaluable opportunities to meet other professionals and exchange ideas. Paper presentations at meeting and international conferences also enhance professional exposure and information exchange.

Professional meetings also play critical roles in identifying technology trends (Burgleman *et al.,* 2001). Making contacts can initiate dialogue to develop business opportunities (Knight, 2015). Researchers endorse professional meetings which can generate innovations and creativity. Professional meetings act as roadmaps to access high quality information, maximizing its full benefits (Galliers and Land, 1987). This way, host countries are in strong positions to exchange valuable information and profit from this exchange (Iansiti, 1998). Moreover, cross-disciplinary meetings help resolve multiple issues when compared to single-discipline oriented meetings (Nicolini *et al.,* 2015). Professional meetings bring enormous opportunities for attendees in terms of access to information and contacts made (Roman, 1980). They further help to curtail information storage and retrieval problems and generate high value information which meets the needs of technology transfer (Farhoomand, 1992).

2.4.4 Consulting services

The Second World War generated American “know-how”, which contributed to the growth of multinational companies and associated consulting services industries (Roman, 1980). Consulting services facilitate technology transfer (Knight, 2015). Although, there is little research on consulting services, in recent times, they have gained increased importance in technology and services (Oliveira and Martins, 2011). Considerable consulting services have been provided by various governmental bodies, multinationals and individuals to developing countries in the form of aid or at negligible cost. Consulting services have gained tremendous importance in providing knowledge and facilitating the rapid flow of technology transfer mechanisms (Gandal *et al.,* 2000). Moreover, consultancies have become very competitive in developed nations, and it does not remain as province of few countries. There is also a shift in developing countries, who want to be independent in technology after seeking the core knowledge, training and technology. They utilize consulting services as a transition phase while having the technology transfer and diffusion process completed (Betz, 1998). The other development is to purchase and utilize the cheap technology and services available in the international market rather than producing it independently at much higher cost at home.

2.4.5 Licensing

Another fast and efficient way to transfer, diffuse or adopt technology is through licensing arrangements (Edosomwan, 1989). Licensing is advantageous when compared to other methods of technology transfer. Under contractual obligations, holders of patents, copyrights, know-how or trademarks on products or processes can allow the licensee to develop production facilities at agreed costs after purchasing the equipment and expertise (Burgleman *et al.,* 2001). In this arrangement, the licensor gets the benefit as new markets are accessed without additional capital investments. Market penetration rates are tremendously increased, due to local contacts and lower production costs. Licensors achieve higher business profits by buying back products at reduced prices and marketing them at original cost (Stephanou, 1981). This means that licensors can strengthen themselves and drastically erode competition, due to lower rates of production (Galliers, 1992).

For the licensee, it is the better deal; they pay fees only for the technology or process development. It also helps licensees to spend their saved cash to develop marketing infrastructures and raise production (Roman, 1980). Licensing, being a fast and easy way of technology transfer, can ‘jump start’ a project due to time saved and the selection of proven and tested technology which can be most suitable to the available market and environment.

2.4.6 Academic institutions

The most salient, but perhaps the least discussed, channels for technology transfer are academic institutions (Bansemir *et al.,* 2015). Education imparts knowledge and plays a

critical role in the transfer of information. Technology transfer occurs not only as part of the formal educational system, but also because of educational leadership and technical training programs or workshops (Burgleman *et al.,* 2001). Educational establishments are the ultimate vehicle for information and technology transfer or diffusion (Bower and Christensen, 2007). Technology transfer disseminates information and knowledge which may not be new but is generally new to those learning it. In some cases, where there is new research available at the educational center it can be conveyed as new knowledge (Brown and Duguid, 2015). In many cases, useful and productive technology is generated outside the confines of the academic institution. This knowledge is ultimately taken in, filtered and processed through educational channels (Caselli and Coleman, 2001).

Technology diffusion or transfer can also happen by 'jump start' through a single incident, distinct from an original process (Fink, 2005). In other cases, institutions may be slow in responding to new technology developments, but there may be times to show desired inclinations to follow new knowledge from a discreet distance (Davila *et al.,* 2006). At other times, educational institutions may be key participants in the generation of new knowledge (Galliers, 1992). Whatever the educational environments might be, technology information will eventually permeate educational institutions for analysis, processing, evaluation and dissemination (Hannan and Mcdowell, 1987).

2.4.7 Joint ventures and consortia

This is another example of technology transfer and diffusion. Joint ventures develop between nations or companies, where extensive resources are required for technology transfer or diffusion (Bansemir *et al.,* 2015). Consortia are similar joint ventures between countries or organizations. Both approaches are similar because they bring together human skills, material and technical resources. They share the risks, develop a common market and encourage standardization (Calantone *et al.,* 2006).

There are differences between joint ventures and consortia. A joint venture does not require embracing high technology, whereas consortia involve high technological considerations. Joint ventures generally exist due to resource limitations, but this is not the case with consortia (Burgleman *et al.,* 2001). For consortia, there may be other types of restrictions, including political, tariff barriers or local labor hiring requirements and marketing expansions which can be resolved through organizing consortia (Caselli and Coleman, 2001). Additionally, consortia are usually large undertakings, with extensive technological goals and resource requirements, when compared to standard joint ventures (Roman, 1980).

Technological consortia are often inspired by political or economic factors, or both, and are common among oil producing countries, e.g. OPEC. Here, the consortium manages oil exports and production quotas at international levels for member states. There are several technological consortia in the European community, e.g. military projects. However, there is no guarantee that joint ventures or consortia are always successful, for example Concorde initially failed due to economic factors (Bozeman *et al.,* 2015). Other factors can negate the building of productive technological consortia; extreme nationalism,

cultural differences, control and management issues and mutual trust (Doss, 2015). Increased understandings and greater mutual respect can bring parties or communities together to build successful joint ventures or consortia for the betterment of all stakeholders.

2.5 Technology adoption challenges

New technology adoption cycles are influenced by different factors. Researchers highlight that whenever changes emerge in processes or procedures, companies face severe challenges, particularly in business environments where competitive forces are fast, unpredictable and dynamic (Betz, 1998). The selection of inappropriate technologies can create serious side-effects, as raised by Rybczynski (Edosomwan, 1989). To overcome these hurdles, companies must improve their own competitiveness through revolutionary management thinking. This helps businesses cope with unexpected complexities and uncertainties for different managerial activities. With rapid changes in technologies, associated challenges are becoming even greater for groundwater companies. They must keep pace with technologies, at procedural and process levels (Gaubinger *et al.,* 2015). Monger stressed that companies lacking market technologies can have more difficulties to adopt and implement new technology at organizational level (cited in Christensen, 1997).

2.5.1 Organisational challenges

Management functions tend to move towards general, rather than specific, as technological adoption change emerges (Doss, 2015). Management point out that as technology brings change, more flexibility in managerial training must be expected. Consistency in the coordination of management functions is becoming increasingly important, because technical staff tend to increase (Burgleman *et al.,* 2001). New technology is not so straightforward, as it requires core knowledge and extensive training. These can be major hurdles due to shortages in educated and trained personnel (Collins, 2001).

Skinner noted the impact of technology on managers in the manufacturing sector. These authors concluded that managers may be averse to handling the consequences of technology adoption, because they must leave technological decision-making to the experts. Only years of training can provide the competence needed to take highly technical decisions, but the author strongly suggests that delegation is, in fact, the key to success (Edosomwan, 1989). Sometimes problems get compounded because several managers fail to precisely conceptualize technology dependent issues. A manger must gain a general understanding of the technology.

The design area is not only the one in which technological changes will affect management: there are other social and economic issues that the companies must tackle which are equally important in determining the management structure in relation to functions (Binns *et al.,* 2015). However, consulting employees, identifying related issues, hiring more trained personnel and highlighting benefits and opportunities can facilitate the transition process more effectively (Maschke and Aufseb, 2012). There is no doubt that

technology creates adverse effects on work and employee well-being. Technology not only affects jobs, but it generates anxiety, leading to relationship turmoil among employees and management (Collins, 2001).

McLaughlin suggested despite satisfaction concerning pay rates and security, the normal worker appears oppressed by some sort of anonymity (McLaughlin *et al.,* 1999). Additionally, technology changes give rise to job dislocation, unattractive locations, layoffs, pay losses, promotions and seniority curtailments. This means technological changes can make some workers redundant but retain the jobs to be filled up with new staff (Stephanou, 1981). This does not mean that technology adoption can be left behind, because it continues to resolve issues that would otherwise be impossible to tackle. So, management must be well organized so as not to affect company cultural aspects and set appropriate operational environments (Betz, 1998). This concept cannot work where there are entrenched interests and strong affiliations at work. This is a human characteristic that creates social issues (Calantone *et al.,* 2006).

Those who are more hesitant need to be convinced that technology adoption can help. Companies may ultimately generate enormous wealth, not only for their employees but also their stakeholders (Bansemir *et al.,* 2012). Having productive discussions creates acceptance from workers directly affected by the change process (Kotter, 2012). Building a collaborative team effort and moving forward with the change processes can be successful (Marek *et al.,* 2014). Team managers must weigh up the benefits and costs, including training and hiring specialists. After doing this cost comparison, they must assure stakeholders that the new technology will improve the organization.

A new technology is not only going to strengthen knowledge and expertise towards the market, but also towards groundwater regulatory authorities (Davila *et al.,* 2006). This can generate extra business and higher revenues through innovative solutions because of having new technology expertise, ultimately, leading to step changes in the application of new technology to take care of efficiency, as well as climate change effects and continuously improving operations through innovative solutions (White and Bruton, 2007). The new technology may not keep pace with organizational requirements and business marketing challenges, but it can be a way forward in building a visionary strategy, tackling business uncertainty (Gaubinger *et al.,* 2015). In a positive sense, the strategy reflects the management's viewpoint and the company's core values and competencies (Teece, 2006). They pave the way to drive strategic processes that will take advantage of its learning. New technology remains at the helm of competitive strategies for any successful organization (Burgelman *et al.,* 1998). It is recognized that those organizations who have continuously reengineered their business processes gain critical advantages in capturing new tacit knowledge (Brown and Duguid, 2000).

It is obvious that once technology changes are adopted, management activities and functions will change. However, technological changes in the groundwater industry will continue to exist due to competition and water scarcity and management must learn and adopt innovative approaches to tackle these issues (Raphael and Zott, 2015). For that they must do more to keep their customers intact and cost down that needs to break some rules

by overturning the received wisdom to understand how things work in business. Research has shown that technology innovation has been more effective in companies breaking various types of bottlenecks in relation to usual in-house ongoing business practices (Ersek *et al.,* 2015). Breaking these rules that include sticking with outdated purchase experience, unnecessary expense category elevated financial risks, disengaged employees and services side effects (Luque, 2002). Most of these bottlenecks emerge because organizations fail to question the viability of services offered to customers (Ulwick, 2015). Companies that analyze their cost structures gain many advantages. Companies often please their customers but are less prepared to employ new innovative ways to motivate their employees (Doss, 2006). They go for tools of choice that include salaries, bonuses, prizes and occasionally recognition, but paying more attention to better hiring and staff retention can lead to more efficient businesses (Iansiti, 1998). Indeed, making the right and rapid decisions, at the right time, are hallmarks of higher performing organizations (Rogers and Blenko, 2006).

A good company must recognize its sources of values and make sure that decision roles are in line. Clarification of roles are key. It is crucial for existing staff to learn and practice it before delivering to customers (Erickson *et al.,* 2007). Companies that are flexible with their human capital can unlock their hidden talents and create value by adding employees to a higher potential category (Cohen, 2005). Moving talent from one position to another can also lead to higher growth and renewed capability at adopting new technologies. Although, technology adoption is crucial, the reassignment of people is important. What truly raises the status of good companies, is their ability to retain and attract talented people (Collins, 2001). Employees who are more satisfied with their jobs and their environment are less likely to move for small benefits or pay rises. They seek different ways to satisfy their own aspirations, while being creative to resolve business issues (Erickson and Gratton, 2007).

The other issue that requires critical consideration is the life cycle of selected technologies. Over time, life cycles shrink, and asking for new procedures and techniques. This shows that understanding the inputs and outputs of various components of the new technology, is crucial in adopting the new technology and its applications (Bower and Christensen, 1995). For most companies, productivity improvement is the most common rationale for new technology acquisition. The last four decades have confirmed that a comprehensive approach to taking care of employees and production related variables is required for the adoption of new technologies. Moreover, human capabilities, job satisfaction, moral issues, productivity, quality and systems flexibility are equally important (Kumar and Pan sari, 2015). To find enduring solutions is to generate new career paths for talented workers (Charan *et al.,* 2015). Working conditions and occupational safety factors are affected by new technology and procedure adoption systems. This means, the work environment needs to be managed carefully to control variables and other parameters, through planning, evaluation, measurement, improvement and maintenance (Edosomwan, 1989).

2.5.2 Implementation issues

Introducing new technologies and procedures requires substantial capital. Researchers agree that a total systems approach must be implemented for financial justification, because it captures the total cost of business execution and total output, based on the anticipated use of new innovative technology and procedures. This does not mean other techniques are not useful, but not as standalone methodologies (Iansiti, 1998). The implementation of new technology is perhaps one of the most daunting and challenging experiences for management. Many projects fail because they lack the proper justification or because the procedures and implementation mechanisms were not precisely followed (Davila *et al.,* 2006). The development of effective teamwork in functional areas including users, vendors and developers is of paramount importance for a successful technology implementation project (Doss, 2006). Maintaining coordination, control, communications, cost analysis and cooperation can successfully implement new technology (Ulwick, 2002). However, the implementation initiative determines the success of the whole implementation process. New technology needs to transfer know-how and core knowledge, which requires setup specialists to build additional infrastructure with employees, involving operational knowledge (Cohen, 2005). Incorporating in-house or on the job training are key parts of the implementation process. Companies and employees who build their own systems are far better in developing innovative solutions (Heath and Heath, 2010).

Developing new protocols and standards by erasing and replacing existing ones is the key to success. Whilst both technology and organizations are malleable and contingent, a degree of continuity is required if the technological adoption process is to be successful (McLaughlin, 1999). Stakeholder assistance is crucial in identifying unexpected problems and finding solutions. Working cultures can also negate the implementation process. Convincing employees not only benefits their relationships, but it improves the working environment to achieve higher results and improvements in performance (Kanbayashi, 2015).

Cost is a fundamental factor for the implementation process to take hold. Companies need to prioritize and make decisions in relation to the acceptance and implementation of the new technology, based on viable, beneficial operations (Kotter, 2012). Other challenges such as security must be dealt with. Cultural issues can emerge as technologies may vary from country to country (Bansemir *et al.,* 2012). In the KSA, security is not a big issue, however training of personnel and shortages of trained workers are challenges for groundwater explorations. Training is not only time-consuming, but it is cumbersome due to shortages of skilled and self-oriented personnel. This means companies must build long term viable strategies to cope with these issues, to mitigate future uncertainty (Gaubinger *et al,* 2015).

The adoption of new technology is widely recognized, but unfortunately conventional wisdom suggests new technology does not bring commercially viable rewards over time (Jelinek and Schoonh, 1990). Managing changes, especially in relation to complex technology contexts, poses serious challenges. Companies are traditionally built for stability

and permanence, but in turbulent times they need to adapt to exist and stay competitive. Company's need to call on extraordinary technological talent, which must be continuously updated (Caseili and Coleman, 2001). Company's need to stay focused on the future whilst managing the present, which demands continuous change and efficiency. Once an organization plans to embrace a new technology, the focus should be on how to blend entities so that core advantages can be captured and pitfalls avoided (White and Bruton, 2008). It is a recognized fact that those organizations that reengineer their business processes while keeping pace with technology trends, gain critical advantages in sustainable and competitive manners (Brown and Duguid, 2000).

2.6 Leadership roles

Organizations must take steps to improve their expertise and knowledge, to ensure profitability and growth. Although exploitation of technological assets is important, an interest in new technology and its transfer has gained increasing momentum in recent times. This can be attributed to emerging markets, liberalization and globalization. The value of technology transfer from a development perspective is not a new concept. Mansfield (1978) raised the point that, "one of the fundamental processes that influence the economic performance of nations and firms is technology transfer" (Mansfield, 1975). From an economic perspective, the organizational goal is always set at growth and profitability but, from a business and technology perspective, the focus is to achieve competitive advantages over the competition through enhancement of client value (Bansemir, 2015). Experience clearly shows that technology transfer and diffusion processes can be difficult to manage effectively, due to a lack of management skills, in some companies. Unless management decisions are made properly, it will be difficult to achieve technology transfer goals and organizational diffusion. Markham (1998) states that technology transfer and diffusion cycles need management to lead and support the new technology. Management can give leaders the authority to establish creative solutions to fix problems. Supported by employees, this allows leaders to utilize organizational resources properly and facilitate cross functional coalition inside the organization (Markham, 1998).

If the technology change is aligned with the goals of management and leadership, technology transfer and diffusion should occur at much higher rates (Amit *et al.,* 2003). This means that management support, influence, advocacy concerning technology implementation and continued commitment should greatly enhance the diffusion process (Green, 1998).

2.6.1 Management systems

A successful technology transfer and diffusion project needs a competent management system. Managers with effective leadership qualities must set correct technological policies to generate environments, conducive to technological innovation. Management may be required to prioritize resources to facilitate development and the marketing of new ideas and technological ventures. It has been stated that organizational

productivity somewhat depends on how innovative the leadership is (Edosomwan, 1989). Managers with leadership qualities, tend to be visionary and are comfortable with technological changes. Technological change flourishes in companies where territories overlap and workers have contacts across functions (Betz, 1998). Moreover, information flow must be unrestricted and coupled with a future oriented reward system (Twiss, 1980). Twiss further concluded that management must play a dynamic role in molding organizational attitudes in favor of technological innovations and change. The importance any organization attaches to technology management must therefore be reflected in the selection, transfer and diffusion at all levels, including functional and corporate levels. After studying the findings of the Canadian research council, the author noted that "All of the successful projects had at least one ably dedicated leader pushing them. No project was successful without a person behind it" (Twiss, 1980).

This means that a formal management system is not enough without a highly motivated technological champion or leader. Researchers agree that a technologically dedicated leader makes innovative technology changes a success, through leadership (Kotter, 2015). The ultimate success of any company depends on the leadership skills of major decision-makers and how wisely they utilize organizational resources. For technology transfer, the diffusion and dissemination across an organization is a prerequisite.

Abernathy promoted another viewpoint that advocated an effective management system for technology transfer and diffusion (Abernathy, 1982). In their research on consumer electronics and the automobile industry in the United States (US), the authors did not find any technological deficiencies in development and other related areas including resource availabilities. However, management failed to be competitive, which may have been the root cause of US competitive performance decline (Abernathy, 1982). A participative management system that encourages new technological innovations and is ready for technology change and the rewarding of talented individuals, is critical for any 21st century organization. A company must set up a technology policy that generates or sets the stage for various innovative technological aspirations, processes, procedures and achievements (White and Garry, 2007).

2.6.2 Management policy

It is necessary to bring areas such as technology selection, specialization, competence in technology, training and proper staffing under an organizational policy focus to satisfy technological aspirations (Bozeman *et al.,* 2015). However, this depends on the capabilities, resources and opportunities within the organization (Didonato *et al.,* 2015). Technology policies are generally viewed as a portfolio of choices and plans that assist an organization's ability to respond effectively to technological weaknesses and opportunities. Edosomwan (1989) viewed technology strategy formations within the framework of business planning (Edosomwan, 1989). Some researchers believe that having an in-depth understanding of organizational culture, built into developmental processes, generates customer and market forces, leading to higher cost-effective performances (Bower and Christensen, 2007). The authors further elaborate that organizational policy must accommodate the timing of technology transfer and diffusion, whether it is first or

second or late to market. Competitive positioning requires planning for new technology transfers and its effective diffusion and dissemination across the organization (Betz, 1998). Organizational change can incur evolution, inspired by marketing and responding to changes in business and economic environments. The leadership, making such critical decisions, may require strategic reorientation to maintain the smooth running of technology transfer and diffusion processes (Kotter, 2012).

To achieve strategic orientation, vision, vigilance and competence are the core qualities required by a manager. A strategic team is also a key requirement. Managing new technology transfers and diffusion processes involves several competencies and it also needs complete consensus for success (Heath, *et al.,* 2010). The management initiating the technology transfer and diffusion cycles must realize the importance of appropriate skills for the project. If these skills are not available, they must be acquired (Bansemir, 2015). Available professionals in the organization must equip themselves with new skills and additional technology experience to effectively support the project (Prahalad and Gary, 1990). Taking the right approach to technology requires leadership support and a clear understanding of organizational strengths and weaknesses, and strategic actions to sustain business growth and development. Therefore, a carefully considered and intelligently managed technology policy can lead to increased political and economic independence (Pisano, 2015). Establishing a structure for future economic viability, technology development or services can ultimately contribute to organizational strengths (Betz, 1998).

2.8 Assessment

In the latter part of the 20th century, the political, social, cultural and economic implications of technological changes came to light (Edosomwan, 1989). Initially, interest was focused towards technological research, development and policy. Research, development and technological policy are now significant components of a much broader and stronger field (Stoneman, 2001). This new field has many facets and despite being in its infancy, it is evolving and potentially important. In a technologically vibrant and knowledge generating environment, managers must be aware of micro-aspects involved in decision-making regarding operational problems, projects selection and management (Strang and Soule, 1998).

It is apparent that managers must be involved with such factors to stay competitive (Betz, 1998). Technological innovation is a critical factor in exploiting dormant resources. Natural and human resources may exist, but unless there is proper utilization of these resources, it will be difficult to achieve viable economic benefits. Improving technology or procedures can lead to productive utilization of resources and ultimately make the organization more viable in the face of market turmoil (Greenhalgh *et al.,* 2004).

This literature review has produced five significant organizational outputs as follows:

- Functional capability
- Resources availability
- Productivity
- Technical knowledge
- Sustainability

The first benefit relates to humanity where technology makes it possible is functional capability (Mclaughlin *et al.,* 1999). For example, modern jets have made travel easier, safer and faster when compared to previous times. There are different kinds of needs for which different technologies are used for different human purposes.

The other benefit is the availability of resources. More than two billion people lack clean water. This issue can be resolved through proper technology, including aquifer exploration for the development of water treatment (Barlow, 2014).

The third benefit is the time required to accomplish tasks, thus leading to increases in productivity (Iansiti, 1998), e.g. cloth production. New spinning and weaving technologies not only increase production, but they decrease the cost of cloth with respect to other goods and services.

The fourth benefit is the increase in knowledge (Bansemir *et al.,* 2015). Technology improves the range and accuracy of perception, through the creation of tools and procedures. Clear knowledge gaps on which research to pursue for ground water companies must be addressed in terms of aquifers exploration and development, particularly in arid regions. This is where my research topic," Managing the adoption of new technology by groundwater development companies in arid regions", fits in. Moreover, technology improves knowledge through computational capabilities to model and simulate system dynamics. Thus, technology can be helpful in providing greater knowledge and improvements in culture (Marshall, 1990).

Literature review summary of various aspects and challenges of technology adoption is given in the following table 2.8.

Summary of various aspects and challenges of technology adoption

Review Item	Challenges Description	Literature Review Output
2.5.2 Implementation Issues	*Managerial decision-making process to improve the firm's operational efficiencies and cutting down risk and uncertainty while heading towards new technology adoption within changing business environment. *Assessment of new technology, knowledge knowhow and technology services for its beneficial use and how to harness the sustainable competitive advantage over others to avoid stagnation *Strengthening of technology adoption process leads towards expertise and knowledge leading to improvement of firm's functional capability *Development of effective teamwork in the functional areas of the firm including employees, vendors, and clients assist in improving firms' functional capability	Functional capability
2.5.2 Implementation Issues	*New technology needs substantial capital to transfer knowhow and knowledge for adoption	Resources Availability
2.5.2 Implementation Issues	*Productivity improvement is the most common rationale in acquiring the new technology. Analyzing cost structures, training, and retraining employees influence higher productivity.	Productivity
2.6 Leadership role	*Firms need to adopt new technology to exist and stay *competitive by improving technical knowledge and expertise	Technical knowledge

2.6.1 Management systems	*Firms need to build up strong technology management system that reflects in technology selection, transfer, adoption, and diffusion at all levels to sustain in the market *This needs a strong company policy in place to establish structure to sustain.	Sustainability

Table 2.8

Finally, technology makes it possible to improve the environment to sustain better lives (Gray *et al.,* 1998). For example, technology helps us efficiently sustain available resources. So, the strategy at an organizational level should be formulated to seek technologies that simultaneously improve organizational capabilities, resources, productivity, knowledge and environmental qualities (Lichtenthaler and Lichtenthaler, 2010). This may be a challenge for management, government agencies and researchers, but it is not impossible. Thus, empirical research is not only necessary, but mandatory. It must explore these challenges, to help practitioners and policy makers resolve water scarcity issues in arid regions.

2.9 Researcher's reflections

It is my belief that this literature review has transcended many assumptions from earlier work in the management field. There is an often-raised concern to go beyond viewing technology transfer or acquisition as a one off moment of capture when pre-existing organizational requirements are reconciled with pre-existing technological solutions, but the demand is for a clearer understanding of the processes whereby organizations come to acquire and transfer technology (Leonard-Barton, 1991). Considering a new focus on the social dynamics of technology transfer and acquisition, different ways are considered of significant importance through which new technology and innovations are diffused into the organizations. There are also factors that promote or inhibit organizational capacities, in making an organization a potential acquirer and user of new technology (Mansfield, 1992). Considering such scenarios, technology transfer and diffusion of new technologies requires technological change and the acquisition of new technical skills (Senker, 1992). The core issue in the literature is whether the adoption of new technologies can be sensed as a response to existing needs. Policy and business interests must identify those technological requirements for present and future market needs.

In my opinion, this scenario demands a greater role by managers, in pursuing technological changes because they build strategies to give and control direction in a viable manner. These new perspectives reappraise assumptions formed by early management analyses. These new analyses have moved away from the simplistic notion of technology impact. This means a reappraisal of management and organizational dynamics. Technological changes are tied up with inter-organizational and broader contexts and failing to make sense of projects as some sort of episodes separated from the historical and organizational circumstances through which they evolve. Therefore, organizational technological changes cannot be perceived as a straightforward process, but instead as an analytical, educational and political process. Opportunities, power and chance are instrumental in shaping outcomes, just like negotiated agreements, designs or master plans (Walsham, 1993b). My view is that the new turn in relation to the analyses of management, technology adoption and diffusion processes is far reaching but yet to be explored further, while existing analyses raise difficult questions about how rational or needs driven management decision-making processes are, this makes it necessary to put up some concrete efforts to comprehend how needs and rationality are developed and utilized through managerial processes.

My argument is that once a technology is adopted and diffused appropriately, managers commit to the strategy, thereby leading to a more rewarding workplace, better trained workforce and increased performance metrics. The problem is that technology is moved by human action that needs to expand the focus of analysis beyond strategic management, to understand and explore the role of others within the organization in shaping technological change. Fleck (1994) stated that technology implementation involved the mutual adoption of technology and the organization, so that resources may be effectively utilized (Fleck, 1994). I agree with this opinion, but there are other issues which need to be resolved. If the adoption process continues post-technology inception, it shows that in addition to strategic managers, other users in the organization are considered as active participants in the technology. These figures play key roles in technology adoption in organizational settings, integrating technology and making it usable. This means a workforce plays central roles in technological changes, and these technological needs are developed and reformed over time as an integral part of the technological change process.

Thus, development of organizational needs in a coherent manner plays a significant role in technology transfer and diffusion processes. Often, new technology in an organizational setting is uncertain, contested and even unusable because workers must face challenges when introducing it. It is not easy to match technological and organizational needs with new technology and transforming it into a successful change in an organizational set up as the literature portrays (Law, 1994). Instead, I aim to generate insights into the introduction of new technologies in organizations involved in groundwater exploration.

Chapter 3: Methodology

3.1 Introduction

In this chapter, I describe the research methodology adopted to make progress towards improving management issues faced by drilling companies in the water sector, while adopting and integrating new technologies. A literature review in Chapter 2 has provided arguments that framed the issues and challenges that drilling companies must overcome during new technology adoption processes. The literature review findings were grouped into general themes that require action, which are often paradoxes emerging from the unique challenges that organizations face when seeking new technologies (Burgelman et al., 2001). The five themes (or organizational areas for improvement) that emerged from the literature review in Chapter 2 are:

* Functional capability
* Resources availability
* Productivity
* Technical knowledge
* Sustainability

No company can provide excellence without adopting and diffusing new technologies, and utilizing available resources in effective ways (Bansemir, 2015). The strategy at an organizational level should seek the latest technologies that not only improve organizational capabilities, productivities, resources and knowledge, but also the environment (Betz, 1998). This may be a challenge, but it is worth taking on, in the best interests of the company, community and the country. These decisions make empirical research necessary in exploring the challenges facing ground water companies in adopting new technologies and embracing knowledge transfer. This is where my research topic," The challenges of having groundwater development companies adopting new technology in arid regions", fits this space. Moreover, technology improves technical knowledge, through computational capabilities in modelling and simulating system dynamics. Thus, technology can provide greater technical knowledge and cultural improvements (Marshall, 1990).

3.2 The utilization of case study as a methodology

This research is concerned with the management challenges of technology adoption at the level of an individual firm. The thesis seeks to generate learning for organizational work within a context (water sector drilling companies) and is therefore highly suited to a flexible, multiple perspective methodology, such as case study. At its core, case study research supports a balanced enquiry in which different (maybe conflicting) perspectives are surfaced and critiqued (Waring, 2012). Although the qualitative case study is very popular, deliberation continues as to whether case study is indeed a method or rather a methodological approach (Pearson et al, 2015). However, Guba and Lincoln consider a study's methodology as the "overall strategy for resolving the complete set of choices and options available to the inquirer". Whereas, a case research

method provides complete details how to collect reliable data and analyze it within the research context for example face to face interviews (Gratton and Jones, 2010). While case study as a methodology explores and critiques a phenomenon in context employing multiple data sources and collection methods (Baxter and Jack, 2008). There is heterogeneity in how the qualitative case study be referred to in literature (Hyett et al, 2014). In this sense it is possible to define case study to be both a method and methodology, depending on the underpinning philosophy. Irrespective of the type of case study, it provides the researcher with the ability to explore a phenomenon through different lenses.

This comprehensive approach is suitable for this thesis project as it enables a very in- depth understandings of the subjects or participants viewpoints in real life situations (Pearson et al 2015). Creswell (2014) argued that qualitative research involving researchers and participants dealing with multiple forms of data has the capability in generating such rich understanding. This whole approach is based on the social constructivist idea that managers hold meaningful subjective views concerning the organizations in which they work; and through social processes these meanings are constructed (Creswell,2014). Consistent with this philosophy, this thesis research work will involve working with managers of drilling companies to co-create a rich understanding of the problem areas and resolving the issues through agreed planned actions.

3.3 The research design

DBA research design connects organizational problems to pertinent (and achievable) empirical research. A research design articulates what data is needed, what inquiry methods will be used to collect and analyze data, and how the entire process will produce viable answers to the overarching research question (how can firms operating within the groundwater sector manage the adoption of new drilling technologies?). MacMillan and Schumacher (2001) defined research design as a plan where subjects, research sites and data collection methods are selected, and the process produces answers to questions. These authors argue that outcomes from sound research design generate results that are credible and valid. The aim of any DBA research plan is to produce research that changes and improves practices, through validation and evaluation processes. In traditional research, it is expected that a researcher will improve their theoretical research by using other researchers' propositions and theories. In action research, it is expected a practitioner will improve their own practice through learning from existing practices, explaining how and why improvements occurred, and how processes were validated. Action research therefore seeks to validate and explain observed practices and, critically it provides explanations concerning ongoing improvements in these practices (Mcniff and Whitehead, 2010).

This is important because a practitioner researcher must articulate how and why claims should be considered valid, and not just provide opinions. Establishing a legitimate claim to validated knowledge is crucial in getting a piece of research accepted by others. It must demonstrate critical engagement in relation to your own thinking and the thinking of others in the academic literature. Action research plans combine purposeful actions with

research intent with testing the validity of claims regarding the process in question. Investigating actions and how they contribute to improvements leads to knowledge generation, providing explanations for how and why things happen. Thus, action research plans provide unique opportunities for the development of inquiry and action (Greenwood and Levin, 2007). The process unites perspectives from different multiple sources to provide deep understandings of organizational issues that require resolution through collaborative. The deployment of this research plan among drilling companies has a sound basis because it is not grounded in formal plans, but instead draws on various forms of knowing (Coghlan, 2007).

Research Design Flow Chart

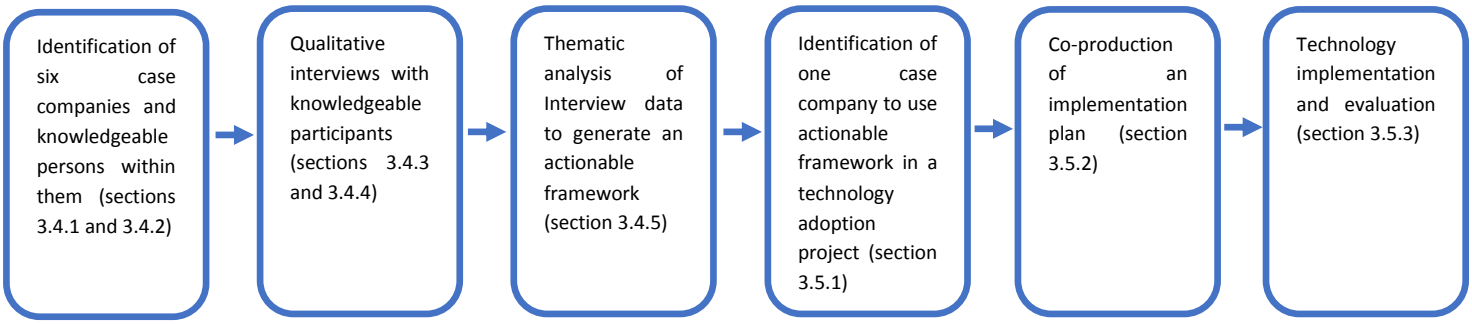

Figure 3.1

This research design plan comprises two stages. Stage 1 develops an "actionable framework" whereas stage 2 makes use of this "actionable framework" in a technology adoption project. Detailed descriptions of both stages are given below.

3.4 Stage 1- Generation of an actionable framework

This research study is designed to generate actionable knowledge that addresses challenges facing drilling companies in adopting new technologies. With reference to Ramsey (2014), "action" is manifested in two ways in this DBA thesis research. The first stage involves "mapping the terrain" (Ramsey, 2016) of the existing technology adoption practice at six water drilling companies. The output of this stage is an actionable knowledge framework for the adoption of new technology in this sector. The second stage is "testing the plausibility" (Ramsey, 2014), where the actionable knowledge framework is used with the top executives in one company to build an implementation plan. This plan was then enacted, and its effectiveness evaluated in this work.

In this chapter, the first design stage starts with a description of the six companies. This includes an introduction to the participants and the positioning of the researcher (and his relationship with the companies) in the overall research project. The data collection section describes how interviews were organized and conducted and gives details about document collection from company resources that complimented data gathering processes

during interviews. Diversification of data strengthens research rigor and relevance (Creswell, 2014).

Coding routines were adopted as part of the qualitative data analysis. These routines generated key themes constituting actionable frameworks on how to adopt new technology in a company workplace (Sull, 2007). The second stage of the design explains how actionable knowledge frameworks were used with Company A management to co-produce an implementation plan for the new technology in the workplace. This action research plan incorporated technological research as part of the technology evaluation. The findings seek to make clear the management implications of any technology evaluation result.

3.4.1 Introducing the six case study companies

Six anonymized water sector companies (Companies A–F) were engaged in relation to new technology adoption and diffusion project. I have been working with these companies for some time as they explored strategies that included the adoption of new drilling technologies. Despite a potential interest in such technologies, I had encountered a hesitancy for them to initiate technology trials. This very hesitancy provided the motivation for this DBA research project, and when approached they were all interested in participating in the DBA research project as it had potential to generate learning in how to implement new technologies in this context. In my researcher guise, this allowed me to organize in-depth interviews with their management to collect purposeful data on technology adoption and knowledge transfer in the groundwater exploration and development arena, for deep aquifers in Saudi Arabia. This new technology had been approved by the KSA regulatory authority, because of its high performance and efficiency outputs. Qualitative data from these companies would help support each company's strategy. It would also help close the adoption gap between strategies and execution in relation to new technology adoption (Sull, 2007).

Technology adoption and knowledge transfer is not just reliant on investment in new technologies. Other factors relating to organizational composition, current capability, resources availability, productivity, trained manpower or acquirement of new skills, are needed to adopt new technologies for companies to stay in business (Burgelman et al., 1998). New technology adoption achieves many intangible benefits, such as the adoption of proper frameworks, company growth and profitability, and better services for customers (McLaughlin, 1999). Measuring and evaluating this effectiveness requires the application of reliable correlation criteria for input-output relationships (Betz, 1998). Although input can be approximately measured, output is not that simple as it takes time to be measured, from new technology inception to full adoption. In spite of such challenges, once a firm's capabilities start growing, the business will become efficient and will flourish at a faster pace.

3.4.2 Accessing companies' sites

The starting point of this research was to examine managerial viewpoints from these six companies on the research question; the adoption of new technology in relation to ground water exploration and development in arid regions. It was crucial to identify research companies and their workplaces that had better organizational capabilities with regard to both the companies and their workforces. Identifying company sites, negotiating access and carrying out research was staggered over a four-month period. This allowed me to manage my time more effectively. The first stage of the research involved securing agreements with managers of company A, to pilot research interviews at their location. This pilot study allowed me to test my research methods in a real company setting. The pilot study was then extended to the other five companies and provided a template for study interviews. The format of the pilot study consisted of three face to face interviews with senior managers, who had become my core group respondents. During these interviews, I explained the purpose of my research and this pattern was repeated with selected management from the other companies.

3.4.3 Interviews

The evidential basis for the actionable framework in technology adoption would be founded upon management interpretations and valuable experiences of new technologies (Betz, 1998). Therefore, one-to-one in-depth qualitative interviewing techniques were used to draw out such experiences and gain an understanding of management concerns and issues concerning the acquisition, evaluation, implementation and use of new technology. Data collection via interviewing is not new and is commonly employed in qualitative research (Mohan, 2009). Luft and Roehrig (2007) stated that one-to-one in-depth interviews brought access to executive thinking and revealed complexities in their belief systems (Luft and Roehrig, 2007). These interviews explored executive experiences, their beliefs and skills in relation to ground water exploration and management. Participants were also asked about their learning experiences that may have been helpful in managing the new technology adoption and its diffusion into the company.

As a complement to the interview data I also collected data in the form of equipment brochures, archival records, notes of direct observations, physical artefacts and company profiles in detailed form (cf. Patton, 2002). These additional data helped position the managers' comments in interview in an organizational context, and thus aided my interpretation of their remarks.

As part of the research ethics procedures of the University of Liverpool, the interviewees were provided with a briefing that included the aims of the DBA research project and how the interviews would be conducted. They were assured about confidentiality, anonymity and publications and they had the right to withdraw from the interview session at any time. All interviews were organized with their consent.

Interviews with managers lasted approximately one hour and a half. This allowed managers to define issues and concerns that were important to them, instead of issues and

concerns solely defined by myself, which might constrain or steer responses. Nine interviews were audio recorded out of twelve and involved senior decision-making managers. Working together had benefits in allowing me more freedom than usual to reflect on and follow up on responses, but this approach was more time-consuming. While each interview was recorded, the recording system was placed out of sight to help interviewees forget it was there. My interview schedule was based on the following themes:

- The managers' position in the company and their professional background in the field of ground water technology, in relation to the company's functional capability.
- Their evaluation of systems and their readiness for change. How prepared were they in having the resources for technological change?
- Their viewpoints and experiences on new technology. Their strengths in making decisions in acquiring new technology for improving productivity.
- Their experience in valuing and acquiring new technical knowledge, the implications and problems of implementation and how they could be resolved.
- Their preparedness to take risks in accepting technological change.

All interviews were conducted at the interviewee's company, in a quiet room. The interview flow was dictated by the interviewees' interests and only occasionally would I fail to cover an issue. This was usually due to times pressures. Once completed, interviews were transcribed into a Microsoft Word document and returned to the interviewee for checking, accuracy and confidentiality. Transcribing also helped develop thematic patterns which greatly helped identify recurring themes that were invaluable for my research (Mohan, 2009).

3.4.4 Interview questions

The overall research question for the research was: how can firms operating within the groundwater sector manage the adoption of new drilling technologies? Specific information was then sought allied to the five themes (or organizational areas for improvement) that had emerged from the literature review in Chapter 2:

Functional capability

* How do you feel about having new technology in relation to your own management skills and organizational functional capabilities for technological change in your own company?

* Do you have the essential skills and competencies in your company to absorb the new technology?

Resources availability

* Do you think you have enough trained workforce and resources to pursue the new technological change process in your organization?

* In your opinion, how and when will you be able to start the technological change initiative and to what extent do you have necessary resources at hand?

* If you are a change leader, how you will build the confidence of your staff in adopting new technology?

Productivity

*At present, do you feel adequately prepared to go ahead with the technology adoption change?

Technical knowledge

***** Do you believe that you must upgrade your equipment and give additional training to your staff before taking a decision to initiate the technological change in your company?

* How confident are you that acquiring technical knowledge in your company will raise confidence, improve organizational image, raise morale, and provide other long-term benefits in the future?

Sustainability

* What is your own thinking concerning adoption of new technology in relation to benefits and sustainability?

* Do you have any negative thoughts concerning sustainability?

* Have you any previous experience of handing such a magnitude of change in an organization and sustaining business?

Sources of Research data

A. Sources selected	**Methods employed**	**Locations**
1.Company Managers and technicians and drillers	Interviews and discussions	Companies site office
2.Company Records	Examining company documents	Companies site office
3.Regulatory evaluation team	Observations during implementation	Companies site office
4.My own field notes	Engineering data collection	Technology company office

Table 3.4

3.4.5 Data analysis

Data analysis uncovered salient themes that supported the development of an actionable framework to allow the adoption of new technology. Qualitative data was analyzed as per the procedures described by Easterby-Smith et al. (2005), such as familiarization, coding and decoding, contextualization and providing detailed research

explanations. A first order theme development approach was followed throughout the data analysis, followed by a first level categorization to produce aggregate dimensions. These ten “first level categories” which are clusters of the first order themes produced four aggregate dimensions. These emerged as building blocks, allowing the construction of an actionable framework to introduce new technologies into water supply companies.

The process used the five themes (functional capability, resource availability, productivity, technical knowledge and sustainability) derived from the literature review (Section, 3.1), which were related to organizational technology adoption. They were used to generate data through qualitative interviews. Interview transcripts were examined for ideas related to these five categories and were summarized in short sentences. These short sentences are described as “first order themes” and totaled 353 (An indicative example of this first round of coding is presented in Appendix 1).

In the second analysis round, these first order themes were organized into clusters, expressing a category for technology adoption practice. In this manner, ten first order categories were generated. These first order categories produced new actionable frameworks that were used to successfully implement new technology in Company A. In building this framework, the first step was to examine procedural relationships between the ten first order categories. With ideas from the literature review, different frameworks were produced showing relationships between categories. This process included a further clustering step where the ten first order categories were grouped into four aggregate dimensions which were organized into a process structure to generate the actionable framework. Detail of this analytical process is presented in Chapter 4.

3.5 Stage 2 - Making use of the actionable framework in a technology adoption project

The newly developed actionable framework was used to create a plan for the implementation of new technology. However, this framework, being general, must be contextualized for a specific organization. The framework thus informs the identification of the actionable task and processes to accomplish the implementation of new technology work. This research presents an approach that bridges the gap between the abstractions available through actionable framework and the actions that are needed by the people or the system in a repeatable routine. The most important feature of this actionable framework is that it brings in a lot of expertise and knowledge on the part of the technology company management. They deliver, define, evaluate and describe the organization, its technological structural compatibility and the context of how implementation process should work.

This means as technology changes, more flexibility in managerial training and of allied staff will be required. Coordination functions become more important because the number of technical specialists of varying kinds tend to increase. Technical managers may be averse to handling the consequences of technology impact directly because they must delegate technological decisions to experts, based on the understanding that only years of

training can give one the competence needed in making new technology decisions. Therefore, successful delegation to experts is, in fact, the key to success. In this way technology experts handle the technical issues including training of staff and technology implementation process stays with the management for necessary actions and coordination. It reflects that as technology changes, the nature and activities of the managerial functions will change because technological change in both the drilling and service work environments will be ever existent in a competitive manner, management must learn and find innovative approaches to cope successfully with it while handling the adoption process.

The core goal of this stage was to develop confidence concerning new technology among the company leadership, drilling managers and the drillers. Additionally, an evaluation team was built, who could monitor the implementation process and provide effective feedback concerning all operational and training activities in relation to new technology.

3.5.1 Selection of Company A

All six drilling companies stated that adoption of new the technology, through an actionable framework, was the only way forward in the current business environment. In adopting the new technology, they were confident trained drilling staff could provide unique technical services that were not possible within the companies' technology set up. However, during the selection process, the most difficult part was identifying a company who could trial the adoption process, in the timescale convenient for my research project. Through extensive conversations and discussions, company A was the most suitable organization for the technology adoption, because it was prepared to adopt the new technology very soon had the necessary resources and its schedule fitted with mine. After meetings and discussion with Company A leadership and management, I successfully convinced them that implementation of the new technology actionable framework was to their benefit. Moreover, continuous interaction with the leadership and the drilling managers facilitated the process of reaching the final selection of Company A. Collaborative environments that enable formal and informal un-structured interactions and knowledge sharing may offer the best viable discussion options for the technology actionable framework to succeed.

3.5.2 Co-production of the technology implementation plan

After reviewing the research findings with Company, A leadership, a strategy and plan for implementation was generated. The details of this plan are provided in Chapter 5. It was felt that the technical performance of the technology was not a key issue; rather it was the implementation and adoption process, because it required concrete commitment from every member of the company including leadership, technical managers and drilling staff. I presented my complete analyses of the new adoption model, with full recommendations on how to implement the new framework. After discussions and listening to their opinions and technical concerns, the implementation plan was finalized.

Co-production of the plan widened the ownership of the adoption model and built a managing capability within the company. In this way, implementation management issues would be resolved easily and speedily. The plan consisted of set training and workshops schedules that were developed following the actionable adoption framework for implementation purposes.

3.5.3 Evaluation of technology adoption at Company A

The research aimed to evaluate technology adoption and prescribe aspects of an assessment rooted in the requirements of the customer and the purpose of inquiry. These included technical skills levels, operational activities, and quality of services or products. Evaluators had to consider the complexities of multiple interventions when selecting appropriate evaluation strategies, but they often relied on evaluation standards set by recognized international bodies and services available in the area.

At Company A, the implementation plan involved two types of evaluations to achieve the best results and included internal and external evaluations. Internal evaluations were conducted on a continuous basis by the internal team which consisted of members from the technology company and drilling managers from Company A. Their function was to generate evaluation reports on drilling staff training and to take immediate remedial action for any lapses during ongoing implementation processes. These reports showed the grade levels of drilling staff and their performances in relation to set schedules.

The external evaluation team was a third party hired to evaluate the drilling staff of Company A and the quality of the finished well. This evaluation covered productivity and the cementing quality as per international standards approved by the Ministry of water in the KSA. The external evaluation team ran data collection tools into the well to gather data on log sheets. The interpretation reports from these log sheets showed whether the completed well met acceptable standards or not. This is how wells are accepted by customers or the Ministry of water. The ministry of water is the only regulatory authority responsible for water control resources in the country.

As the DBA researcher, I ensured the evaluation teams conformed to the implementation plan. I integrated their findings into the research to generate insights about the implementation process and to validate the actionable framework. The next two short sections summarize the two parallel streams of research occurring during the implementation: the (engineering) technology research required by KSA regulators, and the management research that is the primary subject of this DBA thesis.

3.5.3.1 Technology research

While pursuing management research, technological research/data was also collected in terms of quantitative data on the equipment, drilling structure, availability, present conditions and reliability. This provided helpful insights into how competent the company was in executing water projects. This is the reason why technology research is considered the forerunner of technology in groundwater (Roman, 1980). Its direction and

extent can be considered a product of involvement in the water sector companies and regulatory authority directly or indirectly, and the provision of some incentives depending on national goals or interests and availability of funds (Bozeman et al., 2015).

To achieve greater success with limited resources, technology research needs to establish proper planning and control procedures, including company or project selection, resource estimations, equipment compatibility and structure, management skills and evaluation of results in relation to all objectives. In all communities' or societies', social welfare and economic benefit goals are heavily dependent on technology (Bozeman, 2007). Although the management of technology in government and private sectors cannot escape criticism because management are core factors in planning technology transfer, adoption and utilization. Researchers are sometimes too absorbed with immediate inquiries, whereas practitioners focus on projects in a more holistic manner. Research activities must be coordinated using technological and organizational goals, in a realistic sense (Betz, 1998).

3.5.3.2 Management research

In achieving maximum benefits of technology adoption and knowledge transfer, coordination was key to all stakeholders. The management of technology, knowledge transfer and adoption areas is often beset with complexities, which are very different from traditional business operations and may be something of an enigma to management (White and Bruton, 2008). Even then it is considered highly demanding, frustrating and costly, but also rewarding. Therefore, it was important to have the necessary management knowledge to cope with issues, because some management techniques may have been difficult to apply in some instances (Besley and Case, 1993). Failure on the part of leadership to comprehend requirements may have led to ineffective use of resources and affected the technology adoption process (Christensen, 1997).

The aim of this management research was to generate an actionable framework and specific proposals that could inform Company A's adoption of a new technology. This required revisits to the leadership and drilling mangers of Company A to investigate and understand their opinions concerning the actionable framework. This allowed for close collaboration with the leadership and the drilling managers of Company A. I explained the benefits of the new technology and the requirements concerning the adoption of actionable frameworks. After thorough discussions and full understandings were reached, we agreed to an action plan to implement the new technology in their workplace (details are given in Chapter-5).

3.5.3.3 Researcher position

It is important to explain that the researcher had been involved on various water exploration projects with these selected companies in the past. The researcher knew the culture of the companies in depth, their strategies, operational approach and the managers who were interviewed. The researcher was able to draw upon his involvement in water drilling business close to three decades in the Arabian Peninsula and other parts of the

world, in order to capture observations during the action research. This study was launched in September 2016 and the field data collection was concluded by December 2016. As an insider researcher, it was important to recognize how my own expertise might have fed into the issues and conversations with participants, and how I investigated and performed the analysis. My expertise as a researcher, consultant engineer and technology supplier having thorough knowledge of local culture was valuable for the research project. It gave me insights into the firm and what it was like to work there. Taking notes, preparing agendas for discussions, listening and observing others all informed my sensemaking during the action research. I was able to observe and assist the implementation plan in a realistic manner; sticking with timelines and work schedules concerning training programs. Being a consultant engineer, I provided guidance in resolving technical issues and improving efficiency with the positive inputs from the managerial staff and the senior management.

During the collection and analysis of data, I was conscious of the integrity of my research project. While I was an outsider, my relationship with the company, as a consultant, made my position unique. However, this position allowed me to execute this research project in a successful manner (Easter by-Smith et al., 2005). The adoption of rigorous data handling processes minimized biases that might otherwise have been introduced because of my familiarity with the companies.

3.6 Thesis structure: Empirical and concluding chapters

This thesis continues as follows:

- The next chapter, Chapter Four, presents the findings from stage 1 of the research design – constructing the actionable framework
- Chapter Five narrates the findings from stage 2 of the research and includes, discussions with Company A concerning the actionable framework to develop an implementation plan for adopting new drilling technology and evaluates the actions taken to adopt new technology by company A.
- Chapter Six presents the implications of the research for other drilling companies, my own technology company and my own professional practice.
- Chapter seven narrates my reflections on my DBA journey.

Chapter 4: Research Findings – Building an Actionable Framework

4.1 Introduction

This chapter aims to address the management challenges in adopting new technology for groundwater drilling companies that are interested to improve their competitiveness. It is intended that the research findings will contribute to the development of an actionable framework. The research also intends to explore how companies and regulatory agencies are currently working together to promote technology adoption and good practice. These above aims highlighted the core objectives of research in a following manner:

- To identify aspects and challenges drilling companies are currently facing.
- To analyse the current technology practices and their weaknesses regarding companies' performance (compared with lessons from literature - chapter 2) and generate an actionable framework for technology adoption in this sector.
- To work with managers in the company (using the actionable framework) to generate an implementation plan for adopting new drilling technology.
- To support companies in initiating a pilot project in adopting new technology and in meeting these aspects.

This research presents the findings from the first stage of the research and culminates in the construction of an actionable framework for technology adoption in the water drilling sector of the KSA. The research findings are presented as a thematic analysis (cf. Giola et al., 2013) of interview data from the six companies introduced in Chapter 3. The data was collected from in-depth interviews of groundwater companies' chief executives' and managers. The analysis focuses on the challenges drilling companies are facing while adopting new technologies at their workplaces, and how these challenges can be managed by practitioners. The research undertook the broad areas of organizational performance which were highlighted in literature review chapter 2 for improvement and reduced those areas to specifics such as internal operations, financial standings, workforce strengths, drilling infrastructure and organisational management capabilities in relation to new technologies. Each company matters covered a range of complex issues and one of the main challenges was to develop a framework which was acceptable to all stakeholder managers. Policy and practice no doubt remained divergent across companies but greater inter-professional awareness and empathy could have encouraged more effective and sharing of good practice. During my research I observed that Knowing of local Culture is of significance importance in executing research project especially in the KSA. Initially, I did experience cultural difficulties while interacting with the drilling staff but once they came to know that I was one of them interactions became very supportive. I did mention in the interview chapter that knowing of local culture became as one of the enabling factors for me in supporting this research project. If I think of the relationship between culture and technology in times of change as being one of 'mutual adaption' while managers

interpreted technology from within their existing cultural assumptions, at the same time they also developed new interpretations as they interacted more with technology and with their drilling staff who were going to use it to generate services for the customers. It is these interactions as understood by most of the managers and me as a researcher that built as one of the key themes of this research project. This means the mutual adaptation of organizational culture and technological process is framed by broader values associated with new technology. These values allowed forms of speaking regarding technology and mediated experiences. These cultural assumptions about technology could be supported by disclosures of performance efficiencies associated with and legitimating the change process.

The five dimensions of technology adoption initially identified in the literature chapter were used to generate the interview protocol for the managers (see section 3.4.4). Prompted by these questions, the managers revealed lots of contextual information, and it is this information was subjected to thematic analysis. The aim was to identify the key themes of technology adoption that grounded in this water sector context. This provides the justification for emergently developing a new actionable framework. The details of how this analysis was done are explained below.

A coding process was utilised in the analysis of interview transcripts with managers. Creswell explains that coding starts with the abstraction of the scripted interviews into small category information that highlights core themes of the data. Practically speaking, this involves selecting meaningful chunks (sentences) from each transcribed interview and expressing that meaning in a short phrase. These phrases are expressed in terms the interviewees would use. Collectively these phrases are called “first order themes”. By working through all interviews, this generates a long list of such themes. The next stage of the analysis involves clustering of these themes into “first level categories”, (Creswell, 2014).

Clustering is highly iterative and entails continual movement between ideas identified in the literature review and data generated by interviews. Following iteration between the raw data and erasure, this provides the labels which are given to the first level categories (Locke, 2001). This data structure was organised into two columns showing interviewee codes, managerial quotes and first order themes (Appendix 1). The final stage combined first lever categories into aggregate dimensions. Aggregation was informed by ideas drawn from the literature review. The resultant aggregate dimensions are the “building blocks” for the creation of an actionable framework model for the implementation of new technology at a company workplace. In this manner, the thematic analysis of interviews with the managers, at six drilling companies laid the foundations for the actionable knowledge framework that was applied to Company A.

The results of these coding and clustering processes are presented in the following sections. Firstly, the ten first-level categories are introduced and explained. Secondly, the aggregation of these first-level categories into second-level aggregate dimensions is described, along with the actionable framework. The chapter ends with reflections on the framework and further steps.

4.2 Research analysis: First order themes and first level categorisation

The coding of interview transcripts generated 353 first order themes which were organised into a tabulated format (An illustration of the coding structure for one theme is reproduced in Appendix 1). These themes were examined for similarities to generate clusters. Each cluster was known as a "first level category" and represented a distinct aspect of new technology adoption. Labelling each category captured salient ideas from statements from all interviewees that comprised the category. This coding process generated ten first level categories (Figure 4.1) and details of the clustering of associated first order themes are presented in Appendix 1. The first phase of analysis sought to identify which areas were identified as having weak performance and needed developmental priority to inform the design of the second phase. The meaning of each ten first-order category is presented in the following sub-sections.

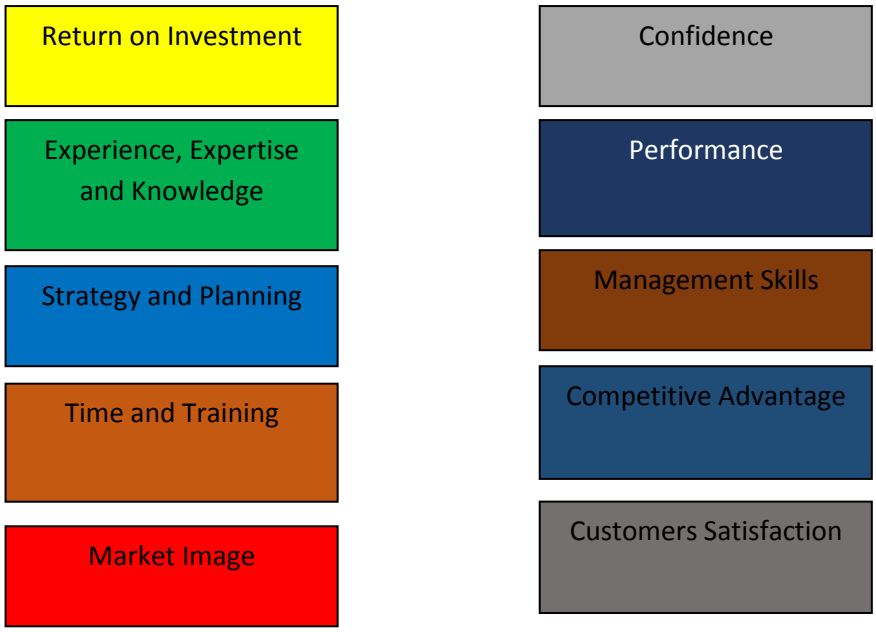

Figure 4.1 Ten first order categories

4.2.1 Return on investment

With ground water exploration companies, choosing the right type of technology can be challenging. Not only are there several types of technologies to choose from but making the wrong investment decision can result in more problems. Moreover, new technologies are emerging rapidly, making it difficult to determine which are worth the investment. Interviewee manager-1 at Company-A argues that, "a majority of managers frequently feel overwhelmed with the technologies available in running their business operations. Without a doubt there is always a risk involved in adopting new technology quickly and possibly could make a compromise return on investment".

> "If you linger too long in the market, then you could potentially hand over the competitors an advantage. Though the managers understand the value of new technology, they really struggle to make the difficult decision in choosing the right technology in a timely fashion to assist their businesses in a big way" (Manager Company B).

Nonetheless, investing in new technology remains an urgent priority for most managers in ground water exploration companies. They believe that new technologies are necessary to keep pace with changing business environments. To avoid intimidation by new technology, ground water exploration companies should be strategic in making adoption decisions. Interviewee manager-2 Company A says that, "they should buy new technology once they have clearly done the proper analysis, defined the processes they need to alter, and analysed how new technology will ultimately induce a positive effect on their businesses."

> "Adopting the right technology, managers can feel less challenged by the market forces in satisfying the customers' needs fully by making their business performance more efficient. They believe very strongly that new technology does have the potential to deliver a great impact in relation to the return on investment. This means the company will work more efficiently at lowering costs, higher quality and shorter delivery times. So, the decision makers must be sure that the technology in question is the best tool for their business and have a clear understanding on how it can effect a positive change to make a reliable return on the investment" (Manager, Company B).

4.2.2 Experience, expertise, and knowledge

The combination of experience, expertise, and knowledge is an asset for a company, as it helps the company workforce perform organisational tasks successfully. In this sense experience, expertise, and knowledge can be taken as "power" that can change a company. Interviewee manager-2 Company B says that, "organisational knowledge and expertise is the most important asset in an organisation, much more important than finances, equipment, market position and other resources. Knowledge also allows us to steer the course of events, to grow economic benefits and improve lives in the organisation ".

The manager at company C argues that "knowledge is a key resource for innovation and success in the workplace". These participants suggest that through new technical knowledge, organisations can increase their abilities, improve their services, thereby satisfying customers and others. This means technical knowledge is the core of any successful organisation, it helps it flourish and grow (Manager Company- B).

Individuals may come and go, but if valued knowledge is lost, then the company cannot perform organisational tasks successfully. My analyses confirm that an organisation's adoption of new technology is a salient discriminator between success and failure, in the competitive world (Chapter 6). My argument is that a successful company needs to share and disseminate knowledge throughout its organisational boundaries after

having adopted the new technology to stay ahead of the competition in terms of quality, speed, innovation, and cost. Yet, many companies are incompetent at managing knowledge, which is the job of every worker at the organisation. Organisations need to learn how to manage their knowledge and expertise. “This is possible through scanning the achiever passive mode of the internal environments of the organisation” (Manager Company- E). The ability to learn from different activities of the organisation can be a good source of added value for the company. Additionally, organisations acquire knowledge internally by tapping into the knowledge of their staff, through their shared experiences.

4.2.3 Strategy and planning

Workplace technology is continuously evolving to address and adapt with the changing needs of companies in the water sector. There are numerous factors that can lead to the acquisition of new technology and tools. Therefore, technology adoption is increasingly important as a company strategy, to not only sustain, but also become more efficient in their business activities. Existing services must be given technical support through the adoption of new technology, to provide greater client satisfaction and improved sales. Continuous technical efforts in the core service areas of the company must be performed so that improved quality and cost services can be provided.

Interviewee Manager-4 Company-C says that:

> “A company that does not plan for new technology or service improvement may find itself bypassed and eventually rooted out of business due to severe competition by others who are actively engaged in new technology at appropriate times.”

With this obvious need, there is a constant need for well-conceived strategic programs to exist and survive in a competitive business market. “New technology purchases and adoption programmes must compete for financial resources of the company, with alternative strategies for revenue generation” (Manager Company-B). Therefore, they must be well organised and have a reasonable chance of success with the involvement of top management in determining and setting strategic goals in pursuing new technology and adoption.

> “It cannot be overemphasised that without setting proper strategic goals and planning, involving technology adoption programmes can drift along the lines of interests of other managers” (Manager Company-C). Success is attained by those companies that plan for innovation through technology adoption rather than following it. “If managers fail in their responsibility to plan, planning efforts will automatically decrease where company interests and goals are not adhered to” (Manager Company-F).

4.2.4 Time and training

Regardless of the size of a company, the research found that technology adoption changes are often disruptive and sometimes puzzling, particularly for companies with an aging workforce and those averse to new technology adoption changes. “Employees feel great pressure with the knowledge that their jobs are dependent on learning new technologies” (Manager Company-C). Betz (1998) argues that close to 50 % of companies face significant challenges in the face of adoption of new changes in relation to new technology. The reason is resistance from some of the employees. Manager-1 Company-D says that:

> “You bring in the best technology, but if employees are not properly trained or aligned with the technology changes, there is always a reasonable chance that the employees will take some time to digest the adoption changes in spite of having a reliable training programme at hand.”

So, how do you get employees ready for the adoption of new technology?

> “This is one of the challenges to deal within the organization to plan an adoption readiness stage effectively. Training within the timeframe is just part of the whole technology adoption and integration process in the company. The actual finish line in technology implementation is when the company starts generating higher productivity and meeting quality parameters set forth in the strategic planning schedule” (Manager Company-B).

Although learning is a slow time-consuming process, it must be accommodated in costs to avoid complex implementation. So, the readiness and training efforts need to be feasible in adoptions to changes while focusing on the end goals and strategic targets.

> “Learning is a part of the training process which brings people closer to understand each other and the technology so that it can be integrated effectively within the company within a set timeframe” (Manager Company-A).

4.2.5 Market image

The ground water exploration companies in this study invest in new technologies to align their business strategies, improve functional operations and improve their market image, to grab a bigger share of the market. Moreover, the adoption of new technologies “helps to foster changes in managing customer relationships in their service areas” (Manager Company-F). Interviewee manager company-B stresses that:

> “New technology is an important ingredient to enhance service capabilities, leading to an improved market image. New technology enhances innovation development which assists the companies to further enlarge their services and grab bigger shares of the market due to an enhanced image”.

So, the success of a company relies on how well it adopts new technology and implements it to create new market shares. Technology adoption practices enhance a company's competitive advantage, to grab a bigger share of the market because of the market image improvement. This means new technology adoption influences services within a company, ultimately leading to market enhancement.

The provision of services to clients is much easier to imitate and more difficult to protect under commercial patents. Even so, improvement in services through new technology adoption is still a huge ask for service companies to stay competitive. Interviewee manager-2 Company-B states, "the market image is improved when a company provides its services more cheaply as compared to its competitors that enhances its market image and company and thus uses bargaining situations to its own advantage" A company's market image is significant in judging its strength and reliability in the market. It means that companies, who constantly adopt new technologies, excel in grabbing huge market shares, improve their market image and enhance client satisfaction. Offering new services to satisfy customer needs helps companies to grow sales and become market leaders. Taking care of client needs leads to sustainable business success, which is advantageous against competitors.

4.2.6 Confidence

Throughout the study, respondents noted that ground water industry consumers or clients were not strong predictors of new technologies. Their reaction to new technology was always slow. For managers of ground water exploration companies, this generates some challenges. Managers understand they need to bring in changes to stay competitive, yet they do not know which change will be more beneficial. One approach is to engage in market research and involve experts to set out a strategy vision, as suggested by Manager Company-D. Mansfield (1992) argues that the answer is hiding in plain sight, most managers know their clients much better than they realise. Knowing that technology can deliver core needs of the clients, managers will overcome hesitation or anxiety. Interviewee Manager Company-B believes that,

> "Instead of looking around for guidance, it is better to build your own confidence and grow employees, trust your clients' insight, and combine it with a thorough understanding of what new technology can deliver". "Perhaps more importantly, foster an internal culture of confidence among employees to succeed with the new change of technology" (Manager Company-B).

A lack of confidence in a company's ability can be a serious issue when adopting new technologies. This anxiety can generate inefficiencies and risk that take root in various ways. Therefore, it is important to understand the cause of this uneasiness and it should be addressed before it starts damaging operational aspects of business. In this sense, a visionary strategy of the business may be required. Interviewee manager Company-B says that, "It is management's responsibility to elaborate it to its employees and customers how new technology can be beneficial in resolving the existing technical issues while promoting efficiency".

> "New technology brings many opportunities to all those who would like to pursue them. You understand your clients and when you combine what they want through new technology, it can raise the confidence of your employees to go in with full courage to cultivate the kind of decisions that lets you move forward to hold the recent leaps. It may be a long shot, immediate results may not be seen, but trusting your newfound confidence to pay off in the end will be a core asset" (Manager Company-A).

4.2.7 Performance

This research found that participants believed that the rate of execution was one of the key differentiations among the competitors. Interviewee Manager Company -C stresses that:

> " Knowledge creation and sharing reuse and technology innovation can significantly assist in reducing time to deliver projects on time or service to clients. This translates into improved performance leading to more revenue and higher shares of the market".

> "In competitive situations it is critical to differentiate yourself from other companies. Demonstrating the company's performance potential to current clients that you have the expertise, knowledge, and technology to provide various ways to come up with increased performance is important so that they can continue doing business with you" (Manager Company-F).

Conversely, they could leave you vulnerable in a lower performance situation to the competitors who can demonstrate higher performances through their knowledge management capabilities.

With increased performance, companies found that harnessing the full knowledge of its employees, through new technology, was very helpful in exploiting a company's power to take performance to a higher level. "Consistently utilising the best practices through the employment of new technology can easily raise the revenues leading to higher performance and strengthening its business share of the market" (Manager Company-B). Otherwise, it will be very difficult to increase revenue in the face of hard competition and a mature market. Innovation change, through technology, can enhance performance. This can be used as an advantage to beat the competition and strengthen a company's share in the market. However, my argument is that future investment decisions in technology and innovations must be technologically driven to raise performance. Manager Company- A believes "that good performance is metrically important to seek outside investment. So, the performance factor is core to a company to maintain its existence in the industry". In this case, technology performance data provide the core evidence that new technology is capable to deliver (Appendix).

4.2.8 Management Skills

A recurrent theme during interviews was that management skills are central to fixing inefficiencies and optimising company performances. One aspect is managing service provision processes effectively, but equally important are the decisions that ensure workers' motivation and efforts. Interviewee Manager-1 emphasises:

> "Managers need to be equipped with a wide range of management skills, including the strategic ability to cope with a changing environment, the organisational as well as supervision skills to handle the business, people and communication skills, full awareness of the information management process, management practices and chalking out visionary processes that can create a coherent system full of incentives that speed up the contribution of employees to company productivity".

These skills may include individual and team skills. Training of the staff for management skills and their enhancement to streamline operational activities is equally critical. Promotion of teamwork and in groups is of significant value to manage the technological change and improver organizational effectiveness. Manager Company –E pointed out that employee rotation engages flexibility and teamwork, while effective communication sorts out employee concerns and brings the spotlight on low productivity areas where improvement can happen. The adoption of new technology raises the requirements for a skilled workforce, by making skilled staff more productive and replacing the routine tasks of a less skilled workforce. At the aggregate level, the availability of a more skilled staff allows the company to exploit skill enhancement technologies that can lead to further innovative services, as mentioned by Manager Company-A.

4.2.9 Competitive Advantage

Like other industries, water sector companies are dependent on new technologies. They need to understand how a new technology can lead to competitive advantages through increased productivity and value maximisation. Business is a strategic game, where only the best teams outperforms the rest. Therefore, maintaining the lead or beating the market competition requires a collective effort. It is not just a task for management, it is a responsibility that everyone needs to fully share. For managers, they must seek the full support of the whole organisation on dealing with the competition. The first step is to define the business or services that show your customers why you are different, and how you can provide better services than the competition. "Standing without clarity can often be beaten up by the competition" (Manager Company E). To stay competitive, you need to be distinctive. Interviewee manager-1 Company- F says:

> " There has to be something special in your service that will influence the customer to have a second thought about leaving you and going to the competitors. This something special needs to be utilised to grow your competitive advantage".

New technology enhances provision of the best services to clients. This means that continuous engagement with customers will be strengthened; thereby bringing new customers on board. My argument is that without having the assistance of new technology, it is difficult to compete. The core ingredient through which competition is disabled is quality, price, and services. These three ingredients are highly iinfluenced by the adoption of new technology and can easily lead to beating the competition, as Manager Company-A pointed out. Building a business based on the best quality service at competitive prices, and successfully exploiting it, can curtail even the severest of competitors, according to Manager Company-B.

4.2.10 Customer Satisfaction

The customer is one of the most crucial factors for any drilling company in the water sector. For a company to flourish, it is important to maintain a loyal customer base. This is possible by providing quality services at competitive prices, through personalised experiences. In this competitive age, the customer will always find alternatives; therefore, their retention is a major challenge. A company which has gained extra advantage through adoption of new technology can easily satisfy and retain its customer base that is needed to enhance its efficiency. Although it takes time to know what a customer's reaction will be to new technology, innovative technology is unique and exciting. Interviewee Manager Company- A says:

> "If you can seek a way to excite your customers to talk about your company as a result of the new innovative services being generated through new technology you continuously come up with, then you have got an advantage over your competition. Once you set the pace in your industry, others will literally look up to follow your lead".

Equally important, the thing about innovative technology or services is that it keeps you alert all the time.

Satisfied customers will keep asking you about some new innovative services, therefore the company must continue the technological change process at a reliable speed, and otherwise someone else will take over. "Communication is the most powerful tool between you and your clients. It is the cheapest and the most reliable tactic against prevailing competitors" (Manager Company-A). Maintaining strong relationships with customers is vital to maintain an edge over others. It is one of the most effective business strategies behind market success of viable companies. "Customers are very expensive to attract and that is the key reason small businesses place more focus on a customer's satisfaction" (Manager Company C). According to Manager Company-B, reliable companies know it is wiser to have satisfied customers and keep them for life. Their greatest success will emerge in the form of better returns on investments, by holding and retaining their faithful clients.

4.3 Construction of an Actionable Framework

Continuous technological change simultaneously generates threats to established technology business models, whilst providing opportunities for novel service offerings (Lai, 2010). Companies with set strategies often seek to reform technological applications to their own advantage. With the advancement of new technologies, how fast drilling companies are accepting these technologies depends on various factors, such as capital resources at hand, the suitability of technology and its availability, convenience and customer needs etc.

4.3.1 Framework development

This study develops a feasible new technology adoption process model that could assist drilling companies in their implementation process, while adopting new technologies. To succeed with new technology, fundamental changes to how you do business must occur, not just how you approach and serve customers, but how you allocate resources and exist in the competitive market (Binns, 2015). It is critical that any company being disrupted by new technology should foresee incoming potential threats to their business. Without this foresight, the situation is challenging. The goal is knowing how and what to change to achieve the smoothest transition from the present to the anticipated future (Betz, 1998).

This probably needs a whole series of new strategies and tactics to win customer confidence and be thoughtful about what constitutes a real disruptive force against the company that is opening a new customers' segment. Moreover, depending on the nature of the change, a company culture can either be an asset or a liability (Bozeman et al., 2015). Many companies assume that new technology and the customers' behaviour is the hardest part of the technology transformation process, but this is not the case. You must ascertain which parts of your present operating model needs to be transformed to adapt to the new reality. All companies have operating models that have been developed to keep market risks at a minimum (Collins, 2001). If the market is disrupted, how strong are the existing measures or controls to help or hurt your ability to adapt and flourish in the new emerging business environment? Some controls may work in the face of disruption, but others do not. In such scenarios, companies must review their strategy and make difficult decisions on how to proceed in a volatile market full of disturbances, new technological disruption and how to make changes to everything from setting strategies, goals, capital allocation, selecting and adopting new technology and retaining staff across the company during the change (Doss, 2015).

Technology adoption varies among companies and it can be categorised into several types, which include the functional level, individual level and the organisational level. Consistent with the present perspective, the focus here is on discussion and analysis at a company level. A technology adoption model is conceptualised and based on ten themes drawn from interviews with company managers (Section 4.3). There is no doubt these elements reflect the positive side of technology adoption and diffusion processes. The literature review has already confirmed that technology adoption and diffusion processes can generate numerous benefits, including increased return on investment, but

it also enhances a company's capability and functional performance improvements (McLaughlin *et al,* 1999). Additionally, technology adoption raises technical knowledge and skills levels (Bans Emir et al., 2015). Thus, technology adoption can be considered of significant importance in improving and generating new knowledge and expertise (Marshall, 1990). Moreover, this technology improves business life in sustaining a company's survival (Gray *et al,* 1998). This means new technology not only efficiently utilises available resources, but it builds effective strategies at company levels; companies' needs are formulated in such a manner that seeking new technology can easily raise companies' performance in each sector (Lichtenthaler and Lichtenthaler, 2010). However, technology which is new to any of the adopting companies helps in identifying and taking opportunities to generate new services, products or work practices (Tushman and Nadler, 1986).

In the face of fierce market competition, it is up to the company to decide whether to pursue an aggressive growth strategy, through new technology adoption. However, some interviewees argued that the return on investment was a critical factor, which had to be returned via client experiences, creating new customers and/or building aggressive marketing strategies. Thus, constructing new viable business models to handle customer experiences, monitoring worker performances and raising managerial skills is an innovation process and is essential competitive market survival. In the development of this model (Fig. 4.3.1), it has a more input-transformation-output structure where inputs are "triggers for new technology adoption"; transformation is the "organisation of adoption" and outputs are "business outcomes". Thus "business outcomes" are concerned with first order themes of "return on investment", "competitive advantage" and "customer satisfaction". These are all themes related to outcomes at the business level. The "triggers for technology adoption" theme relate to general dissatisfaction with current technologies and is built from the first order themes of "strategy and planning" and "expertise and knowledge". The "organisation of adoption" is divided into two stages; stage one includes "becoming familiar with the new technology" and is built from "time & training". Stage two involves "making the new technology work in company context" and is built from "management skills", "confidence" and "performance".

This model shows the dynamic relationships between the aggregate categories (Figure 4.2). In effect, it shows the sequence of organisational events, leading to the adoption of new technologies. The whole actionable framework process model is shown in (Fig. 4.3). Moreover, the adoption of new technology raises companies' capabilities in bringing to the market higher quality services at competitive prices, over a shorter time, thereby raising the service process to a new higher level. Therefore, arguments can be made that technology adoption not only creates positive effects on business, but it also generates significant effects in improving and promoting services process systems. In this sense, services being developed through this model could further enhance the quality of services among drilling companies. The technology adoption process model raises the quality of drilling services, to include performance, production and efficiencies (Vermeulen and Dankbaar, 2002).

Figure 4.2, Dynamic relationships between the aggregate categories

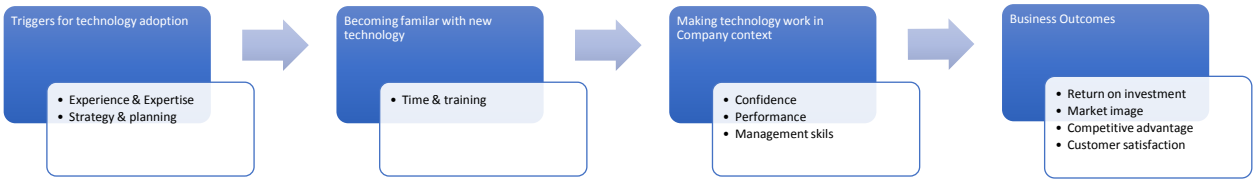

Figure 4.3, the actionable framework for managing technology adoption

4.3.2 Framework utilization

The use of new technology, through an adoption process, enables employees to compare current experiences with previous, leading to the updating of skills and knowledge. In doing so, companies develop new services that are better suited to meet market demands and provide customer satisfaction (Demirhan *et al,* 2006). Thus, it can be argued that service companies that adopt and utilise new technologies properly, will perform much better than their competitors. This means technology adopting companies will gain competitive advantages through outstanding company performance and value creation capabilities; and it can be viewed externally as well as internally a company of having much higher financial as well as leadership status in the market. It will add to competitive advantage through the provision of quality services, while meeting customer demands, market changes and understanding competitor strategies. In building strategies, many companies rely on the effective utilisation of internal resources to enhance profitability and develop successful innovative practices (Roberts and Amit, 2003). The effect of service process practices on external competitive advantage can be judged by evaluating the companies supply chain systems, customer satisfaction, speed of service delivery and the product or service cost. This means those companies who have adopted effective technologies at the right time, are more successful in facing business and marketing challenges (Tushman and Nadler, 1986). Moreover, launching new services or

products and improving existing services, help companies to increase sales volumes and strengthen their market leadership roles (Iansiti, 1995).

Providing new services for customer needs will help companies to keep pace with shifting market trends and help improving market images. To exploit companies' internal competitive advantage again depends on the internal capabilities of the technical personnel and the technological resources of the process system. A company with technologically strong systems and competent manpower will encourage the creation and promotion of a healthy work environment, where staff plan, develop and launch new services, with ease. Its effects can be judged through worker job satisfaction, domain knowledge and expertise (Van Riel et al., 2004). I argue that companies with satisfied and motivated employees learn and create new knowledge to enhance business prospects, more effectively in the marketplace. However, other factors can help or curtail a companies' capacity and help in making the companies to be potential acquirers and users of new technology (Mansfield, 1992). In this sense, it can be argued that technology transfer and diffusion is a change process, which requires new technical skills growth (Senker, 1992), whether technology adoption is a response to market needs or business interests, raises a logical concern to identify those requirements in the perspective of the existing and future needs of the companies.

Therefore, technological change is not a simple straightforward process, but it is a more managerial, educational and political process. New opportunities, power and even luck, play pivotal roles in shaping the technological outcomes just like any master plan or agreements (Walsham, 1993). There is also a general perception that newly adopted technologies, through committed managers, can lead to higher order workplace efficiencies. The problem is that the overall situation sometimes does not align with the statement. The reason is there are lot of other workers in the companies who play significant roles in the technology adoption and diffusion processes. So, other participants are equally important to shape this adoption and change processes. This makes the process challenging due to uncertainty and contested organisational setting. However, if these challenges are resolved through the adoption of new technology actionable framework (Figure 4.3), the company will go on to enjoy socio-economic benefits for all stakeholders.

4.4 Management challenges at each stage of the actionable framework

To remain competitive in the market, drilling firms need to adopt new technologies to meet their customer needs. Staying competitive; it means continuing to evolve as an organisation, introducing changes to processes and technologies to achieve competitive advantages over competitors. Companies need to become adept at introducing new technologies and managing challenges that emerge during the implementation process. Change management must play its role in a constructive manner, because new technology implementation will change the way people work, they must be aware that change is for the better, both for themselves and the company.

4.4.1 Triggers for technology adoption

This is the initial part of the new technology adoption actionable framework "triggers for new technology adoption" (Figure 4.3) and includes experience, expertise and knowledge, strategy and planning.

4.4.1.1 Experience, expertise and knowledge

A company undertaking technological change must consider the various levels of organisational technical capabilities. For instance, technology service capabilities can vary from total self-sufficiency in each technology, to full dependence on other technologies (Bozeman *et al,* 2015). The cost, complexity and availability of resources of several technologies may prevent a company from being totally self-sufficient in developing services for all phases. Therefore, it is likely that there will be a company technological range covering self-sufficiency, capability, knowledge and partial dependence. Perhaps the most salient consideration in developing a policy directed at acquiring and establishing technical service capabilities would be the goal (Didonato et al*.,* 2015).

Other factors that influence policy making decisions are market relevance, the availability of capital or resources and unique social, religious or cultural issues. In making a decision to establish technology capability, it will not meet existing market standards unless it meets the specific standards of qualified staff, their educational level, expertise, knowledge, support technicians and their training, the quality of facilities, existing, as well as new ones with testing equipment, research and development, and utilisation (Bower and Christensen, 2007). It is important to note that the development of new technology services can be a futile exercise, if there is no utilisation or customers. Companies with limited resources may not be able to afford these technologies, unless proper cost analysis is done (Edosomwan, 1989).

There can be no simple answer as to where the resources of the company can be most effectively utilised. This can vary from situation to situation, company to company and from one technology to another. Service facilities promote learning from which long-term benefits can accrue. On the other hand, requirements may be more apparent, and successful development efforts can be more beneficial and productive. However, the political environment is equally crucial to technology policy (Betz, 1998). Political ideologies vary from commitment, to free enterprise, to some degree of control. In such scenarios, technology services can be developed with or without government control or support, such as the KSA regulatory authority. The other critical challenge is to view technology policies in the light of the uncertainity and unpredictability of public attitudes, which can have a telling effect on the political environment (Prahalad and Gary, 1990).

Customer opinion shifts can be politically influential in promoting or not, technological change projects. There has been a change in government policy concerning the development of water resources, due to falling groundwater levels, and the drop of oil revenues in the Arabian Peninsula. Unfortunately, sometimes politics proves to be a deterrent to cooperative and policy efforts in promoting technology services facilities at a

company level. Therefore, the company needs to carefully consider where, when and what type of technology should be acquired (Pisano, 2015). Reviewing technological forecasting is critical if the proper assessment is to be made based on expertise and knowledge. With a carefully planned strategy in place, a sound technology policy can raise economic independence through experience, expertise and knowledge.

4.4.1.2 Strategy and planning

A new technology adoption process needs planning and a set strategy. Without these criteria, it is difficult to achieve desired goals. It is also equally important to evaluate why a firm seeks a new technology, whether it has the capability and know-how to apply it to issues at hand and how well managers will comprehend the organisational implications of the new technology change. Evidence from the literature confirms that only a small number of companies have been successful in establishing precise strategies and planning goals for the successful adoption of new technology (Iansiti, 1998). Strategy and planning processes are considered fundamental re-conceptualisations of what the whole business is about and how it can turn into something dramatically different. In any industry, a company must take a position on different strategic issues, such as who is going to be the main customer and what services and products can be offered through the new technology in a cost-efficient way (Iansiti, 1998).

These are very difficult choices but before long, the market gets filled up and strategy and planning need to be in place to implement the new technology. In fact, strategy and planning becomes critical when a company identifies gaps in the market that are evolving through customer dissatisfaction. This can be helpful in the provision of better services and raising product quality. Moreover, these market gaps can also be perceived through global or local changes in the policies of the governments or through the company visionary policy. In this scenario, it will be difficult for companies to decide to do business in a different way when they are already successful; but visionary managers can disagree and prefer to take the different route rather than waiting until there is a crisis. Although this scenario looks utopian, there will be companies who will be ready to take the plunge before it is too late. Companies that are able and willing to make difficult decisions after having completed analysis of different starting scenarios are likely to escape existing assumptions and move ahead with new strategies and plans (Edosomwan, 1989).

Therefore, viable players who have adopted specific strategic and planning processes can find a way to proceed with the process, through different angles. There may not be a right or wrong way. However, every visionary company adopts a dominant way of perceiving. A visionary company can decide to abandon their ongoing strategy and planning process and develop a new strategy and planning process which has a better chance for success in a more innovative and sustainable way (Heath and Heath, 2010). The key challenge facing companies is uncertainty surrounding strategic and planning processes. In a given time, it can be difficult for a company to know that new change processes will be successful and what competencies are essential for the future. This means that being able to create a successful strategic plan depends on the management's ability to incorporate the essential competencies into their operational systems (Markham, 1998). Management

with competent skills can create this purposely, with the clear understanding at the expense of efficiency and sustainability, leaving it to the market to decide its success. If technology adoption and diffusion processes can be aligned with a company's planning and strategic goals, the technology transfer and diffusion can proceed quickly and efficiently (Ambit *et al,* 2003).

4.4.2 Becoming familiar with new technology

This is the "organisation of adoption" section as shown in Figure 4.2 and includes time and training. Time and training play crucial roles in the adoption of new technology frameworks and is described below.

4.4.2.1 Time and training

Time and training are considered more than a challenge among water exploration companies when acquiring new technologies. New technology strategies, regardless of the size of the company, often bring disruptive changes to employees, particularly for those companies that have ageing workforces. Employees feel pressure to acquire new knowledge as their jobs are entirely dependent on this acquisition (Burgleman et al., 2001). An organisational system is a value-adding transformation system, from resources into services. An organisational workforce plays critical roles in adopting new technologies and learning skills to make the new technology strategy successful. Betz argues even if you bring in the best technology, if the employees are not trained or knowledgeable, there is always a good reason that employees can resist the new changes despite having a sound training programme at hand (Betz, 1998).

This means that employees' personal growth is equally as important as their professional growth. Self-improvement, with attendant performance improvement, requires an expanded general awareness of developing knowledge, methods and tools as well as sharpened skills to meet professional obligations. With market changes on a global scale, knowledge, activity and performance which may have been satisfactory in the past are often painfully inadequate in the present situations (Collins, 2001). What might have been acceptable knowledge and performance five years ago would not suffice today. So, human obsolescence is not only real, but also expensive to the company and the individual concerned.

It is understandable that the transformation of work is not an unmixed blessing. It attracts and repels in different ways**.** It attracts because if offers an intellectual stimulation and the opportunity to grow professionally (Bansemir et al., 2012). It repels because of the uncertainty it brings for future assignments. Moreover, another challenge can be that if an individual is a harbinger of change, this it is not a valid reason for social pressure brought to bear on the individual, even if criticism appears logical at the time (Binns et al., 2015). Management is often obsessed with timing and requires immediate technological change. 'Too much too fast' can hardly be swallowed in a short time. Patience, a gradual introduction, and careful implementation can be helpful in improving the probability of acceptance of new technology. There may be times, of course, when a situation is so

confusing that it makes it virtually impossible for the manager to untangle it (Calantone et al., 2006).

My argument is that most technical issues can be resolved through group or team-oriented approaches, where interdisciplinary inputs and insights are required to fix the issue. This can be stimulating and productive, but if it represents a compromise or dilution of solution, it will not be effective for the staff nor the manager, unless the latter has a tremendous stature and the right skills to handle the staff (Marek et al., 2014). Other recognisable hurdles among staff can be ignorance, negative attitudes, and lack of activity, indecision and fear of ridicule. Many workers are susceptible. This means environments can arise where apprehension of criticism and concern over professional and social ostracism, can create disastrous effects in relation to smooth technological changes and operational processes.

4.4.3 Making technology work in a company context

This is part of the second stage of "organisation of adoption" shown in Figure 4.2, and includes confidence, performance and management skills. Given the rapid advances and incorporation of new technologies, the water sector holds valuable opportunities in addition to economic benefits. It may take time to adopt them through actionable frameworks, but once they are embedded in the organisational set up, they could raise organisational confidence, performance and management skills. This has been shown through this research at company A (Chapter 6). These organisational traits and improvement areas are elaborated in more detail in the following sections.

4.4.3.1 Confidence

For companies in the water sector, it is more than a challenge to choose the right technology to ensure a return on an investment. Not only are there numerous technologies to select but making the wrong decision can result in large problems down the line (Edosomwan, 1989). Moreover, new technologies are emerging more rapidly and becoming available, making them difficult to source and investigate. Furthermore, water exploration companies are always split in assessing the right technology in terms of cost, expertise, knowledge, timing and other related resources. Although, companies understand the value of new technologies, they often struggle due to a lack of confidence (Strang and Soule, 1989).

To avoid technology intimidation, water exploration companies must be confident in their assessment and adoption processes (Betz, 1998). Greenhalgh and others argued that the leadership of a company should only purchase a new technology, if they have full confidence in the processes they are purchasing (Greenhalgh *et al,* 2004). It is important to understand that technology cannot make up for aging processes. Therefore, water drilling companies should determine which new technology is the most suitable to meet their business needs and improve confidence (Iansiti, 1998).

It is equally important for decision makers to select not just the technology, but a business partner who is willing to help throughout the sale of the technology, by making proper partnership decisions and focusing on a technology that serves their best interests (Bansemir et al., 2015). The decision makers need to be confident during the assessment process, so that second-guessing is eliminated. Marshall stresses that confidence and efficiency, at viable costs, is at the core of the technology selection and adoption process (Marshall, 1990). Managers should develop services with confidence in alignment with the goals to achieve higher efficiency with more functionality at a competitive cost; and that can be reflected in the business results keeping the services, productivity, and quality at its highest. Before reaching a final decision to purchase the right technology, managers must be confident that the technology is suitable for their business operations and profitability going forward (Lichtenthaler and Lichtenthaler, 2010).

4.4.3.2 Performance

It has always been a challenge for management to overcome the hurdles of technology adoption and diffusion across a company. Planning is intimately connected and is a vital precedent in managing and controlling the process, it involves setting the organisational performance goals. The measurement of performance can be achieved through a monitoring process, e.g. conversations, formal meetings and reports (Burgleman et al., 2001). Based on conclusions or evaluations derived from the monitoring process, actions can be taken to stay on course. Three aspects need to be reviewed to monitor the technology inducement process; cost, schedules and performance.

Once technical staff is involved at the right time, monitoring, and evaluating the process of the workforce becomes part of planning to perform and progressing with precision. To maintain effective control, a communications system needs to be in place to resolve issues speedily and hastily (Betz, 1998). Such issues can centre on personnel, technical impasses, funding and a host of other difficulties. To maintain effective performances, the communication system must promote oral and written reporting. Communication between technical personnel and management can be either formal or informal (Gaubinger *et al,* 2015). However, management must be immediately told about the smallest of crises, before they become real challenges.

Oral communications can be through meetings, when called by management. Regularly scheduled meetings are always preferable because of scheduling issues (Doss, 2015). These meetings help technical personnel doing the presentations and inform the others who are attending. Comments and questions from the attendee can create a synergistic effect which can lead to new ideas and improvements. Weaknesses or omissions in the work can also be reflected due to the result of questioning. However, written reports from the technical personnel concerning progress of their work are equally desirable, because this forces them to polish their thinking so that it can be more precise, definitive, and can be critiqued by others. Moreover, such documents serve as a record for future reference (Collins, 2001). Attempts to really quantify the performance of technical personnel or teams are challenging, if not impossible endeavours, because every evaluation comprises a combination of subjective and objective factors which are solely

dependent upon the judgment and personal characteristics of the evaluator. Nevertheless, the evaluation process, however inexact, must still be performed in order to raise the probability that company and client satisfaction goals are achieved precisely (Binns et al., 2015). Evaluation of team performance can be achieved through making comparisons with other similar teams or with the set established criteria of performance developed by the company.

In some companies, there are often opportunities and requests for work to be executed by technology groups or teams. The quality of such work can act as an index of their activity and how valuable they are to the company. A team that is constantly being sought to perform tasks would be rated higher than one that receives fewer requests for assistance or troubleshooting (Iansiti, 1998). This is how a communications process ends up in developing leadership skills, ultimately leading to company performance.

4.4.3.3 Management skills

New technology and its adoption can be part of a larger technological management system. There is no doubt a successful technology transfer and diffusion project needs to be part of an efficient managerial system. Management with effective leadership skills are required to evolve the most feasible technological planning and strategy policies to create environments conducive to innovated technological changes (Inanity, 1998). This may require prioritisation of resources to facilitate the creation of new ideas, to acquire new technology and to develop marketing strategies in an effective manner. Edosomwan argued that organisational productivity depended on how the leadership believed in innovating changes (Edosomwan, 1989). Leaders who have managerial skills prove that they are not only visionary but also feel comfortable with technological change and leading it in an effective manner.

Technological change progresses smoothly among those companies where overlapping of territories occurs and technical personnel have a free hand to have contacts across functions (Twiss, 1980). Moreover, information and knowledge flow need to move without restriction. Top management can play a dynamic role in shaping organisational attitudes towards innovative technological changes. It is therefore a challenge for the leadership to manage its technology, its selection, transfer and adoption across the company (Abernathy, 1982). Unless the company has a dedicated skilled leadership, technological change projects can face derailment, hardships and challenges.

An efficient and well-equipped leadership is not only a prerequisite for a good management system, but it plays a dynamic role in making the technological change process a success by making good decisions in a timely manner. The success of a technology change project depends on the management's leadership skills, to make effective decisions in utilising organisational resources (Bans emir, 2015). This shows that how challenging the technology transfer, adoption and dissemination process is across the companies if an effective management system is not in place. An effective management system not only deals with clients in a proper manner, but it ensures their satisfaction, while enhancing business prospects (Lichtenthaler and Lichtenthaler, 2010).

In this sense, an argument can be made that efficient management systems can overcome challenges if the proper management system is in place. Therefore, without a collaborative management system, it is difficult to perceive how a company can achieve a 21st century organisational status (Greenhalgh et al., 2004). It is critical for a company to organise and set up effective management systems that manages the various phases of technological aspirations, processes, procedures and achievements in an effective way. The maximisation of technical efforts cannot occur in an environment where there is a management system vacuum (Stoneman, 2001). To achieve the full potential benefits of a new technology, an exclusive management system must overcome demanding, costly, unpredictable and frustrating circumstances.

4.4.4 Business outcomes

The new technology actionable framework adoption process generates two important business outcomes for a drilling company in the water sector. They are competitive advantage and customer satisfaction (Figure 4.2).

4.4.4.1 Competitive advantage

Technological expansion is critical to any company's well-being. Technology is the economic growth motivator. With organisational evolution in a technologically dynamic environment, the requirements for leadership have grown complex, so that no one individual can have the complete knowledge, skills, time or energy to sort out technological issues. There is an increased dependence on subordinates for more professionalism and specialisation (Galliers, 1992). Essentially, the decision process involves intense consideration of three inseparable areas. These three areas are, marketing of technological services, technical feasibility and managerial ability (Roman, 1980). The decision to invest is based on the viable market, its size and control. Successful technology adoption relies heavily on effectively meshing all three areas to achieve competitive advantages in the marketplace.

In marketing the new technology, the company needs to take the initiative in setting the price as per its acceptance and the market demands (Burgleman *et al,* 2001). Prices can fluctuate considerably depending upon the time of entry into the market and completion. Freedom of entry into a market has a significant influence on market behaviour. Entry restrictions run a progressive course, from slight barriers which are easy to overcome, to absolute prohibition preventing new companies from entering, even though the projects are a pretty good size and highly profitable (Frick, 2015). Where entry is restricted, it affects the organisational attitude and behaviour of the company, in terms of long running trends and adjustments. With the government, the company does not need marketing and distribution channels. However, with a public company, it needs to establish not only marketing and distribution channels, but also research and development facilities that contribute to a severe entry challenge (Hart, 1999).

Many water companies appear sound; however, they suffer from financial or managerial inadequacies. New technology services, having increased in quality and

automation, assist in saving more time and can be helpful in forecasting and restructuring existing consumer patterns and the formation of new ones. New quality services and processes can be a pivotal means to enter into these potential markets. Population growth equally offers another clue to future markets (Doss, 2006). The company doing business in the public sector must make careful market forecasts**,** keeping in view the market competition, technological developments and performance and service costs. Moreover, the company needs to foresee and add to technological developments, economic, sociological, political influences, and the opportunity costs to have the full picture in relation to return on investment, profit on sales, utilisation of facilities, and skills efficiency (Iansiti, 1998).

Moreover, a company must evaluate its present and future position in the market, depending on the competition. A high price, coupled with customer acceptance can increase revenues, but it depends on service demands, sales expectations and the company's strength in the market. Prahalad argued that new technology is an important component to enhance service capabilities, leading to an improved share in the market. New technology enhances innovation development, which helps the company to expand their services and grab a bigger share of the market (Prahalad, 1990). The success of a company relies on how well it adopts to new technology actionable frameworks, how it creates new quality services and sets marketing strategies to take advantage of the markets.

4.4.4.2 Customer satisfaction

In today's business environment, decision makers in the water companies must make the most of scarce water resources and face the challenge of ever-increasing demands from customers. These competing requirements generate a scrutiny of resources and costs for new technology inception. In water exploration and other areas, technology failures have raised serious concerns about how technology investments sometimes fail to meet anticipated goals (Iansiti, 1998). As a result, most new technology investment processes require vigorous analysis of costs and available resources, in relation to return on investment (Edosomwan, 1989). Unfortunately, water sector companies often lack processes that help them perform such analyses. There is not just one component to the process; instead, it is based on collective activities and methods such as skills, tools, activities and ideas.

These can be combined and utilised in many ways to understand or assess the investment value over time to achieve a decision (Bower and Christensen, 1995). Any new technology investment in the water sector is embedded in an organisation's technology infrastructure process, business environment and external relationships. Concerning infrastructure, there will be direct costs associated with the new technology and associated services, which need investment. Moreover, there will be a cost of the technology impact on existing technology systems (Kumar and Pan Sari, 2015). The benefits can vary from workflow performances to the provision of services to customers. Other costs and returns can be linked to the company's resource flow and workflows. The external environment may also be significant, because resources are committed from these environments to

support the new technology and how services will be rendered to clients later after adopting the technology will be an added cost (Erickson and Gratton, 2007).

Conducting the right type of analysis will remain a challenge. It requires substantial knowledge to evaluate costs relating not only relating to technology but to revenue generation, in accordance with the accounting practices. Cost and revenue generation may be projected over a multiyear timespan to reflect an acceptable timely pay-back (Edosomwan, 1989). In addition to direct and indirect costs, an opportunity cost could be considered as the loss of revenue if a different alternative has been chosen. Revenues can be expanded beyond cost savings, while raising performance levels in relation to company goals. This is usually established in the form of a return value for a given cost. Furthermore, the cost analyses that provide answers to economic benefits must reflect social benefits to the workforce (Collins, 2001). Recognising uncertainty and potential damage as half the battle, careful cost analyses, based on the best available estimates will benefit cost and resource analyses in adopting new technology actionable frameworks.

4.5 Reflections on the interview findings

This is my reflection on the research study findings, based on experiences from analysing workforce interviews. Ten themes have emerged from the interviewees' data analysis. On the basis of these ten themes, a technology adoption actionable framework process model was conceptualised (Figure 4.3.2). In every company, the adoption framework carries within it assumptions concerning technology management. This means that technology needs adoption compatibility, to a greater or lesser extent, that can coexist within the company's structure, expertise, knowledge, and culture. Due to variations in each company's financial stability, performance, confidence and strategy, technology adoption and stabilisation processes will vary, based on the usefulness of the technology and its acceptance in the market.

Some of the companies in this study are already undergoing instability and uncertainty due to their financial backgrounds, old drilling infrastructure and local economic changes. If they adopt new technologies as per this model, without improving their capital base, drilling infrastructure, trained manpower forces and technology company support, they could face disruption in one way or another, for years to come. The interpretation and articulation of this actionable framework gives the company and its employees a sense of identity, function and the know how to adjust with changes and market threats.

All managers were of the opinion that when a new technology entered a company, both the technology and the company become disrupted. New technology no doubt brings challenges in the shape of uncertainties, instabilities and unforeseen issues. While technology itself is reworked and rebuilt, the management must add value to it, to be successful. This comes from those managers who are responsible for this disruption process. They must maximise efforts to curtail uncertainty and create safe environments to move the company forward in the face of such disruption. Such positive efforts can rapidly reduce company-wide uncertainties. However, those wanting higher rates of return on their investment must invest in staff training, for more efficient outputs

This variation, the different ways these six companies are prepared to embed new technology in their ideal settings, brings to attention the degree of interpretative flexibility that is associated with the new technology and actionable adoption framework. Moreover, the managers view was that technology integration should not be regarded as a process involving simple and straightforward stabilisation procedures. This is because new technology adoption and integration systems do not necessarily start generating revenue immediately just by virtue of their adoption. Companies need to make these systems workable, at the local level through their clients. Only through local customers can the services systems gain market acceptance. This is how technology, once embedded efficiently in a company, gives value to the system through which the company itself gains value and uses it as an advantage over the competitors in the market.

The trained professionals and the workforce will find that their knowledge, skills and needs will keep changing due to the implementation process as it will be constructed and reconstructed on continuous basis for initial times. In developing value, these trained professionals must use alternatives, like competing systems for the same technology within their company. This means that new alignments and a cooperative and cohesive workforce can emerge within the company. Professional confidence, as well as the company space, varies as they have to a certain degree to maintain some distance from the senior management. The majority of interviewed managers argued that knowledge claims must be mediated to let the system function fully. Though, not all professionals will deploy knowledge resources at the same time. However, some trained workers will pick up the information faster and utilise the new technology in a more effective manner than others. So, the condition of possibility that shapes actions within a company does not need to be restricted to the actionable framework, but also be foreseen in the political and economic contexts at a local scale.

A company's success, which ascribes importance to the adoption of new technology, is a strong imperative for company management. This clearly makes sense for increasing demands on the management for change. On one hand, the management hopes to see a stable and standardised services regime, prevailing within their company. While on the other hand, they must acknowledge new technology systems, which their competitors or collaborators are adopting. During interviews, managers were constantly anticipating what new technological developments were required next by their companies. They were looking forward to how the company's management were adjusting to new changes, to achieving their strategic goals. However, the extent to which a company's management can gain a clients' satisfaction, depends on the dynamics of a company and its inner structural relationships.

This does not mean that localised practices are inimical to the successful implementation of new technology systems. This raises the question on how localised practices resist new technologies. Adoption managers argued that initial resistance by staff, will turn out to be a facilitation process, once concerns are diffused and the new technology system is stabilised. This shows how strong commercial and managerial drivers are behind these systems, they require high levels of standardisation to generate revenues on one hand, and efficiency on the other. Furthermore, managers wanted to explore the socio-technical

relationships between new technologies and companies that acquire them, to see how the technology is already embedded into the company fabric previously.

The managers' argument was that the new technology actionable framework could lose value if it failed to generate anticipated returns on investment. This could happen if untrained or a low-cost workforce was employed to run the process. This shows that values ascribed to new processes are more socio-cultural. It not only depends on an efficient workforce, but also on the broader process of acquisition, incorporation and diffusion, which determines the value of the new technology. Economic arguments are still likely to be used by the management to justify decisions for a technological change, or the acquisition of a new technology. Managers agreed that such decisions do not in themselves reflect how technology can add value over time in the company. Unless the management and the workforce play their respective roles, only then can value be added over time.

In moving on this research project, I presented my research findings and the actionable framework to the leadership of Company A. At this company, I made remarkable progress in convincing the leadership and the drilling management to adopt this new technology actionable framework process to integrate my new technology into their company. The discussion process is described in the next chapter; it covers discussions with the management and staff of Company A to achieve consensus on adopting new technology actionable framework.

Chapter 5: Making Use of the Technology Adoption Actionable Framework and Evaluating the New Technology Adopted by Company A

5.1 Introduction

This chapter focuses on discussions with the leadership and technical staff of company A and the external evaluation team as they made use of the actionable framework; and evaluation team's results on the technical performances of drillers and the new technology. It covers the newly developed technology change adoption model, its outcomes, and how it can be successfully implemented and evaluated in the light of my recommendations. The objective was to involve both the leadership and the technical staff in determining various implementation processes, and to motivate them to take full ownership towards making implementation a success. This included all details relating to the model, its outcomes, and how it could be implemented in the company.

For full effectiveness, two main stages, stage 1 and stage 2, were identified as core elements in the implementation process (Figure 5.1). The next steps were to create actionable strategies, within a practicable framework of recommendations on how to build capabilities within the company to use the new technology. Suggestions from in-depth discussions with the leadership and drilling staff, in conjunction with my 25 years of drilling experience, greatly assisted me in developing effective change proposals for action. The programme for change constituted a significant part of my participatory research, to inform management of technology adoption within the company. Some ideas and concerns raised by the leadership and drilling staff were helpful in shaping the change proposal. This was a salient aspect of the collective effort. Practical solutions were generated to resolve organisational issues, thus promoting self-confidence and morale.

An effective strategy and plan for action was developed following a critical review of responses to the research findings. The review suggested changes to improve company productivity and its leadership role in the market. At this point, just discussing the explanations was not enough, it was necessary to involve each respective role in the change process. These discussions remained focused on stage 1 and stage 2 of the model (Figure 5.1) and had several aims:

(i) To familiarise the drilling staff with the new technology through workshops in the workplace;
(ii) To train staff to build self-confidence;
(iii) To improve business performance, and
(iv) To enhance technical and management skills to make the implementation process a success

At the outset, it looked simple and straightforward, but it became a challenge. In a technical sense, it seemed that anything was possible, whatever they wanted to achieve was within reach. Successfully implementing technology in the company was therefore not a technological issue, but rather one of organising the adoption process. Moving toward

the change process after identifying the organisational issues and writing down the prescription for problem resolution were critical steps in the process. The leadership, senior company managers, and other support staff were crucial to interact with as they were influential people. They had vested interests in making the change process a success, not only for the company, but for themselves and their careers. Presenting my research analyses and a new adoption model; and hearing their opinions on the model and perspective on various technical issues, were key objectives during my time at the company. Access to empirical data proved to be meaningful and was useful for the leadership, the drilling managers, assistant drilling managers, and other supervisory staff, as this core information had not been accessible before. The main purpose of engaging these personnel in my research was to widen ownership of the adoption model, thereby building a capability within the company for managing the technology adoption process.

Research findings and the adoption model was discussed in detail with personnel. Their comments were sought before triggering the implementation process. The management team and the staff saw that the research and adoption model were both timely and critical, as prior to this, no one had carried out such a comprehensive review before. The management team were candid and open; during discussions it became obvious that their drilling staff were not competent enough, because they were over reliant on old technologies. This could have caused difficulties, but through cooperation with staff and the drilling staff, they resolved to fix these issues. In further discussions, technology weaknesses were present when they first purchased their existing technology; however, they overcame these hurdles through rapid training, as confirmed by data records.

Personnel were optimistic in resolving these adoption difficulties, through rapid training over a short time. They knew their weaknesses and were prepared to overcome them through proper staff training, acquisition of new knowledge and expertise and enhancing management skills. This was why the leadership, technical managers, and all staff agreed to my detailed proposal in proceeding with the new technology adoption model. I suggested that the adoption process be divided into two stages:

Stage -1: staff will be made familiar with the new technology through a comprehensive training workshop programme

Stage-2: The aim of this stage is to build confidence with the technology within the company (Figure 5.1). During this stage an internal evaluation team was created to observe, reflect, and feedback on training effectiveness and operational performance with the new technology.

The leadership, drilling managers, and supervisory staff were the most influential people. They played vital roles in achieving the desired results from the new technology. The leadership played the most influential role, from acceptance of the new technology, to its purchasing, implementation, and integration into the company. Their commitment provided all critical resources such as financial, managing internal conflicts and open communications. The drilling managers played vital technical managerial and coordination roles in the change process. The instructors and supervisors provided much-needed training services for staff.

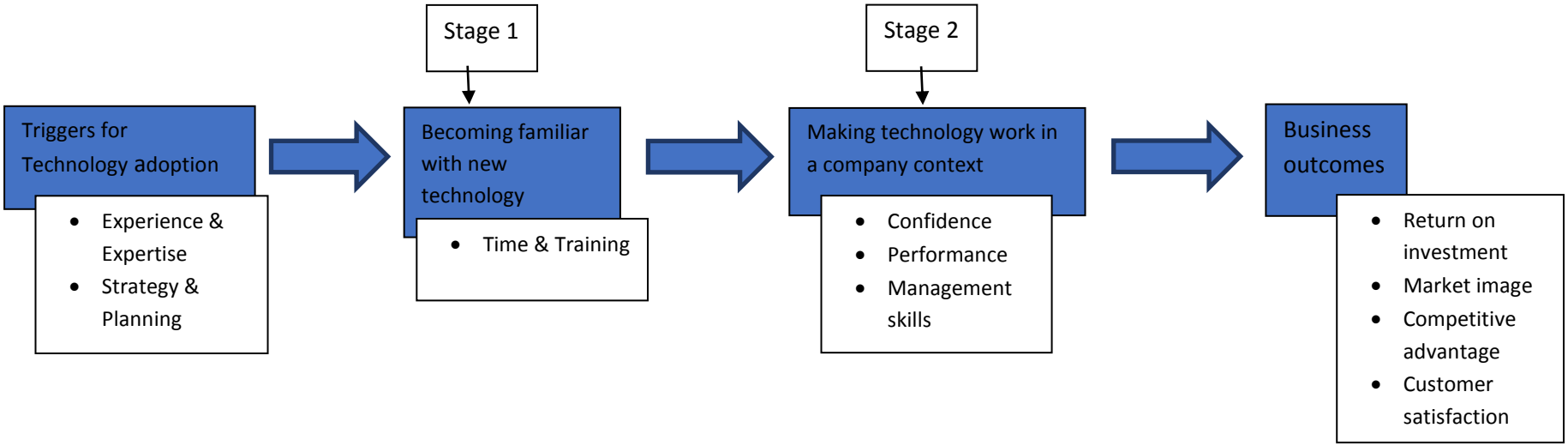

Figure 5.1: Stages of actionable framework applied during action inquiry with Company A

5.2 Stage 1: Familiarization with the new technology and co – production of training program

A full training course and complete familiarisation with the new technology was the prelude to becoming a professionally trained driller. This transitional period was crucial, as drillers acquired basic technical knowledge through dynamic interactions and engagements with supervisors, instructors and other drilling professionals.

5.2.1 Time and training

Everyone was convinced the value and benefits of training. They knew if it is done properly, it will make them more efficient leading to higher production, revenue, and profits while decreasing costs, waste, and inefficiencies. Moreover, effective training can lead to increased compliance with regulations and standards. It can even lead to a happier, engaged and more satisfied workforce, which in turn reduces extra turnover costs. Keeping all these benefits and other related factors in mind the training programme was designed. The related factors included: staff experience and skills set, complexity of technological procedures, the time required to learn these changes and the time allocated to this learning. The training programme covered staff needs and future training requirements. Training programmes were initiated after communicating with all staff. Overall training goals were defined, after engaging with the leadership and the technical teams on how that training should be delivered (Table 5.1, Appendix).

Looking at the adoption model (Figure 5.1), it showed the aggregate categories (blue) and the sequence of organisational events. The managerial leadership, after reviewing the comparative technical data, were surprised to see such a high performance and efficiency of the new technology, in comparison to the existing technology. However, the CEO was not too surprised at the efficiency of the new technology, as he had been previously informed of the technology from company literature. He pointed out skill gaps of current drillers; when tested on their operational knowledge and competencies, they did not perform well. He pointed out that supervisors were responsible to train, equip and support drillers so they could gain full knowledge and strengthen their skills in operational aspects of the new equipment. He also remarked that the mindset of some drillers that new technology operational knowledge was bit difficult to be equipped with within the set time frame which they made it obvious during conversations with them could be a serious concern, if they failed to equip themselves with this new operational knowledge, it could lead to failures in operating and mastering the new technology.

The drilling team reported after reviewing a full technology operational demonstration. They stated that supervisors were not sure about the expectations of drillers and the support staff concerning their management skills in relation to their shift subordinates. However, the leadership were not only sure, but they looked forward to improving worker management skills to integrate the new technology. The drilling manager

stressed that the new operational skills were key in strengthening the operational skills of the drillers and support staff. This would be achieved through training workshops and implementing strict operational protocols.

5.2.2 Learning and skill gaps

While conducting the initial training part of the familiarisation stage, during questions and answers sessions operational, behaviour, attitude and teaching skill gaps were observed amongst drillers and supervisors; however, instructors were not overly worried about these skill gaps. They commented these gaps would be resolved through training programmes. However, they emphasised that learning processes with each individual varied. Some learned at faster speeds, whereas others learned at slower rates. Nevertheless, after training, all workers would be equipped to satisfactory levels. However, instructors were not satisfied with the attitudes and behaviours of the drillers and support staff. It was perceived that working under stress was considered a significant factor in relation to skill gaps and was similarly an operational challenge in relation to safety.

The instructors made it clear to the leadership that the drillers be consulted on a regular basis, concerning their approach towards new technology integration including behaviour, attitude and workloads not only during training periods, but also after working hours, otherwise this issue could risk the training programme schedule. Additionally, it could allow the company to take up additional workloads or contracts with the same number of drilling staff. This could easily generate performance and efficiency issues, due to a shortage of trained drillers or support staff. Nevertheless, incentives, rearrangement of workloads and schedules might be helpful in managing these contractual workloads. This would provide better learning opportunities for the drillers to gain more expertise and knowledge during the learning and training process. The leadership and the drilling team agreed.

5.2.3 Drilling shifts and staffing levels

Staffing levels made it clear that the placement of one supervisor and one driller for each drilling shift team would be sufficient for training purposes. However, one supervisor for two drilling shifts would be enough at project sites. This could enhance drilling project efficiency to a higher level and achieve higher productivity in the shape of higher well casing cement bonding strength leading to longer resource life and making the client more satisfied. It was agreed that a balance needed to be established between work schedules and training sessions. To strengthen the operational and staffing effectiveness, the drilling manager suggested that there should be some sort of measure to evaluate input efforts, against output results. It means new drillers must meet a set drilling standard and time schedules for training while passing the training programme. Opinions varied on the requirements and the level of drillers, depended on whose suggestion or opinion was accepted (CEO, drilling manager, supervisor, or instructor). The management team, after full consultation with the drillers, agreed there should be clear set work schedules for drillers, as well as supervisors. The selection of the supervisor needed to be taken very seriously; he is the expert and carries responsibilities in maintaining quality, efficiency, and safety of personnel and equipment.

Additionally, supervisors develop work values, attitudes, and impart professional behaviour through their positions as role models.

5.2.4 Drilling works Standards- staff expertise levels

The leadership and the drilling management team agreed that drillers and supervisors should meet set drilling work standards. The drilling manager supported the premise that supervisors should have not less than 10 years solid experience in operational work, teaching skills and safety regulations at an organisational level. Drillers should have 7 years' experience in drilling rig operations in a reputable organisation doing groundwater exploration works. For shift support staff, it was necessary to have 2 years' experience or training on operational rigs, after receiving a technical educational diploma. Shift support was equally important in making projects successful in relation to new technology integration.

These new technology operational skills were considered key in improving confidence and performance among drillers and support staff. This was achieved through training and following strict operational protocols. The leadership approved all standards. It was noted that the company would make this a policy for all training programmes and also for hiring new drillers or promoting existing ones. All drillers had to go through training and testing to become professional drillers.

The leadership made it clear to all staff that it was imperative to stick to training programmes. They made sure that all resources were available to implement the new technology, maintaining proper drilling standards in the company. Because it was imperative to follow these standards when hiring new drillers and support staff with new emerging technological challenges, supervisors were obliged to train young and senior drillers; as they had not attained the operational skills for the new technology. On the other hand, new drillers and support staff had to take on new skills to meet the required standards. After training, it was vital to execute projects with expertise to achieve organisational strategic goals. Therefore, a full commitment was required, from the technical teams to the drillers. The technical team followed reflective practices to ensure all went well. If something did not function as normal, it was reported back to the supervisor or instructor. This practice effectively allowed the supervisor to guide the drillers in their learning and fill gaps in their knowledge.

5.3. Stage-2: Making the technology work in a company context

Having set out the rationale, content, and works standards for training in 5.2, this section reports the actions and reflections as this training was implemented and new technology was trailed in real Company A's operations. In parallel to the actual training activities, a team of internal evaluator was convened comprising me, instructors and drilling managers. The role of the team was to evaluate the drilling performance standards with the new technology. This evaluation exercise was an internal equivalent to the external industry evaluation that takes place at the next stage of the commercialization of the technology (and will be presented in Chapter 6). The internal evaluation proceeded in a series of short action-reflection cycles. Thus, following training then observations (by the internal evaluation team)

were made of drilling operations. The implications for the management of the new technology are set out in the following sub sections.

5.3.1 Improving the confidence of the drilling staff with the new technology

The “internal evaluation team” commented on skills building for the drilling staff. They observed that supervisors were not sure of their own management skills in relation to building the confidence of drilling staff, and thereby improving drilling performance. However, the “internal evaluation team” were not only sure, but they looked forward to improving the management skills of drillers and supervisors. The drilling manager stressed that new technology operational skills were key in strengthening the confidence of drillers and support staff. This would be achieved through setting training and strict operational protocols, under the supervision of the supervisors (Table 5.1). One particular discussion point concerned what would happen when hiring new drillers or promoting existing ones. Previously, drillers were hired or promoted with a couple of years of experience, even without having a technical diploma. However, with the inception of the new technology, the “internal evaluation team” argued that precise skills with proper technical educational backgrounds were absolute prerequisites to operate this technology.

In the ever-changing business environment and technology world, it was not considered feasible to follow old schools of thought when training personnel. Therefore, it became imperative to follow newer, and higher standards when hiring new drillers and support staff to cope with emerging challenges of adopting and integrating the new technology in the company. This would mean that new drillers and support staff would need to equip themselves with new skills to meet the required standards, to progress in terms of professionalism and value to the company.

5.3.2 Staff attitude and behaviour

The drilling manager who was the member of the “internal evaluation team” raised further concerns about the attitude and mindset of drillers, regarding workloads. He expressed his worries about a wider gap regarding drillers’ expectations for better rewards in relation to new technology and the previous older technology. He was of the opinion that drillers and support staff must accept greater responsibility in handling operational workloads and training courses, during the interim period. He argued that this was important if they wanted to move up in their careers. Similar observations were made by the assistant drilling manager concerning how drillers and support staff performed during the training exercises. He stated that if they did not behave in a responsible manner and approach the training process wholeheartedly, the new technology adoption process would suffer. The drillers and support staff needed to realise that they were expected to be more responsible being important member of the drilling staff, like lead drillers, rather than trainees.

The drilling manager stated that teaching personnel about the new technology would be an on-going challenge. New drillers and support staff would have to adjust and reconcile

themselves to company planning and strategy contexts. He suggested that the availability of adequate technical literature and support on the new technology would be helpful in reducing the training period and achieving better outputs. The "internal evaluation team" acknowledged that training and imparting skills to the drillers and support staff would be most critical in achieving efficient technological integration. They observed that in the past, supervisors had been tough on drillers and support staff because they took longer to grasp simple tasks.

The drilling manager believed that the supervisors were good training facilitators, and could ensure that, drillers and support staff did not have to be anxious in pursuing knowledge and new skills. The assistant drilling manager suggested that the drillers and support staff would feel more valued for having the status of professional drillers, rather than untrained undergraduates.

Regarding learning styles and opinions on inherent weaknesses of drillers and support staff, the drilling manager stated that these personnel needed to adjust to the training, regardless of their own preferred way of learning. There were no set procedures, except adjustments for timing schedules to match with driller learning styles. The drillers must adjust to the learning programme to maximise learning benefits.

The "internal evaluation team" believed that the efficiency and performance of the new technology, in relation to return on investment, was heavily reliant on the drillers. Drillers had to stay focused: equipping themselves with new technology skills was a serious matter, as the success of the new technology integration and performance depended on them. They had to follow operational standards to satisfy client expectations. All members of the management team agreed that supervisors should engage very closely with the drillers, while teaching them new skills. This was to avoid uneasiness when difficulties arose when imparting skills or knowledge. Management recommended running a workshop for supervisors to set ground rules. This would require approval from the leadership, so as not to disturb training schedules. Equally, a session with the drillers would facilitate coping with operational difficulties.

5.3.3 Scheduling pressures and implications for promotion of drillers

In relation to supervisor availability and training programme scheduling, the drilling manager explained it was not an issue, that it would not be disruptive. My consultancy company, the new technology supplier, confirmed the availability of enough supervisors to provide training for drilling or assistant drilling managers. However, it was stressed that training must not exceed the schedule, so that water resource development project plans would not be disturbed. Regarding the timeframe, the management team decided, in view of difficulties emerging during the training programme, that it would be wise to create extra training schedules during the night, to cover time shortages. The drilling manager commented that as long as the drillers and supervisors remained engaged in their required hours, the effectiveness of the supervision should be considered achieved. He added that time for training was provided, but how well it was being utilised remained critical. There was some confusion and misunderstandings over the timing and utilisation. I suggested that time consumption and training outcomes required clarification. There was no doubt that

supervisors were utmost professionals, but the drillers must not be treated as just raw hands, because they were being paid during training.

The drilling manager further added he would like to run a session with the supervisors, regarding training guidelines and technological operational issues. He highlighted that it would be the key training programme for a selected group of drillers who had shown willingness to embark on the training programme to become trained supervisors. While responding to a question whether there was a better ratio of supervisors to drillers, the management team was of the view that with the passage of time, the supervisor to driller ratio would change. This would be due to availability of more experienced and trained drillers from whom the lead drillers could easily be selected to take up the available supervisory positions after going through a strict evaluation process. The drilling manager emphasised that once the "industry-mandated" evaluation process was set in place; driller technical knowledge and expertise would be improved.

I enquired whether there was a possibility that support staff could become trainee drillers. If someone was interested in being a trainee driller, could they apply and ultimately become a professional driller? The question arose because some support staff had expressed a desire to go through the training programme. The drilling manager responded that there were strict criteria for the selection of a driller. If someone met the criteria and showed a willingness to change their career pathway, they would be assisted in becoming a professional driller. The management team agreed to review the selection criteria for drillers, to accommodate the selection of support staff after assessing competencies in this group.

The management team was satisfied with the contents of the training program for drillers and support staff. They visualized that the training program would be a key milestone in developing better relationships among supervisors, drillers and support-staff.

5.4 Critical Review of discussions, planned action and justification

Discussions with the "internal evaluation team" provided an opportunity to investigate the whole process from a different angle. Their comments, responses and explanations gave me a clear idea of their sense of the research data and findings. Their comments also reflected their own assumptions, past experiences and operational needs, mixed with personal sentiments. I realised the relevance of their experience and sentiment and how it would be possible to progress to the stage of the external evaluation mandated by the Ministry of water being the water resources Chief regulatory authority here in the Kingdom. In general, the comments and responses to my recommendations were positive; either management was making efforts to implement change processes, or they were taking decisions to implement these changes at their earliest. My reflections on this discussion are elaborated below.

5.4.1 Restructuring the drillers' training programme

My proposal mentioned four months' compulsory training for trained drillers under full supervision, or until these drillers were capable of handling drilling shifts independently. The leadership believed that any trained driller who was competent enough would be allowed

to run the drilling shift independently. There were no regulatory requirements for the four-month training protocol. Leadership suggested that the training duration be limited to those trained drillers who were weak in grasping new knowledge and knowhow. My argument was that training was necessary for all, because new technology equipment was expensive and there were other serious safety issues, which were equally important to avoid any human accidental mistake.

Previously, practices were in place to promote any trained driller (even with a lower educational background) to run the drilling shift independently. However, it was key to remind personnel that equipment and crew safety was of paramount importance to the company and employees, e.g. to attain a drilling standard, required a minimum of four months' training. A driller was held responsible for all operational issues, including equipment safety, project work and the personnel under their care. Ultimately, these matters were agreed. The leadership affirmed that the learning process refresher workshops would be initiated from October 2017 to the end of January 2018. The first evaluations of drilling staff would be concluded accordingly; so that qualified drillers, with new technology skills, could be placed on projects. The feedback was very satisfactory; both the refresher and operational workshops have proven to be both timely and of immense value.

The drilling department had produced a "drilling guidelines" document for drillers and supervisors. After reviewing these guidelines, they were more focused on the operational aspects of drilling works. My recommendations were more specific and concerned "new technology adoption", covering all aspects of training, learning, performance, and management skills. Inclusion of these concepts would add enormous value to this document. Drilling operations are best taught and learned using strict supervisory protocols. In responding to the development of a training protocol in a format that maintains the development growth records of all the drillers, the leadership believed they were conducting a formal and informal assessment of drillers on a regular basis.

The drilling manager confirmed that submissions were carried out on a biannual basis. Feedback reports on learning and development were then submitted to the leadership. Although all submissions and paperwork were in order, the true intention, to make sure the operational competency development and management skills is improving at various levels of practice, needs to be reinforced. It was important that drillers gain expertise, knowledge, and professional confidence in managing drilling projects of various complexities. This should be in parallel with a training programme, incorporating a feedback process, through proper channels. However, the leadership was now planning to gather data through supervisor, driller, and face-to-face annual interviews.

The drilling department fully supported the proposal that drillers be given extra paid time to cover educational activities, while simultaneously handling their project workloads. The leadership approved this plan and its implementation. Promoting a healthy workplace environment in relation to personnel was a significant step forward. The management team agreed to make this critical improvement with immediate effect. It was anticipated that these steps would lead to better working communications between drilling staff members and the leadership, regarding informal meetings and organised feedback sessions. In terms of newly

hired or entry-level drillers, the leadership fully accepted the recommendations to improve training at entry level, ahead of the demanding learning pathway in becoming fully trained practising drillers. They agreed to create a "training for the entry drillers" internship programme as part of the company training and growth development protocols. This approach would give entry drillers the best start in building their career.

5.4.2 Training for supervisors

The leadership stated that newly promoted supervisors would go through an orientation or refresher workshop to equip them with technical and management skills. Workshops would include how to teach, train, and lead personnel. These administrative requirements were compulsory for supervisors. They would not only be better equipped to handle projects, but they would manage their staff better. These workshops needed to take care of administrative issues, compiling daily, weekly and monthly reports and submitting them to management teams. In the present circumstances, where no structured training programme for supervisors was in place, they were expecting supervisors to learn independently. However, as a leader in my field, I suggested that staff needed to be equipped with the essential tools to optimally manage their projects. Even instructors with great passion and the best intentions required the necessary tools and skills to train or educate others.

My plan, discussed with instructors and leadership, gave shape to a set of educational and training programmes for supervisors. The programme for "training the trainees" included key content and covered all operational and management issues. Training guidelines were previously developed by the drilling department. Supervisors were not informed on how a drilling supervisor could be equipped for supervisory roles in managing drilling projects. I encouraged instructors to review the existing guidelines for supervisors and add specific guidelines for them. Once finalised, the guidelines on how to become a "drilling supervisor" were disseminated amongst all supervisors. The leadership accepted the proposals to distribute these guidelines.

These guidelines included what drilling supervision were all about, their roles and responsibilities and the ethical, professional principles and obligations required to maintain the characteristics and attitudes of a lead drilling supervisor. Some important characteristics included non-judgmental feedback, encouraging questions and being calm. The implementation timeframe was expected to be initiated after four months of training and start-up. Once the first batch of trained drillers and supervisors were out, they would be ready for drilling projects.

5.4.3 Building staff capacity and capability

The leadership and drilling management team believed that the drilling department would have enough supervisors once the first batch of trained drillers was completed in five months' time. Some of the trained drillers, with exceptional grades, were expected to take the role of drilling supervisors. However, my viewpoint was that with increasing workloads, the requirements for drillers would increase with the addition of new rigs. In such a scenario, more supervisors would be required. With this likelihood, I wanted to convince the leadership

to increase the number of trained supervisors so that company capacity, capability, and readiness to handle additional workloads would not be compromised.

Additional supervisors could be hired to maintain backup strengths to meet shortfalls in supervisors. This contingency would meet any unforeseen workload emerging from the public sector. The instructors were of the view that they had the right selection criteria for the supervisors, but on the ground, the reality was very different. Their selection criteria were: five years' minimum work experience as a trained driller in a drilling operational works; competent to lead and train drillers; able to demonstrate and teach drilling operations and associated technologies in a competent manner. The selection criteria for supervisors in relation to drilling operations, expertise and knowledge should be at minimum seven years' experience, without any exception, to maintain project works' quality and efficiency at a maximum level.

6. External evaluations of technology performance

This section covers the main discussions with leadership, drilling management and the external evaluation team as they made use of the evaluation team's results on the technical performances of drillers and the new technology. The role of the external evaluation team was to operate specific tools in the well and to collect data in the form of continuous data sheets. These data sheets provided evaluation results concerning the operational success of the technology and the drilling staff's performance. They also confirmed the performance status of the new technology and the drilling staff.

My role as a researcher and consultant was to critically analyze these technical results and assess the management of the new technology adoption process. Reflections on the implementation of the technology process, the training of drilling staff and the technology results are provided. Efficient utilization of new technology, after passing challenging training and implementation phases, was a critical achievement in receiving an investment from Company A. Despite completion of the training programs and the technical success of the drilling equipment, several organizational challenges remained. Most problems were evident at the beginning of the implementation process and integration into the company environment. However, my main research focus was to reflect on management of the implementation process and determine whether strategy targets and objectives were met. I assessed whether all original planned benefits and goals were achieved. During the technology adoption process at Company A, various problems relating to technology training were also discussed.

Local competition in groundwater exploration puts increasing demands on groundwater exploration companies. They must take every opportunity to sustain or even improve their positions in these competitive markets. Groundwater companies strive to cut costs of drilling operations. They aim to improve the quality of their services through new technology adoption, to overcome competition and win more clients. These are critical factors that help achieve these strategic business goals. The new technology provides sophisticated technical roles ranging from drilling of bore holes, installing a variety of casings and cementation of casings to gravel packing operations of screens. However, it was understandable that new technology deployment would not guarantee lower operating costs

and higher quality services, without a highly trained work force. Vigorous training of drilling staff was therefore undertaken to improve work quality and lower operational costs. Without this approach, it was impossible to generate profits.

Company leadership and drilling managers were aware of the importance of the new technology and its competitiveness within the market. During discussions and observations, the leadership and drilling managers were committed to making the new technology adoption process a success, despite constant economic, operational and training pressures. They stressed that it was a tough long-term investment decision, and it would take time to reap benefits. Having gone through extensive and intense staff training processes, I agreed with their perceptions.

This evaluation determined whether these initial expectations, goals and benefits were met. Early challenges arising during the process were resolved swiftly and efficiently, so as not to upset schedules.

6.1 External evaluation of engineering standards

The American Water Works Association (AWWA) and American Petroleum Institute (API) set procedures that evaluate operational and technical performances of new drilling technologies. Evaluations are generally performed by approved external specialized parties. They perform tests and run well bore logs that are internationally accepted by the water industry. Similarly, for this company, evaluations were performed on specific well logs, and the data drawn from internal and external parties, evaluation testing results. Standard technical procedures state that once a well bore is drilled, as per Ministry of Water specifications (the legal regulatory authority that monitors ground water resources in the Kingdom of Saudi Arabia), the bore hole is logged for casing installations. Upon completion, cementation operations are executed by drillers, allowing 72 hours for cement curing. The cement bond log is held by the external evaluation party, under supervision of the Ministry's supervisor, to witness logging operations. Once operations are completed, the log results are printed on continuous log paper, reviewed and evaluated as per API standards and approved by the Ministry of Water here in the Kingdom of Saudi Arabia. The minimum acceptable value for cement bonds for water well casings is 50%. Lower than 50% is not acceptable or considered low quality, whereas over 50% is considered good. Over 60% is considered excellent quality. Similarly, well production results were computed from data, from the well sheets and well testing reports.

The first three wells were drilled successfully using the new technology. Cementation operations were also completed by company drillers. Data collection was performed by the external logging party. Cement bond logs were evaluated as per API standards and details were presented in tabulated form (Appendix 2). The results confirmed that cementation operations were well organized and conducted by trained drillers, and that all jobs exceeded previous standards, set by the Ministry of Water. It was no big surprise for drilling managers to find out that well logging standards were so widespread, since these standards are used in the petroleum industry too.

To benefit from this evaluation technique, many water exploration companies function to maintain water well's cementation quality and customer satisfaction. The important issue for me was the correct selection of standards and logs to assess the success of a job, and efficiency of the new technology. Most water exploration companies employ these techniques, logging evaluations and testing standards to collect viable data on well operations. In Saudi Arabia, these standards are required by the Ministry of Water. They are also employed by the oil fields. Similarly, these API standards collected valid data from well logs and tests for evaluation. The data collected reflected the technical efficiency and staff performance in operating the new technology.

These standards provide a set of qualification indicators that are measurable in relation to productivity cost savings, well life and customer satisfaction. Knowledge of techniques and interpretation of log data allows the calculation of benefits. In this research, I utilized established industry evaluation techniques to calculate these benefits. However, benefits were achieved after deployment of the new technology. This was the biggest achievement for the company, for its leadership and drilling staff. These benefits were based on data collected at post implementation evaluation stages. Four core benefits were provided by Company A and included; return on investment, market image, competitive advantage and customer satisfaction. It was clear, the 'returns on investment' benefit, had not been fully realized, but it will be in the future. The second benefit, 'market image' is expected to improve over time.

The third benefit, competitiveness, improved continuously since commissioning of the first well. The fourth benefit, customer satisfaction, drastically increased from 38% to 78%. This 40% increase strengthened the customer base and improved sales. Based on these assessments, the leadership's predictions will be fully realized in the future. Nevertheless, deployment of the new technology was the right thing to do. This research indicates that post implementation assessment of new technology, could serve as a valuable source of experience for further smarter investments into new technologies.

6.2 Training evaluation

Training is an important part of any new technology adoption processes. Staff training is necessary to fulfill technology requirements, as set down in the training schedules. The objectives were that drilling staff equipped themselves with all new technology operational skills, so that external evaluation teams could evaluate their drilling work. They were to confirm that completed drilling work met Ministry of Water standards. After completion, the external evaluation team was called in to evaluate the work.

The evaluation team ran special tools into the bore well to collect data, in the form of printed sheets. Data sheets were interpreted and positive and encouraging evaluations were presented (Appendix 2). Evaluations confirmed that the drilling work had surpassed the standards set by the Ministry of Water. Drilling staff training was a success, from a company and drilling staff perspective. This research supports this view. The extent and quality of technology training not only positively affected drilling staff, but it affected their attitudes and beliefs towards training. In the beginning, drilling staff attitudes were of great concern, as the

leadership worried how well drilling staff would absorb the new technology and adapt to changing processes.

A proper assessment plan was created to understand how drilling staff would effectively use the new technology. Training sessions were organized and scheduled for drilling staff. The internal evaluation team looked after the training and later it was evaluated by the external evaluation team. These teams confirmed the required certifications for project work. Results showed that drilling staff equipped themselves to meet external evaluation team standards, concerning training and technology performance. This inspired greater productivity as drilling staff quickly became familiar with the new technology and rapidly modified their routines to adapt to the new technology. An important leverage used by the company was using existing rig infrastructure, in combination with the new technology. This saved on costs and time, thereby helping the company to speed up training schedules and achieve business goals.

The other positive aspect of new technology was the early introduction of new technology to all drilling staff members that maintained the credibility of the leadership within the company. Additionally, from the beginning, and over the course of the implementation process and training, communications with drilling staff about the new technology remained active. Open communications between drilling staff and the leadership boosted the success of the training programs and the introduction of the technology. Staff quickly understood the usefulness of the new technology.

It was noted that some drillers quickly grasped the new technology. They in turn shared their technical knowledge with novice drillers, thereby creating a positive team environment. This resulted in speedy training and a greater acceptance of the new technology. Some of the drilling staff championed the new technology, allowing others to accept and respect it. This meant a well-trained staff would encourage management to take on additional workloads that would have not been possible previously in a routine or delayed schedule which could add an extra return on investment.

I believe this training evaluation was critical in improving the confidence of the drilling staff, the quality of the drilling work and the redesigning of training schedules. Additionally, evaluations were important in facilitating learning retention amongst drilling staff, making them more proficient at their job.

6.3 Management challenges

The data generated in the technical evaluation (section 6.1), suggested the adoption of the new technology had great potential for business development. To realize this potential, it was necessary to integrate the technology into daily operational routines. This was the next stage in the technology adoption process, and it brought multiple challenges, including managing employee acceptance, their trust and coping with training and learning difficulties. My argument to the leadership was that learning from this research should be extended throughout the company. The leadership agreed and continued to follow these outcomes, thereby assisting and integrating the technology into the company.

The data collected by the external evaluation team confirmed that sufficient training was being provided by technology supervisors. Drilling staff were equipping themselves well with new technology skills and knowledge. A range of skills were required to exploit market opportunities because the drilling staff's skills were crucial in improving the effectiveness of the technology production processes and allowing utilizing the technology improvements as an edge in the competition. In achieving this objective, swift decisions were taken, and training schedules announced. Drilling staff were informed at monthly staff meetings, with time set aside for questions.

As training in the new technology was extended to all drilling staff, the same concerns were voiced as with the first cohorts to be trained, but most staff accepted it as a way forward. Initially, there were problems understanding the new technology and functionality of the tools, reinforcing staff fears. However, these fears subsided with training and familiarity. Technology use was slow in the beginning as some drilling staff was hesitant in learning the new technology. But as time passed, they acquired the necessary skills. Frequent meetings with the drilling manager and supervisors also helped. Additional training sessions were created for those who were slow to take on the new technology. After sorting out these issues, management issues subsided. It quickly became clear there was only one way forward, and that was to learn aggressively to maximize the benefits in learning the new technology.

Once fears and justifications for change were resolved, the staff started to build confidence and increase efficiency with the new technology. The drilling manager agreed to extra training time for those who required it. Drilling staff, who had training delays and were stressed, were given additional time to ask questions and talk about the new technology challenges. All questions were listened to and heard; it was important to allow the drilling staff to express how they felt. Once their training hit the desired standards, they became more efficient with the new technology.

Drilling staff were continuously encouraged to reach out for additional training, as and when it was needed. The utilization of tools and technology went to 100%. However, some confusion and questions about how to use the technology to the best of its efficiency were still present with some of the staff members. Training was found to be adequate and readily available, but precision would take time. Research confirmed that effective training goals were met, as per training schedules. Management was happy with their decision to invest in new technology, even though it was a real challenge to overcome all adoption challenges. Management's open communication policy worked effectively to prepare the drilling staff for what was to come and how to implement the new technology. If there had been a more open communication policy, some of the resistance could have been avoided. This may have resulted in smoother technology integration, a better trained staff and increased workloads.

Managerial capabilities played central roles in adopting the new technology. Managers kept the adoption process on course and ensured it was implemented effectively. Management allowed talented drillers to hold more senior positions, to improve technology operational capabilities and project efficiencies. A wide range of skills were required, including decision making, ability to adjust to changing environments, supervisory skills, communication skills and organizational skills. Managers were also involved in the training of new technology

and associated management practices. This provided a serious incentive system which enhanced drillers' contributions to the company's performance.

Incentives included teamwork, additional training arrangements, job assignments, pay incentives and employment security pledges. Open communications revealed drillers' concerns and provided added benefits to making the technology process a success. The company's knowledge resource management also appeared to make positive contributions to the technology adoption and integration. My argument suggested the technology itself aided its implementation, because it matched the existing drilling equipment infrastructure. However, operational skills were the most difficult to learn and they took up most of the implementation processing times. Management played a key role in the development of the technology knowledge base. They structured the new knowledge to bring it within operating routines, to dynamically and rapidly embrace technological changes. As noted previously, the visionary leadership and the effective drilling management team proved to be significant factors in smoothing the path of technology implementation.

The range of technical skills and abilities required by the drilling workforce were achieved through vigorous training schedules. However, cognitive capacities and behavioral traits, including motivation, trustworthiness and leadership qualities appeared to influence the adoption process. Problem solving skills, adaptability and interpersonal skills were significant as these traits played salient roles in technology learning and successful adoption of the change process.

6.4 Interactions and reflections on the change process and the evaluations

The interaction with the leadership proved to be a great opportunity to reach positive understandings on both organisational issues (based on empirical research data) and the researchers' views. This stage in the research reflects the perceived urgent need for change within the company and, for the leadership, the question of who has been in control to effect change has remained crucial.

All recommendations were accepted and were taken to the implementation process within the agreed timeframes. I re-engaged with the leadership at the end of the training period. Exposure to different stages of training, at various set-ups during a four-month period, was vital to equip the drillers with a professional attitude upon entering the workforce. Additionally, capacity and capability development were crucial in meeting future drilling, educational and supervision requirements, while maintaining higher quality standards to meet client needs.

The discussion and engagement with the leadership and management team proved vitally important for me as a change leader. Winning the overall agreement of the company leadership and other staff was a great achievement. Identification of issues during discussions and meetings with the leadership and other drilling staff was essential in finalising core recommendations for improving training protocols. Most recommendations were accepted and implemented with immediate effect. The leadership maintained full authority in advancing these change processes. They advanced these at a swift pace, but they stuck with

the agreed implementation process plans and timeframes, to achieve strategic business goals for the company.

This is a small part of the overall picture derived within the framework of my research and logging data. To narrow my research focus into relevant issues, my argument is that taking the core benefits at their face value provided by company A, it showed that in spite of some economic and management issues Company A's overall benefits have exceeded its expectation results to a great extent. However, from the point of view of drilling companies, it does not mean I should not be satisfied with the technical performances presented here. The casing cement bond strength exceeded 20% on average, when compared to previous benchmarks, but they could have been higher. Productivity values, taken from production well testing data confirmed an overall increase of 30% in new wells. The data showed improvements in company performance, estimated as four core benefits (Section 6.2), needs to be improved over time in a consistent manner without underestimating it.

It was very interesting to note that the attitude of the Regulatory Authority towards new technology has changed appreciably. They saw the technical performance of the new technology and were completely satisfied with its results. They have adopted it as technology policy and inserted it into the new water resources speciation program. Therefore, I look forward to seeing how other drilling companies' use the new technology in their business. It should be helpful in answering the question above. It will also strengthen my ability as a researcher and allow me to examine the capability of any drilling company in the face of economic downturns. It will help me understand the role of new technology and how it could change the whole scenario. Moreover, I shall be able to determine whether a drilling company was successful with new technology adoption. On the other hand, it would be interesting to know whether a company utilizing new technology has significant advantages during a period of cost recovery, what are the rates of recovery and whether new technology adoption is actually fast enough to recover the previous losses suffered during the pre-technology period.

Working with company A suggests that similar benefits may be realized by other water exploration companies, struggling with obsolete or aging technologies. In company A, huge support was given by the leadership and the drilling management in implementing the technology adoption processes. They had good knowledge of procedures and relevant project appraisal techniques on how evaluations were done in the groundwater industry. I observed increased engagement and understanding of technology adoption by the leadership and drilling managers. They engaged with the DBA research and external evaluation processes and together drew lessons on technology adoption. They knew evaluation processes would not only make the new technology project a success, but it would improve prospects.

Based on these research results, it is imperative to change the way new technology is adopted. I believe the water regulatory authority can play significant roles in this process. They must enhance new technology adoption processes in the water industry and disseminate novel training and assessment methods, among water drilling companies. Furthermore, in making drilling companies aware of the benefits of new technologies, this can lead to more technology adoption projects. This approach could be significant for water security issues in the future.

Chapter 6: Research Implications

6.1 Introduction

This chapter builds on the research findings to propose implications for other firms implementing new technology. The implications may be speculative as some findings may have applications or implications beyond the set research parameters. In this chapter, I used literature, my research experiences and judgments to argue for implications for management at three levels: i) other drilling companies, ii) my own technology company and finally iii) my own practice as a scholar-practitioner. This research may generate a real difference in water sector drilling in relation to water scarcity and the economy. Moreover, it may contribute to academic advances in technology adoption methods, theory and applications. The knowledge generated by this research should benefit and influence drilling companies, consulting companies, government agencies and society.

6.2 Implications for drilling companies

Across the globe, new technologies are transforming the economic outlook of many companies and generating changes at an unprecedented and unpredictable pace. In the specific context of this study, the findings suggest the potential for this new technology is enormous. Put simply, this potential amounts to better quality services at lower costs. The adoption of this new technology can deliver benefits, if it is integrated properly in a timely fashion, as shown with Company A. My hope is this research will stimulate chief executives and managers of other companies to review how this technology could impact their own businesses. Executives, managers and even drilling staff can no longer be satisfied with old technologies, when they know that new technologies can outperform their existing technology.

There is no doubt that new technology adoption is not a simple process. It carries challenges that must be overcome before reaping really financial and economic benefits. Technology induced change has already become an integral part of societal restructuring in major parts of the world. In considering the history of the water sector in the KSA as a reliable indicator of future change, technological change processes will continue at a higher pace due to competition, client requirements and pressures from regulatory authorities, under the national plan. However, the adoption of new technology may influence a company's plans, as decision making processes and developing capabilities requires time and forward planning. The failure of companies not to realise the benefits of new technological changes can lead to poor comparative performances. Taking a progressive technical initiative may not only give a company an immediate upper hand, but also raise its marketable image to profitable levels. The leadership must be vigilant and flexible in making strategic plans to adopt the new technology. Indeed, this research shows that external consultants and their expertise are important factors in the adoption of new technology. A drilling company's leadership must consider the fact that external support is critical when they do not have the expertise to implement the new technology.

This research also confirmed that the factors which determine the effectiveness and success of a new technology change model, do not lie solely in the technology itself, but also depend on the implementation process (Frick, 2015). The acquisition and implementation of new technology within companies is complex. The leadership's notions of technical requirements are designing these into operational models; and then rolling out the system making. Yet my argument does have lessons for the leadership of drilling companies who handle technological change processes.

Firstly, it is important to consider the technological change introduction as a process. It inevitably requires drilling staff participation and some reshaping of the organisation. The roll-out begins as a technical change process; however, it can become more of a new technology acquisition exercise. In contrast, company A embraced the new technology framework and its implementation processes. A risk associated with company enrolment in such an exercise, is that the perceived benefits can be regarded by management as nebulous or yet to be developed. For example, at company B, managers felt much of the disenchantment among the drillers was due to the system being offered for sale prior to taking them into confidence. At company C and D, no serious explanations were provided to drilling staff regarding technological benefits. Therefore, change processes if implemented, must be discussed by management or the leadership with the workforce. Therefore, technology companies must explore structures, cultures and the organisational set up to determine the best way an acquisition and implementation process can satisfy drilling staff interests.

Secondly, the two notions of system adoptability and utility must be clarified and explained to the drilling staff, to enhance their confidence, ease of use and understanding of the new technology. This process will provide attractive guidelines on how different users approach new technologies. Enrolling the buyer or user is not, therefore, a once and for all process technology model that can be implemented straight into any company; the process requires constant engagement with a variety of different user needs, which may express themselves differently at the acquisition and implementation stages. Although technology usability and utility values are pre-given, they need to be developed and tested in local settings.

Consequently, I never regard drilling systems as finished, but successful model systems can enable users to develop usable relationships and provide beneficial services. In a more positive sense, using the adoption model at Company A suggests that new technology operational relationships and benefits can be aligned. My research analysis suggests (Chapter 5, Section 5.3) that matters may become difficult or complex within companies, because of organisational requirements as they reform and reconstruct as part of ongoing technological change processes. This means that drilling managers must mix up the drilling workforce to have different skill levels within teams. Doing this would bring more cohesion to the drilling workforce. This could add social value to the company's culture and lead to higher performance efficiencies.

Thirdly, as explained in my case study, new technology adoption frameworks must remain flexible during the implementation process, however this may generate tension which

managers have to resolve. This tension can be more pronounced in drilling companies where standards are at odds with local practices. In such a scenario, my research suggests that standardisation must be introduced to make the technology more efficient, therefore drilling managers must engage continuously with the drilling workforce to successfully implement the technology implementation process.

In terms of personal development, a question arises whether it is possible to create opportunities for drilling staff in the new technology systems? This could mean some drilling staff becomes empowered in ways they have not encountered before. Clearly, shifts towards this model would involve political choices by leadership and drilling management, on how best to promote newly trained drillers. On the other hand, I have indicated how, as in the case of company A, the new utilisation values that supervisors derived from the drilling staff; the leadership assisted in reinforcing overall genuine empowering of the drilling staff on the ground. This means these staff could provide opinions or raise their voices in any future acquisition of new technologies, because of their experiences with current technology models.

However, an argument can be made that the adoption of this model by any company is closely related to how much the technology might be valued, by virtue of the fact that a variety of different people have been involved in its implementation. This is clearly far removed from the general conventional criteria through which success is measured. Such criteria involve a self-evident improvement in technical specifications, operational practices and organisational pay offs brought by a new technology adoption system. Such perceptions can only be sustained when one considers a standard set of project requirements that can be met by this new technology adoption process.

Another important implication derived from this research highlights the set of capabilities, decision styles and attitudes towards new technology that may signify the role of leadership from the drilling management and the drilling staff. This issue has been discussed with the technology company and the leadership to review how this area can be improved. This reflects my own leadership role on how organisational issues can be tackled in an effective manner. The other implication evolving from the research findings is the issue of knowledge transfer and how to support this concept. My argument is that knowledge transfer requires a series of practices and tools that both fosters and hampers knowledge ability. Developing leadership and management may be personal, but organisational capability needs to be learned and refined over time in a technological context or tasks because central to technology adoption in drilling companies is the understanding that not all such firms are immediately willing to embrace the new technology. There may be a sense that drilling businesses are dictated by the customer who is not the new technology adopter, but instead prefers to have new technology services benefits. However, new technology competencies will allow drilling companies to be more able to take advantage of the medium for the longer-term profitability of the company.

From the above arguments, it follows that considerable efforts must be invested in the training of drilling staff. For companies in this study, economic arguments were used by the leadership to justify decisions concerning technological changes and the acquisition of new technologies. Implementation processes could have serious impacts on the workforce through

training. But such decisions do not in themselves reflect how technology changes will add value, over time in companies. In whatever way the technological change adoption model plays its role in relation to economic growth or decision making, the leadership, drilling management and staff will only be able to build value if they are fully prepared to integrate it, and the practices required to run it. By being sensitive to context that the utility can be construed in a real sense; those drilling companies who wish to be sustainable in the competitive market, need to challenge their existing efficiency targets and look to invest in new technologies, to increase profitability. Once they embrace, absorb, integrate and start utilising new technologies, they can efficiently execute drilling projects, maintain higher works standards and construct better and more long-lived water wells for local communities.

6.3 Implications for my technology company

The research data in Chapter 6 (Tables 6.1, 6.2 and 6.3 in Appendix 2), reflects improvements in technical and financial performances at Company A. It is satisfying for my company to know that its technology is making a positive impact at such an organisational level. Additionally, it is expected this technology will enable the water industry to embrace technological changes that will open more business for my company (Fleck, 1994). It was a great struggle to influence the leadership of Company A to acquire and adopt this new technology, but equally it was a difficult decision for them to make to realise the potential of this technology. Although this new technology was dependent on having a highly trained workforce, the consistent efforts from all sides, including my company, the leadership, the drilling management and the drilling staff made it a success (Leonard-Barton, 1991). New technology adoption models' skill levels concerning trainers appeared to be playing a key role in the technology integration process and that was emphasised right from the beginning. Looking at the technical performance results of my technology company, an argument can be made that this new technology adoption and integration may start impacting other areas of the company in a positive sense. This process will benefit my company in terms of recognition, higher financial rewards and being regarded as an in the field.

Skills availability is another sensitive area contributing to the success of new technology. This research suggests that new technology adoption requires a better trained drilling workforce. Better skills and knowledge contribute to a company's pursuit of efficiency and market opportunities (Senker, 1992). My company must strengthen its expertise in workforce training programs, because a trained drilling force is vital for best practice technology performance. Increasing new technology skills and capabilities across the company will provide the best quality services to clients. This may be achieved through training supervisors who train and motivate drilling company staff. My argument is that new technology adoption change processes have increased the requirements for technical training supervisors, who have the technical skills to implement new technologies rapidly and efficiently.

It can be argued that having gone through these experiences with the drilling companies, my company's economic outlook will improve. As a company, we must facilitate the adoption of new technology processes which is vital for the productivity, competitiveness and sustainability of my company. Harmonising standards and regulations with the regulatory

authorities will enhance my business potential in the markets. Adopting and implementing new technologies through effective strategies and introducing new services in a timely manner are critical in ensuring long term trust in my company.

The process of adoption and integration of new technology is by no means a linear process. There is evidence to suggest that a potential adopter's enthusiasm would dampen if the parties involved in the brokerage role were threatened (Kimberley, 1981). This means relationships among parties must be intact to maintain the course of the adoption process. This means my company must have clear understandings of it, because joint efforts are the only way forward. Effective communication allows the parties to strengthen business relationships to keep business prospects safe. In this respect, my company has established an independent team to streamline and strengthen communications and relationships, by paying curtsey visits to client workplaces.

An organisation, with good trainers, would be in a better place to market its technology products or services to industry (Gaubinger et al., 2015). My experience suggests that once the management of a technology company know they have better technology and services, they would be in strong positions to use it to their advantage against any competition. However, arguments can be made that the staff of drilling companies, with different skill levels, are not the right substitutes because various drilling tasks within the company and the drilling projects are sensitive to skills. As the technology is skills biased, it requires special trainers. To maintain such skills levels, my technology company must provide special trainers to impart project specific skills to meet specialist project needs (Christensen, 1997). Consequently, if my technology company develops a marketing strategy and realises various issues, including project specific skills provisions and maintenance needs of technology that would encourage other drilling companies to seek and adapt new technology.

Enhanced managerial capabilities are also central to raising a company's efficiency, productivity and services. It is the role of the technology manager to handle technical training procedures, ensuring that these are implemented properly to curtail inefficiencies. My technology company's manpower strength is approximately 48, with three administrative managers, four technology managers and 12 trainers, who hold different skills and expertise. The management is now considering allowing its senior technology supervisors to become elite task specific trainers, who can exert influence in providing better training services to drilling companies. Raising managerial capabilities in technology trainers could contribute to improved working relationships among the staff of Client Company's (Edosomwan, 1989). The company's productivity could be further enhanced through better workplace practices. This may include involvement in decision making and team building, as reorganisation and technological change processes are complimentary to one other. The actions of a technology manager may have effects across the company, being the source of core technical knowledge in making technology training supervisors more productive through such management practices.

The other important implication for my company is to locate other business opportunities. With improved expertise, knowledge and contacts, this would take no time. However, this time may depend on how drilling company approach my company or even the

regulatory Authority in KSA or in another country. No doubt extra reorganisation and additional resources will help gain a new technology market ready status, but my argument is that once the systematic effects of new technology become more pronounced, other companies may come forward at their earliest to acquire and adopt new technology.

6.4 Implications for my scholarly practice

It has always been my passion to pursue innovations and research projects. This research study has provided that for me. This research is already generating many implications for me as a researcher, consultant and practitioner. My main aim in this study was to find well established drilling companies, with suitable drilling infrastructures and better-quality drilling staff. In these companies, I would approach their chief executives and managers to collect data that would allow me to understand their viewpoints. In this way, I would sense how ready they were to acquire and adopt new technologies for their organisations. This research has succeeded in developing an actionable framework that could assist any struggling drilling company in the water sector, to adopt new technology to sustain itself in the market. I have investigated this by directly interacting with the managers of six drilling companies and negotiating with one of them, Company A. Here, I was successful in influencing the management to adopt this new technology, to improve their business prospects through actionable frameworks. I feel it has been more than personal fulfilment for me and has assisted me in better understanding of various ways in which my own personal characteristics, values and position interacted with others in developing the actionable framework and implementing the new technology.

It is not only a great achievement for me but also more than my personal recognition as a researcher, manager and scholar practitioner. This research demonstrates that new technologies have provided core benefits and returns on investment, at every level at company A. Considering this, a strong argument can be made that this process has strengthened my creative thinking to come up with another innovative idea that could lead to the development of another new technology. This technology could help the KSA and other countries in arid regions of the world, to resolve their water scarcity issues.

The major practical contributions of this research are that it provided me the opportunity to collect all empirical data concerning a company's situation, preparedness and how they viewed the technology in relation to improving their business. This information was significant because there were no comparable studies in the water sector, within the last decade. Communicating the development of actionable frameworks and its successful implementation at Company A will allow me as to design initiatives, tools and actions on what drilling companies need to do in terms of practices (rather than what they are doing). For example, on a personal level while doing this research study, I realised the work I was doing carried significant value for me as a practitioner, and importantly it was making me feel good about what I was doing. The other satisfaction was talking to people from technical backgrounds, at different levels. Broadening their horizons to consider how to deal with people and learning about their thinking, finding out what they think pragmatically about new technology, all assisted me in improving my own practice. Learning requires an exchange of knowledge, which places greater emphasis on supporting constructive dialogue that facilitates

interactions between myself and my subjects, leading to profound shifts in their attitudes to their work.

The other important implication for me is that the new technology can support and drive innovative work practices in the water sector. This provides great satisfaction and achievement for me as a practitioner. The other important lesson I learned is the collaborative approach used in the implementation process at Company A. This included task management, resource planning and tracking operations that provided me with valuable experiences that could be implemented at my own and other workplaces to improve managerial practices. Additionally, research is the key for improving practice, managing organisational functions and human resource utilisation. I will achieve these full benefits once I implement them at my own workplace. Moreover, in consideration of other implications of new technology as a practitioner like me have a unique responsibility to act with the insights of this research. My hope is that new technology and actionable adoption framework models will encourage me to consider the consequences of my actions in relation to new technologies.

During this research, I have focused on making sense of the various complex organisational issues. This focus allowed me to understand how knowledge is produced and co-constructed; it helped me hone my skills as an all-round professional. Professional development is increasingly seen as an important factor in improving professional standing, raising my profile nationally and internationally. This means I could serve my community or society in resolving water scarcity issues across the arid world.

In understanding the innovative technology and provision of services, I believe this research may provide me with a unique opportunity to expand my practice and have more interactions with new customers in the KSA, and other arid countries around the globe. This may allow me to win the trust of the regulatory authorities in the KSA, thereby strengthening my own practice. Finally, the critical benefit of this new technology adoption and implementation framework has provided me with the opportunity to improve my knowledge, the range and accuracy of my perception through the creation of tools, training schedules and development procedures to become a better practitioner.

Chapter 7: Reflections

7.1 Introduction

From a DBA researcher's perspective, an essential component of scholar –practitioner inquiry is the ability to present a transparent account of the research process. A researcher's personal reflections and insights will evolve as a result of their research experiences. In this chapter, I reflect on my personal insights into the lived experience of conducting research into new technology implementation in the water sector. My insights include, but are not limited to, the importance of preparation in conducting research, the role of the researcher, the research experience, uncertainties and maintaining authentic rigour. In making sense of my role in this project, I reflect on my personal, cultural and religious background, as well as my experiences in management as a consultant, a practitioner and a researcher.

Reflexive analysis emerges from phenomenology; a school of thought evolved by

7.2 Reflexive analysis

Husserl (1859-1038) which concerns the nature of challenging phenomena and how they emerge in management research. One of the challenging phenomena from this research is that it contributes to technological research while pursuing management research objectives. The research promotes and supports technology research (collecting qualitative data on equipment and reliability). This research is important because it provides in depth information on equipment and technical expertise, which supplements the qualitative management approach in transferring technology and knowledge. This does not mean that I would be leaving the qualitative paradigm because I was dealing with technology research. It all depends on my own values and background as to how satisfied I am within this qualitative paradigm, while conducting this management research. My focus had been to understand the complexity of the technological research issue and its unique connection with management research (Bozeman et al, 2015).

These reflective thoughts have strengthened my own personal characteristics, my ability to influence the research approach, the methods employed and the collected data and interpretations. My reflections have helped me make sense of the ways in which management knowledge is generated and co-constructed (Glesne, 2011). The elements that impact on research and result interpretations require a reflexive stance to identify and comprehend the effects of these elements. Reflexivity is an important part of qualitative research because it plays a significant role in subjectivity, objectivity, social sciences knowledge and research (Pullen, 2006). In qualitative research, another important aspect of reflexivity is to identify researcher bias, which is fundamental for researchers to be aware of (Hamersley, 2008). Reflexivity not only makes the researcher more aware of his role, but it increases the trustworthiness of the data and the integrity of the entire research process: who I am, how I perceive the world, how I feel and what I know about these vital elements in the research process. The researcher not only has to take care of his own viewpoint, but also those of his

interviewees (Rose, 1997). Reflexivity generates authentic analysis and can only be produced when a researcher questions his own viewpoints in understanding each research phase, right from formulating questions to writing the subject matter, to being mindful of ethical issues that shape the research (Olson, 2008).

Conducting research in an organisational set-up can be difficult from a reflexive context. Although reflexivity is a familiar concept in qualitative research, it has not previously been experienced as an ethical notion. The argument is that participants should have view and respond to the eventual texts and the researcher needs to question his own statements. This is how ethical reflexivity functions; a researcher chooses to ask certain questions, collects data, interprets the findings and then decides which findings are worthy or more or less emphasis (Hamersley, 2008).

I experienced difficulties with the concept of reflexivity, because there are no set procedures for it; however, its importance in social sciences is fully acknowledged. I therefore decided to share my reflections on initiating this research, the contents and my experiences in dealing with day to day research. I began with my own background because it revealed what motivated me to take up this research topic. It also covers some of the feelings and emotions I have experienced in the last six years, while remaining engaged with Liverpool, in pursuit of my qualification.

7.3 My journey from practitioner to scholar-practitioner

Education and business have always been important to my family. My generation was first to experience the opportunity of pursuing higher education. After completing my engineering degree from Lyallpur University in Pakistan, I got a trainee engineer's job with a British subsidiary company operating in Pakistan where I enhanced my cognitive skills in becoming a better practitioner. It provided me with another job opportunity at an international level, with a multinational company in the Middle East. While working with this company, I wanted to fulfil my dreams of a higher degree in groundwater exploration and development.

This inspiration allowed me to move to the United States, where I completed graduate and post graduate degrees in water resources engineering at prestigious institutions. While in the US, I worked with a multinational company in the area of my expertise. This was a great experience for me; it enhanced my management and cognitive skills to another level. Eventually, my expertise and educational achievements helped me to seek greater business goals that brought me back to the Middle East. I worked there for 18 years at a senior management level before establishing my own technology company. These achievements provided more business opportunities to work with world class water sector multinational organisations, as a consultant, practitioner and researcher.

Consolidating my research and management successes in achieving greater business and organisational goals inspired me to pursue a Doctor of Business Administration (DBA) programme at Liverpool University. I believed that acquiring management, research and meta cognitive skills at Liverpool would provide significant value to not only my own personal

development, but also to my company. It is my passion to pursue innovation and research to raise my personal and organisational performances, even in difficult times. My research publications and my recent paper presentation at Toronto at an International Conference on water security, and two residency programmes have greatly helped me in strengthening my research skills and leadership abilities. Working around the globe has allowed me to meet water scarcity challenges, especially in arid climates. While working with different companies, I observed that operations and development procedures were not meeting minimum standards; and this therefore provided me with the chance to develop a new technology, resolve cementing and productivity issues.

Through frustration, experimentation and testing, I finally developed a new technology, which not only extended the life of water wells, but it increased their productivity by over 30%, through special cementing techniques. This invention was approved by the Water Ministry of the KSA and the patent is now in the final stages of approval in the US. My argument is that organisational business success is a special type of sustainable journey, but without a destination, because goals and targets keep changing (Senge, 2006). Equipped with a drive for innovation, research techniques and knowledge, are critical for facing a complex world of business and management (Spreitzer and Porath, 2012). A change process consistently needs adaptive cultures. I am fortunate in being at the helm of a consultancy business, which is submerged in action learning, research practices and innovation techniques. I believe that learning at all levels is the only viable way for my technology company to excel in the water sector.

This thinking was further strengthened at Liverpool through improvements in my research and meta cognitive skills, while completing my DBA programme and research project. My argument is that even the best practical reasoning cannot get rid of learning's unpredictability. It is like water rafting. Tranquillity and excitement go hand in hand. Calm periods are suddenly jolted by frenetic turbulence and reflection coexists with action, but it does not mean I lose confidence if the situation becomes difficult. In fact, it is the opposite. I like to courageously face such learning or problematic dilemmas to resolve them through an informed manner rather than haphazardly (Shelton, 1997). It helps to build trust, an intuitive sense of confidence, validity and accuracy of insights and judgments. I can say with confidence that this is the way I have been growing as a researcher throughout my DBA journey at Liverpool. However, to expect to experience no pain or only feel pleasure during learning is unrealistic, because learning is an emotional activity. So, having such emotions is reasonably predictable and acceptable. Managing those emotions precisely can be considered an added skill while managing and pursuing research projects (Hilson, 2006). Learning and research occurs through a set philosophy, which is based on insights, values, beliefs and convictions which are embedded practice. This also exhibits features which are essential to learning and researching with a set purpose.

Therefore, I hold such a learning philosophy, because a conscious sense can lead to a better organisational vision, conviction and clarity. Moreover, it is critical in improving and achieving coherence in the fog of chaos and gaining clear directions. This is how I have learned to maintain direction in the middle of a storm, whether learning discussion, research problems or organisational issues. I never forget that learning issues and organisational dilemmas bring

surprises but having my working philosophy will always assist me in overcoming the confusion in times of crisis. This is critical for personal sanity and professional morale (Cranton, 1996). Thus, education brings knowledge, skills and competencies to life. Though acquisition of technology, technological skills, training programs and managing research projects is a necessary part of effective practice and professional development, even then the literature remains inconclusive and divided with different perspectives. No one perspective has all the elements in one model. However, understanding practical differences and resolving them through reflection is one of the most important ways of action learning in practice (Mezirow, 1990). This research philosophy complements the action-oriented and qualitative case study methodologies in this research project. Having meaningful social interactions in an organisational set-up influences the working environment, ultimately leading to social and technological change. This is what I have experienced throughout my working life, at Liverpool and at Company A while pursuing this research project.

7.4 My development as a researcher

My prior management and research skills played instrumental roles in completing modules at merit level. Having a postgraduate degree in engineering sciences helped my leadership role in my previous company. In seven years, I went from project manager to project superintendent and then finally obtaining the top organisational position took me only seven years. These positions not only helped me sharpen my research skills, but they improved my management skills too. Being a competent engineering researcher and practitioner, I resolved difficult issues that helped me become a trouble-shooter and team leader. While holding these positions, I worked closely with others at all levels in the organisation. Here, I delegated to subordinates, so they were prepared to shoulder responsibilities and become independent. During these times, I started understanding the core benefits of action learning and research, as well as the importance of team collaboration. I truly enjoyed those moments working at lower level positions, enabling workers to overcome weaknesses and become better performers. Though I experienced setbacks in the form of organisational issues, my strong moral and ethical background never let me take a backseat in resolving such issues. Holding such beliefs and values helped me inspire those around me.

As a leader, believing in strong moral and ethical values, I have never had to bend the feedback rules. No matter who was getting feedback, it was critical to stick with the set procedure. I made sure to have all necessary data and details to support the feedback process. I do not talk about traits, but I always discuss behaviours and emphasise the future, giving the employees the opportunity to change in a set period (Bass, 2008). I have noticed sometimes that even great performers get results by ignoring some basic human values such as caring for others, strengthening bonds or maintaining a healthy work environment. In this sense, these strengths become weaknesses. I would never let such practices flourish at my company.

I found additional strengths in my ethical and moral background. I was raised in a religious family, where ethics and human values were revered. So, my values, beliefs and attitudes are inherited from my family. They never let me down when I face ethical challenges and business dilemmas. It is my belief that strict regulations, laws and elections are not sufficient to stop powerful and rich people plundering ethics, values, and economics (Newton,

2003). Unless they consider that morals, values, and ethics apply to them and in turn realise that they have some social responsibility towards society laws and regulations that would be imposed on the masses. For these reasons, I advocate transparent procedures, a culture of voice, openness and safe practice in relation to the working environment in my company. These morals and working practices have helped me manage harsh working environments, even during economic turmoil. This is how I transform myself with new knowledge and innovation, through cooperation with my team, while facing emerging challenges. In this sense, I institutionalise ethics and moral codes into my workplace, so that the leadership and employees become good business citizens (Verhezen, 2010).

I came to Liverpool University with a clear vision. Their DBA programme could offer me far more than a just a passport to a great business career. I am pleased to say the course broadened my career track and made me aware of my various skills and their transfer values. It helped me grab new business opportunities in my practice area. My leadership and managerial skills were strengthened through research, modules and residency programmes. I not only polished my existing skills in engineering, but also acquired new skills in social sciences. In my opinion, action learning and research is a great way to promote and transfer quality knowledge, in a much shorter time span. However, the resolution of problems and taking responsibilities are always tasks for the leadership (Revans, 1981). I always viewed social sciences as a great learning opportunity in collecting information, providing resources and shouldering full responsibility in resolving problems, through collaboration. My argument is that the process of learning and reflection is critical in developing leadership at all levels, in an organisational context. This is how I developed my management, leadership skills, and strengthened my research and practitioner skills. It was through critical evaluation of my assumptions, attitudes, and biases (Rigg and Trehan, 2004). I am fortunate that these action learning and research skills were used at Company A during my research.

Additionally, these skills strengthened my ability to manage change and handle crisis's, specially while keeping stakeholders interested during the new technology implementation process at Company A. Being a competent practitioner, I view practice as a necessary mode of learning that brings together knowledge and action, so resolutions can be achieved. This is how I understood action knowledge and reflection, which reinforced my leadership abilities in organisational learning and research. A competent researcher and practitioner can identify the most difficult issues in a business and management environment, and importantly they can discuss and resolve it quickly to move on.

My role and personal beliefs, ethics, and values came under the spotlight while pursuing research problem, building strategies and action research designs. Knowledge generation is an interaction between the insights of an organisation and outsider perceptions. Putting together these key insights and developing a shared understanding, becomes a practical problem resolving mechanism. While pursuing research at Company A, understanding this process became imperative for me in relation to context based dialectical knowledge creation because of its strong link to problem resolution in a practical sense. For example, after building the technology actionable framework, I went to the leadership of Company A and explained to them the various stages and asked for its adoption. The leadership spoke of weaknesses and strengths in relation to adoption. I understood their

insights and appreciated them; therefore, we reviewed these insights together for three consecutive days to resolve them.

Consensus is central to action-based knowledge. However, it is not required that knowledge generated must reflect a consensus of the researcher and the participants. My argument is that new knowledge generated through collaboration carries enormous value. This is how I comprehend this dialectical and dynamic relationship. In such environments, truth is assessed from perceived knowledge, discussed in collaboration and accepted by the parties. This knowledge may be provisional and may be further challenged. It will then probably change previous results of sense making. I believe even new positions can equally be challenged or accepted individually or collectively concerning new knowledge and that may further motivate the dialectical flow process (Greenwood and Levin, 2007). In an organisation where action research is pursued, the company insiders are the co-researchers and co-subjects. They give rise to many actions and new knowledge for the concerned enterprises. Although conventional social science accepts this idea, many social researchers are not prepared to accept that insiders can be equally good social researchers, they can create quality knowledge in the research process. Probably, it is hard for them to realise that this knowledge may be different in being embedded in participants' actions, but still presents practical wisdom, tacit knowledge characteristics, and forceful reasoning (Greenwood and Levin, 2007).

In my new time at Company A, I strengthened my knowledge of management research through positive research outcomes, rather than strengthening my research skills. I enhanced my qualitative inquiry case study frameworks. I strengthened my knowledge on how to interpret published research and its application in the workplace. Although equipped with research experience, I enhanced my research skills while implementing the new technology adoption frameworks (Chapter-5). This new technology not only enhances the lifetime of water wells by novel cementing techniques, but it increases well productivity by over 30%. These results are significant because of water scarcity issues in the KSA and other arid regions of the world. These situations generate more opportunities for researchers like me in the development of ground-breaking water technologies.

7.5 My own impact on my research project

While conducting the first stage of my DBA, and conducting interviews at the six drilling companies, I sought to remain as objective as possible. I realised during interviews that our lives mirrored each other, because of similar cultures and technical backgrounds. I understood the context (for example the Arabic culture) that managers were making claims about. I asked them to explain these contexts in more detail. Even though I was an outsider, I had close working relations with these companies. I conducted interviews as an insider who understood their contexts. In this way, I collected rich data from my interviewees. This was not difficult because I understood them because of our similar technical backgrounds. I did not lead during the interviews, but instead questioned and listened to managers because they had the technical information about company infrastructure and knew the drilling workforce expertise, that was central to the implementation of the new technology.

These researcher characteristics play key roles in shaping good research. Although most researchers, including myself, have tried to maintain genuine ethical values and independence, it has never been easy to isolate research from politics and ethics. This includes situations where researchers have had significant professional influence over others. These crucial issues could emerge during research between the researcher, the companies, and concerned managers because of their understanding of various issues. Some of these issues could be political in nature and would prove difficult to handle. For me, if any such situation developed, I had to maintain my integrity and morals. Moreover, many organisations are controlled and structured, and researcher access is not that simple and accessible. This was not the case with me, I was fortunate in having a highly technical background, research experience and leadership capabilities that facilitated my full access to these companies.

Other ethical issues could arise while collecting research data, because of a researcher's personal intentions and motives. Such a stance could damage the objectivity and independence of the entire process. Hence, the researcher rarely puts forward the emergence of those questions and ideas, as well as the reasons why they have come up. However, most social researchers, including myself, would like to become more reflexive. Although prior research experience is considered important, it is not that simple to derive good research ideas from the literature. In fact, researchers often participate in theoretical rationales of their own work and are explained later in a thesis or paper (Easter by-Smith, 2008). In this sense, being a motivated and strong researcher meant that my research characteristics would have impacted my research in a very positive sense. This would have included my personal experiences, attitudes, cultural background and external stakeholders' influence on me when I had to interact with them during interviews, which includes research study. My understanding is that when a researcher collects data from a workplace where participants are in their natural setting, this could affect the research data if the researcher was an outsider. I was lucky to be an insider. This assisted me with sensitive discussions and made complex situations easy to handle.

This means that critical characteristics, which could impact on research, are of the researcher himself being the key instrument, as he is not going to rely on others for data collection. The other factor is inductive data analysis; because a researcher constructs categories and patterns through data organisation and achieves abstract information while interacting with participants. He then includes their opinions to shape the abstract information. By understanding statements from interviewees and making sense of them is of critical importance because it not only affects the research, but it also reflects participant opinions. The research process is emergent, it keeps changing while the data is being collected and includes data collection procedures, sites and the participants.

Researchers often view their own research through their culture, gender and/or class (Creswell, 2009). Additionally, the researcher represents a complex picture of the issue or research through multiple perspectives, providing a bigger picture, reflecting the involvement of numerous factors, not just by cause and effect relationships between factors, but rather by taking care of complex situations of interactions of different factors in any emerging situations (Creswell, 2007). This means the researcher must be strong and provide a full commitment to research the issues in a rigorous way. They must use the best research approaches,

understand them, get comfortable with them and proceed in a concise and clear fashion. For this reason, I selected an actionable case study methodology, which would generate a sound research project. This research project generated many implications (Chapter 7) that could positively affect not only other drilling companies, but my own technology company and regulatory authorities in the KSA.

7.6 Reflections on my role as a consultant and researcher

I believe consultation is useful in seeking proper solutions to many of the complex issues and problems that people and organizations facing in the business world. In this sense consultants offer workable assistance by suggesting feasible action to the client in resolving the issues or problems (Blake and Mouton 1983). This is also the role of an action researcher too being a change agent, which makes it difficult to distinguish between the two roles while facing varied situations constantly. However, there are differences in that an action researcher is not only to be responsible for the organizational development process but also to produce academic research results whereas in the case of the consultant role then the contribution is limited to practicalities. The benefits for a researcher and also a consultant, the participants ability to specify a valid specification regarding the change process improves significantly that is what I observed during my research at company A, otherwise it could have been limited if I was just the consultant.

The participants and I were making joint decisions in the formulation and resolution of problems. The changes were communicated as part of the overall training program concerning action framework implementation process which took place simultaneously. There was a complete support from the management. We identified the key work – strands with the managers where we felt we could add value and set about promoting with other teams. We wanted to promote a professional practitioner image and so we spent lot of time designing the training procedures that enhanced the implementation process. Such collaborative work, particularly investigating the implementation process, had a positive effect on the execution of the research project; it assisted in avoiding conflict in relation to loyalty or validity problems.

The main challenge for me was the acceptance by management of those six drilling companies, particularly the company A, that my technology company and I provided more than just an additional pair of hands. I needed to constantly ensure that I continued to operate as consultant as well as a researcher. A key issue, of course, was credibility which was earned by results over passage of time.

7.7 My future research plans based on stated attitudes & abilities

My plans reflect a realistic assessment of my abilities and attitudes in light of the above explanation regarding my DBA goals. I understand the research path is full of many difficulties and obstacles, but my abilities will help me pursue a successful research project. I believe I have what it takes to complete a quality research project. I know that research projects are not just intellectual efforts, but also psychological ones, which must endure with self-confidence and emotional resilience. Being at the helm of groundwater research is the core of my business.

My company has great expertise in groundwater exploration and research. It maintains a vast database of groundwater research. Being a groundwater specialist and an experienced engineering researcher, covering groundwater exploration and development is a great asset for me. I can pursue engineering research with confidence, and it helps me resolve issues through expert knowledge and groundwater research techniques. Having expertise and knowledge in groundwater exploration and management, my core research focus has remained scientific inquiry using the mixed methods approach. However, at Liverpool for my DBA thesis, a case study inquiry through action management research was a great learning experience in my life. Previously, I have published my research in the engineering sciences; however, with this experience I can now publish research in the management sciences.

In an arid climate like the KSA, with dwindling water resources, my research focus now shifts towards finding more firms to adopt my technology actionable frameworks to assist the KSA cope with its water and associated problems. I understand that borehole cutting sample analysis is a great way to conclude aquifer yields, but the application of the new technology actionable framework is proving to be the best practice (Chapter 5). Moreover, research in new technology adoption and implementation processes has remained weak, until now. During my research at Liverpool, I developed an actionable framework to acquire and implement new technology in this sector (Chapter 5).

In such a development, I would like to shift my attention to actionable framework research in managing groundwater resources, not only because it is my business, but also because of increased societal interest. During my DBA, I reviewed the literature in relation to the topic can be a great asset but picking up the right methodology and gathering proper qualitative data was the core of the research. This was because sometimes data can be misleading where it provides information, which is just not true. These are important lessons I learned while doing my research project. Moreover, I must be vigilant while gathering and validating this data to overcome uncertainty and obscure inherent biases. Uncertainty in research findings is neither indecisive nor indicative of an issue. The core problem is just thinking that certainty exists when it does not (Ransbotham, 2014).

I believe this learning will assist me in future research projects. Similarly, the advice from my professors and supervisors at Liverpool University will be taken home to be used at other times, on other actionable frameworks. The experience of the researcher plays a critical role in interpreting results from the gathered data; knowledge of the study area is of vital importance (Roberts, 2010).

I am more confident because I believe my expertise and knowledge could lead to successful findings, thanks to my DBA research experience. This has been proven at Company A (Chapter 5). Implementation of the action framework will significantly contribute to the existing body of knowledge and society as a whole, because of water scarcity across regions of the world (Chapter-7).

My research project is important because it can present the complexity of not only researching the issue, but also the importance of the syntax required to build and present the research in a coherent manner. This research study helped me focus on how to appropriately analyse my research and contribute to knowledge in the subject area. I believe Liverpool

University has provided me with an excellent opportunity to grow and experiment intellectually, which was beyond my imagination prior to commencing this journey. The set of skills I have developed and honed through the DBA programme have elevated my strengths as a professional. It is critical to continue demonstrating and practising these skills and analytical techniques through my research at Liverpool University and in my workplace and beyond (Bernard, 2000).

7.8 Concluding remarks

Action learning and management research is not only restricted to academics, it can also be pursued by practitioners. There are many views concerning the nature of management research and these have implications for management research processes (Chapter 7). Action learning and management research has unusual characteristics, which make its form and content distinctive when compared to other social sciences disciplines. Therefore, careful consideration of underlying assumptions is necessary, because they may lead to new research applications in other fields (Easter by-Smith, 2008). It is my thinking that transformative learning generates trust building climates, leading to better understandings of thoughts, beliefs, and assumptions (Rigg and Trehan, 2008). I further believe my technology company must continue maintaining a culture of transparency and employee empowerment. This can be done via collaborative efforts to keep unethical practices and procedures at bay, while continually enhancing ethical business practices (Ghoshal, 2005). I am keen to pursue this strategy at my workplace while leading groundwater consultancy services in both business and research. My team members see me as a tenacious and optimistic problem solver, who believes solutions are attainable for each problem (Northhouse, 2013).

I continuously seek improvements at each obstacle, while remaining open to constructive criticism. I provide constructive criticism to my team and others, having learned how to do it tactfully and professionally (Cranton, 2006). My newly acquired personal and professional skills are the results of intensive interactions and experiences, derived from my time at Liverpool University, six drilling companies, Company A and my workplace. These were core abilities that helped me excel in my DBA research journey and lead a team at my company. Although formal skills and knowledge are necessary for research projects, working with experienced researchers in the social sciences is a great way to acquire new research experience and insights. Moreover, establishing an open thought system is of paramount importance in pursuing a research project. This needs continuous testing, reviewing and critiquing thoughts or ideas, and a preparedness to generate new ideas. These ideas will remain a key feature of my professional practice.

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Appendix 1 Indicative example of coding structure

First order themes and first-level categories		
Data structure for first-level category of "Return on Investment"		
Company A- Manager 1	First- Order Themes	First level category
New Technology, beat competition on costs	new technology promotes Cost-efficiency	Return on Investment
Need to organize resources; train workforce before making critical financing decision	cost-analysis is critical in making decision	
Have to have enough financial resources at hand to purchase new technology	funds availability is the key factor in decision making process in adoption	
Need to upgrade existing equipment to match new technology	new equipment is essential in adoption	
Have to have enough financial resources at hand to purchase new technology	funds availability is the key factor in decision making process in adoption	
Manager 2		
Emergence of new technology has generated alarming cost competition among organisations	new technology promotes cost efficiency	
Manager 3		
Technology makes work easier and effective leading to better business efficiency and services	new technology enhances cost efficiency	
Adoption of newer technology is necessary cost to any company due to fierce cost competition	new technology adoption is cost effective	
Analysis of all costs and training parameters though of and put into practice	cost analysis is critical in technology adoption	
Upgrading equipment essentially means replacing old equipment	new equipment essential	
Decision relies on staff feedback, customer	efficiency improvement	

feedback, and if improved efficiency and benefit is seen during controlled tests	strengthens decision making process
Company B-Manager 1	Themes
Technological change reinforces continuous improvement and adaptability	Technology enhances efficiency
New technology allows us to work more efficiently and cost effectively	New technology promotes cost efficiency
Technological change will allow us to continue to be competitive in the drilling market and keep the organisation as a company well-equipped to take on new challenges and projects	Improves efficiency
Lead forecast for company to remain profitable while continuing to uphold the company's goals and vision	promotes efficiency
Market is very competitive and is constantly changing over time	Improves cost efficiency
Have new equipment that has come in for the change process	New Equipment enhances change
Have necessary resources to start technological change initiative	Funds are critical
Manager 2	
Utilizing new technology to complete the projects successfully, integrating new technology over past two decades has been beneficial for advancement in company	New technology promotes cost efficiency
Technology to integrate brings about great benefits to efficiency, cost effectiveness and ability to tackle complex projects quicker	new technology promotes cost efficiency
Company C-Manager 1	
New technology is cost efficient	New technology promotes cost efficiency

The marginal benefit of new technology must be greater than the cost	raises profitability
Knowledge of increased productivity will increase due to new technology integration	improves efficiency
New technology at the operations level must be proven to be cost effective in the area of ground water	new technology promotes cost efficiency
Changes are deployed sector by sector to maintain productivity and efficiency	New technology promotes cost efficiency
Always capable of going ahead with change process as we have the expertise and resources always ready	funds availability is the key factor
Manager 2	
Even if new technology has increasing costs, benefits and progress outweigh that cost	raises cost efficiency
Equipment always needs changing and modernisation	new equipment assists in adoption
Manager 3	
Positive and negatives involved with technology change that require consideration before adopting new technology	raises cost efficiency
Need to improve equipment in order to handle and properly absorb any new technologies	new equipment assists in adoption
Company D-manager 1	
New technology will allow company to be better equipped to deal with new problems that arise	technology increases efficiency
Benefits of new technology include cost reduction in operations and day to day management	new technology increases efficiency

For technological change, new infrastructure can be added on to the old or completely replace the old	equipment aids adoption
Company E-Manager 2	
Introduction of new technology into workplace is key driver of productivity	technology raises efficiency
Infrastructure is mechanism by which change is evaluated through standard systems and practices	equipment aids in adoption
Initiative requires sufficient resources and funding	resources aids in adoption
Company F-Manager 1	
Adopting newer technology can increase efficiency, reduce overhead costs, allow job and role expansion	raises cost efficiency
Large-scale technological changes do not necessarily predicate need for large scale investments into newer equipment	equipment aids adoption
Manager 2	
Ultimate benefits outweigh costs to technological change	raises cost efficiency

Appendix 2 Table 5.1: Training programme and workshop schedules

Recommendations	Timeframe	Remarks
Recommendations for familiarising and operating new technology. Implications for leadership, drilling managers, instructors, supervisors, drillers and support staff.		
1) Compulsory presence of shift staff during refresher workshops	4 weeks	All experienced drillers and entry level staff in each shift must go through this exercise, for four weeks
2) Refresher operational workshop for drilling staff at the office site.	8 weeks/ 16 weeks	A refresher operational workshop needs to be conducted for eight weeks for trained drillers. For new drillers, this is sixteen weeks. Every staff member is taken through the literature, operations, and safety requirements.
3) Operational workshop for drilling staff and trained drillers; how to assemble and operate new technology at project sites	8 weeks	Trained drilling staff are put on operational segment on the new technology by the instructor.
4) Assessment workshop for drilling staff and trained drillers to track their developmental growth in the last 16 weeks at office site	1 week	Evaluation done by the instructor as part of formative assessment; oral, writing and operational outputs.
5) Additional workshop for slow learning drilling staff, including trained and entry level drillers at office site	2 weeks	Slow moving drilling staff as per the evaluation results are given additional time to master the technology.
6) Organising independent operational workshops at the project site; to run the new tools inside the well bore, and to build confidence and drill home an understanding of safety requirements.	1 week	Trained drilling staff will be allowed to perform operations to complete the task in the presence of an instructor
7) Task assessment workshop by third party assessment and evaluation to build client confidence.	1 week	Third party assessment and evaluation log results will be presented to the leadership

To satisfy leadership at project site.		and the drilling manager.
8) Organisational leadership and instructor meeting workshop. Necessary to maintain the adoption process.	1 day	Leadership and instructor viewpoints noted and incorporated for further training (if any).
9) Final workshop with the leadership and clients after satisfactory results	1 day	Leadership demonstrates to clients how successful they have been with the new technology and performance results.

Recommendations for Entry Level Staff (with little or no experience)		
1) Educational workshop, to upgrade knowledge and operational skills	16 weeks	Entry level drilling staff given additional training through educational workshops to build confidence and enhance performance levels.
2) Further educational workshops to enhance operational skills	2 weeks	Every quarter, two weeks of educational workshop will be organised to bring participants up to par with colleagues.
3) Provision of paid extra time for each week of education and learning	16 weeks	Put extra time in the routine schedule for the new drillers
4) Six monthly provision of educational workshops for all drilling staff.	1 week	Incorporate into workload schedule to attend one week workshop every six months.
5) Develop a performance check protocol for all drilling staff after six months	28 weeks	Evaluation reports to be presented to the leadership for staff promotions and appraisal.
Recommendations for Supervisors		
1) Develop a training protocol for supervisors under the instructor.	2 weeks	Organise special workshops for supervisors; new supervisors need to learn how to treat drillers to realise their best performance.

2) Organise and integrate an informed note on the characteristics of a good drilling supervisor with leadership skills	Will be added to the learning protocol in 3 months	This will assist supervisors to develop their own leadership attributes/skills.
3) Develop and disseminate a guiding note on how to replace the trained drillers in emergency	To be worked out	Helpful in bridging a skills gap and getting higher performances from drillers.
Recommendations for the leadership on how to build confidence, performance, and management skills of the drilling staff		
1) Increase the numbers of trained supervisors	To be raised slowly	Hopefully the number will reach a satisfactory level in a year or so
2) Increase the numbers of trained drillers	In progress	Number is already being increased, probably this year (2018) it will hit the target
3) Hire at entry level, smart drillers with higher technical backgrounds	Currently being incorporated as company policy	Human resource department has adopted recruitment protocols
4) Set up qualification standards for supervisors and drillers	Being implemented	Supervisor: 7 years as trained driller with a technical diploma. Driller: 5 years as trained driller with a technical diploma.

Appendix 3

Table 5.2 Cementing log results

Ref Wells	Previous Bonding Strength	New Bonding Strength	Percentage Increase
M-1	61.8	81.2	19.4
M-2	62.4	82.5	20.1
M-3	60.2	82.9	22.7

Table-5.3 New technology benefits

	Expected %	Observed %
1. Return on Investment	100	63
2. Market Image	36	55
3. Competitiveness	42	58
4. Customer Satisfaction	38	78

Table-5.4 Productivity improvement results

Ref Wells	Specific Capacity with Standard Procedures	Specific Capacity with Innovative Procedures	Percentage Increase in Specific Capacity
M-1	14.61 GPM/ft	19.8 GPM/ft	35.5
M-2	14.8 GPM/ft	19.9 GPM/ft	34.45
M-3	13.5 GPM/ft	18.2 GPM/ft	34.81