INVESTIGATING THE FEASIBILITY OF IMPLEMENTING E-VOTING SYSTEM IN GHANA

Samuel Agbesi[1], Fati Tahiru[2], and Alexander Osei-Owusu[3]

[1]Information Technology Masters Student,
Kwame Nkrumah University of Science and Technology,
Kumasi, Ghana

[2]Information Technology Masters Student,
Kwame Nkrumah University of Science and Technology,
Kumasi, Ghana

[3]Research Coordinator, Graduate School,
Ghana Technology University College,
Accra, Ghana

ABSTRACT: E-Voting has been attracting a lot of interest in the country and has been a subject for discussion in various media during the past years after elections. The current method of voting during general elections in Ghana is through paper base voting which comes with a lot of problems ranging from delay in voting resulting in long queues, double voting, result manipulations, spoilt votes due to wrong thumb-printing and delay in declaring results. To study seeks to investigate the feasibility of e-voting implementation in Ghana. The findings of this research will likely generate greater awareness about the e-voting system in Ghana and also provide useful knowledge to stakeholders about the benefit of e-voting system and also provide useful knowledge in policy formulation concerning Ghana elections. The study adopted mainly exploratory and descriptive analysis as well as a combination of qualitative and quantitative data collection approaches. Purposive and simple random techniques were used in selection and administering of questionnaires to employees of Electoral Commission and the voting population from selected regions in Ghana. The result of the findings shows that for e-voting system implementation to be successful, Government must show strong commitment to provide support by securing donor fund to improve on the existing infrastructure and provide the needed resources to support the successful implementation. The study also shows that Government need to improve infrastructure in most part of the country and Electoral Commission should also embark on educating the people on e-voting and creating awareness. It was recommended that e-voting for now should be implemented on pilot basis and run alongside paper voting until infrastructure is available nationwide.

KEYWORDS: E-Voting, DRE, I-Voting, EC, GEVS.

1 INTRODUCTION

Electronic voting, also known as **e-voting**, is a term which includes several different types of voting, that is electronic means of casting a vote and electronic means of counting votes. An electronic voting (E-Voting) system is a voting system in which the election data is recorded, stored and processed primarily as digital information. Sanjay et al (May 2011) also define e-voting as any system where voters cast their vote using an electronic system instead of paper ballot. Sanjay further explained that this electronic vote which is stored digitally is transferred from voting system to a counting system. E-Voting can be seen as a better form of voting as it eliminates several drawbacks in the traditional voting system. But Randolph C (2004) explain that even though e-voting system plays important part in the general election process, there are several other important factors that will contribute to the overall success of an election and this include processes, people and technology.

The current method of voting during general elections in Ghana is through paper base voting which comes with a lot of problems ranging from delay in voting resulting in long queues, spoilt votes due to wrong thumb-printing and delay in declaring results. Ghana has held eight (8) successful presidential elections after independence, but always issue of vote rigging and the credibility of the results becomes an issue. **(**Nana Karikari-Apau, 2012). These concerns arise from the fact that people don't have trust in the current paper base voting system. The current paper base system is perceived to give room for manipulation of votes by officials at various polling stations and also at the collation centers.

Also other issues faced with paper-based voting in Ghana are the perception of political opponents stuffing the ballot boxes with already voted ballot papers, and delay in counting after vote has ended. These concerns are the main initiator for the investigation into a possible electronic voting system implementation for subsequent elections in Ghana. As stated in Aviel D. Rubin (February 27, 2004) report, elections allows the citizen to select their people who they deem fit to represent them. Naturally, the integrity of the election process is fundamental to the integrity of democracy itself. He further stated that any system that is design for election must be a system that can withstand any attack, and also must be a system which the voters can accept and the various candidates can accept the election results without any dispute. But most often elections are being manipulated in order to influence their outcome. The researcher in this light intends to research into the feasibility of adopting e-voting system in Ghana national elections, and identify any potential challenges and benefits of e-voting implementation, and to determine if available ICT infrastructure can support nationwide e-voting implementation.

Several research works has been carried on E-Voting to remedy the problems associated with normal paper base voting in various countries. Most countries and politicians are proposing for some form of electronic voting system and they see a lot of possibilities in this new phenomenon. Their arguments is on the fact that E-voting will be the cheapest more efficient and quickest way of managing elections as well as vote counts. They also argue that it will increase voter turnouts and reduce the long queues during voting periods (Stănică-Ezeanu, C. "e-Voting Security", 2008). In addition, Kim K (2007) explains in his article that e-voting using internet does not require geographical proximity so far as you have internet access you can vote anywhere. E-voting system are used for elections in various countries with the sole aim of reducing voting errors such as thumb printing wrongly to invalidate the vote and to make counting faster after votes has ended (Sanjay Kumar et al, 2011). Hence implementation of e-voting in Ghana elections will aid in minimizing elections irregularities and voting populace and the various political parties will have faith in the elections results. The researcher's main concern will be to discuss the feasibility of the implementation of voting electronically using a dedicated machine at polling stations or in controlled environment termed as a Direct Recording Electronic (DRE) voting systems and remote voting via Internet termed as I-Voting.

Direct Recording Electronic (DRE)

DRE voting system as define by Dieterich, E. is any computer device that consists of a touch-screen monitor, a permanent storage medium such as a write-once memory card, and software, Congressional digest report (November 2006) by Eric A Fischer also explain DRE as any computer device that records votes directly onto a computer memory device. Randolph, C. (2004) explained that DRE voting systems was first introduce in the 1970's where votes were recorded electronically without paper ballots, and about 12% voters used this technology in 2000 US elections and 29% in 2004 elections. Furthermore he did point out that DRE comes in two types, that is the push button and the touch screen with the latter being the latest technology. Ballot information is displayed electronically on the screen which allows voters to make their choice of candidate to vote for. Ballot information or the voting program is programmed onto a chip or a storage medium which is installed into the DRE machine. Randolph, C, (2005), further stated some of the latest DRE systems use a smart card that can be used by voters for authentication. DRE voting system records votes and after voting, produce a tabulation of all votes cast stored on an internal memory. It can also provide means of transmitting the vote cast onto a central location via public network. Even though DRE system offers a lot of benefits there have been several debates about exiting security vulnerabilities and hence has recommend for the DRE system to provide paper printout after voting to confirm that their vote were cast correctly to prevent any voting fraud (Congressional Digest. Nov, 2006), and this approach was termed as VVPAT (Voter-verified paper audit trail).

Dieterich, E. also expressed similar concerns, he stated that DRE systems are subject to various risk notable among them are:

- Software errors that can affect the voting pattern which can bring the whole election process into a halt
- Fraud – whereby a fraudulent code when install into the machine can compromise the vote cast to favor one candidate

But Eric A Fischer was with a different opinion. He was of the view that even though some researchers has raise some security concerns about DRE, those security flaws are not known to have compromise any elections and also has not affected any elections integrity. He further stated that there are different models of DRE in current use and they vary substantially in

their design, hence any problem that may exist in one model may not occur in others. He argued that most of these problems are procedural but not weakness in the technology. He was clear that most of the elections problems encountered in the 2004 US elections were not associated with DRE's (Eric A. Fischer, 2005).

Remote Voting System Using Internet (I-Voting)

Another area of e-voting that has gain lot of discussion is Internet Voting known as I-Voting. I-voting can be defined as a remote voting process through the internet from an unsupervised location. Gibson (2002) also defines I-Voting as a process of casting a secure and a secret electronic ballot that is transmitted over the internet to officials. As further stated in Gibson (2002) research, I-Voting is a new phenomenon which has not being used in legally binding elections until 2000 when Arizona Democratic Party held its primary election online. Several research works has gone on in this area and more academic scholars are still researching into it. Notable among them are Mohammed Awad, Ernst L. Leiss, (2011). They believe that I-voting can provide ease to elderly citizens and people with disabilities. Also their believe is that the convenience that the internet offers will attract young voters, and hence increase voter turnout.

But the main issue with I-Voting had to do with security. Various researchers believe I-voting can be considered as another voting option if it can provide same security as the main traditional voting methods (Mohammed Awad, Ernst L. Leiss, 2011; Jefferson, D., Rubin, Aviel D., Simons, B., Wagner, D, 2004). They doubt that the current internet infrastructure is cable to support this option of e-voting. Even though I-Voting has become a major discussion subject in the Information Technology field, but because of public distrust of I-Voting (Internet Voting) and various security threats associated with it various countries that tried to implement it are taken a second look at it. In 2004 the US Department of Defense canceled their internet based voting system called SERVE (Secure Electronic Registration and Voting Experiment) because of security concerns raised. (Jefferson, D., Rubin, Aviel D., Simons, B., Wagner, D, 2004).

SERVE is an internet-based voting system built for the US Department of Defense FVAP (Federal Voting Assistance Program). FVAP's mission was to reduce voting barriers for all citizens of US oversee, that is US military service personnel and their families and non-resident US citizens. SERVE has much vulnerability and security threats, notably among them are Cyber-attacks (DOS attacks, spoofing, and virus attack on voter PC), any of these attacks can put the voting into disrepute. With internet voting also there is a great risk of outsiders hacking into the system as well as enemies, there could be vote buying and selling as well as reversing an outcome of an election (Jefferson, D., Rubin, Aviel D., Simons, B., Wagner, D, 2004).

2 OBJECTIVES

The main objectives of this research is to investigate the feasibility of implementing e-voting system in Ghana's national elections.

The specific objectives are:

- To identify the potential benefits for e-voting implementation.
- To identify potential challenges of e-voting system implementation.
- To determine whether the current ICT infrastructure can support e-voting
- To investigate whether e-voting will be the preferred voting technology by voters.

3 METHODOLOGY

For this study the researcher adopted descriptive and exploratory research methods. Descriptive research method was selected because it will help to have a clear picture of the phenomena on which data will be collected. With descriptive research the researcher gathered fact about events through surveys and observations. The aim of this research is to investigate e-voting system and their suitability for national elections and also to identify the likely challenges for e-voting implementation and potential benefits, hence descriptive method was the appropriate method since it allows both quantitative and qualitative data collection and data analysis. For this research the researcher analyzed case-studies of various electronic voting systems from various countries to have deeper understanding of how it works, its security implications, challenges and benefits. With Exploratory method, the researcher also reviewed literatures on the subject area and conducted interviews with EC staff to clarify his understanding of the e-voting adoption requirements. Experts in the area of e-voting were interviewed, this include the research department of the Electoral Commission (EC), IT department of EC and Technical department of Expresso Telecom GH.

Both quantitative and qualitative data collection and analysis techniques was used. Qualitative techniques was first used to gain in-depth understanding of the problems associated with voting by interviewing top EC officials and to get their views

on the adoption on e-voting. Secondly since the researcher want to get the opinion of a larger population of voter's quantitative methods through questionnaires was appropriate. The quantitative method help the researcher to obtain responds from a larger sample from the population of interest and this also gave the respondents ample time to respond. The population for this study consists of the entire group of eligible voters across Greater Accra, Central, Western, Eastern, Ashanti, Volta and Brong-Ahafo region who are 18 and above, and are citizens. It also include Top management and Technical staff from Electoral Commissions, and Network/Software engineers from Expresso Telecom.

The sampling method adopted for this study was simple random and purposive sampling technique. Simple random sampling techniques gives each member of the population an equal chance of being chosen and this helped achieve the needed information (Neville, H., Sidney,T. 20 June 2005). Purposive sampling allows the researcher to select the particular participant for specific information needed. The researcher adopted this sampling method for the selection of EC top officials and other staffs who has direct relation with the organization of elections as well as selected staff of Expresso telecom with ICT background. The sample size was 278, which comprised of voters from Greater Accra, Ashanti, Central, Eastern, Western, Brong-Ahafo and Volta region, as well as Top management and technical staff of EC head office in Accra as shown in Table 1.1. These companies were grouped into departments and units and specific staff base on their knowledge in specific fields were selected and interviewed, and others were randomly selection to responds to the close-ended questions. Qualitative and quantitative procedures were used to analyze the data collected during this study. The Statistical Program known as **SPSS** was used to analyze the quantitative data which was generated from the questionnaires and the result was presented in tables using frequencies and percentages. Microsoft Excel was used to generate graphs from the results of the respondents.

Table 1.1 – Questionnaire distribution to EC and Voting population

	Top management, Research and Technical Department of EC Office Accra	Voting Population
Number of questionnaires distributed	22	300
Number of responses	22	256
Response rate (%)	100	85.3

4   RESULTS AND DISCUSSIONS

This section presents the results of findings and analysis of the field data in line with the research questions and objectives. The findings have been analyzed in frequency tables and charts.

Objective 1: To identify the potential benefits for e-voting implementation

From figure 1 and figure 2 below, the potential advantages has been grouped and ranked and it can be observed that the highest rank of the benefits are e-voting eliminating voting errors, eliminating delays in vote counting and speeding up voting process.
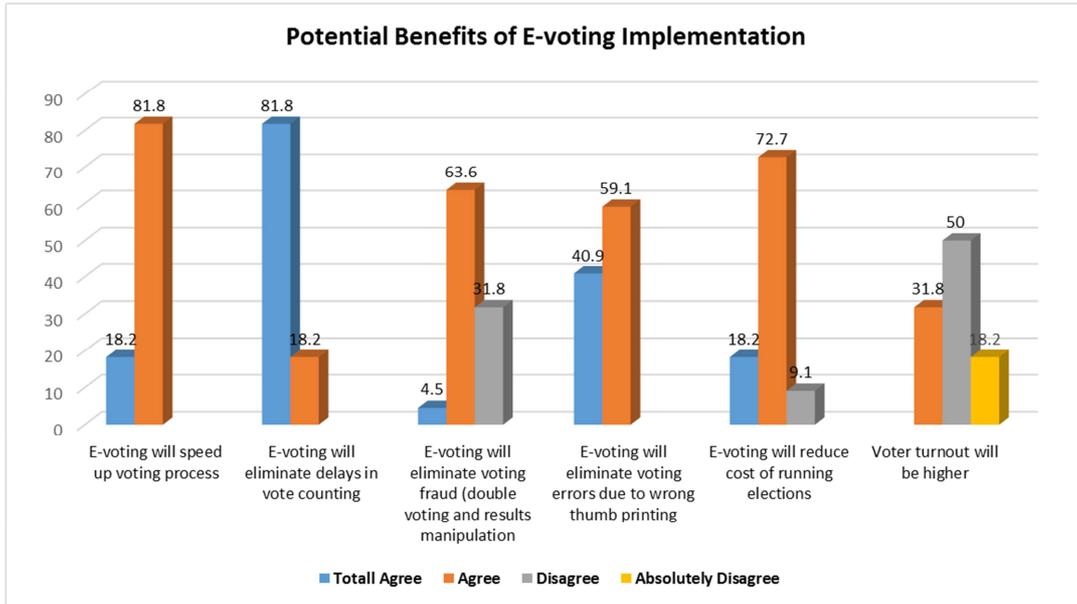
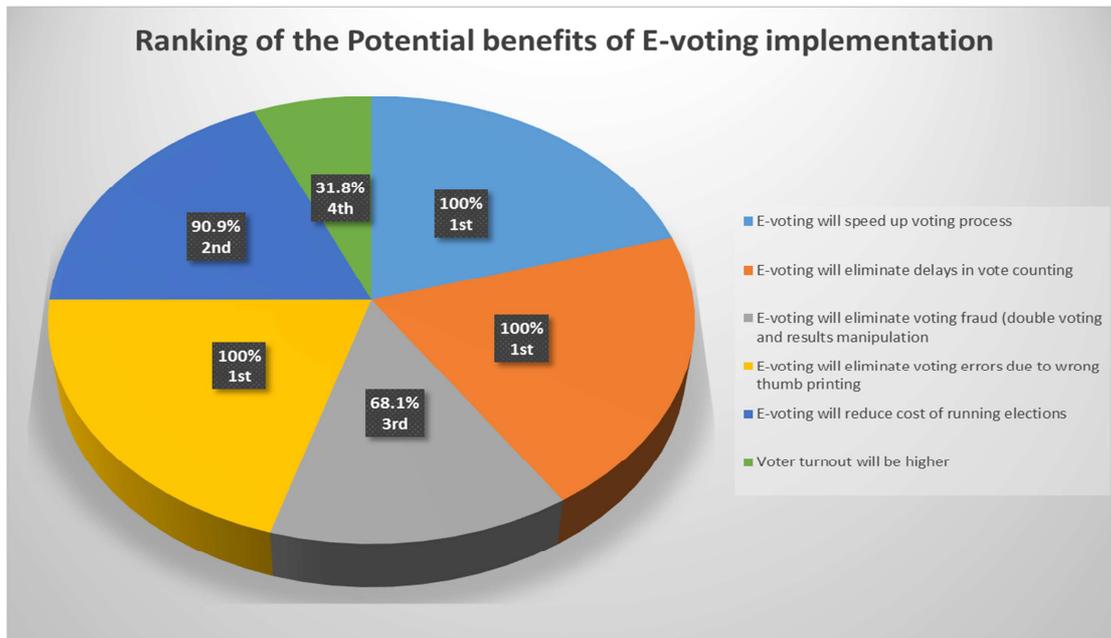*Figure 1- Potential Benefits of E-voting Implementation (Source: Fieldwork, 2013)*

Figure 2 - Ranking of the Potential Benefits of E-voting Implementation (Source: Fieldwork, 2013)

Objective 2: To identify potential challenges of e-voting system implementation

The challenges has been grouped into technical challenges and general challenges. Figure 3 and 4 shows the technical challenges that are likely to surface if e-voting is implemented. Base on the ranking it was obvious that power outages to disrupt elections has the highest ranking. This is due to the fact that most of election polling centers has no efficient electricity power. This was followed by Security issues and unstable communication link on Election Day.

For the general challenges as shown in figure 5 and figure 6, it can be observed that the challenges raked highest is the difficulty of the use of the e-voting system due to higher illiteracy rate in the country, this was followed by how voters will confirm their vote cast and the cost of the e-voting implementation.
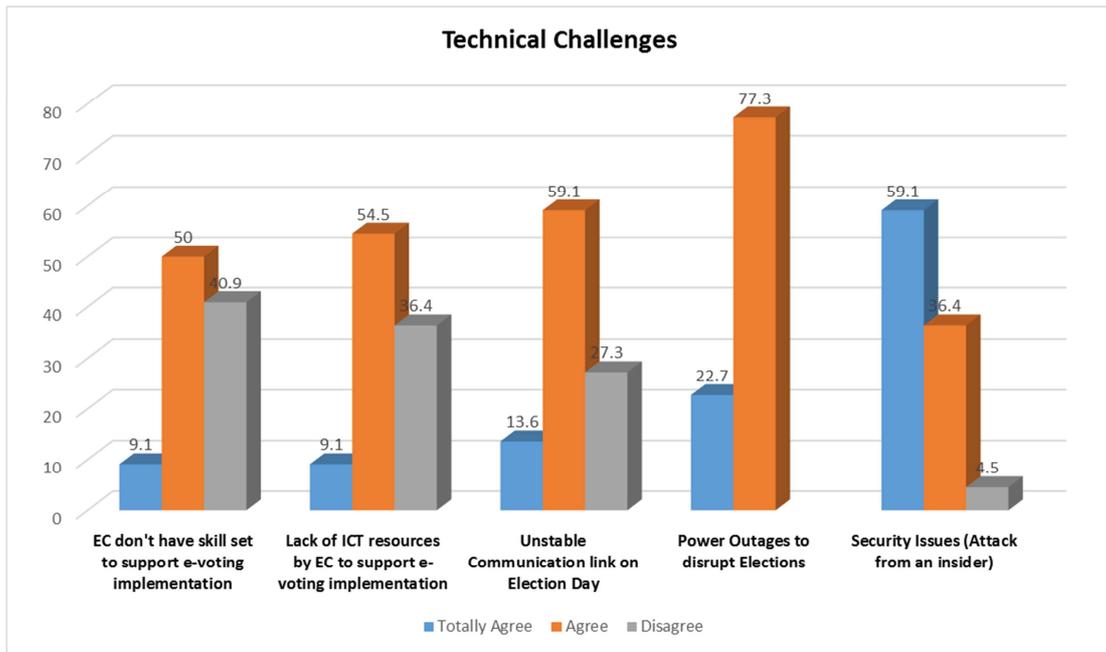
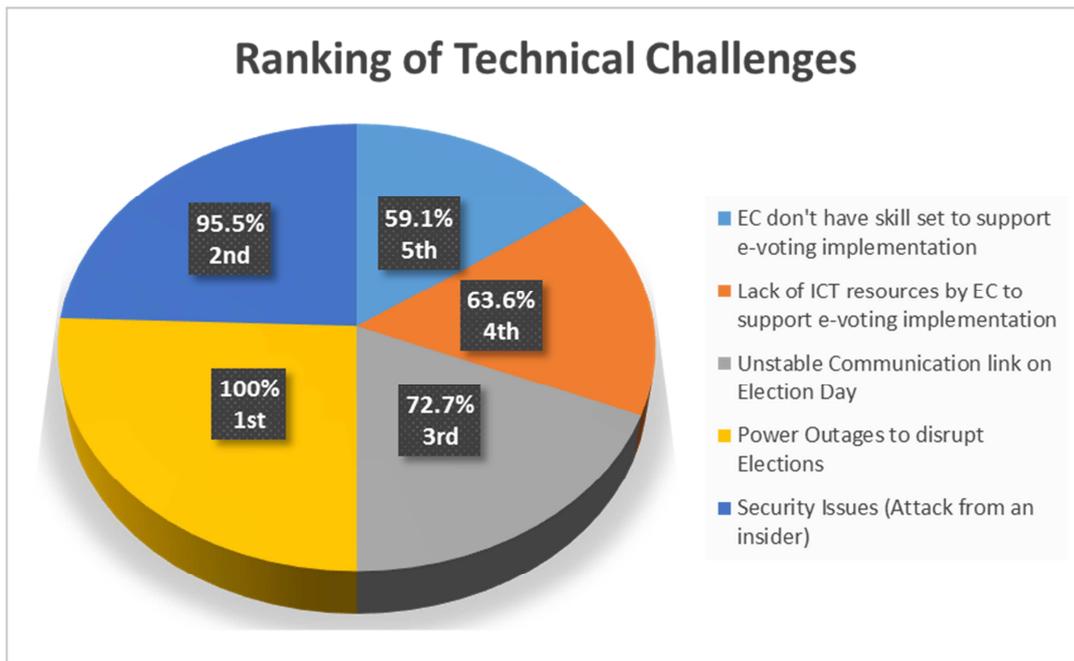*Figure 3 – Technical Challenges (Source: Fieldwork, 2013)*

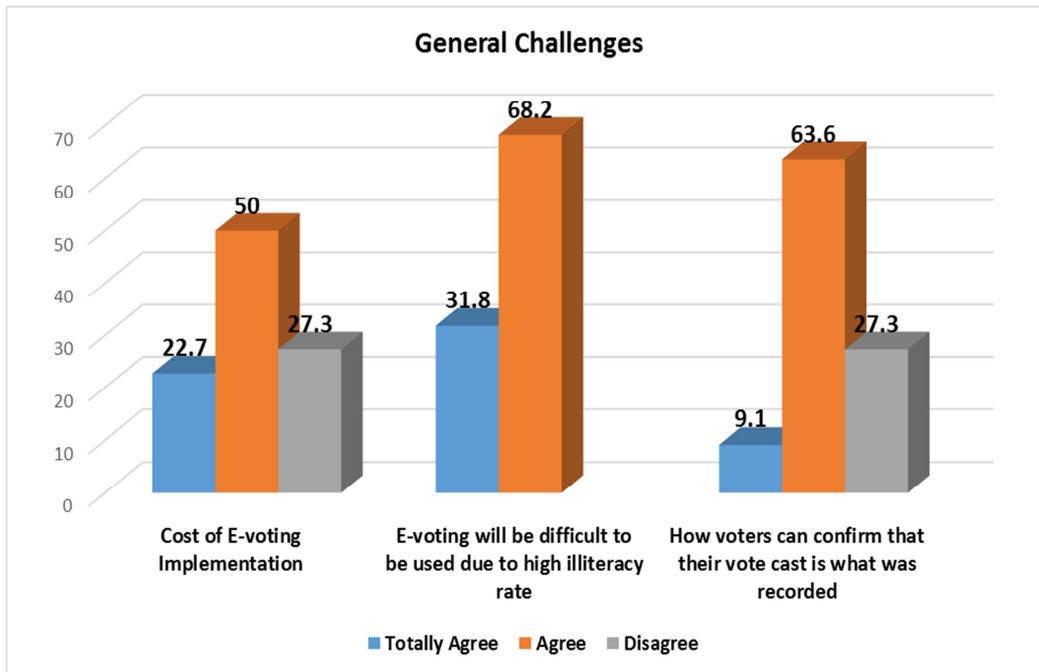*Figure 4 – Ranking of Technical challenges (Source: Fieldwork, 2013)*

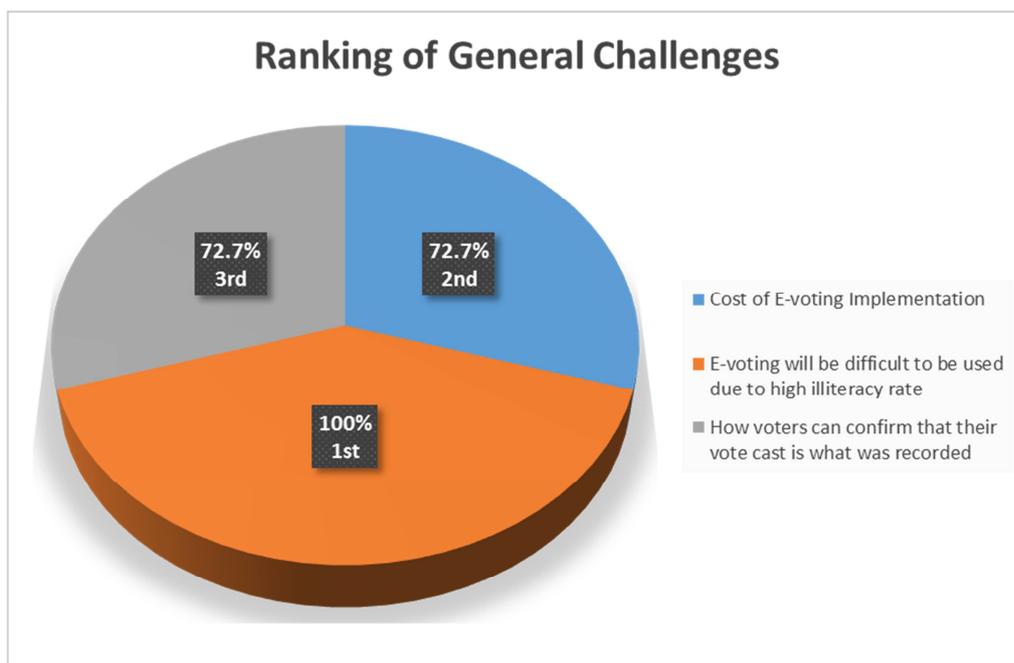*Figure 5 - General Challenges (Source: Fieldwork, 2013)*

Figure 6 – Ranking of general challenges (Source: Fieldwork, 2013)

Objective 3: To determine whether the current ICT infrastructure can support e-voting

From figure 7, it is believed that the current ICT infrastructure cannot support nationwide e-voting implementation. The electoral commission believes that this infrastructure have to be improve to allow for nationwide e-voting adoption.
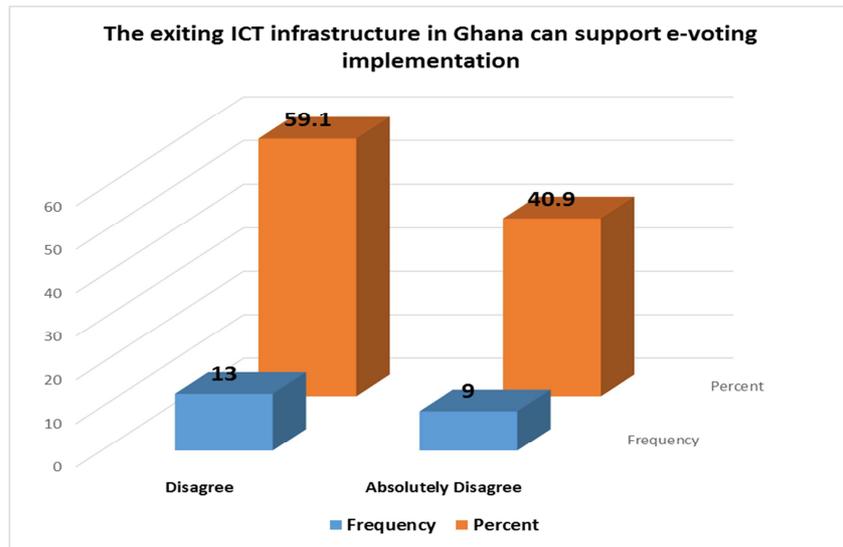
Figure 7 - To determine whether the current ICT infrastructure can support e-voting (Source: Fieldwork, 2013)

Objective 4: To investigate whether e-voting will be the preferred voting technology by voters

From figure 8 below, it can be observed that the voting populace are willing to use e-voting technology in casting their votes as a total of 78.9% opted to use e-voting instead of paper-based voting
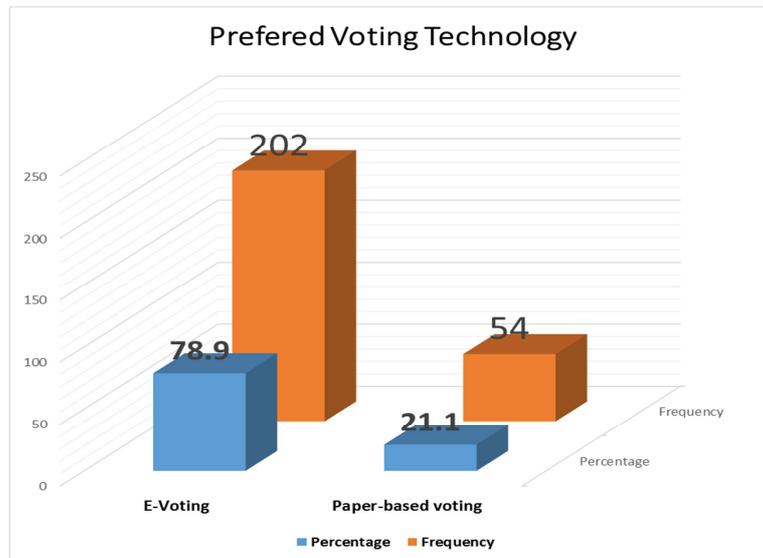

Figure 8 – Preferred Voting Technology (Source: Fieldwork, 2013)

5 OBJECTIVE NON-QUALITATIVE EVIDENCE (EXPERIMENT CONDUCTED)

The experiment consist of participants voting using GEVS DRE and also voting with paper ballots. The participants were first introduce to how the GEVS system work by taking them through the various interfaces for each slot. They were also taking through the manual (paper) voting steps. Participants were purposively selected based on their age, education and computer experience. A 5-point likert scale was used to assess self-rated computer experience with 1 representing a novice and 5 representing expert. A total of 31 participants were involved in the experiment and their ages range from 20-70 with a mean age of 37.48 years with a standard deviation (SD) of 14.66 (table 1). All the participant had previous voting experience.

Table 1 - Mean Age

Age

N	Valid	31
	Missing	0
Mean		37.48
Std. Deviation		14.651

The DRE used was the GEVS system created by the researcher, and the ballot papers were with the same candidates as in the GEVS system for both presidential and parliamentary interfaces. The System Usability Scale (SUS) was used to assess the subjective user experience with the GEVS and the Paper ballot voting methods. In addition a survey questions were answered by each participant after voting. Each participant were instructed to vote for specific candidates as agreed upon for both presidential and parliamentary. Participants cast two ballots, one with GEVS DRE and another with paper-based voting system. The SUS was administered after each ballot was completed.

Evidence 1 – E-voting will speed up voting process

For both GEVS DRE and paper ballot, the completed time was measured from the time the participant entered the voting booth and ends at the time the participant exit the voting booth. The average ballot completion time for GEVS (Table 2) was 54.6 seconds (SD=10.15), while the average ballot completion time for paper voting (table 3) was 95.7 seconds (SD=8.7).

Table 2– DRE Completion Time

DRE completion Time

N	Valid	31
	Missing	0
Mean		54.6129
Std. Deviation		10.14783

Table 3- Paper Completion Time

Paper Vote Completion Time

N	Valid	31
	Missing	0
Mean		95.7419
Std. Deviation		8.70237

Completion time for GEV and paper is shown in Table 4 shows a mean Paper vote of 95.74 seconds (SD=8.7), and a mean DRE competition time of 54.61 (SD=10.15)

Table 4 - Paired Samples Statistics for DRE and Paper vote completion time

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Paper Vote Completion Time	95.7419	31	8.70237	1.56299
	DRE Competition Time	54.6129	31	10.14783	1.82260

Paired t-test shows a statistical reliability between GEVS DRE and Paper voting, t=22.3, p=0.01. Another observation from the experiment shows that participant who rated themselves higher in computer experience took less time to vote on the DRE than those with less compute experience (Figure 9).
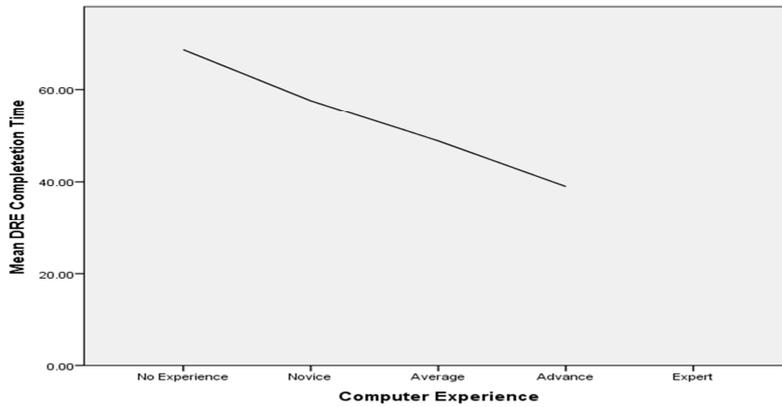
Figure 9 – Average DRE ballot Completetion time by computer expertise

Evidence 2 – E-voting will reduce voting errors

Errors

In this experiment paper based voting errors is define as:

- Wrong thumb printing
- Voting more than one candidate
- Ballot without thumb print
- Voting for wrong candidate (voting for a different candidates as compared to what was agreed on)

For DRE, errors were defined as:

- Voting for a wrong candidate
- Incomplete voting process

Out of the 31 ballots counted for paper-based voting 4 representing 12.9% had error, with mean error rate of 0.13 (SD= .34). These errors were combination of wrong thumb printing, and multiple thumb printing on ballot paper. For DRE, out of 31 voters who cast their vote electronically only 1 representing 3.2% had errors with mean error rate of 0.03 (SD= .18). The only type of error encountered was a voter not completing the vote after the vote summary was displayed.

Evidence 3 – E-voting will be the preferred voting technology

Subjective Usability

The average System Usability Scale (SUS) scores in terms of the satisfactory level of the two voting methods is presented in table 5. The satisfactory level of the voting methods were rated from 1 to 10, with 10 being the highest satisfactory level.

Table 5 – Mean Scores between DRE and Paper Voting

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	DRE Satisfaction Rate	8.0968	31	.59749	.10731
	Paper Satisfaction Rate	4.2581	31	.72882	.13090

DRE mean scores were reliably superior than paper base, with a mean score of 8.1 (SD= .60) and paper mean score of 4.26 (SD = .72)

In comparing the GEVS DRE against the Paper-based system, there were differences between the two in terms of efficiency, effectiveness and satisfaction. But the major difference were seen in the satisfaction level of the use of DRE against Paper voting. Participant preferred the use of the DRE system to Paper-based system. It was also observed that participant with less computer experience waste more time in voting, but this does not affect the satisfaction level of the DRE system.

6 MAJOR FINDINGS

The results from survey, experiments and the interviews conducted with the EC official's shows that e-voting implementation in Ghanaian elections is feasible, and also the survey also revealed that there are problems in the current paper-based voting and e-voting technology can reduce these election problems and irregularities. The study further reveals that the potential challenges that are likely to impede the adoption and implementation of e-voting in Ghana will be that lack of adequate infrastructure, high illiteracy rate among voting populace and security issue. It was further reveal that the existing Infrastructure in Ghana cannot support nationwide e-voting implementation for now. EC believes that governments must show strong commitment and support by securing funds through donor organizations, to provide the necessary IT infrastructure and other resources needed to support the e-voting implementation. There were some suggestion that, e-voting can be introduce as pilot project for political party elections, and it will help the EC to identify any challenges and find ways to mitigate it.

7 CONCLUSION

From the case studies, the survey and the experiment conducted in the preceding chapters, the researcher can conclude that E-voting can reduce the irregularities and problems associated with our paper-based voting and voters will prefer to use e-voting system to paper technology. Electronic voting system adoption and implementation in Ghana is possible, but the necessary infrastructure must be available and voter education must begin now. Also EC can begin to implement e-voting system for political party's elections, this will help the commission to identify any potential challenges and find ways to mitigate those challenges.

8 RECOMMENDATION

E-voting should be introduced on pilot basis and should run alongside manual paper voting until such a time where we will have adequate infrastructure spread across the entire country. Most Ghanaians in the rural areas need to be educated on the use of the system as well as general computer literacy, and EC should create the awareness of e-voting using the print and electronic media. EC with support from the Government should introduce a new type of Identity Card (ID card) or smart-card for registered voters that has an embedded chip similar to what Estonia is using. This chip should have security features that can be used to encrypt electronic vote for online transmission and also to authenticate the voter.

REFERENCES

[1] A Comparative Assessment of Electronic Voting (http://www.elections.ca/content.aspx?section=res&dir=rec/tech/ivote/comp&document=benefit&lang=e) (accessed 10 August, 2013)

[2] African elections database, (2007). (http://africanelections.tripod.com/gh.html#1960_Presidential_Election) (accessed January 27, 2013)

[3] Ahmed H. Tolba et al " Individual and cultural factors affecting diffusion of innovation" (http://www.aabri.com/manuscripts/11806.pdf) (accessed 10 August, 2013)

[4] Alan D. Smith, John S. Clark, (2005),"Revolutionising the voting process through online strategies", Online Information Review, Vol. 29 Iss: 5 pp. 513 – 530 (http://dx.doi.org/10.1108/14684520510628909) (accessed 19 September, 2012)

[5] Alhaji Mohammed Salisu Baba, (2011) "What is e-voting? Various types Of e-voting, USA to Venezuela - Issues to consider" (http://www.danquahinstitute.org/docs/prospectsevotingghana.pdf) (accessed 10 July, 2013).

[6] Amit Chakradeo Inc. (May 2005) "India's Electronic Voting Machines compared to Diebold" (http://amit.chakradeo.net/2004/05/14/indias-electronic-voting-machines-compared-to-diebold/) (accessed February 16, 2013)

[7] Amoakohene M. "Ghana : Media and Democracy in 50 Years of Independence" (http://www.ucalgary.com/tettey/files/tettey/ghana_media_democracy.pdf) (accessed January 20,2013)

[8] Anderson D., (2006) Qualitative and Quantitative research (http://www.icoe.org/webfm_send/1936) (accessed August 6, 2012)

[9] Aurora. (April 2009). "Electronic voting machines: A boon in Indian elections" (http://www.sankalpindia.net/drupal/electronic-voting-machines-boon-indian-elections) (accessed February 16, 2013)

[10] AVIEL, D., TADAYOSHI K., ADAM S. (July 23 2004) "Analysis of an Electronic Voting System" (http://avirubin.com/vote.pdf) (accessed on the 10 July, 2012)

[11] Bishop, Matt; Wagner, David. "Risks of E-voting" Communications of the ACM. Nov2007, Vol. 50 Issue 11, p120-120.

[12] Brooke, J. (1996) SUS: A "quick and dirty" usability scale. In P. W. Jordan, B. Thomas, B. A. Weerdmeester, & A. L. McClelland
(Eds.), *Usability evaluation in industry* (pp. 189-194). London: Taylor and Francis.

[13] Business Dictionary (http://www.businessdictionary.com/definition/survey-research.html) (accessed 12 July, 2013)

[14] CODEC (2013), "WAEON Press Release on Post–Election Violence in Ghana" (http://codeoghana.org/index.php/waeon-press-release-on-post-election-violence-in-ghana) (accessed 10 July, 2013)

[15] Commonwealth Secretariat, 2008
"Commonwealth Observer Group says Ghana's run-off presidential election was robust and credible" (http://secretariat.thecommonwealth.org/news/190591/163072/186347/301208ghanainterim.htm) (accessed 10 July, 2013)

[16] Comparison of electronic voting machines: India and elsewhere (http://lifeearthlife.wordpress.com/2009/04/20/electronic-voting-machines-india-and- elsewhere/) (accessed 10 July, 2013)

[17] Cooper, D. R. and Schindler, P.S. (2006), Business Research Methods, 9th Ed. McGraw-Hill.

[18] Cory Janssen "Rapid Application Development" (www.techopedia.com/definition/3982/rapid-application-development-rad) (accessed May 10, 2013)

[19] Diebold Election System, (2006)."Electronic Voting Information Machine Sheet" (http://w2.eff.org/Activism/E-voting/infosheets2006/DieboldAccuVoteTSx.pdf) (accessed December 16,2012)

[20] Dieterich, E."Direct Recording Electronic Voting Systems" (http://www.leagueissues.org/tutorial.html) (accessed December 16, 2012)

[21] Direct Recording Electronic Voting Machines. (Nov 2006) Congressional Digest; Nov2006 Vol. 85 Issue 9, p262-288, 8p

[22] Dogbevi E. (2011)"Internet users in Ghana reach 14.11% of population in 2011 – ITU. (http://www.ghanabusinessnews.com/2012/09/04/internet-users-in-ghana-reach-14-11-of-population-in-2011-itu/) (accessed January 20, 2013)

[23] Election Protection, (2006),
"Election Systems & Software - iVotronic" (http://w2.eff.org/Activism/E-voting/infosheets2006/iVotronic.pdf) (accessed February 18, 2013)

[24] Electoral Commission of Ghana, "Electoral Reform" (http://www.ec.gov.gh/page.php?page=375&section=42&typ=1)

[25] Electoral Commission of Ghana. (2000) "Demarcations of the Electoral Boundaries" (http://www.ec.gov.gh/page.php?page=374&section=42&typ=1) (accessed February 09, 2013)

[26] Electoral Commission of Ghana. (2000) "Mission, Vision and Functions Vision" (http://www.ec.gov.gh/page.php?page=286&section=41&typ=1) (accessed February 09, 2013)

[27] Electoral Commission of Ghana. (2000) "Steps on how to Vote" (http://www.ec.gov.gh/page.php?page=504&section=49&typ=1) (accessed February 18, 2013)

[28] Electoral Commission of Ghana. (2000) "Structure of the Electoral Commission" (http://www.ec.gov.gh/page.php?page=341&section=41&typ=1) (accessed February 09, 2013)

[29] Electoral Commission of Ghana. (2000) "Voter Registration" (http://www.ec.gov.gh/page.php?page=391&section=49&typ=1) (accessed February 18, 2013)

[30] ELECTRONIC VOTING NOW!…Remedy to possible violence in 2016 (http://www.todaygh.com/2013/09/11/electronic-voting-now-remedy-to- possible-violence-in-2016/) (accessed 10 August 2013)

[31] Eric A. Fischer, (2005) "The Direct Recording Electronic Voting Machine (DRE) Controversy" http://fpc.state.gov/documents/organization/60725.pdf (accessed December 16,2012)

[32] Erika D. Smith. "Startups Challenge Diebold in E-Voting Machine Paper Trail Scramble" Akron Beacon Journal (OH). 04/20/2004

[33] Estonia.eu, 2005 "Estonian e-voting system" (http://estonia.eu/about-estonia/economy-a-it/e-voting.html) (accessed February 18, 2013)

[34] Ghana Election 2013 (http://elections.myjoyonline.com) (accessed February 18, 2013)

[35] Ghana Statistical Service (2012). "2010 Population Census" (http://www.statsghana.gov.gh/docfiles/2010phc/Census2010_Summary_report_of_final_results.pdf) (accessed February 18, 2013)

[36] Ghana's Electoral Commission boss voices pessimism on e-voting (http://www.humanipo.com/news/4422/ghanas-electoral-commission-boss-voices-pessimism-on-e-voting/)

(accessed 10 August 2013)

[37] Gibson, R. "Elections Online: Assessing Internet Voting in Light of the Arizona Democratic Primary " Political *Science Quarterly.* Winter2001/2002, Vol. 116 Issue 4, p561. 23p

[38] Hari K et al (2010) "Security Analysis of India's Electronic Voting Machines"

[39] Hines, Matt. "E-voting and security concerns" eWeek. 10/27/2008, Vol. 25 Issue 31, p12-12. 3/4p.

[40] Human Right Watch (2011) "Nigeria: Post-Election Violence Killed 800" (http://www.hrw.org/news/2011/05/16/nigeria-post-election-violence-killed-800) (accessed 10 July, 2013)

[41] Illiteracy rate in Ghana will not impede e-voting – PPP (http://graphic.com.gh/Politics/illiteracy-rate-in-ghana-will-not-impede-e-voting-ppp.html) (accessed 10 August 2013)

[42] Indian Electronic Voting Machine compared with Diebold (US Voting System)" (http://www.asadasif.com/?itemid=59) (accessed February 18, 2013)

[43] Instruments and Procedures (http://linguistics.byu.edu/faculty/henrichsenl/ResearchMethods/RM_2_17.html) (accessed August 7, 2012)

[44] International Committee for Information Technology Standards. ISO 9241-11. (1998). Ergonomic requirements for office work with visual display terminals (VDT)s - Part 11. Guidance on usability.

[45] Internet Penetration Grows To 10% (http://www.ghana.gov.gh/index.php/news/features/11725--internet-penetration-grows-to-10) (accessed February 18, 2013)

[46] Internet Usage Statistics for Africa (http://www.internetworldstats.com/stats1.htm) (accessed January 20, 2013)

[47] Internet World Statistics. (http://www.internetworldstats.com/stats1.htm) (accessed February 18, 2013)

[48] Jefferson, D., Rubin, Aviel D., Simons, B., Wagner, D. "A Security Analysis of the Secure Electronic Registration and Voting Experiment (SERVE)" Technical report, 2004. (http://servesecurityreport.org/.) (accessed January 19, 2013)

[49] Jefferson, D., Rubin, Aviel D., Simons, B., Wagner, D. "ANALYZING INTERNET VOTING SECURITY." *Communications of the ACM.* Oct2004, Vol. 47 Issue 10, p59-64. 6p. 1 Illustration, 1 Chart.

[50] John Amponsah, (29 November 2009) "Electronic Voting Machines and New Era of Fixing Elections" (http://www.ghanaweb.com/GhanaHomePage/NewsArchive/artikel.php?ID=172603) (accessed 13th Decemeber,2012)

[51] John Marcheur, eHow Contributor "The Disadvantages of Manual Elections" (http://www.ehow.com/info_8740257_disadvantages-manual-elections.html) (accessed 13th July, 2013)

[52] Kevin Zhu, et al (2006) "Innovation diffusion in global contexts: determinants of post-adoption digital transformation of European companies"

[53] Kim, K., Hong, D. (2007). "Electronic Voting System using mobile terminal" Proceedings of World Academy of Science: Engineering & Technology Vol. 36, p33-37, 5p, 4

[54] Kitcat, Jason. (2007)."Is e-voting a threat to our democracy? "Computer Weekly. 2/27/2007, p20-20. 2/3p. 2

[55] Larsen, Kai R.T. (1999) "VOTING TECHNOLOGY IMPLEMENTATION" Communications of the ACM. Dec1999, Vol. 42 Issue 12, p55-57. 3p.

[56] Laskowski, S. J et al. (2004). *Improving the usability and accessibility of voting systems and products*. NIST Special Publication 500-256.

[57] Leigh Egerton, 2012 "Electronic Voting Counting System" (http://www.niassembly.gov.uk/Documents/RaISe/Publications/2012/ofmdfm/9112.pdf) (accessed 13 July, 2013)

[58] Madise U., Martens T. "E-voting in Estonia 2005. The first practice of country- wide binding Internet voting in the world" (http://neu.e-voting.cc/wp-content/uploads/Proceedings%202006/1.1.madise_martens_e- voting_in_estonia.pdf) (accessed February 18, 2013)

[59] Mohammed Awad, Ernst L. Leiss, (2011),"Internet voting in the USA: analysis and commentary", Transforming Government: People, Process and Policy, Vol. 5 Iss: 1 pp. 45 – 55 (http://dx.doi.org/10.1108/17506161111114644) (accessed December 12, 2012)

[60] Musah Yahaya Jafaru "'Adopt E-Voting For 2012 Election'" Daily Graphic publication (http://www.modernghana.com/news/289272/1/039adopt-e-voting-for-2012-election039.html) (accessed 10 August, 2013)

[61] Nana Karikari-Apau, (2012) "Ghana president re-elected, a result opposition claims was 'manipulated" (http://edition.cnn.com/2012/12/09/world/africa/ghana-elections/) (accessed 10 July, 2013)

[62] Neville, H., Sidney,T. (20 June 2005) "Simple Random Sampling" http://www.coventry.ac.uk/ec/~nhunt/meths/random.html (accessed August 6, 2012)

[63] Obetsebi-Lamptey, J. "NDC, some EC officials colluding to doctor election results"

(http://www.modernghana.com/news/434976/1/ndc-some-ec-officials-colluding-to-doctor-elect.html) (accessed December 9,2012)

[64] Otchere-Darko Gabby Asare, (2009) "Why Ghana must soon decide on E-voting" (http://ghanaweb.net/GhanaHomePage/soccer/artikel.php?ID=170417) (accessed 10 July, 2013)"

[65] Plumer B. (2012) "Estonia gets to vote online. Why can't America?" (http://www.washingtonpost.com/blogs/wonkblog/wp/2012/11/06/estonians-get-to-vote-online-why-cant-america/) (accessed February 18, 2013)

[66] Quarshie, H.O, Ami-Narh, J. "The Growth and Usage of Internet in Ghana" (http://cisjournal.org/journalofcomputing/archive/vol3no9/vol3no9_6.pdf) (accessed February 18, 2013)

[67] Rajasekar S et al (2006) "RESEARCH METHODOLOGY" (http://arxiv.org/pdf/physics/0601009.pdf) (accessed February 18, 2013)

[68] Rajaseker S. (2013) "Research Methodology" (http://arxiv.org/pdf/physics/0601009.pdf) (accessed 12 December, 2013)

[69] Randolph, C.(2004) "Electronic Voting Offers Opportunities and Presents Challenges" GAO Reports, 7/20/2004, p1, 47p

[70] Roger Clarke, (1999). "A Primer in Diffusion of Innovations Theory" (http://www.rogerclarke.com/SOS/InnDiff.html) (accessed 10 July, 2013)