Green ICT Governance Maturity for Sustainable Computing in Developing Nations: Case of Kenya

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Abstract— **Green Information and Communication Technology (ICT) governance is management capability to put in place environmental criteria and framework to guide ICT activities management. The lack of proper alignment and application of ICT uptake and governance challenges the reaping of the benefits often stated of ICT. Multiple case study design with case from different sectors of the economy selected based on information richness, accessibility, size as well as diversity in application of ICT was employed. Triangulation of data collection and findings interpretation was utilised. The study established that green ICT governance maturity was very low. There is therefore great need for institutionalizing well established responsibility structures on green ICT in organisations.**

Index Terms— **Carbon footprint, Green ICT assessment metrics, green ICT governance, green ICT governance maturity**

I. INTRODUCTION

Green ICT, which sometimes is referred to simply as Green IT, means different things to different people. The lack of a completely agreed upon definition makes it difficult to measure the effectiveness or the extent of an organisation's implementation of Green ICT [1]. This therefore leaves a gap as to how to apply it and hence reducing the potential of green ICT. Likewise the use of ICT with its negative impact may hardly be recognized as some personnel may not consider it to have any due to lack of governance. This in turn leads to ICT contribution to footprint from ICT equipment through its manufacture, use and disposal.

Unfortunately the disparity in the level of green ICT understanding has caused confusion within the ICT user community or personnel [2]. Due to the lack of a uniform understanding, many do not know how or where to begin with green ICT and are unwilling to implement it [2]; [1]. This has led green ICT not being applied by many organisations. There are green ICTs in the market but unfortunately they are not bearing fruit [3]. For the purpose of this study green ICT was considered to be the systematic application of ecological sustainability criteria to the design, production, sourcing, use and disposal of ICT resources in order to minimise costs and environmental distraction. Resources in this study refered to ICT personnel, ICT hardware and software. There is need to have ICT personnel that have the same meaning of green ICT to handle green ICT matters. This will enable them to consult each other on the matters whether they are applying new technologies or imported technologies irrespective of where they are.

The concept of Green ICT brings together themes concerning the future of our current world, technology and the environment. It's important for people to understand what Green ICT is, as businesses engage with it. Decision makers have to be aware of its consequences and potential in helping users get to a sustainable world [1] for them to advocate for its implementation.

Green ICT Governance is the operating model that defines the administration of green ICT initiatives and is closely related to the policy dimension [4]. It refers to the ICT management capability to put in place environmental criteria and frameworks to guide the sourcing, use, and disposal of the ICT technical infrastructure and activities of ICT personnel [5]. Effective ICT governance is the most important predicator of the value an organisation generates from ICT [6]. According to Weill and Ross (2004), it is the practice that allocates decision rights and establishes the accountability framework for ICT decisions. And according to Schmidt & Kolbe [7] green ICT governance specifies the decision rights and accountability framework to encourage environmentally desirable behaviour in the sourcing, use and disposal of ICT. It is needed to establish clear roles, responsibilities, accountability and control of Green IT initiatives. For this to be achieved the roles responsibilities, accountability and control for green ICT initiatives need to be clearly established [8]. Well established responsibility structures on the matter may thus be a very good indicator of the organisations green ICT preparedness. It also implies allocating a budget for actualizing green ICT and putting in place metrics for establishing the impacts of green ICT initiatives [9]. In creating such structures the human personnel plays a major role. It has to provide sound management decision to understand impacts, prioritize actions and manages the enterprise's responses as required to implement successful green ICT initiatives [8]. It is ICT technical human personnel that align ICT with the organisation goals. But this has to be done in line with what the managerial human personnel has set.

No single governance approach may be applied across organisations in line with green ICT [7]. This is entirely because specific external and internal factors of a given organisation, derivation from organisational settings,

regulatory markets, socio-cultural, ecological, and technological environments are unique to each organisation [10] and often does influence the organisation's actions and this are directed by the ICT personnel. How the ICT personnel perceives the importance or uncertainty of green ICT determine the level of implementation of green ICT in the given organisation [11]. Every organisation will thus attempt to encourage different behaviours [7] majorly dependent the managerial personnel equipment with the necessary green ICT skills. Without paying special attention to the managerial infrastructure therefore implies minimal chances of green ICT being successfully applied.

In Kenya most of the organisations are heavily dependent on imported technology and skills with little priority being given to adaptation to the local needs [12]. Skilled and qualified ICT personnel are inherent part of ICT and are important to the development and utilisation of technology [13]. The ICT personnel play a critical role in the spread of technological innovations. It is the humans and not machines who advance and who can control the spread of a technology [14]. Kenya, for example, is on the verge of an ICT revolution as it moves towards being ICT-driven [13]. It is experiencing a rapid ICT uptake with globalization putting pressure on management and ICT staff. The situation for the human personnel is complicated by the various ICTs acquired by the Kenya from the 1980's to date that has been piecemeal, un-coordinated, and haphazard [15]. With the limited knowledge found within, the personnel have been struggling to provide adequate and effective direction as well as support [15]. The personnel is an inherent part of ICT innovation and crucial for future developments [13] hence need to be properly aligned with green ICT for its benefits to be realized in developing nations.

The study was of great importance as there is increasing evidence that environmental threats to a large extent can be minimised through solutions provided by appropriate application of ICTs. Green ICT can be undertaken to address three overarching and interrelated goals. The first goal is that green ICT can help to mitigate ICTs direct contribution to the global warming. Secondly, it can be used to enhance all sectors' contributions to economic sustainability. Thirdly, green ICT can be used to tackle the country's overall contribution to climatic degradation. The study provides literature that will promote understanding of the complex nature of ICTs in realising sustainability. The understanding of the interdependence between the environmental, social, and economic systems will enable ICT personnel to think strategically and act proactively by devising holistic, robust, and well informed solutions to mitigate the negative ICT impacts. The contribution of the study to the world of knowledge is of great importance at this time when the area of study is considered to be new. The model developed for enhancing green ICT implementation will be help the organisations to realise the benefits of applying green ICT.

1.2 Statement of problem

Many firms are heavily dependent on imported technology with skills and policy adaptation to local needs receiving less priority. This has led to rise in costs, dematerialisation of resources and environmental degradation [16]. Not much can be achieved in technology implementation when policy and ICT personnel receive inadequate attention paid to them. It is estimated that ICT project failure rate ranges from 33% to 60% in developed nations [17] probably due to lack of paying attention to ICT governance. Green ICT has been widely promoted as an important strategy to reduce energy, materials consumption, and environmental degradation leading to sustainability [18]. Green hardware and software are readily available in the market to reduce energy and materials consumption [3]. The lack of a close relationship between the manner in which the ICTs are taken upon and green ICT governance being aligned accordingly across nations challenges the reaping of green ICT benefits. It is this gap that this paper seeks knowledge to.

II. GREEN ICT GOVERNANCE

With a leadership strong enough for the change having clear vision for change expressed with visible support from senior management and the level of commitment from other human personnel being high, standards are enforced, the organisation stands higher chances of employing for green ICT. Governance may be considered to involve change management, knowledge management, strategic planning and alignment and policies [19]; [20].

Where people articulate what change is needed and the need for change is clear to most, deployment of green ICT will be seen as a management priority. Clear expectations may be easily communicated and the human personnel are more likely to be generally positive about coming deployment. Where the human personnel have the right skills there is the likelihood of having minimal resistance to the introduction of green ICT. For governance to actualize green ICT, it has to have clear structures in place where the role for coordinating green ICT initiatives are defined and the CEO plays a leading role in green ICT initiatives. It has to provide for responsibilities that clearly define within each green ICT initiative that necessitates establishment of metrics for assessing the impact of green ICT initiatives and setting targets to reduce the organizations carbon footprint. Governance would realise much where ICT department is responsible for its own electricity bill.

Lack of skills among top management affects the ability of an organisation to make decisions to adopt technologies hence their implementation since adoption leads to implementation [19]. Lack of technical skills arises out of lack of training or limited training opportunities or having inappropriate training being undertaken. Training for this study is considered to provide all the necessary training to the ICT personnel about

the technology, the use, the purpose and its benefits. Top management provides the forward motion for initiation of technology implementation. Without such support from top management not much can be realised [21]; [22]; [23]. It is these ICT managerial personnel that fund and motivate the employees of an organisation towards taking up and implementing the technology. It is this same cadre of ICT personnel that make the policies of organisations and hence may make those that would or would not support green ICT. Top management's commitment is very crucial to successful implementation of technology [24] that is a prerequisite for implementation of green ICT. Top management makes decisions towards adoption and implementation of IT innovations [25] such as green ICT. Lack of top managements top support of an innovation leads to failure of its implementation [26]. Employees normally take the lead of the direction that top management propagates. If it is positive, it encourages commitment from employees and if it's negative, it de-motivates employees and encourages indifference by employees to the technology and resistance [27]. De-motivated personnel may do very little to cope with the ever changing ICT hence affecting their implementation on the same in a sustainable manner.

III. METHODOLOGY

A multiple case study which was the preferred option for this study referred to conducting several case studies [28] and this implied several holistic cases in which each holistic case consisted of only one unit of analysis. The multi-case study strategy allowed the study to retain the holistic and meaningful characteristics of real-life events at the centre of the study (hardware and software, individuals, organisational and managerial processes life cycles to mention but a few [28]; [29]; [30]. The multi-case was chosen for this study since it provides robust and rigorous grounds for good quality research derived from triangulation of evidence [28]; [31]; [30].

Experienced researchers are in agreement that selection of cases should be based on purposive theoretical sampling [32]; [33]; [34]; [29]; [30]. For this study, four cases were selected based information richness, accessibility, largeness, leading, diversity in applications and the well-establishment in their respective sectors while balancing between urban and rural settings. One organisation was selected from each of the four sectors for the study: the university which train ICT manpower, the sugar manufacturing industry, government county offices and the ICT regulator by virtue of the application of ICT in many different functional units in the day to day activities ranging from the core business to none core business.

Data was collected via interview, questionnaire, focused groups, observation, and documentation analysis. This allowed for triangulation of results to increase their credibility. Each case study was considered as a single unit of analysis so that flexibility and elasticity that distinguished semi-structured interviews that allowed for changing and modifying interview questions when need arises.

The study ensured the truthfulness, accurateness and replication possibility of the study in a number of approaches. The major validity observed in this study was construct validity, internal validity and external validity.

Construct validity was fulfilled by designing case study questions and asking questions during the interview and using multiple sources of evidence (triangulation) [35]; [28]; [30]. Internal validity / credibility were fulfilled through pattern-matching by matching and contrasting the emerging themes during data analysis with established themes in the existing literature reviewed [35]; [28]; [30]. In this study a combination of secondary data, observation and interviews were used. Secondary data in particular was used to inform and verify the findings. Another way of increasing the validity consisted of showing the research participants a summary of the findings for their interpretation. This took place in the field research and significantly, subjects were contacted where necessary to clarify data gathered and verify research findings.

External validity or generalization or transferability was fulfilled through use of replication logic in the multiple case design [28] whereby the findings from the selected case studies were replicated, adopted with purposeful sampling in selecting the case studies [33], writing rich-information case study report for data of each case [36]; [30] and by the use of multiple case design itself in which all selected cases were organisations from Kenya and representing four different sectors.

Generalisability was be enhanced by studying the same issue in four different research sites, using similar methods of data collection and analysis [37]. The possibility of studying numerous heterogeneous sites made multi-site studies a potentially useful approach to increasing the generalisability of the qualitative work.

Reliability was achieved through all selected cases and participants being subjected to the same entry and exit procedures [28], intensive documentation and appropriate recording keeping [36]; [28]; [30] and in-depth interviews with participants and follow up as well as involving them in conclusions drawn for clarification.

IV. FINDINGS AND DISCUSSION

According to Cooper and Molla [5], green ICT governance is the administration of green ICT initiatives and is necessary to establish the roles, responsibilities, accountability and controls. This therefore formed the key variables upon which governance was studied. The analysis of the governance variables is graphically summarized in Figure 1.
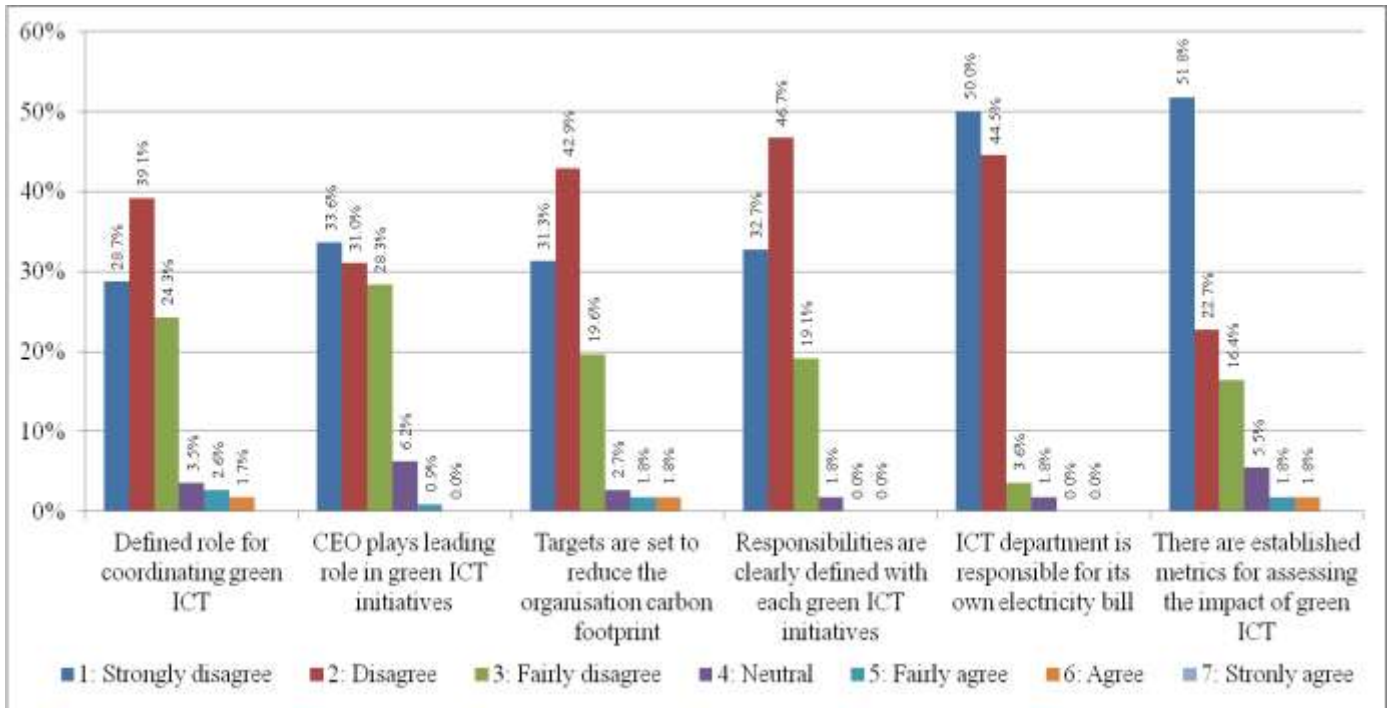
Figure 1: Green governance maturity

The findings on whether organisations had defined positions or role for coordinating green ICT are presented in Figure 1. From column 1, it can be observed that a total of 28.7% of the respondents strongly disagreed that organisations had clearly defined roles for coordinating green ICT. Another 39.1% disagreed while 24.3% fairly disagreed to the same. Of the respondents 3.5% were neutral in their response as to whether the organisations had clearly defined roles for coordinating green ICT. There was a total of 2.6% of respondents who fairly agreed with 1.7% agreeing and a total of 0.9% strongly agreed to the fact that organisations had clearly defined roles for coordinating green ICT. From the interviews, the respondents could not easily name the office responsible for green ICT. From observations, there were hardly any organisations organ-grams from the institutions studied that had the position for green ICT responsibility. This was an indicator that green ICT may not be receiving the attention as an area of major concern by the organisations. However the manufacturing industry had a defined role and office for an environmental concern to the name of environmental manager.

The study also sought to establish if the CEOs of the organisations played leading roles in green ICT initiatives. The findings are given in Figure 1. According to column 2 a total of 33.6% of the respondents strongly disagreed and 31.0% disagreed that the organisation's CEO played a leading role in green ICT initiatives. While 28.3% fairly disagreed, 6.2% were neutral in their response as to whether the organisation's CEO played a leading role in green ICT

initiatives. There were no respondents who fairly agreed that the organisation's CEO played a leading role in green ICT initiatives while 0.9% agreed to the same. Where the CEOs take a leading role in such initiatives there is a likelihood of the initiative being implemented more. This could probably explain the low levels of green ICT implementation in the organisations.

Governance may ensure implementation of green ICT if there is set targets to reduce the organisations carbon footprint. The findings on this are presented in Figure 1. Based on the findings of column 3, 31.3% of the respondents strongly disagreed to the organisations having targets of reducing the organisation's carbon footprint set. Another 42.9% disagreed while 19.6% fairly disagreed to the same. Of the respondents, 2.7% were neutral to their organisations had targets of reducing the organisations' carbon footprint. There were a total of 1.8% of respondents who fairly agreed that their organisations had targets of reducing the organisation's carbon footprint set with another 1.8% agreeing to the same. This results tally with what was established through observation as there were no records of passed records on the same or current targets. The respondents could not state any current targets for the organisation to achieve in reducing the carbon footprint. Without such targets, there would hardly be any motivation to direct members of the organisation to strive to achieve green ICT especially if there are also no clearly defined responsibilities within each green ICT initiative.

The findings on the clarity of responsibilities within each green ICT initiative are presented in Figure 1. Clearly from

column 4, 32.7% of the respondents strongly disagreed to organisations' having clearly defined responsibilities within green ICT initiatives if they existed. Another 46.4% disagreed indicating that organisation's did not have clearly defined responsibilities within green ICT initiatives if they existed while 19.1% fairly disagreed to the same and 1.8% was neutral.

When it came to responsibility for the ICT department's electricity bill, it was found that it hardly was the responsibility of the ICT department. The findings are presented in Figure 51. According to column 5 a total of 50.0% of the respondents strongly disagreed to ICT departments being responsible of their own electricity bills. Another 44.5% disagreed that the ICT departments were responsible of their own electricity bills while 3.6% fairly disagreed and 1.8% were neutral. When a section is responsible for the bill, it is bound to seek ways of reducing the costs. Where the main source of power is electricity, reduction on its consumption would go a long way to reducing the carbon footprint on a national level.

The last dimension to be assessed on governance was whether institutions had established metrics for assessing the impact of green ICT initiatives. The findings are presented in Figure 1. From column 6, 51.8% of the respondents strongly disagreed that organisations had established metrics for assessing the impact of green ICT initiatives. Another 22.7% disagreed that organisations had established metrics for assessing the impact of green ICT initiatives while 16.4% fairly disagreed and 5.5% were neutral. A total of 1.8% of respondents fairly agreed that organisations had established metrics for assessing the impact of green ICT initiatives with another 1.8% agreeing to the same. The findings are in agreement with the findings established during the interview and observation sessions within the institutions that participated in the interview. Without such metrics, it would not be easy to establish whether good progress was being made or not to motivate further undertakings of implementation of green ICT or not.

The analysis by means for governance G-readiness maturity was analysed for each case had the findings obtained were as presented in Table 1.

Table 1: Green ICT governance maturity means per case study

Company where one is		Role for coordinating green ICT initiatives are defined	CEO plays a leading role in green ICT initiatives	Targets are set to reduce the organisations carbon footprint	Responsibilities are clearly defined within each green ICT initiative	ICT department is responsible for its own electricity bill	There are established metrics for assessing the impact of green ICT initiatives
Manufacturing Industry	Mean	1.97	2.33	2.00	1.67	1.47	2.31
	N	30	30	28	27	30	29
	Std. Deviation	.765	.994	.720	.734	.629	1.004
ICT regulatory body	Mean	1.96	2.21	2.38	2.38	1.54	1.59
	N	25	24	26	24	26	22
	Std. Deviation	.790	1.382	1.551	.711	.508	.854
Public University	Mean	2.56	1.98	1.96	1.76	1.71	2.00
	N	45	44	45	45	42	44
	Std. Deviation	1.358	.698	.824	.712	.774	1.414
Government Office	Mean	1.80	1.87	1.92	2.00	1.42	1.13
	N	15	15	13	14	12	15
	Std. Deviation	.775	1.060	.954	.784	.515	.352
Combined mean	Mean	2.17	2.11	2.06	1.90	1.57	1.88
	N	115	113	112	110	110	110
	Std. Deviation	1.078	1.003	1.034	.766	.656	1.163

The first governance dimension to be analyzed was that of the role for coordinating green ICT whose analysis is presented in Table 1 and Figure 1. According to the analysis, the mean value of the response on the role for coordinating green ICT was 2.2, which implies it hardly exists. Its maturity level therefore was low and skewed to the left. Having a standard deviation of 1.08 was an indication that the respondents were fairly consistent. A good number of the ICT personnel interviewed said that no such role exists in their organisations other than an environmental officer who has little to do with ICT. Most of the ICT personnel on being asked who performed the duties of seeing to the best utilisation of ICT attributed it to the work of the head of ICT section including that of creating awareness of green ICT. Role for coordinating green ICT initiatives were not well defined in all cases as have means of less than three. The manufacturing sector had a mean of 1.97, the communications regulator had a mean of 1.96 while the public university sector had a mean of 2.56 and the government office had 1.80.

With regard to the CEO playing a leading role in green ICT, the analysis is a presented in Table 1 and Figure 1. From the analysis, it can be observed that the CEO playing of leading role in green ICT maturity was skewed to left on the 7 Likert scale around the mean of 2.1. The standard deviation value of 1.00 indicates that the responses were fairly consistent. Interviews also revealed that some CEOs were fairly concerned with green ICT through their constant emphasis on cutting costs through the use of ICT. Hardly did the respondents through the face to face interviews acknowledge that CEOs directly discussed green ICT as an agenda of the organisation. Others studies do attribute to the fact that such direct discussion of the issue would real increase the chances of a new technology being adopted and implemented. On other hand, having CEOs play a leading role in green ICT initiatives within the manufacturing sector had a mean of 1.97, the communications regulator had a mean of 1.96 while the public university sector had a mean of 2.56 and the government office had 1.80.

On the maturity of having set targets for reduction of the organisations carbon footprint, the analysis is provided in Table 1 and Figure 1. The analysis of findings with regard to having set targets for reduction of the organisations carbon footprint indicates that organisations maturity was skewed to the left around the mean of 2.1. The respondents were fairly sure that organisations did not have set targets for reduction of the organisations carbon footprint having a standard deviation was 1.03. This finding correlates with what was observed in the organisations documentations that did not have any records on the same. With regard to having targets being set to reduce the organisations carbon footprint, the manufacturing sector had a mean of 2.33, the communications regulator had a mean of 2.21 while the public university sector had a mean of 1.98 and the government office had 1.87.

The maturity level of having clearly defined responsibilities within each green ICT initiative analysis is presented in Table 45 and Figure 51. From the analysis it low at a mean of 1.9 that was skewed to the left on a scale of 7. The responses were fairly consistent and not spread as they had a standard deviation was 0.77 hence giving the surety of the view held by ICT personnel. Responsibilities being clearly defined within each green ICT initiative had the manufacturing sector record a mean of 2.00, the communications regulator had a mean of 2.38 while the public university sector had a mean of 1.76 and the government office had 2.00.

The maturity level of ICTs responsibility for its own electricity bill is presented in Table 1 and Figure 1. According to the analysis the mean value of ICTs responsibility for its own electricity bill use was 1.6, which implies it was hardly the responsibility of the ICT sector. It can be observed that ICTs responsibility for its own electricity bill maturity was low and skewed to the left on the Likert scale of 7. Having a standard deviation of 0.66 is an indication that the respondents were fairly consistent. A good number of the ICT personnel interviewed indicated the responsibility for electricity bills to be of the corporate organisation. Hardly were there any records availed to show that power bills were the responsibility of the respective sections. It is worth noting that without the bill or the consumption levels being brought to the awareness of the consumers of power little may be done to utilize it efficiently. The ICT department being responsible for its own electricity bill had the manufacturing sector with a mean of 1.47, the communications regulator with a mean of 1.54 while the public university sector had a mean of 1.71 and the government office had 1.42.

The last item on governance maturity analysed was the existence of established metrics for assessment of green ICT impact whose analysis was presented in Table 1 and Figure 511. Based on the analysis it can be observed that the existence of established metrics for assessment of green ICT impact within the organisations was skewed to the left around the mean of 1.9. The respondents were fairly consistent, with a standard deviation of 1.16. The analysis is in correlation with the findings of an observation of documents and procedures that yielded not even a single set of established metrics for assessment of green ICT impact. The interviews conducted also gave similar results as hardly any of the respondents indicated to being aware of any established metrics for assessment of green ICT impact. When it came to having established metrics for assessing the impact of green ICT initiatives, the manufacturing sector had a mean of 2.31, the communications regulator had a mean of 1.59 while the public university sector had a mean of 2.00 and the government office had 1.13.

Graphically presented in Figure 2, it can be observed that the governance maturity was low in all cases that were under study.
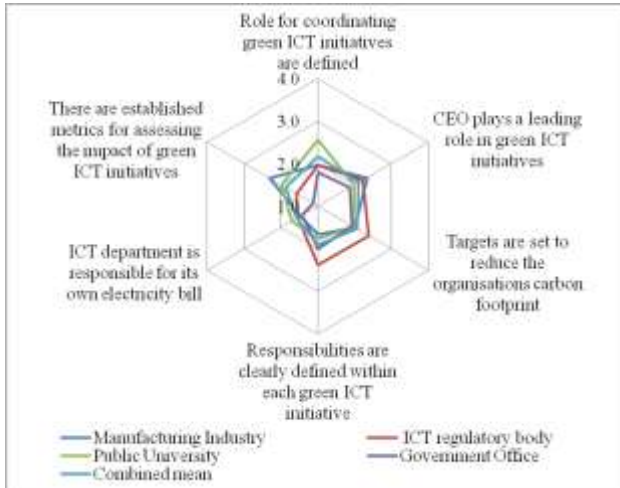
Figure 2: Case study comparison of green ICT governance maturity

From Figure 2, the ICT regulator seemed to be slight mature than the other cases on targets being set to reduce the organisations carbon footprint and responsibilities being clearly defined within each green ICT initiatives. The university sector was better of when it came to having a defined role for coordinating green ICT initiatives.

The last component of G-readiness for which the relationship was evaluated was governance whose results are presented in Table 2.

Table 1: Spearman's correlation of demographics and green ICT governance

		Age of respondent	Respondent's gender	Highest academic qualifications	Highest ICT qualification
Role for coordinating green ICT initiatives are defined	Correlation Coefficient	.157	-.013	.083	.046
	Sig. (2-tailed)	.094	.887	.378	.624
CEO plays a leading role in green ICT initiatives	Correlation Coefficient	.117	.082	.078	.299 (**)
	Sig. (2-tailed)	.217	.387	.409	.001
Targets are set to reduce the organisations carbon footprint	Correlation Coefficient	-.143	.040	.235 (*)	.107
	Sig. (2-tailed)	.134	.673	.013	.261
Responsibilities are clearly defined within each green ICT initiative	Correlation Coefficient	-.179	-.096	.001	-.021
	Sig. (2-tailed)	.061	.317	.991	.825
ICT department is responsible for its own electricity bill	Correlation Coefficient	.088	.003	.035	.187
	Sig. (2-tailed)	.362	.971	.718	.050
There are established metrics for assessing the impact of green ICT initiatives	Correlation Coefficient	-.094	.057	.071	.098
	Sig. (2-tailed)	.329	.553	.461	.310

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

From Table 2, it can be observed that the respondent's age and gender had no significant relationship with any of the elements of governance. The highest academic qualification had a positive weak relationship of 0.235 at 0.05 in 2-tailed significance level with targets being set to reduce the organisations carbon footprint. Finally the highest ICT technical qualification had a positive moderate relationship of 0.299 at 0.01 in 2-tailed significance level with the CEO playing a leading role in green ICT initiatives.

V. SUMMARY

The study found the role for coordinating green ICT initiatives being not fairly definite. It was also established that where CEOs were playing a leading role in green ICT initiatives such organisation had some semblance of its agenda. It was observed that in most organisations targets were not being set to reduce the organizations carbon footprint and responsibilities were not clearly defined within

each green ICT initiative for green ICT. Hardly was there any organisation save for very few had their ICT department being responsible for their own electricity bill. Across board there were no established metrics for assessing the impact of green ICT initiatives. The means revolved around a value of 2 that correspond with disagreeing to an item being there on a scale of one to seven with seven being strongly agreed.

The governance maturity in the organisations was found to be low. There is therefore great need for institutionalizing well established responsibility structures on green ICT in organisations.

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