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Applications and Challenges of Information and Communication Technology in the Forest Sector: A Case Study of Morogoro Municipality, Tanzania

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Abstract: In Tanzania there is rapid adoption of Information and Communication Technology (ICT) in the forest sector and other allied sciences. Many of the uses of ICT in the forest sector are relatively new or still on the horizon and majority are not documented. Despite that, studies on the application and challenges of ICT in the forest sector of Tanzania are still limited to up to date. This study was conducted in Morogoro Municipality to document the current application and challenges of ICT in the forest sector. Data on awareness, type of professional experts with ICTs based, ICTs application domain in forest, infrastructures, software used and outputs were collected from different forest institutions located in Morogoro Municipality using structured questionnaires. Descriptive statistics of the parameters were done using Statistical Package for Social Science (SPSS) and R statistical package. The results have shown that, there is a promising trend towards applications of ICT in the forest sector, where about 75% of the respondents were aware of the ICT applications, while 25% were not. There were eight types of professionals in the forest sector with background in ICT's based technology with higher application on data storage and analysis, documentation and forest inventory. The main challenges observed were related to the availability of infrastructures, internet connectivity and qualified personnel.

Keywords: Information, Communication, Technologies, Forestry

1. Introduction

Information and Communication Technologies (ICT) includes all phrases used to describe a range of technologies for gathering, storing, retrieving, processing, analyzing and transmitting information. Over the last 15 years there has been a tremendously increase in the use of Information Communication Technologies (ICT) in most of the developing countries especially in Africa. Currently almost all governments in developing countries have ongoing information systems projects aiming at improving efficiency of administration through the applications of ICT in different sectors [2, 11]. Their expectations for developmental effects from these uses of ICT are high. They include contribution to economic growth as well as the enabling of the achievement of sustainable development goals (hereafter SDGs) in different sectors [4].

In Tanzania, the history of ICT within the Tanzanian Government can be traced back to 1965, when the first mainframe computer was installed in the Ministry of Finance [22]. In 2003 the first formal National ICT Policy (Tanzania-ICT-Policy, 2003) was adopted by the Government [11], the main theme for the policy was to assist Tanzanian Society to achieve the 2025 SDGs. Later in 2009, the President's office launched the Tanzanian e-Government Strategy, which aims to improve the application of ICT in the government processes, and make services efficient and easily accessible for communities. Among other things, the strategy aims to enhance, especially in the rural areas, the link between the community-based initiatives and e-government facilities by

improving ICT-services in the existing community centers [17]. Irrespective of all these efforts, there is a lack of information on the applications and challenges of ICT in some of the key sectors which contribute to the national economy. Much of the work to date has focused on applications of the ICT in education, health and public services management.

Historically, the main relevance of ICT to the forest sector has been seen in terms of its possible impacts on paper consumption. Even today, when one discusses ICT in the context of the forest sector, people's minds immediately turn to such issues as "the paperless office." However, this is too narrow a view. ICT has been applied in the global forest sector in many other ways [9].

Many of the impacts of ICT on the forest sector are relatively new or still on the horizon and the majority are not documented. For example, in the recent decade, ICT has played a crucial role in the monitoring and managing of forest resources, Geographic Information Systems (GIS) being the cornerstone of most forest management information systems. The use of forests for many types of services, such as recreation, biodiversity, and carbon sequestration, has also been influenced by modern ICT including GIS and remote sensing techniques [7]. It is evident that ICT is having wide impacts on the forest sector, from silviculture to the marketing of forest products and the recreational use of forests. With the increasing access to reliable and up-to-date location-based digital information through technologies such as Global Positioning Systems (GPS), cloud-based satellite image archives, open-source software, telecommunication and mobile technology [10], the opportunity for the use of ICT in the forest sectors has tremendously increased. It is therefore important to understand the applications and challenges for ICT applications in the forest sector as a strategy towards efficient use of ICT. Currently ICT based applications such as GIS, satellite remote sensing and mobile technologies are rapidly being used by different forest institutions for meeting different forest management objectives. Despite such rapid adoption, studies on the application and challenges of ICT in the forest sector of Tanzania are limited to date. Most of the studies have documented technical efficiency of the individual ICT technology, whose major focus is on GIS and remote sensing. The study conducted in 2017 in Tanzania reveal that, majority of land uses and Land Cover studies explored the use of GIS and remote sensing for about 92%, wildfires analysis (5%) and participatory mapping (3%) [18]. Furthermore, different researches documented the use of GIS and remote sensing technology in different forest management activities [1, 13, 14, 16, 19-21, 23]. Yet we still lack a single harmonized study which has attempted to document the current applications and challenges of the different ICT based technologies. Thus, this study intends to address this knowledge gap. Furthermore, the study provides an eye sight for the potential future applications of ICT in different disciplines of the forest sector of Tanzania. Thus, the main objective of this study was to assess the applications and challenges of ICT based technologies in the forest sector of Tanzania. Specifically, the study aimed at; 1) assessing awareness of ICTs based technologies, 2) determining the professional experts with ICTs based background, 3) assessing ICTs application domain in forest, 4) assessing ICT's based infrastructures, software used and outputs, 5) assessing problems of ICTs in the forest sector.
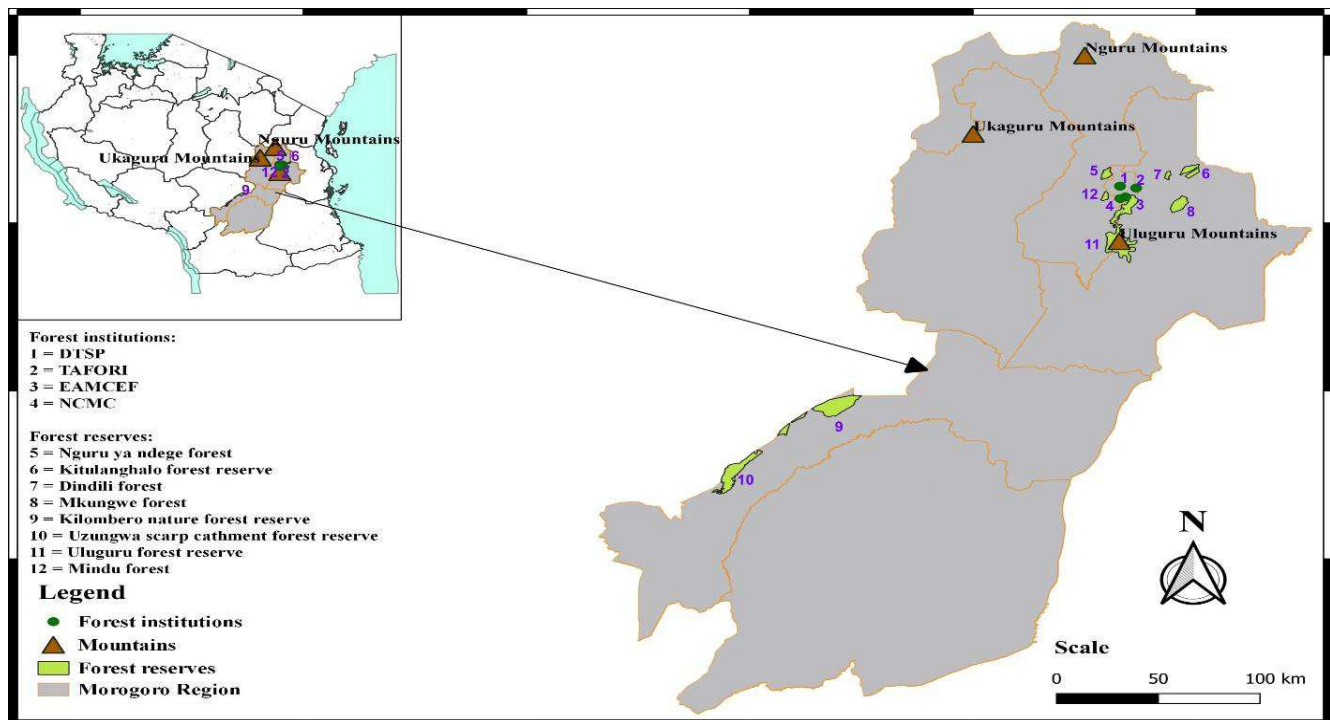

Figure 1. Map showing study locations.

2. Materials and Methods

2.1. Study Area Description

This study was conducted in the municipality of Morogoro which is found in the middle of Tanzania. (URT 2019). The topography of Morogoro is characterized by remarkable natural mountainous and hilly features covered with forests. Apart from unique geographical positions, Morogoro municipality has a number of forest-based institutions which include both government and non-government institutions (Figure 1). A total of six forest institutions located in the area including, DTSP (Directorate of Tree Seed Production), TAFORI (Tanzania Forest Research Institute), Eastern Arc Mountains Conservation Endowment Fund (EAMCEF), Catchment forests (TFS-Morogoro), National Carbon Monitoring Centre (NCMC- SUA), Uluguru Nature Forest Reserves (UNFR) were visited as study sites.

2.2. Sampling Design

In this study, random sampling was used to ensure that existing information on the use of ICT in the forest sector of Tanzania is captured. All individuals with background of ICT from visited institutions were included in the study including ICTs technicians, forest managers, planners, users, surveyors, government officials and researchers in providing information. From each visited institution at least 1 to 4 respondents were randomly selected making a total of 20 sample size.

2.3. Data Collection

A simple structured questionnaire was used in collecting data from the respondents. A set of total 20 questions were prepared based on the objectives of the study and distributed to 20 respondents. Data collected through questionnaire included; type of professional that requires ICTs and their qualifications, level of awareness, type and number of ICTs hardware, forest operations that requires the use of ICTs, Outputs of ICTs used in forest, supporting strategies for ICT, type of softwares and Open source softwares that are used in forest sector. Data on history and background of ICT in the forest sector were obtained from previous studies on ICTs from reports, libraries and online sources.

2.4. Data Analysis

Data collected through literature review were subjected to content analysis. The content analysis is a technique for compressing many words of text into fewer content making sense. The collected information was broken down into smallest meaningful units of information or themes. The data collected through a structured questionnaire was coded with values ranging from 1 to 9. Coded data were analyzed using Statistical Package for Social Sciences (SPSS) software. Descriptive statistics on awareness of ICTs based technologies, type of professional experts with ICTs based background, ICTs application domain in forest, infrastructures, software used and outputs were generated. Further plotting was done in R statistical software.

3. Results

3.1. Awareness of ICTs Based Technologies

Level of awareness on the ICTs application in the forest was generally good where about 75% of the respondents seemed to be aware, while 25% of them were unaware of the uses of ICTs based technologies in the forest. It was further revealed that most of respondents who were unaware of usage of ICTs in forestry were those with low level of education (diploma level) and those with poor resource capacity. It was also observed that institutions like TAFORI, NCMC, EAMCEF and DTSP are very aware of ICT's activities other than remaining institutions.

3.2. Professional Experts with ICTs Based Background

The results have shown that there are eight types of professionals in forest with background in ICT's. Among the professionals, forest officers and researchers ranked the highest (Figure 2) in terms of having background in ICT's technologies and their relevance in forest applications.
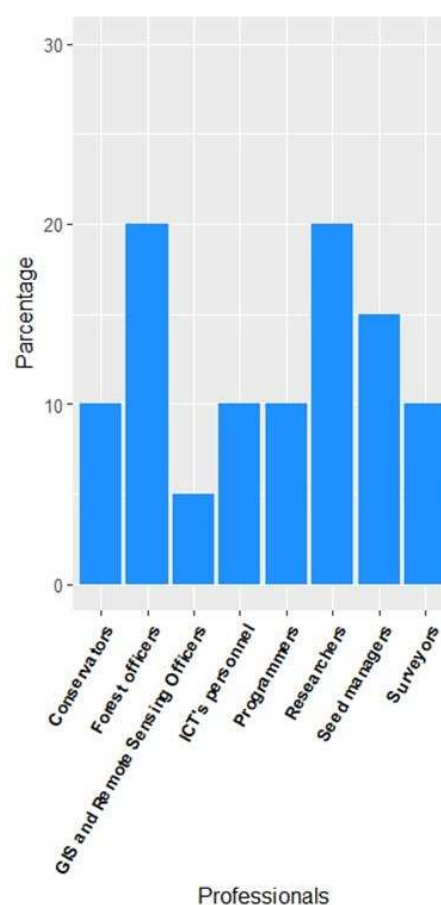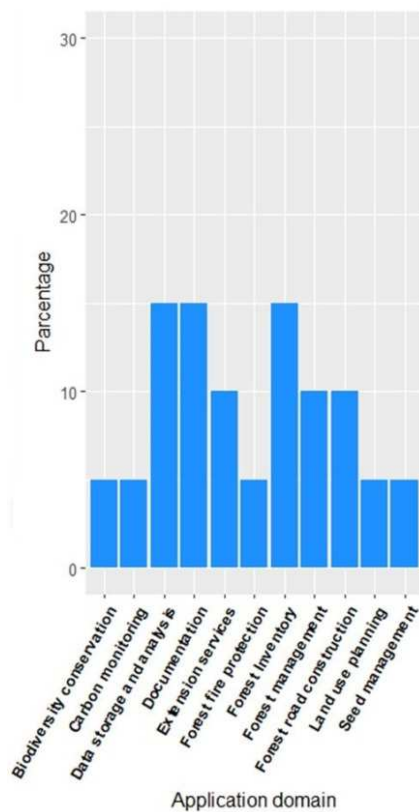

Figure 2. *Forest professionals with ICTs.*

Figure 3. *ICTs application in forest sector.*

3.3. ICTs Application Domain in Forest

Applications of ICTs in the forest (Figure 3) depends on the missions of the respective institution. Higher applications as indicated in Figure 3 were on data storage and analysis, documentation and forest inventory.

3.4. ICTs Based Infrastructures

Most of the available infrastructures in the visited institutions were mobile devices. This included; GPS, cameras, scanner, computers, projectors and printers. Two servers were also reported at NCMC and TAFORI. The distribution of the ICTs based infrastructures is presented in Figure 4.
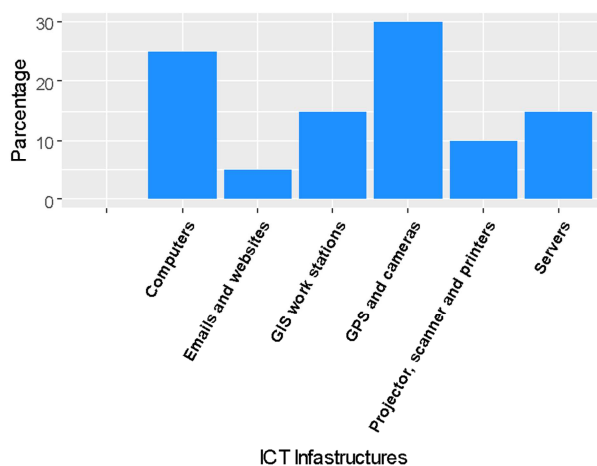

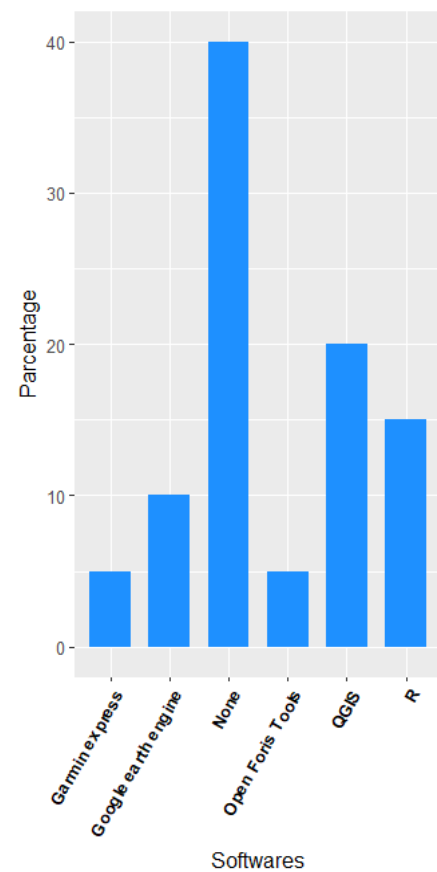**Figure 4.** *Available ICT Infrastructures in the based institutions.*
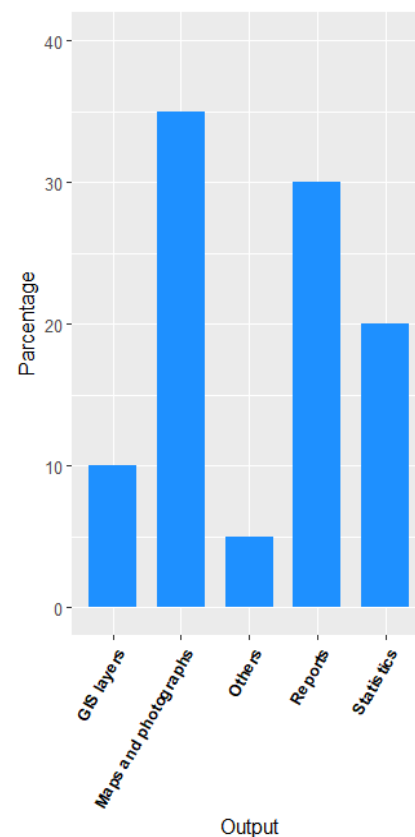

Figure 5. *ICT's software.*

Figure 6. *ICT's Outputs.*

3.5. Software Used and Outputs

A number of software were reported to be used by the respondents in different institutions. Of all the software, QGIS seemed to be highly used as compared to others (Figure 5) though the majority of the respondents indicated that they were not aware of the use of open-source software. ICTs based outputs such as maps, photographs, GIS layers, reports and statistics, were reported to be generated. These outputs were used for forest management and decision making. However, of all outputs forest maps and photographs contributed to the highest, followed by reports as represented Figure 6.

3.6. Challenges of ICT's Based Applications in Forest

The major reported bottleneck for the development of ICT in the forest sector is the shortage of ICT's infrastructures to support the needs of the institutions. Results show that 65% of respondents from all visited institutions were not satisfied with the available ICTs while only 35% were satisfied. However, the majority of the respondents from large institutions such as TAFORI, NCMC and EAMCEF were satisfied with the available ICTs infrastructure while most of those from small organizations were not satisfied**.** As well as the problem of internet facilities and outdated ICTs facilities are also accounted as the one the challenges in the visited institutions.

Availability of ICT personnel with relevant qualifications was another reported challenge. Over all institutions visited it was observed that only 30% of the institutions had qualified ICT personnel. This means that 70% of the institutions did not have qualified ICT personnel. However, of all qualified ICT personnel, only 10% have a master's level, while 55% have a bachelor degree in ICT. Others, (35%) did not have ICT academic qualifications but had ICT knowledge through long-term working experience in areas of ICT in forestry management and short course training.

4. Discussion

Applications of ICT in the forest sector have tremendously increased in the last decades, however their applications particularly in the developing countries are rarely documented. This study presents the applications and challenges of ICT in the forest sector of Tanzania using Morogoro Municipality as the case study. Generally, the study has found a wealth of experiences on the use of ICT in the forest sector, which can be used as a baseline information for future improvement on the use of ICTs in the forest sector of Tanzania and across the region. The fact that more than 50% of the respondents were aware of the use of ICT in particular GIS and remote sensing technologies is an indication of knowing about the existence and importance of ICT tools. This might be attributed to the current forest policy which recognizes ICT as a tool for enhancing forestry extension services presence of various promotional programmes on ICT applications through social media and training [12]. Moreover, presence in-situ and ex-situ training within institutions also accounts for the promising trend of ICTs application. All these factors have contributed towards more awareness of the use of ICT among the respondents and a large number of professionals within the forest sector who apply ICT based technologies.

Currently ICT has been used in different forest operations however; GIS, remote sensing, cameras and GPS based applications remain to be cornerstone of ICT in forest for about 75%. The most frequently applications domain are mapping, forest inventory, forest road construction, forest protections and conservation activities, natural resources discovery/management, water management (irrigation and hydrology), ecological monitoring, tourism, agriculture, land information systems, demography, analysis of census an in forestry [24]. It was reported that because of the ecological and economic values of forests in Tanzania and elsewhere, globally use of ICT has emerged as the potential strategy towards sustainable forest management [6]. For stance, applications of remote sensing for the assessment of degradation as well as estimation of forest attributes is also widely practiced in Tanzania [1, 6, 13]. The state of art that shows both optical remote sensing and active remote sensing such Light Detection and Ranging (LIDAR) have also been applied in Tanzania [15]. Generally, GIS and remote sensing as part of the ICT technologies have a promising increasing trend of applications in different forest operations. Similar trend has been reported elsewhere [3, 8, 9].

Availability of infrastructures and use of appropriate software for data processing are the two important aspects to consider when using ICT in forest. A number of ICT based infrastructures were recorded in different institutions. Among the infrastructures mobile devices in particular GPS has shown to be highly used and also available nearly in all visited institutions. This may be attributed to cross cutting functionality and roles of GPS in providing unique positions needed for different forest operations ranging from silvicultural management to harvesting operations [24]. On the other hand, our study noted that there was an interesting trend towards the use of open source softwares for processing GIS and remote sensing data. The findings may be supported by the fact that, motivation for the less costs, free-access (restriction-free) and distribution, freedom in use and modification of the program [21]. However, there were a large number of people who were not aware of the use of open-source software. This is not surprising because the majority of them are technical staff who in most cases they assist the researchers and forest officers to collect data. Moreover, the number of technical staff with poor knowledge on the open source softwares are also the one with poor ICTs knowledge and they are also characterized with low level of education, majority with secondary and diploma level.

Despite the growing potential for ICT application in the forest sector of Tanzania, there were a number of limitations and challenges related to the availability of infrastructures, internet connectivity and personnel with appropriate ICT skills, which are relevant with forest applications. The findings are

similar to the ones reported by others that, high performance computers, smart autonomous sensor systems and data managing centers are the important factors in ICTs operations [5]. Thus, any problems among these factors will bring difficulties in operating. For stance; many computers found in the institutions were of outdated versions with low speed (1.6 GHz) and window 7 while in some of the institutions even the outdated ICT infrastructures were not enough. Most of the higher institutions such as TAFORI, NCMC, EAMCEF and DTSP despite the challenges faced but they were found to be satisfied with the available ICTs facilities and have ability to conduct their activities by at least 70%.

5. Conclusion

To conclude, the study had shown that, though there are challenges for the application of ICT, in forest sector of Tanzania, but there is promising progress towards its use over time. The major applications of ICTs in the forest sectors using Morogoro municipality, as case study were mostly on data storage and analysis, documentation, forest management and forest inventory. Major challenges observed were internet facilities, poor infrastructures and lack of qualified personnel.

6. Recommendations

The study recommends that researchers and forest officers are to be equipped with adequate ICT skills, enhance availability and usability of ICT tools and applications among stakeholders in the sector. Develop adequate ICT infrastructures and proper strategies such as training program within the sector and between sectors to ensure effective use of ICT in sustainable forest management. Further studies with more coverage are also recommended in the future.

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