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NATURAL RESOURCES INVESTIGATION USING THE BOREHOLE DRILLING METHOD: REALISTIC ASSESSMENT BASED EXPLORATION INTO NATURE AT NSUTEM, EASTERN REGION – GHANA.

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Abstract

Nature is enriched with varied amount of resources positioned to be discovered, assessed, mined and processed for the wellbeing of mankind. Man as an explorer, discoverer, investigator has the potential to harness such resources which will yield Billions of Pounds Sterling and cedis for the development of the Great Britain, United States of America, Canada, Dubai, Japan, Korea, China, all countries in Africa and worldwide. This is the reason for this research work which sorts to investigate whether Nsutem, which is a town in Eastern Region is enriched with other natural resources apart from Gold which is mind in the town. The method employed in this research work is the borehole drilling method for harnessing underground water which is also a natural resources. With this method, as engineers sort to hit water at a given depth beneath the ground for drinking and other domestic purposes, other natural resources such as gold, copper, bauxite and oil are investigated for their presence. Research findings yielded the discovery of the first natural resources which is water at a depth of 80m. This is abstracted upland from aquifers with pumps for storage and use. Further probing during the research gave traces of fine oily substance suspected to be oil. This requires further investigations for validation and if true, to what amount deposited underground for mining and processing into consumable products. With these results, it is justifiable to say that, borehole drilling method used for harnessing water which is a natural resource, is best fit method for exploring and investigating other natural resources buried underground in Nsutem and Ghana.

Key words: Aquifer, natural resources, borehole drilling, underground, oil, gold, water.

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1 INTRODUCTION

1.1 Background of the investigation

Water as a basic or physiological need is a great assert needed by man for survival and sustenance on the surface of the earth. The human body constitute about 60% water for the normal functioning of the body for all kinds of processes such as reproduction, excretion, metabolisms etc in the human body. The human body requires constant water for functionality, equilibrium and temperature regulation. The body hence require constant replenishment as what in the body is used for these and many processes. Mankind hence depends on surface water, rain water and ground water sources in obtaining this need to satisfy their thirst. Surface water in Ghana is now a big problem as almost all surface water bodies in Ghana have been polluted turning them into muddy water due to the illegal mining (*Galamsey*) activities in Ghana. Ghanaians been so greedy have destroyed all the surface water bodies in the Eastern Region of Ghana as a result for the search real gold to enrich their lives. The mineral is mined in most communities in the Eastern Region of Ghana and Nsutem which is the study area is no exception. River Birim is the main river in the community and this has been destroyed due to the search for the natural resource – Gold. Currently, the only source of water for the community is ground water. Mostly, ground water is harnessed and pumped into Rambo poly tanks for storage and distribution. Community then buy the water per bucket at a fee for domestic uses in the homes. The community also depends on rain water which is harnessed during rainfalls to supplement what is in existence. Others also makes use of hand dug wells but these wells easily get dried especially in the dry season.

Because of the above built points, ground water harvesting through the borehole drilling method is now a major activity in the community to harness the precious natural resource. Different borehole drilling companies from Accra come to the community for borehole drilling business either for individual personal use or for community use. Evidence is mounting that we are in a period of climate change brought about by increasing atmospheric concentrations of greenhouse gases. Atmospheric carbon dioxide levels have continually increased since the 1950s. The continuation of this phenomenon may significantly alter global and local climate characteristics, including temperature and precipitation. Climate change can have profound effects on the hydrologic cycle through precipitation, evapotranspiration, and soil moisture with increasing temperatures. The hydrologic cycle will be intensified with more evaporation and more precipitation. However, the extra precipitation will be unequally distributed around the globe (Kumar, 2012). These factors are contributors when it comes to the quantity, quality and amount of water to be obtained in aquifers for abstraction and use on the surface of the earth.

Wells usage in the community is also on the rise as poor and middle Ghanaian income homes in the town harness the water

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for domestic use in the homes. These wells which are of about 7m deep are unconfined aquifer dependent. This means that such wells are obtained since the ground water flow is within an unconfined aquifer. One disadvantage of the wells is that, the easily get contaminated when the water is not enough in the wells. Once rate of well water fetching is high, it leads to contamination making it use very difficult.

Natural resources exploration, investigation, and hitting of target has helped Ghana, Africa and the world as various minerals like Gold, Bauxite, Copper, oil etc have be exploited for the benefit of mankind and the world. Ghana, a gold mining country is exploring gold to a greater extent which is helping in the development of the country and the world at large. A lot of countries have benefited from Ghana's gold when it comes to development since the world is seen as one. Scientist and Engineers continue to get involved with natural resources investigations in order to find other precious minerals which can be exploited, mined and exported to boost the growth of the economy. Researching into natural resources involves the use of technology to investigate such fine resources which are deposited in the soil. The planet earth is full of natural resources which needs exploitation, exploration and investigations in order to discover them in their raw states, refine them into products which will be beneficial to mankind. Every countries potential to self-dependence, development and self – sustenance depends on discovery of natural resources and refinement of these resources into consumable products for use and export. It again depends on the buying of technology from well developed countries and applying them based on national or local climatic conditions. These are some of the reasons why natural resources investigations is of utmost importance in every countries development and self – sustenance. For every country to grow into a well-developed country, it calls for investigations, exploitation of every resources within it limits and seeing the need for it and what it can be used for the benefit of all. These are some of the reasons for this investigations into natural resources investigations and discoveries in Nsutem in Eastern Region of Ghana.

2 RELATED WORKS ON NATURAL RESOURCES INVESTIGATIONS

2.1 Natural resources conflict risk perspective

Every country worldwide is endowed with natural resources which when exploited and utilized well will lead to the enrichment of individuals and the development of the country. For a developing country facing high poverty levels, a growing population with high expectations, a low revenue-base, a sluggish economy with weak institutions, and at the same time possessing abundant natural resources, the exploitation of these resources will present a relatively quick and simple avenue to secure revenues that can be used to mitigate poverty and modernize infrastructure. The opportunities offered by

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natural resources to developing nations are extraordinary. However, experience from a range of otherwise very different countries shows that reaping the benefits of natural resources is not a straightforward process. Indeed, the exploitation of mineral wealth is all too often associated with increased conflict risk, corruption and an arbitrary and unstable system of government (Smith, 2013). This is a as result of the fact that, most academically inclined people or leaders are very corrupt and wants such discovered resources to be in their personal names, accounts or be seen as a family property. Never has there been an armed conflict with a single cause. In every conflict, a number of features of the social and political landscape interact with each other; this process is different in every case. Analyzing conflict risk involves paying close attention to the particular circumstances of the country, especially its recent history and current development trajectory. However, a number of elements repeat themselves in different shapes and hues across recent armed conflicts (Smith, 2013). The mix of these elements, the weight each one carries in each case, how individual political leaders respond to and use the elements for their own advantage all vary, but the basic elements are similar. Key among them are;

Institutional deficiencies - Risks are high when there is a dearth of well-developed institutions, such as departments of state, parliament, courts, police, local authorities, chambers of commerce and other business organizations, professional associations and civil society organizations. They all play a role in handling conflict, channeling it for constructive outcomes and avoiding violence. Access to justice and the chance to participate in decisions that shape citizens' lives are not only basic human rights, but also basic elements of a peaceful society; when these are inadequate, those with grievances may have no place to go except into radical organizations and militant action, often leading to violence (smith, 2013). This is usually the case when an individual or group sees the cheat in the use and utilization of natural resources within the country preordained for all.

Economic deficiencies - Risks are also high where the economic wherewithal to meet the reasonable basic needs of ordinary people is lacking, or when ordinary people's livelihoods are hit by a sudden economic shock, such as a downturn in the terms of trade. Such developments sharpen the effect of inequalities, including not only the gap between rich and poor but those between different ethnic groups and between different regions of the country. All these provides fertile soil in which conflicts are generated, grow and explode. Access to a reasonable degree of prosperity is a legitimate expectation and a further ingredient of a peaceful society (Smith, 2013).

A lack of social well-being - Frustrations arise with the poor or non-existent provision of basic public services in sectors such as health, education, sanitation, social amenities and transport, as well as from divisions and group resentments in society. These

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sources of frustration form an impediment to social cohesion. They are often expressed in terms of resentment of the advantages enjoyed by another group – a different clan, tribe or ethnonational group, or from a different part of the country, or immigrants into the country – even when those advantages are mythical. The sense of belonging that develops when a society visibly looks after its members, whether this is achieved through the state sector or by other means, is a contributing factor in a peaceful society; its absence is a debilitating weakness (Smith, 2013). The presence of ethnocentrism also increases the risk factor when looking at natural resources allocation in a country like Ghana. Some ethnic groups think they come first in all aspects when it comes to natural resources allocation, utilization and this can easily lead to conflict if not well handled or managed.

Community shift or movement - Resource extraction has an impact on the environment in which people live, because it implies village or communities have to be moved so mining can go ahead (eg. Newmont site in Kenyase at Ahafo Region), or because of environmental degradation. If these issues are handled poorly by the authorities, through inadequate consultation with local communities about how to meet their interests, grievances can turn quickly to unrest. The exploitation of natural resources offers many opportunities and incentives for unscrupulous looting of the wealth by the economic elite if it can get hold of the levers of state power, and equally by armed militias if they can take control of resource-rich areas. As a result, natural resource extraction is widely associated with high levels of corruption, rent capture by the elite, and ineffective governance. In some documented cases, groups that are ostensibly engaged in violent conflict with the state are acting in covert alliance with some segments of the state, to their mutual advantage and to the detriment of the country as a whole and its ordinary citizens. The heart of the issue is not the quality or abundance of resources themselves, but how they are governed. It is, first, a question of who is able to access them and for what purposes. For example, predatory extraction of natural resources by foreign multinationals can lead to loss of sovereign control over them and thus loss of national sovereignty in exchange for short-term gain for a narrow segment of the country's elite. Secondly, the social and environmental impact of resource extraction determines whether these are addressed by government policies and how (Smith, 2013). When such problematic issues or unrest are unattended to, they results in national conflicts and instability such as demonstrations leading to wars hence the need to.

2.2 Natural resources as a national development input

Natural resources discoveries is a key factor in every countries development. Once these resources are discovered, harnessed, mined, processed and utilized effectively, it leads to the development of the economy, its citizens and then the internationally market. For a developing country facing high

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poverty levels, low revenue base levels, a sluggish economy with weak institutions, and a growing population with high expectations, and at the same time possessing abundant natural resources? The good exploitation of these resources will present a relatively quicker and simpler source of additional revenues than the accumulation of domestic tax revenues or the negotiation for loans that in turn can be used to mitigate poverty, build and modernize infrastructure, access finance, promote competitiveness, and generally transform the economy. However, at the same time, these goals could all be compromised by the inappropriate management of those natural resources. While there are many successful resource for rich countries, several examples exist of others that have suffered from what is referred to as the "natural resource curse" and even descended into conflict (Herbert, 2013). This can be seen in the case of Ghana and other African countries.

2.3 Mineral resources for development

Ghana, formerly Gold Coast is a resourceful land bountiful with Gold and other minerals such as bauxite, manganese etc. These are mined in large quantities, processed and either exported or utilized locally. Hence generating billions of pounds sterling or cedis for the development of the country. The minerals subsector has extensive interrelationships with other development goals, such as employment, infrastructure, education, diversification and revenue management, as well as linkages with land, environment, water and agriculture, among others. The interlinkages and their implications must be analyzed at an early stage to ensure coherence among policy goals at the national level, and also to create synergies among them (Herbert, 2013). At the early stages of economic growth and world development, this sector could be the principal driver of economic activities because of the heavy investments required for mine development, the potentially large revenues from mineral taxes, demand for pre-production employment, and, when properly managed, backward linkages to the rest of the economy (Herbert, 2013). Most great nations such as Canada, USA, China, Japan, Great Britain, Argentina, South Africa and middle income countries like Ghana, Nigeria, Burkina Faso etc. have seen national development to a higher degree due to mineral discoveries, exploration, mining, processing and equitable distribution and utilization.

However, at the same time, tensions will have to be managed to deal with pressures for exemptions from the prevailing law governing almost all mining operations, including: from rules and regulations governing all forms of taxation on enterprises, maintaining respect for human rights by both artisanal and industrial mines, enforcing transparency in contracts and agreements, and penetration of conservation areas for mining. Tensions could also emerge between mining operations and environmental protection or pollution, agriculture and other land-use opportunities (Herbert, 20130). Measures that have mitigated these tensions and managed the pressures include:

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- The formulation of a clear mining policy to ensure transparent and public knowledge of the rules of the game and the country's aspirations for the sector;
- A standard and publicized fiscal regime to reduce the provisions for negotiations;
- A modern legal framework that is comprehensive and contains provisions for community issues as well as national concerns, reconciles environmental and conservation demands and development goals, standardizes fiscal provisions for all, and singles out artisanal mining issues;
- A separate revenue regime for the management of highly unpredictable revenue flows (Herbert, 2013).

2.4 Land as a resources and the need for its good use

Land, as a resource is, or forms part of the basis for the development of each of the other resources. In addition, land is instrumental in the promotion of almost all other sectors. Whether be the discovery of copper, bauxite, gold, iron, oil, water, plant species, wildlife reserves etc., the land plays the key role in this regard. The competition for land by sectors such as agriculture, industry and transport, as well as the protection of water catchment areas, environmental management, hydrology of water on the land surface etc., make it essential to seek a national consensus for a comprehensive land-use and planning policy as soon as possible. In Africa, the existence of several often conflicting policies for land allocation and use has constrained agricultural development, rendered the erection of factories uneconomical, and threatened wildlife reserves (Herbert, 2013). A classic example is the protection of a nature reserve, which is often the prerogative of the unit responsible for parks and wildlife, while the allocation of a mining license is with the ministry of mining. These institutions may find themselves at loggerheads over how to best use the land. However, the unplanned use of land in rural areas by mining or by land grabbing can result in pollution and the destruction of ecosystems. A politically challenging question is how to modernize agriculture while retaining the cultural and traditional ties of communal land ownership? Similarly, unplanned settlements for mining or due to rapid urbanization can create other tensions that clash with overall national economic development goals (Herbert, 2013). Measures that can mitigate land related risks issues and see it as good fundamental resources for national development include;

- Formulating a comprehensive land-use and land-tenure policy after extensive consultations;
- Establishing effective coordination mechanisms for the management of competing demands, such as for building permits, mining rights or property rights;
- Setting up a land registry or offices;

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- Building land administration capacity;
- Establishing an integrated Web-based Geographic Information System (GIS) for land management (Herbert, 2013).
- Establishing non-degradable land procedures to protect the rich lands for activities such as farming, afforestation, management of wildlife's.
- Establishing policies to ensure that lands are for all citizens but will be used in an equitable manner for the benefit and development of the country's economy.

2.5 Water as a resources and human basic need

Water as a resource for industrialization, rather than for human consumption, is a distinction that is useful both for planning purposes and in relation to other developmental goals. Until recently, water pricing for industrial use was not appropriately priced as long as domestic consumption was not affected. Yet energy, agriculture, inland fisheries, hydropower generation and mining all compete for ground and surface water resources. In addition, ecosystem preservation depends on the maintenance of the delicate balance between water availability and quality, and also the hydrological cycle balance (Herbert, 2013).

Water as a basic need is of utmost importance when it comes to human's existence on the planet earth. Plants growth depends on water, human growth and development from infancy to adulthood depends greatly on water. Life cycle and exchange between plants and animals depends solely on water. Therefore, there is the need to keep the hydrological cycle in balance in order to obtain the desired quantity of water in its right proportions for generations to come. Measures to address water include:

- Setting up the appropriate institutional and legal framework for comprehensive water management;
- Building capacity and raising awareness for water resource management at all levels;
- Creating effective monitoring systems for ground and surface water resource assessment (Herbert, 2013).
- Ensuring stakeholder participation when it comes to water resources management locally, nationally and internationally.
- Seeing water as a good and basic need by all hence the need for its good usage and protection at all levels.
- Seeing the relationship that exist between surface water, groundwater and water from above (rain water) and by that, the need to manage and protect the hydrological cycle for its continuity or permanence.

2.6 Oil and Gas as natural resources

Oil and gas is one of the natural resources buried under bare ground or under sea which when discovered, abstracted upstream and processed, refined to obtain products like

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Gasoline (petrol), Paraffin (kerosene), diesel oil, bitumen etc. for national use and development. Tallow oil in Takoradi, Ghana is a good example in this regard generating Billions of Pounds and cedis for Ghana and the international market.

Despite this advantage, conflicting minds and ideas exist on the minds of Ghanaians when it comes to use of this natural resources. Oil and gas bidding rounds are currently more transparent than in the past, with the most recent onshore and offshore block process advertised in the state newspapers and in publications online in some countries. Local partnership requirements in current bidding for onshore and shallow water blocks in Ghana present risks of potential corruption locally because, while there are compelling arguments for ensuring joint ventures with local partners, abuse of similar requirements elsewhere illustrates the potential corruption risk. Hence seeing no need for the natural resources as a result of the youth not seeing its benefit in anyway. If an international company enters into partnership with a local company without knowing its beneficial owner, and the owners turn out to be local officials or politicians, then the international company could find itself in breach of either international or its home country's anti-corruption legislation (Alley, 2013). These are some of the conflicting ideas among Ghanaians when it comes to a natural resource like Tallow oil.

3 RESEARCH AREA

Behind Nanahene – Madam Gyadu's house, Nsutem in the Eastern Region of Ghana is the exact place where this natural resources investigation was done. The research involved feasibility studies by Kaari Borehole to determine spots for aquifer lines, establishment of exact point for drilling and final drilling process to hit water whiles exploring the possibility for other natural resources such as oil, gold, manganese, copper etc. The spot is named Nanehene – Madam Gyadu spot in Nsutem. Nanahene – Madam Gyadu Spot lies at exactly latitude N $6^{o}18^{l}3.1374^{ll}$ and longitude W $0^{o}28^{l}33.11364^{ll}$ at an elevation of 210m above sea level (a.s.l) as seen in **plate 1** below. Nsutem is a community located in the Eastern Region of Ghana and is found on the Accra – Kumasi road serving thousands of people daily as it's the main stop over point for buses and vehicles from Brong and Northern sector to Greater Accra Region and vice versa. It has a population of 70,000 people according to 2021 population census. The indigenous are mainly farmers involved with subsistence farming of which small amount of produce are sold to meet family financial demands. Gold mining is now a major employing working activity in the community which has employed thousands of people and making the town a lively one. The discovery of gold in the community has rendered the community up and going will all kinds of activities making it a commercial zone together with the tourist activities of Linda Dor and Paradise serving thousands of travelers from Greater Accra to the Brong and Northern Sector cities and towns.

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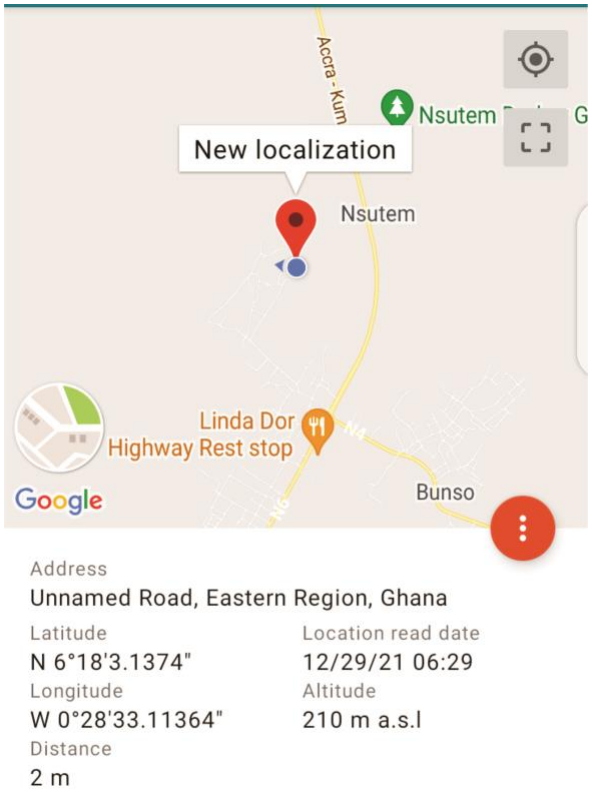

Plate 1: Global Position of the Study Area (*Source: google maps*)

Gold mining activities within the community is developing the community and enriching the young ones financially. This has led to national and international migration as young men and women migrate from within and other countries, towns and cities in search for greener pastures and opportunities. Some of the gold mining companies in Nsutem includes Kibi Goldfields Limited, Nawara Mining Company Limited, BSD Mining Services Limited, CG gold mining Limited etc.

Plate 2: Research field after discovery

4 RESEARCH METHODOLOGY AND DISCUSSIONS

4.1 Research Methodology

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Before underground water can be brought upland for usage, there is the need for drilling, pump installation and abstraction upstream. There is the need for installed pumps to pump water against gravity as the water cannot travel upland from underground. Before all these, there is the need for hydro-geological survey for the proposed site. Generally groundwater is unequally distributed in aquifers and there is the need for surveys to ascertain suitable sites (spots) for exploration of significant quantities of groundwater before carrying out any drilling exercise. The drilling exercise involves;

a. Identification of drilling spot

Every borehole drilling work involves feasibility studies of sites and locations, hydro – geological surveys, identification of exact sites and spots for the borehole work. Kaari borehole through feasibility studies, investigations, site visits and spot identifificaltion and hydro – geological investigations identified Nanehene – Madam Gyadu's Spot as the exact spot to drill and hit a clean water at a given depth for the employed community.

b. Drilling and Metal rod removal (First Phase Drilling)

The first and foremost thing is to remove the overburden soil. With the help of about three metal rods (6m per rod), drilling is done to a depth of 18m for the fitment of metal casing (8intches per metal casing) for further drilling. This is to ensure that, drills can be done to a given depth by preventing contamination of fresh water well zones. It again prevents unstable upper formation from caving in and sticking the drill string or forming large caverns.

There is the necessity for the installation of a stone or gravel pack (which surrounds the borehole screen) and/or to seal off the impermeable layer above the second aquifer. These are all important aspects of the construction of a borehole with a good yield of clear and clean water, which is free of contaminants (Arjen, 2010).

Besides the direct use of drilling logs in the field, drilling logs are also very important to record the hydro geological information of the drill site. For example, if at a later stage other borehole have to be drilled in the same community or area, it is very useful for the drilling team to know the geology, depth of the water table and likely total drilling depth. Previous drilling logs are an essential source of information for these purposes, before the new drilling starts. This information could be important for the choice of the drilling equipment. The drilling logs can be kept together in a file, which is called a database. By taking care to record and preserve good drilling logs, the drilling team will present itself as a professional and skilled team to their clients (Arjen, 2010).

The first step in making a drilling log, is to take representative samples of the soil (geological formations) encountered in drilling. This means: the sample should be a pure piece of the layer that is being drilled at the moment of sampling (avoiding mixing the sample with soil from other layers!). Samples should

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be taken every meter and/or every time the formation (soil) type changes. The samples should be put on a plastic sheet (writing down the depth if the sample is not immediately described), away from the drilling activities. Then described and recorded on the drilling log with the depth at which the soil sample was taken (Arjen, 2010).

c. Fitting of Metal casing

This involves the process of fitting about 3 metal casing (about 18m long) for further drilling with metal rods. A good quality casing pipe and column pipe is indispensable for all of the following reasons; preventing a borehole from caving in due to collapse pressure. It also involves with the stopping of fine sand particles from entering and clogging a borehole. Again, casing is used in maintaining water safety by preventing contaminants and seepage. Along with grout, the casing keeps possibly contaminated surficial water from reaching the aquifer zone underground and prevents contaminants from mixing with the water.

d. Fitting of rod inside metal casing (Second phase drilling)

This is the next phase of drilling. Once the metal casing has been fitted into the drilled holes, the next process is to insert the metals rods into the metal casing each at a time after drilling. At this stage, a metal rod is fitted into the metal casing, drilled until the whole length of metal rod is about 2m above the land surface, then another is fitted again for drilling until another 2m above land surface is obtained. This is continued for all the other metal rods until an aquifer is reached, broken and water hit. During this process, various types of soils, rocks and if possible other natural resources like oil, gold, copper, bauxite, Manganese and other precious minerals are drilled through. This process is continued until water is hit at a given depth (as will be seen in the discussion).

e. Removal of rods and Casing after hitting Water

Once water is hit within an aquifer at a given depth, the next process is to remove the metal rods. Metal rods totaling 80m are removed from the borehole one after other to make way for the installation of PVC pipes. This should be sequentially and gently removed in order to prevent borehole from caving in even though the metal casings are serving this purpose.

f. Fitting of PVC Pipes

Removing metal rods from metal casing is to make way for the fixing of PVC pipes from hit aquifer to the land surface. The materials used for this process is the PVC pipes. During this process, a total length of 80m long PVC pipes are fitted indicating the total length drilled before hitting water underground or within an aquifer.

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g. Borehole screen/Sanitary Seal installation

This involves the pouring of rocks chippings and gravels into the borehole around the installed PVC pipes close to the hit water underground in order to obtain clear clean water void of contaminants during abstraction to the surface. This is called the fixing of screen. According to Arjen (2010), the screen usually does not exceed a length of 6 meters, for manually drilled boreholes. Fine materials are often present in the extreme upper and lower parts of an aquifer. Also thin clay layers might exist in the aquifer. To prevent the fines (which may cause turbidity and pump damage) from entering the well-screen, it is important NOT to install the well screen at the same level as these fines in the aquifer. In other words; be sure that the whole screen length is installed in a permeable layer, consisting of sand or gravel (Arjen, 2010).

It is essential to install a sanitary seal if the Borehole needs to yield good quality water (Arjen, 2010). The sanitary seal can consist of cement or bentonite pellets (the volume of the bentonite pellets will increase many times when it gets wet, and so it seals the hole by expanding). Also natural swelling clays can be used, but they are more difficult to handle than processed bentonite. In many countries, bentonite pellets are expensive. In these cases it is recommended to use a cement-water mixture (cement grout). The water and cement are mixed until a thick slurry is created (26 liters of water to one 50 kg bag of cement will make about 33 liters of cement grout). If cement grout is used as a sanitary seal, first a half meter of clay should be backfilled on top of the gravel pack to prevent the grout from penetrating the gravel pack (Arjen, 2010).

h. Removal of metal casing and filling with gravels /stones

At this point, all the metal casing used in supporting the metal casing for stability during drilling, avoiding collapse of soil and helping in installation of PVC pipes are removed. This is done gently and sequentially to avoid collapse and any eventuality.

i. Filling around installed PVC pipes for compactment

This involves the collection of drilled soil, gravels and stones to fill around the installed PVC pipes in the borehole. This is to ensure stability of the installed PVC pipe within the borehole and also for its compactibility within the borehole. This process ensures that the installed PVC pipe is seen as part of the soil and not a loose material fixed inside the soil.

j. Fixing of water pump.

The final stage of the whole process is the fixing of an electrical pump to abstract the water from underground in aquifers to the land surface for storage in polytanks and use. For good borehole operation, the best options for borehole development are electrical pumps and airlifting. However, these pumps are expensive but to meet the requirement of a

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maximum flow rates, electrical pumps are used. Once the pump is perfectly installed and connected to an electrical source, water will be abstracted to the land surface whenever the pump switch is switched on from the electrical source.

4.2 Research Findings and Discussions

4.2.1 Aquifer detection lines for maximum Water

The word 'aquifer' in simple terms means 'a water bearing layer'. A good aquifer for the installation of borehole – screen is a permeable layer below the groundwater table in rocks. During drilling, Kaare Borehole came across different aquifers (unconfined) at different depths, separated by impermeable layers. These areas gave some amount of water but not in high quantity to be abstracted for longer years hence the need to go further down for maximum quantity of water within a specific aquifer. Most of the aquifers found within the initial drilling are unconfined or phreatic aquifer.

That is, the upper aquifer is called the 'phreatic' aquifer. Rainwater directly infiltrates the soil during rainfall. The water moves down and when it reaches the water level it is added to this aquifer. The water can take contamination (such as bacteria or pesticides) down into the groundwater. Therefore an unconfined aquifer is prone to pollution from activities taking place on surface of the land or within surface water bodies. Phreatic groundwater exists in a permeable layer above an impermeable layer. If this phreatic groundwater layer is just a few meters thick, it may run dry during the dry season, leaving your well empty.

The next aquifer, covered by an impermeable layer on top (for example, a clay layer) is called the confined aquifer. The impermeable layer above this water bearing layer forms a barrier for bacteria and pollution and prevents them from traveling down to the second aquifer. Water was hit within a confined aquifer at a depth of 80m by the drilling team and abstracted by pumping to land surface for storage and use by the community.

4.2.2 Drilling through soil and rock layers

To obtain water, it's either by rain water, surface water or water from underground moving within aquifers. Ghana as country have almost all of its surface water sources destroyed due to illegal gold mining activities within the country. This has resulted in most people, installing borehole water in the homes and communities. This is the main reason for the need for another borehole for the Nsutem community as it's one of the communities whose rivers (Birim and Supong) have been destroyed due to illegal gold mining activities within the community.

Drilling to hit water within an aquifer is in stages. Each stage is composed of soil structures or rock layers within the land being drilled for water within a given aquifer.

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An essential quality of the professional drillers is their ability to recognize and describe different types of soil (formation material) encountered during the drilling behind Nanahene – Madam Gyadu's house Spot. For the classification of the different particles in a soil sample the following table can be seen in **Table 1**.

Table 1: Soil structure type and particle size

Soil Structure Type	Particle Size
Clay	<0.004mm
Silt	0.004mm – 0.06mm
Sand (Fine, Medium, Coarse)	0.06mm – 2mm
Gravel and pebbles	2mm – 64mm
Stones and Boulders	>64mm

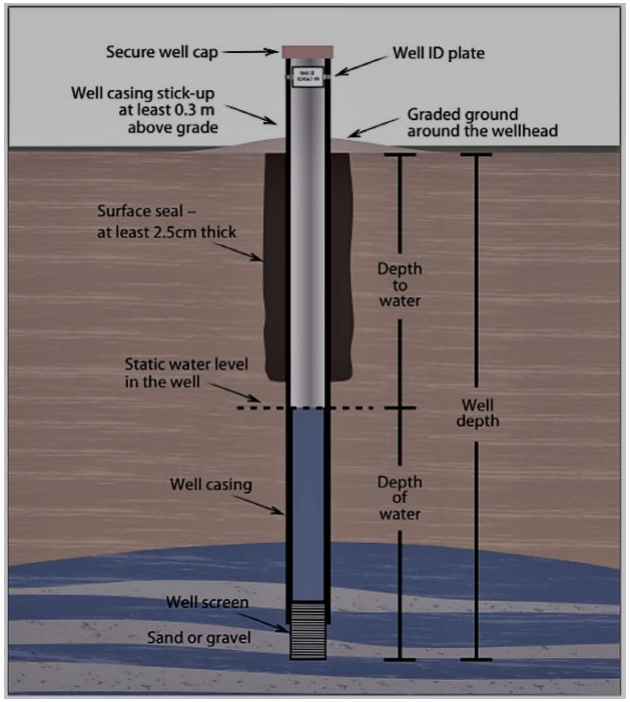

Plate 2: Well-designed Borehole for water abstraction upland without pump (*Source: www.google.com*)

4.2.3 Hitting water for use

Hitting water for use implies the process from drilling through soil and rocks and getting to water in huge amounts within the confined aquifer for abstraction upland for storage and use. The drilling team embarked on series of drilling through different layers of soil structures, rock layers, gravels, stones, water within unconfined aquifers before finally hitting quality

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clear water in huge amounts within a confined aquifer. With the help of metal casing, 36m long different metal rods were arranged sequentially and used for the drilling until an 80m depth water moving within confined aquifers was hit. This was indicative when clear underground water was gushing upland through the metal rods at the time water was hit within the aquifer. Observation gave muddy water at the beginning and clear water later on representing the dugged muddy areas drilled during the process. Metal rods were removed and 80m PVC pipes fitted with screens, metal casing removed, electrical pump installed and water abstracted upland for storage in polytanks and used by the community.

4.2.4 Natural Resources assessment

The first natural resources of focus here is the water. According to the Dublin principle, water is an economic good. Since the Dublin conference on Water and the Environment in 1992, this notion has been widely accepted among water resources managers. Besides being directly consumed by humans, water is an important production factor, in the broadest sense, and it is scarce. Hence seen as an economic good and natural resources. This natural resources and economic good was obtained when drilling hit water within a confined aquifers at a depth of 80m underground. This was after several hours of drilling and investigations with metal rods fixed within metal casing moving though different soil types and structures, rocks and stones. Clean clear water was seen gushing out of the ground from aquifers when this depth of 80m was achieved by the drilling team hence obtaining the first natural resources. Other natural resources which were of focus was gold and crude oil. Natural resources investigators on site were seriously observing the drilling process as different types of soil and rock dust were collected at even distances and times, observed for traces of gold dust or crude oil. Fine structures of soil types such as clay, silt, coarse sand, dusty rocky samples, stone dust were all observed to ascertain if deposits of gold can be seen. Water from unconfined aquifers was also observed at given depths for possible deposits of crude oil. A fine oily nature watery substance was critically observed during the monitoring and observation period. The oily liquid substance gives a clear indication of oil deposits buried underground which requires further probing, investigation, verification, validation and if true, the defined deposited amount. And if quantified by well verified research probing, mined and processed for national and international use. By this, Ghana's economy, international economy will be boosted in all directions of oil benefits to mankind. The Nsutem community will also grow economically as thousands will be gainfully employed with all kinds of developmental projects coming to the community.

5 CONCLUSION

Every countries growth and development depends mainly on the discovery of natural resources, its mining and processing

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into consumable products and Ghana is no exception. Water as an economic good as defined by the Dublin principle is one of such natural resources. The destruction of Ghana's surface water bodies has resultant citizens sorting to underground water hence the use of borehole drilling machines to mine water from aquifers underground to overland for storage and use. This research work which sorts to discover water which is an economic good and natural resource for human usage in all endeavors also sorts to investigate the possible existence of other natural resources such as gold, oil, bauxite, copper, Manganese etc. Research work and procedures gave a clear clean water buried underground in aquifers at a depth of 80m. This was finally abstracted from underground by pumping through PVC pipes installed in the soil to upland and stored in polytanks for human use by the indigenous of the community. Further probing and observation gave observable results of traces of oil buried underground which needs further investigation and research for its validity, and if true the approximate quantity buried in the ground for exploration and refinement or processing for the benefit of the country. With these results, it is justifiable that borehole drilling in search of water which is a natural resource, is best fit method for exploring and investigating other natural resources like gold, oil, bauxite, Manganese etc in Nsutem and Ghana.

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