THE UNITED REPUBLIC OF TANZANIA
NATIONAL AUDIT OFFICE

PERFORMANCE AUDIT REPORT ON THE CONTROL OF RADIATION SOURCES

CONTROLLER AND AUDITOR GENERAL
MARCH 2023

About National Audit Office

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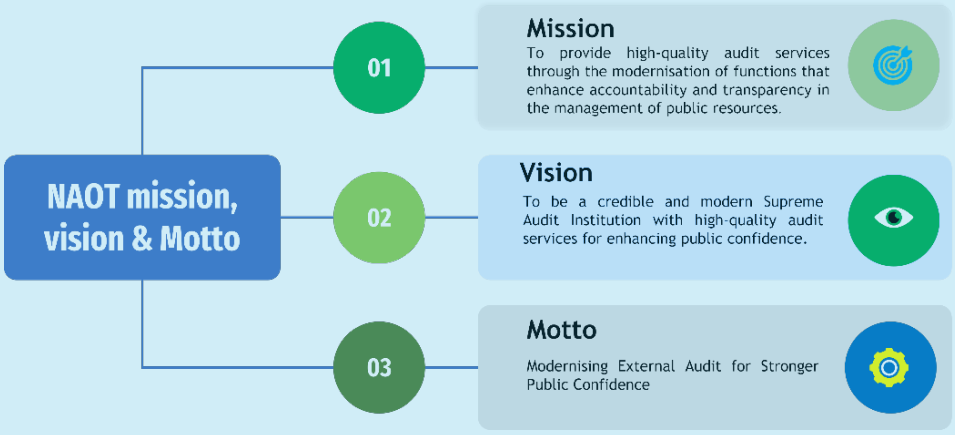

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PREFACE

Section 28 of the Public Audit Act, CAP 418 [R.E. 2021] gives a mandate to the Controller and Auditor General to carry out Performance Audit (Value-for-Money Audit) to establish the economy, efficiency, and effectiveness of any expenditure or use of resources in the Ministries, Departments and Agencies (MDAs), Local Government Authorities (LGAs) and Public Authorities and Other Bodies which involves enquiring, examining, investigating and reporting, as deemed necessary under the circumstances.

I have the honour to submit to Her Excellency, the President of the United Republic of Tanzania, Hon. Dr. Samia Suluhu Hassan, and through her, to the Parliament of the United Republic of Tanzania, the Performance Audit Report on the Control of Radiation Sources.

The report contains findings, conclusions, and recommendations that are directed to the Ministry of Education, Science and Technology and the Tanzania Atomic Energy Commission.

The Ministry of Education, Science and Technology and the Tanzania Atomic Energy Commission had the opportunity to scrutinize the factual contents of the report and comment on it. I wish to acknowledge that discussions with the Ministry of Education, Science and Technology and the Tanzania Atomic Energy Commission have been useful and constructive.

My Office will carry out a follow-up audit at an appropriate time regarding actions taken by the Ministry of Education, Science and Technology and the Tanzania Atomic Energy Commission in implementing the recommendations given in this report.

In completing the audit assignment, I subjected the draft report to a critical review of subject matter experts, namely Dr. Ismael Ndesario Makundi from the University of Dar es Salaam, and Dr. Mwijarubi Melkizedeck Nyaruba, a retired Officer of the Tanzania Atomic Energy Commission, who came up with useful inputs for the improvement of this report.

The report was prepared by Mr. Deogratius B. Shayo (Team Leader), Mr. Sayi E. Sayi and Mr. Odilo Mwesiga (Team Members) under the supervision and guidance of Ms. Asnath L. Mugassa (Chief External Auditor), Ms. Esnath N. Henry (Assistant Auditor General) and Mr. George C. Haule (Deputy Auditor General).

I would like to thank my staff for their commitment in preparing this report. I also acknowledge the audited entities for their cooperation with my Office, which facilitated the timely completion of the audit.

Charles E. Kichere
Controller and Auditor General
The United Republic of Tanzania
March, 2023

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LIST OF ABBREVIATIONS AND ACRONYMS

CAG	Controller and Auditor General
CRWMF	Central Radioactive Waste Management Facility
CT	Computerized Tomography
DSTI	Division of Science, Technology and Innovation
HQ	Head Quarter
IAEA	International Atomic Energy Agency
JNIA	Julius Nyerere International Airport
M&E	Monitoring and Evaluation
MEF	Monitoring and Evaluation Framework
MoEST	Ministry of Education, Science and Technology
MoFP	Ministry of Finance and Planning
MoH	Ministry of Health
MUHAs	Muhimbili, Health and Allied Sciences
MUST	Mbeya University of Science and Technology
NAOT	National Audit Office of Tanzania
NEMC	National Environmental Management Council
NMAIST	Nelson Mandela African Institute of Science and Technology
OSBs	Out stationed Border Post Offices
RRHs	Regional Referral Hospitals
RSO	Radiation Safety Officers

SAUT	St. Augustine University of Tanzania
TAA	Tanzania Airports Authority
TAEC	Tanzania Atomic Energy Commission
TANROADS	Tanzania National Roads Agency
TBS	Tanzania Bureau of Standards
TCU	Tanzania Commission for Universities
TLD	Thermoluminescent Dosimeters (TLD)
TZS	Tanzanian Shillings
UDOM	The University of Dodoma
UDSM	University of Dar es Salaam

DEFINITION OF TERMS

TERM		DEFINITION
Board	:	Board of the Commission as provided for in the Schedule to the Atomic Energy Act, 2003.
Calibration	:	A set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by measurement standards.
Commission	:	The Tanzania Atomic Energy Commission that was established under section 5 of the Atomic Energy Act, 2003.
CT-scan	:	A diagnostic imaging procedure that uses a combination of X-rays and computer technology to produce images of the inside of the body.
Disposal	:	The emplacement of waste in an approved, specified facility (e.g. near surface or geological repository) without the intention of retrieval.
Disposal facility	:	An engineered facility where waste is emplaced for disposal.
Disused source	:	A radioactive source that is no longer used, and is not intended to be used, for the practice for which an authorisation has been granted.
Dose	:	A measure of the radiation received or absorbed by a target.
Dosimeter	:	An instrument used to measure ionising radiation exposure.
Emergency Plan	:	A set of procedures to be implemented in the event of a radiation accident.
Facility	:	Any assembly of devices, equipment, structures or natural features whether simple or complex which serves some purpose or performs some function, in the course of which radiation is, or is capable of being emitted.
Half-life	:	The time required for the activity to decrease, by a radioactive decay process by half.
Ionising radiation	:	The radiation of gamma rays and x-rays or corpuscular radiation, capable of producing ions directly or indirectly in its passage through matter.
License	:	An authorization granted by the Commission on the

TERM		DEFINITION
		basis of a safety assessment and accompanied by specific requirements and conditions to be complied with by the licensee.
Licensee	:	A person holding a license granted under the Atomic Energy Act, 2003.
Nuclear Technology	:	Technology that involves the nuclear reactions of atomic nuclei. Among the nuclear technologies are nuclear reactors, nuclear medicine and nuclear weapons.
Person	:	A qualified experts registered for administering ionising radiations to patients.
Qualified expert	:	An individual who by virtue of certification by appropriate board or societies, professional license or academic qualification and experience, is duly recognised by the Commission as having expertise in a relevant field of specialisation.
Radiation device/equipment	:	An equipment capable of generating ionizing radiation when energised and it does not contain radioactive material.
Survey meter	:	An instrument used to measure radiation exposure and detect radioactive contamination.
The Ministry	:	The Ministry of Education, Science and Technology.
Thermoluminescent Dosimeters (TLD)	:	A versatile tool for the assessment of dose from ionising radiation.
Nuclear Density Gauge (Troxler Machine)	:	A device designed to measure the moisture and density of soils, aggregates, cement, and lime treated materials, and to measure the density of asphalt concrete.

EXECUTIVE SUMMARY

Background

Radiation sources are radioactive materials or by-product that are specifically manufactured or obtained for the purpose of using the emitted radiations. Radiation sources can either be a radioactive material (ore) such as Uranium, Cobalt-60 and other similar elements or a device which depends on being electrified in order to become energised and emit radiations. Examples of radiation devices are such as X-ray and CT-Scan machines which are used in health diagnostic as a result of projected radiations that penetrate tissues of human bodies.[1] Currently, radiations have emerged to be useful in human life activities ranging from medical diagnostic to nuclear power generations.

A study on evaluation of use of radiography conducted by Mgonja, (2017) reported an increase in the number of registered radiation facilities from 22 in 1985 to 436 in 2008[2] equivalent to 1,882% in 23 years. On the other hand, TAEC data base, indicated that, the registered radiation facilities as of June, 2022 increased from 436 in 2008 to 1169 in June 2022, equivalent to 168% change in 14 years. This significant increase in the use of radiation sources in the country, indicates that, there is a necessity of strengthening the radiological protection infrastructure in order to keep the potential radiation exposures as low as reasonably achievable.

Moreover, if precautions are not taken in controlling the radiation sources, they would become hazardous to the personnel using them, the public and the environment as well. Therefore, effective control of radiation sources is necessary to ensure proper and safe use or operation of radiation sources[3].

In response to this, the Government of the United Republic of Tanzania through the Atomic Energy Act No. 7 of 2003 established the Tanzania Atomic Energy Commission (TAEC) as a sole regulatory body responsible for regulating and

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[1] IAEA. Nuclear Security Series No.5, Technical Guidance Reference Manual "Identification of Radioactive Sources and Devices"

[2] Mgoja.C.I (PhD), Paper on " Evaluation on use of industrial radiography for weld joints inspection in Tanzania"

[3] https://www.ehs.washington.edu/radiation/radiation-producing-devices

controlling safe and peaceful utilisation of nuclear technology in Tanzania. In addition, it established the Atomic Energy (Protection from ionising radiation) Regulations, 2004 that specifies practices designed to ensure that, unnecessary exposure of persons to ionizing radiation are avoided.

Considering the effects that might occur due to uncontrolled radioactive sources, the Controller and Auditor General was compelled to undertake a performance audit on the control of radiation sources in order to determine whether the system for controlling radiation sources functions effectively.

The main objective of this audit was to assess whether the Ministry of Education, Science and Technology through the Tanzania Atomic Energy Commission (TAEC) has ensured that, there is effective control of radiation sources in the country to minimise risks to the users, the public and the environment.

The audit covered a period of four fiscal years starting from 2018/19 up to 2021/22 in order to come up with adequate and reliable audit conclusions and recommendations from this established performance trend for MoEST and TAEC to ensure the control of radiation sources in the country.

Moreover, the audit focused on the adequacy of control mechanisms of radiation sources, effectiveness of monitoring of radiation sources in ensuring safety to the users, the public and the environment, the effectiveness of coordination between TAEC and other stakeholders. It also, assessed on whether the Ministry of Education, Science and Technology effectively monitored its performance and that of TAEC in controlling the radiation sources in the country.

The summary of the audit findings, conclusions and recommendations is presented below.

The Main Audit Findings

Despite the noted efforts made by TAEC, such as licensing users of radiation sources, inspecting facilities possessing radiation sources, construction of a Central Radioactive Waste Management Facility at TAEC HQ in Arusha, and construction of a Complex Dosimetry Laboratory at TAEC HQ, the audit noted that, there were still ineffectiveness related to the control of radiation sources that can bear risk on both users (operators) and the public at large.

The deficiencies are as detailed as follows:

66% of Registered Radiation Facilities in the Country were not Licensed by TAEC to Possess and use Sources of Radiations

The audit found that, TAEC's licensing of facilities with radiation sources ranged from 31% to 37% over the past 4 years, with the highest extent of licensing at 37% in 2020/21, on average, 66% of registered radiation facilities were not licenced by TAEC over the period of four years from the year 2018/19 to 2021/22. This was contrary to the Atomic Energy Act, which requires TAEC to issue licenses to all the facilities using radiation sources each year. Lack of a proper licensing system led to TAEC losing an estimated TZS 424.650 million from the year 2018/19 to 2021/22 by not issuing licenses to 2,831 registered facilities.

The Presence of Undisposed Disused Radiation Sources

The audit found that, TANROADS' Regional Offices had 40 active radiation sources and 15 defective radiation sources on their premises that were not disposed. This finding concurs with what the audit found at TAEC that, it had only records of 53% of radiation sources present in TANROADS' Regional Offices. This was a clear indication of a lack of effective tracking mechanisms. Similarly, the audit found that, none of the 55 radiation sources had a return agreement with the manufacturers for proper disposal, as required by Regulations 62 (1) (a) & (b) and (3) of the Atomic Energy (Protection from Ionising Radiation) Regulations, 2004. Also, the absence of a proper radiation sources database management, and a lack of information on the respective disposal time and location of radiation sources were the main causes of having undisposed disused radiation sources.

83% of Registered Radiation Facilities by 2021/22 were not Inspected by TAEC

The TAEC's inspection of facilities possessing radiation sources was inadequately done, as evidenced by reviews of inspection reports for a 4 years period from 2018/19 to 2021/22. The annual inspections covered only 7% to 42% of all registered radiation facilities in the country, with a decline trend to 4% and 16% in year 2019/20 and 2021/22 respectively. On average, for the period of four years, 83% of registered facilities were not inspected by TAEC. This was contrary to the requirement of the supplement to International Atomic Energy Agency

(IAEA) safety standard series No. GS-G-1.5 and the Operational Policy and Procedures of TAEC of October 2021.

In addition, radiation sources or mobile radiation sources that remain uninspected for a long time than the prescribed time in the IAEA standards and the Operational Policy of TAEC could have leakage that emit radiations to the nearby surroundings. Thus, increases safety risks to the users of radiation sources, environment and the public at large.

The Inadequate Functioning Mechanism for the Control of Radiation Sources

The audit team noted that, TAEC managed to develop and have an approved National Nuclear and Radiological Emergency Response Plan by 11th February, 2022. However, the approval process to the National Nuclear and Radiological Emergency Response Plan delayed for 2 years from year 2019/20 to 2021/22. Besides that, the safety procedures which were already in place emphasised that, both documents are intended to bring not only safety in the use of radiation sources but also prevent illicit trafficking of radioactive sources into the country.

Likewise, the Audit Team found that, TAEC did not manage to adequately register all experts, specifically radiographers, who were required to be issued with operating license subject to renewal on annual basis. It was established that, TAEC managed to license from 60% to 75% of the registered experts by the Tanzania Medical Radiology and Imaging Professional Council for the 3 calendar years from 2020 to 2022. The licensing efforts was equivalent to an increase from 6% to 9% only per annum. As a result, the Commission lost an estimated revenue amounting to TZS. 47.2 million, as a result of leaving out other persons unlicensed for the period under review.

Moreover, the Audit Team found that, TAEC had shortage of scientific inspection equipment/tools at Headquarter Zonal Offices, Regional and Border Post Offices by 72%. However, the Commission did not conduct Needs Assessment on the category, quantity and clearly set out budget required to facilitate the acquisition of potential radiation inspection equipment. This led into inability of the Commission to plan and budget for the acquisition of the required radiation control equipment hence, compromised the required standards and quality of inspection activities to facilities with radiation sources in the country.

The Inadequate Monitoring of Radiation Sources

The Audit team noted the following challenges indicating ineffective Monitoring of radiation sources to ensure safety to the users, the public and the environment:

The Inadequate Monitoring of Premises with Radiation Sources

Reviewed TAEC's Inspection Reports from the financial year 2018/19 to 2021/22 revealed the presence of radiation facilities with deficiencies such as inadequate shielded premises, lack of survey meters, lack of quality assurance programme, lack of warning symbols and notice, and presence of operators who did not attend radiation safety training which are conducted either within or outside the country as required by the Atomic Energy Act 2003.

Similarly, in the visited facilities it was further noted that, all 21 visited radiation facilities which was equivalent to 100% lacked a waste management plan, 17 out 21 facilities, equivalent to 81% lacked survey meters for monitoring radiation leakages from the facilities, 8 out of 21 facilities equivalent to 38% did not have radiation safety working rules and procedures, 10 out of 21 facilities equivalent to 48% were found with inadequate safety gears such as gonad shields, lead aprons, gloves and goggles and 4 out of 8 visited medical facilities equal to 50% were found without a waiting area for patients .

This was attributed to a lack of adequate knowledge on safe use of radiation sources and a lack of follow-ups to issued recommendation by TAEC regarding inspection of radiation facilities. The existence of deficiency in the radiation premises has a risk of not only exposing operators to high radiation doses beyond the recommended values but also pose a radiological risk to members of public, and the environment at large. This in return could probably raise the risk of adverse health hazards to the general public.

The Inadequate Number of Radiation Detection Instruments to Users Possessing Radiation Sources

The review of TAEC's survey meters services for the year 2018/19 to 2021/22 noted that, facilities that possess sources of radiation in different practices such as medical diagnostics, mineral processing, research and construction rarely had survey meters in their premises for area monitoring. The extent of facilities that

did not possess survey meters for premises monitoring ranged from 91% to 100% in different practices, whereby construction activities and medical facilities had a deficit of over 99% of survey meters for their facilities monitoring.

This was contrary to Section 30(1) & (2) of the Atomic Energy Act, 2003 which requires every licensee to ensure availability of adequate number of survey instruments for area monitoring at radiation workplace and send the radiation survey instruments to an approved dosimetry laboratory at least once a year and after every maintenance or repair for calibration.

Moreover, through the Audit verification in selected 21 radiation facilities, it was observed that, none of 8 facilities for medical and 6 for construction found possessing radiation survey meters, while in the visited airports 4 out of 7 were found having radiation survey meters. On the other hand, out of 4 survey meters found in the visited airports were neither calibrated by TAEC nor operated by qualified Radiations Safety Officers and were also not utilised for the intended purpose. The inadequate survey meters to the users with radiation sources was attributed by TAEC not fulfilling its legal obligation of creating awareness regarding radiation sources to users.

Therefore, radiation facilities without survey meters could experience attenuation to radiations that could be emitted from misbehaved sources of radiation and lead to health implications to occupationally exposed workers and members of the public.

Ineffective liaising between TAEC and other Stakeholders in Controlling Radiation Sources

The Audit Team found that, collaborations between TAEC and Universities existed only in 3 Universities out of 30 approved and accredited Universities in Tanzania by the Tanzania Commission for Universities (TCU) as of May, 2022[4]. This was due to insufficient learning infrastructures in various Universities that would enhance cooperation in academic and researches with TAEC. Consequently, this situation hindered early dissemination of nuclear science technology to many scholars in Tanzania that would ultimately affect the country strategic objectives of promoting peaceful use of atomic energy.

[4]https://www.tcu.go.tz/sites/default/files/LIST%20OF%20UNIVERSITY%20INSTITUTIONS%20IN%20TZ%20AS%20OF%2012%20MAY%202022%20FINAL.pdf

Moreover, the Audit Team further found that, TAEC has not provided sufficient awareness to various users of radiation sources such as in medical, industries, mining and construction sectors practices. This was mainly attributed by non-incorporation of training and seminars in their annual plans for the entire period under the review. This practice was found to be contrary to Objective D of its approved Strategic Plan 2018/19 – 2022/23. However, the Inadequate provision of training and awareness to the users of radiation sources was attributed to the absence of sufficient knowledge by the users on compliance requirements to safety standards while possessing, using or transporting radiation sources or security of radioactive sources. This would also affect the awareness on the illicit trafficking of radioactive materials in the respective facilities.

Additionally, TAEC did not manage to establish a national coordination waste management programme. The Audit Team found out that, the developed National Policy and strategy for Radioactive Waste Management of January, 2017 has been in a draft form for five consecutive years since 2017. Non-functioning of National Policy and Strategy for Radioactive Waste Management resulted into absence of clear and comprehensive procedures for managing dis-used radiation sources.

The Ineffective Monitoring and Evaluation of the Performance of MoEST and that of TAEC by MoEST

MoEST did not adequately monitor its performance in controlling radiation sources activities. This was manifested by the non-consideration of radiation control activities in their annual plans for the financial year 2019/20 to 2021/22. In addition, monitoring of objective F in the strategic plan which was nuclear technology promotion and regulation implementation by the Ministry revealed ineffective monitoring plan due to a lack of planned timeframe, reporting mechanisms and presence of a responsible section/unit for monitoring and assessing the stated performance indicators.

Moreover, through the review of MoEST's implementation reports, the Audit Team found that, the Ministry focused much in monitoring sponsored development projects that are implemented under TAEC and putting less focus on regulatory and promotion activities such as licensing, inspection, researches /publications, and illicit traffic at border posts. This was mainly caused by inadequate planning by the Ministry due to the fact that, during the entire audit period the Ministry

planned to monitor and evaluate the developed projects sponsored by the International Atomic Energy Agency (IAEA).

Similarly, the Audit Team noted that, the Ministry of Education, Science and Technology (MoEST) did not have a Monitoring and Evaluation Framework for monitoring and evaluating the performance of TAEC on radiation control activities instead the available plan covered only the education sector.

Consequently, the Ministry of Education, Science and Technology could not monitor and evaluate the Performance of TAEC on the regulatory and promotion activities leading to the Ministry lacking information regarding the actual performance of TAEC on regulation and promotion of nuclear technology.

Audit Conclusion

Based on the findings presented, it is concluded that, MoEST through TAEC has not effectively controlled radiation sources to minimise the risks to the users, the public and the environment due to lack of adequate mechanisms of licensing, inspection and monitoring of radiation sources in the country. Also, the Audit Team acknowledged the efforts made by the Ministry of Education Science and Technology and the Tanzania Atomic Energy Commission in controlling and promoting safe and peaceful use of nuclear technology in the country. These efforts included; construction of complex laboratories in Arusha and 5 other laboratories in 5 Regions to facilitate control of radiation sources.

Other notable efforts included, improved cooperation with the International Atomic Energy Agency (IAEA) which enhanced the implementation of projects such as strengthening and expanding the Cancer Control Programme, establishing a Graduate School of Nuclear Science and Technology at the Nelson Mandela African Institute of Science and Technology and establishment of a Multipurpose Irradiator Facility supported by the IAEA to enhance industrialisation.

However, the Audit Team noted that, more interventions are still needed for further improvement of the control of radiation sources in the country. This was due to the fact that, TAEC had not managed to ensure licensing of the users of radiation sources as it is required by the Atomic Energy Act of 2003.

Moreover, it was found that, for the past 4 years, the licensing of possession and use of license by TAEC was gradually increasing to 37% which was attained in the

financial year 2020/21. This is an indication that, there was positive improvement on licencing by TAEC. Furthermore, TEAC could not adequately track mobile radiation sources. The Audit noted that, in the past 4 years of the review period, TAEC managed to track only 47% of troxlers machines available at the users' premises. As a result, there was an increase of risks to the users, the public and the environment due to exposure to uncontrolled radiation sources with radioactive materials such as beryllium (Be), caesium (Cs) and americium (Am) that emit radiation continuously even when not in use.

Generally, TAEC did not collect an estimated amount of TZS 479.05 million as a result of inadequate licensing of the users of radiation sources, inadequate qualified experts and radiation emitting devices for the Audit period.

Audit Recommendations

Recommendations to the Ministry of Education, Science and Technology

The Management of the Ministry of Education, Science and Technology is urged to:-

1. Develop and implement a comprehensive and effective Monitoring and Evaluation Plan capable of periodically assessing its performance and that of TAEC regarding the control of radiation sources and radioactive materials in the Country;

2. Ensure timely review of the National Research Policy and the Research Policy Implementation Plan to ensure that, they address matters related to nuclear technology; Radioactive wastes; and

3. Strengthen and empower TAEC's research section for researchers to conduct research in different sectors and publish research papers for the national economic development to increase the application of nuclear sciences/technology in the country.

Recommendations to the Tanzania Atomic Energy Commission

The Management of Tanzania Atomic Energy Commission is urged to:

1. Develop licensing mechanisms that would ensure qualified experts responsible for administering ionising radiation to patients are entirely licensed as per the requirement of Regulation 18(1) of the Atomic Energy (Protection from Ionising Radiation) Regulations, 2011. Also, the mechanism should effectively enhance periodical tracking of licensing status of each person, facilities and radiation emitting devices;

2. Ensure the functioning of the National Coordinated Radioactive Waste Management Programme to ensure that, there clearly and comprehensive established procedures for managing dis-used radiation sources available to both medical and non-medical practices in the country;

3. Ensure drafted National Nuclear Radiological Emergency Plan is rolled out at National and facility level. Also, the rolling-out should ensure that, each responsible government agency develop and maintain its own unique agency plan and detailed reporting procedures to carry out the response;

4. Conduct needs assessment to determine the requirements of inspection equipment to establish the available shortage and appropriately cover it. Also, it should facilitate TAEC to know the type, quantity, quality, location and budget needed for acquisition of those inspection tools;

5. Enhance follow-up mechanisms on the implementation of the recommendations ranging from inspections to the users of radiation sources. These are expected to enable the users of radiation facilities to comply and facilitate them to work and fix deficiencies in radiation premises to meet the desired quality in provision of radiation services;

6. Enhance a functional Mechanism for effective tracking of Mobile radiation sources in the Country. This will ensure that, mobile radiation sources are acquired, used, stored, transferred and disposed in accordance with radiation safety requirements; and

CHAPTER ONE

INTRODUCTION

1.1 Background of the Audit

Radiation is the emission of energy as electromagnetic waves or as moving subatomic particles, especially high-energy particles which cause ionisation. Radiation sources are materials or by-product that are specifically manufactured or obtained for the purpose of using the emitted radiation. Such sources are commonly used in medical field such as radiotherapy; in industries such as industrial radiography, gauges, irradiators, gamma knives and as power sources for batteries (such as those used in spacecraft). Also, those sources used in research such as various radioisotopes.

These sources usually consist of a known quantity of radioactive material, which is encased in a manmade capsule, sealed between layers of nonradioactive material, or firmly bonded to a nonradioactive substrate to prevent radiation leakage. Other radiation sources include devices such as accelerators and X-ray generators[5].

Radiation sources can either be a radioactive material (ore) such as Uranium, Cobalt-60 and other similar elements or a device which depends on being electrified in order to become energised and emit radiations. Examples of radiation devices are such as X-ray and CT-Scan machines which are both used in health diagnostic as a result of projected radiations penetrates tissues of human bodies.[6] Currently, radiations have emerged to be useful in human life activities ranging from medical diagnostic to nuclear power generations.

[5] http://nuclearsafety.gc.ca/eng/resources/radiation/introduction-to-radiation/types-and-sources-of-radiation.cfm

[6] IAEA. Nuclear Security Series No.5, Technical Guidance Reference Manual "Identification of Radioactive Sources and Devices"

A study conducted by Mgonja in 2017 reported an increase of registered radiation facility from 22 in 1985 to 436 in 2008[7]. According to TAEC's register of radiation facilities in the country as of June, 2022, radiation facilities have increased to 1169.

This significant increase in use of radiation sources in the country, establishes the necessity to strengthen the radiological protection infrastructure in order to keep the potential radiation exposures as low as reasonably achievable.

Moreover, if necessary, precautions are not taken into account to ensure that there is a control of the radiation sources, it will result into hazardous effects to the personnel using them, the public and the environment as well. Therefore, effective controls of radiation sources must be in place to ensure proper and safe use or operation of radiation sources[8].

In a nutshell, the control of radiation sources refers to measures executed to control hazardous effect that radiation sources can cause during its use and/or disposal. These measures are such as registration of radiation facilities, licensing of radiation sources, monitoring of users of radiation sources through inspections and to ensure proper disposal mechanism of radiation sources.

In the United Republic of Tanzania, the Atomic Energy Act No. 7 of 2003 established the Tanzania Atomic Energy Commission (TAEC) as a sole regulatory body responsible for regulating and controlling the safe and peaceful utilisation of nuclear technology in the country.

1.2 The Rationale for the Audit

The Audit was motivated by various reported challenges related to the control of radiation sources and their associated health risks to the users and the environment as presented below:

[7] Mgoja.C.I (PhD), Paper on "Evaluation on use of industrial radiography for weld joints inspection in Tanzania.

[8] https://www.ehs.washington.edu/radiation/radiation-producing-devices

(a) Cancer Risk Associated with Exposure to Radiation Sources

Cancer is a major long-term health effect of ionising radiation. Many scientists who experimented with radiation at the turn of the century later developed skin cancer. This was the first link established between radiation exposure and cancer e.g. Leukemia, a cancer affecting bone marrow, has been linked to several types of radiation exposure. Some risk for lung cancer has been attributed to radon gas, particularly among mine workers. Other types of cancer linked to radiation exposed humans include bone diseases (other than leukemia), breast, stomach, and thyroid[9].

Moreover, the National Cancer Control Strategy of 2013-2022 indicated that, there is a notable increase of a number of new cases for cancer in the past ten years[10]. In Tanzania, Cancer is a major cause of morbidity and mortality, being the fifth (5^{th}) cause of death among adult men and the second (2^{nd}) among female adults. In the year 2020, it was estimated that, about 50,000 people develop cancer each year, and recent forecasts suggest that, by 2030 this number will increase by 50%[11]. This disease has cost implication associated with medical treatments.

Moreover, the high risk for cancer disease therefore, increase the demands for effective controls of radioactive sources in order to minimize the risks associated with the treatment costs and loss of human life. This implication is also supported by a study conducted by Lee *et al,* 2018[12] in assessing projected lifetime cancer risks from occupational radiation exposures among diagnostic medical radiation workers in South Korea. The study reported that, the estimated risks for specific occupational groups, from highest to lowest, were generally in the order of radiologic technologists, nurses, radiologists, other physicians, dental hygienists, and dentists. The study further indicated that, the estimates for female

[9] www.energy.gov>radem3_1

[10] The United Republic of Tanzania "National Cancer Control Strategy" 2013 – 2020.

[11] The Ministry of Health; "National Cancer Treatment Guideline", First Edition, 2020.

[12] Won Jin Lee*, Yeongchull Choi2 , Seulki Ko1 , Eun Shil Cha1 , Jaeyoung Kim3 , Young Min Kim4 , Kyoung Ae Kong5 , Songwon Seo6 , Ye Jin Bang1 and Yae Won Ha1 (2018).

radiologic technologists were considerably higher, a situation which drew much attention[13].

(b) Supports the Achievement of the United Nations Sustainable Development Goals

Target No. 3.4.1 of the Sustainable Development Goal Number 3 emphasises assurance of healthy lives and promote well-being for all at all ages and reduce mortality rate attributed by cancer by 2030. The fulfilment of this target will be contributed from improved control of radiation sources used for cancer treatment and diagnosis, also improved premises of radiation intended for treatment or diagnostic without deteriorating the healthy tissue of human being. The use of well controlled radiation sources further will help to reduce premature deaths from diseases which is the priority for the International Atomic Energy Agency too (IAEA).

Based on the established reasons, the Controller and Auditor General decided to carry-out a performance audit on the control of radiation sources in the country. The intention was to examine the performance of the MoEST and TAEC in relation to the control of radiation sources and recommend areas for further improvements.

1.3 The Design of the Audit

1.3.1 The Audit Objective

The overall objective of the audit was to assess whether the Ministry of Education, Science and Technology through the Tanzania Atomic Energy Commission (TAEC) ensure effective control of radiation sources in the country so as to minimise risks to the users, the public and the environment.

[13] https://bmccancer.biomedcentral.com/counter/pdf/10.1186/s12885-018-5107-x.pdf

Specific Objectives of the Audit

In order to address the main audit objective, four specific audit objectives were established. These objectives aimed to assess whether:

i) TAEC has effective control and safety mechanisms of radiation sources;

ii) TAEC has effective monitoring and surveillance programme of radiation sources to ensure safety to occupationally exposed workers, members of the public and the Environment;

iii) There is effective coordination between TAEC and other stakeholders in controlling the radiation sources; and

iv) MoEST effectively monitors and evaluates periodically its performance and that of TAEC on the control of radiation sources.

In order to clearly operationalise the above specific objectives of the audit, specific audit questions and sub-audit questions were prepared as presented in ***Appendix Two***.

1.3.2 The Scope of the Audit

The main audited entities were the Ministry of Education, Science and Technology (MoEST) and the Tanzania Atomic Energy Commission (TAEC). MoEST was selected because it is the ministry responsible for overseeing control of radiation sources by formulating and reviewing policies, laws and regulations and promoting research in the area of radiation protection. TAEC was selected because it is a commission mandated to take charge on all matters relating to the control of radiation sources, promoting safe and peaceful use of atomic energy and nuclear technology including radiation sources. This is in the view of promoting their applications, while at the same time protecting workers, patients and the public in general from harm caused by radiation.

The audit mainly assessed the effectiveness of TAEC in controlling radiation sources in the country. The Key focus areas were on the availability of functioning mechanisms for control of radiation sources, adequacy of monitoring of radiation sources, effectiveness of coordination between TAEC and other stakeholders in

controlling the radiation sources. It also assessed the effectiveness of MoEST in monitoring its own performance and that of TAEC with regards to control of radiation sources.

In assessing the functioning of radiation control mechanisms, the audit examined established strategies and plans for control of radiation sources, procedures for authorisation of radiation sources, adequacy of conducted inspections to users of radiation sources and operations of radiation emitting devices.

With regarding to monitoring of radiation sources, the audit assessed the extent to which MoEST and TAEC ensure compliance to the required quality and standards for premises with radiation sources, protection of users exposed to radiation sources, and availability and effectiveness of monitoring tools (mechanisms for tracking mobile radiation sources, availability of radiation survey instruments to users and assessing on whether the radiation instruments are adequately calibrated.

Besides that, the audit assessed the effectiveness of coordination between TAEC and other stakeholders in ensuring that, radiation sources are adequately controlled. In this aspect, the audit assessed the coordination mechanisms and implementation of planned coordination activities.

Moreover, the audit assessed effectiveness of MoEST in evaluating its performance and that of TAEC in controlling radiation sources in the country. The focus on the adequacy of monitoring, evaluation, reporting and effectiveness of corrective actions taken to enhance control of radiation sources.

The audit covered the entire country. In this respect, both medical and non-medical categories of the radiation sources were assessed in order to determine TAEC's performance in controlling both categories of radiations.

The audit covered a period of four fiscal years starting from 2018/19 up to 2021/22. This was purposely done in order to come up with adequate and reliable audit conclusion and recommendations based on the established performance trend for both MoEST and TAEC regarding the control of radiation sources in the country.

Also, the review period is within the timeframe when the Government in collaboration with the International Atomic Energy Agency (IAEA) implemented various projects in nuclear science and technology in the country. These projects include, cancer therapy programme focusing on strengthening provision of radiotherapy and nuclear service medicine. It also built and equipped TAEC complex laboratory with modern equipment to strengthen services through calibrating and testing of radiation detection equipment to increase the safety and control of radiation sources in the country. Therefore, the selected timeframe enabled the audit team to assess the performance trend for both MoEST and TAEC and come out with adequate and reliable audit conclusion and recommendations.

1.3.3 Assessment Criteria

In order to assess the performance of TAEC in the control of radiation sources, assessment criteria were drawn from legislations, guidelines, good practices and Strategic Plans of MoEST and TAEC.

The following are the audit criteria for each of the specific audit objective:

(a) Control Mechanisms for Radiation Sources

According to Section 6(1) and 6 (1) (h) of the Atomic Energy Act, 2003), TAEC is required to formulate and operate a National Radiological Emergency Plan and Preparedness. TEAC is also required to carry-out regular inspections and take corrective actions if unsafe or potentially unsafe conditions are detected.

Also, Principle 3 of IAEA Nuclear Energy Policies and Strategies for the Decommissioning of Nuclear and Radiological Facilities Series No. NW-G-2.1 of 2011, requires the use of nuclear energy to ensure that, people and the environment are protected in compliance with the IAEA safety standards.

Further, TAEC's Corporate Strategic Plan for the Year 2018/19 – 2022/23, among the strategy of the Commission for strengthening dosimetry services, the Commission is required to increase dosimetry services to person and the environment ranging from 1800 to 2200 radiation workers and calibration services ranging from 20 to 30 centres by 2023.

In addition, Section 11 (1) (2)) and Section 18 of the Atomic Energy Act, 2003, TAEC is required to ensure that, no any person shall use, posses, export, store or transport any ionizing radiation sources unless is licensed and registered. It is also required to issue license to person (body of persons, corporate or incorporate) intending to become a user of radiation source (s), the license issued shall not be transferable and shall expire upon a financial year period and may be renewable after fulfilment of the safety requirements prescribed by the Commission.

Similarly, according to TAEC's Corporate Strategic Plan for the Year 2018/19 – 2022/23), TAEC is required to ensure regulatory infrastructure for safety and control of ionizing and non-ionizing radiation sources for protection of the public and environment is established and improved by June, 2023. The infrastructures include to equip and re-tool the existing offices with radiation detector equipment (survey meters); laboratory equipment; special vehicle for transportation of radiation sources, wastes and construction of 5 new laboratories.

(b) Monitoring of Radiation Sources to Ensure Safety to Users and the Public

According to Section 6(1) (o) of the Atomic Energy Act of 2003, the Commission is required to hold or facilitate seminars, workshops or short training courses including public education for the safe and peaceful uses of atomic energy and nuclear technology in Tanzania.

Similarly, Section 56(2)(a) of the Atomic Energy Act of 2003, requires TAEC to provide personal radiation measuring devices to be worn by individuals occupationally exposed to radiation and establish a system which will facilitate the determination of extent of exposure to radiation among workers, students, and personnel employed in research, teaching and hospitals.

Likewise, Regulation 30 (2)(a) of the Atomic Energy (Protection from Ionizing Radiation) Regulations of 2004, requires TAEC to make available an adequate number of survey instrument for area monitoring at radiation work place.

Moreover, Regulation 30 (2)(b) of the Atomic Energy (Protection from Ionizing Radiation) Regulations of 2004, requires TAEC to ensure that every licensee send the radiation survey instrument to an approved dosimetry laboratory for calibration at least once a year and after the maintenance or repair for the

instrument. In addition, Regulation 57 (c) requires TAEC to ensure Licensees submit a summary of the monitoring results to the Commission every year and promptly inform the Commission of any abnormal results which lead or could lead to an increase of public exposure.

Furthermore, TAEC's Corporate Strategic Plan for the Year 2018/19 – 2022/23 through its strategy of strengthening dosimetry services TAEC set a target to increase dosimetry services to personnel and the environment from 1800 to 2200 radiation workers and calibration services from 20 to 30 centres by 2023.

(c) Coordination between TAEC and other Stakeholders

According to Section 6(1) (p) of the Atomic Energy Act, 2003, TAEC is required to promote national and international co-operation or collaboration on the applications of atomic energy and nuclear technology already introduced or intended to be introduced in the United Republic of Tanzania.

In addition, Section 6(1) (q) of the Atomic Energy Act, 2003, requires TAEC to liaise with Ministries and the appropriate institutions in order to facilitate the incorporation into the syllabi of all relevant and appropriate knowledge in nuclear science and technology for the practical applications of atomic energy and the related safety and protection during utilization.

On the other hand, Section 6(1) (s) of the Atomic Energy Act, 2003, requires TAEC to establish and operate or facilitate the operation of a system for management of radioactive waste emanating from various atomic energy and nuclear technology applications.

(d) Monitoring and Evaluation of Performance of TAEC in Controlling Radiation Sources by MoEST

According to the responsibilities of MoEST through its Division of Science and Technology, the Ministry is responsible to formulate and review science, technology, innovation and research policies, guidelines and standards and

monitor their implementation[14] including promoting research in areas of radiation sources and widen usability to benefit the public.

Similarly, Section 7 of the Executive Agency Act CAP 245, MoEST through the Ministerial Advisory Board is responsible for the strategic management of the Tanzania Atomic Energy Commission. This includes monitoring and evaluation of TAEC's performance in controlling radiation sources in the country. It also required to request submission of its annual reports including report on the operations of the Agency during that financial year so as to evaluate the Agency's performance.

Furthermore, TAEC's Corporate Strategic Plan for the Year 2018/19 – 2022/23) requires MoEST through TAEC to set a target and ensure national, regional projects and researches on nuclear science and technology are formulated, coordinated, implemented and monitored by June 2023.

1.3.4 Sampling, Methods for Data Collection and Data Analysis

Various methods for sampling, data collection and analysis were used by the Audit Team as follows:

(i) Sampling Technique

The Audit Team used purposeful sampling technique to select categories of radiation sources, facilities, TAEC's Offices and regions to be covered during the audit in order to ensure that sufficient and appropriate evidence is collected.

Sampling of Categories and Types of Radiation Sources

The audit purposefully selected both medical and non-medical radiation sources in order to widely assess the performance of MoEST and TAEC in controlling all two categories of radiation sources. Medical radiation sources that were covered include radiation emitting devices applied for medical diagnostic and treatment because of health effect such as injuries and cancer risks associated with improper management of radiation sources for medical use.

[14] http://www.moe.go.tz/sw/menu-item/idara-na-vitengo/idara/sayansi-teknolojia-na-ubunifu

Similarly, for non-medical radiation sources included radiation sources used for security purposes, road constructions, mining activities and industrial use because they pose high risks to workers, the public and the environment if are not properly administered and disposed.

Further, the Audit also assessed the radiation detection equipment which are survey meters and Thermoluminiscent Dosimeters (TLD) used for detection and monitoring level of exposure to radiation sources. The summary of radiation sources covered under each category are summarized on **Table 1.1**

Table 1.1: Summary of the Selected Radiation Sources/Equipment

Category of radiation sources	Radiation sources/equipment selected	Reason for selection
Medical Radiation Sources	X-rays equipment	• The widespread use of X-rays in the diagnosis and management of patients has led to increased risks of radiation exposure
	Mammograph	
	CT-SCAN	
	Brachytherapy and external beam radiation therapy	• Because of gamma radiation external exposure to large sources of Co-60 and Cs-137 can cause skin burns, acute radiation sickness or death. • Improper administration of nuclear medicines to patients may lead to cancer risks such as bladder cancer, breast cancer, borne cancer, liver cancer, oral cancer, etc.
	Nuclear Medicines	
	Cobalt 60	
	Caesium (Cs-137)	
	Nuclear Medicines	
Non-Medical Radiation Sources	X-rays equipment	• Mismanagement of both X-rays and Nuclear Density Gauge may result into health and environmental risks such as cancer, death and environmental effect to flora and fauna
	Nuclear Density Gauge(troxler)	
Equipment	Thermoluminiscent Dosimeters (TLD)	• Poor handling for TLD and survey meters can lead to

Category of radiation sources	Radiation sources/equipment selected	Reason for selection
	Survey Meters	spread of uncontrolled radiations, hence posing health risks to both users and the public

Source: *Auditors' Analysis on the Selected Radiation Equipment (2022)*

Sampling of TAEC Zonal, Regional Offices and Regions Covered

The Audit Team covered all 2 TAEC Zonal Offices namely Dar Es Salaam Zonal Office and Mwanza Zonal Office in order to assess the performance of TAEC in those Zonal Offices. Since the available two TAEC Zonal Offices are not sufficient to represent the geographical coverage, the Audit Team also purposely selected regions from the remaining Zones (Northern, Southern, Southern Highlands and Western Zones) where TAEC has regional or border post Offices in order to ensure that all administrative zones are covered.

Regarding regions visited, the Audit Team selected a total of eight regions, covering all seven administrative zones; whereby three regions were selected from the two TAEC Zonal Offices and four from other administrative zones.

In selecting the regions, the audit took into consideration the availability of selected radiation facilities with radiation sources within the regions. Regions with TAEC's Regional Offices and those without TAEC's Regional Offices were selected. Summary of the selected regions in each zone is presented on **Table 1.2** below:

Table 1.2: Regions that were Visited during the Audit

Name of TAEC's Zonal Offices	Regions Served by the respective TAEC's Zonal Offices	Name of Selected Region	
		Region with TAEC's Zonal Offices	Region without TAEC's Zonal Offices
Eastern Zone	Dar es Salaam, Morogoro and Pwani	Dar es Salaam	
Lake Zone	Mwanza, Simiyu, Shinyanga, Kigoma, Kagera, Tabora, Mara, Geita	Mwanza	Kigoma

Name of TAEC's Zonal Offices	Regions Served by the respective TAEC's Zonal Offices	Name of Selected Region	
		Region with TAEC's Zonal Offices	Region without TAEC's Zonal Offices
Selected Regions from other Administrative Zone that are not Falling within TAEC's Zonal Offices			
Northern Zone	Arusha	Arusha	
	Tanga		
	Kilimanjaro		
	Manyara		
Southern Zone	Mtwara	Mtwara	
	Lindi		
	Ruvuma		
Southern Highland	Mbeya	Mbeya Songwe	
	Njombe		
	Songwe		
	Iringa		
Central Zone	Dodoma		Dodoma
	Tabora		
	Singida		

Source: *Auditors' Analysis on the Selected Regions to be Visited (2022)*

Sampling of Radiations Facilities (Institutions) Covered

From each selected region, the Audit Team purposefully selected one medical and one non-medical facility. One Referral government hospital in each selected region was also selected since is the only level of health facility with at least one or more category radiation sources for medical diagnostic or treatment.

Health facilities at the regional level were selected based on the fact that, the sampled radiation sources are mainly found in regional level health facilities compared to facilities at the lower level. These sampled sources are such as X-rays, CT-scan and Mammography. Also, the regional health facilities were preferred over the national and zonal hospital level since they have large coverage over the country and serve a large number of people compered to hospitals at the national and zonal level. For that case, effective control of radiation sources is significant to the Tanzania population if well implemented at this level of healthcare facility.

For the case of non-medical facilities with radiation sources, the Audit Team selected one facility in the construction sector (TANROADS) and one facility in an aviation sector (Tanzania Airport Authority) to represent both radiation sources used for either construction or security activities. Whereby, in each selected region both Regional TAA and Regional TANROADS' Office were visited in order to have a representative coverage of radiation sources used in security and construction sector.

Moreover, the Audit Team made consideration of TANROADS, since it owns and use radiation sources namely Troxlers during road construction purposely for compaction tests. Also, Aviation Sector was selected because it uses sources of radiation for security purposes in cargo scanning and human body scanning which require much attention and care to reduce negative effects to people and the environment.

(ii) Methods Used for Data Collection

Both qualitative and quantitative data were collected for information triangulation to strengthen the evidence regarding the performance of MoEST and TAEC in the control of radiations in the country.

The Audit Team used various methods of data collection such as documentary review, interviews and observation through physical visits and verification of instruments/ infrastructure etc.) as detailed below:

Document Reviews

The Audit Team reviewed various documents as shown in **Appendix Three** of this report that were prepared by MoEST and TAEC during the financial years 2018/19 to 2021/22.

Interviews

The Audit Team conducted interviews to Officials from MoEST, TAEC headquarters and in the selected regions. Moreover, the Audit Team conducted interviews with officials from the government entities owning medical and non-medical radiation equipment in the visited regions. Interviews were conducted in order to gain insights and clarifications on the information regarding control of radiation

sources and to validate information from the reviewed documents. The details of Officials interviewed during the study is presented in the **Appendix Four.**

Physical Verifications

The Audit Team conducted site visits for physical verifications whereby it observed workers working in the environment with radiation sources as their day-to-day activities and assessed of storage facilities with radiation sources on whether they meet the set requirements. Moreover, observation was conducted in order to verify information obtained from the reviewed documents. During observation, notes and photos were taken on the actual setting of the workers exposed to radiation sources and storage facilities for both medical and non-medical facilities.

Also, the Audit Team verified the availability and condition of the radiation detection devices as well as the way they are managed by the users in ensuring safe use.

(iii) Data Analysis Method

The collected information was analysed using both qualitative and quantitative methods to obtain sufficient information that enabled to establish the overall performance of MoEST and TAEC with respect to the control of radiation sources in the country.

Quantitative data were collected through structured interviews and documentary review. Responses were quantified by counting the frequencies at which different positive or negative statements about the issues, were given by the respondents. In addition, the frequencies at which similar statements were given by different respondents were counted. The data were organised, summarised and compiled using different statistical methods for data computations. Simple pie-charts and graphs were also used to describe and compare the proportion under each main theme identified. The analysed data were then presented on tables and graphs.

Qualitative data were described, compared and related so that, they could be explained in the form of findings regarding the audit questions. The analysis

involved looking for categories such as events, descriptions, consistencies or differences so as to draw inferences from the collected data on explaining the control of radiation sources in the country.

1.4 Data Validation Process

The Ministry of Education, Science and Technology (MoEST) and Tanzania Atomic Energy Commission (TAEC) were given the opportunity to go through the Draft Report and comment on the information and figures presented. MoEST and TAEC confirmed on the accuracy of the information and figures presented in this Audit Report. The information was also cross-checked and discussed with experts in the field of the nuclear technology in order to confirm the validity of the information and facts presented in the audit report.

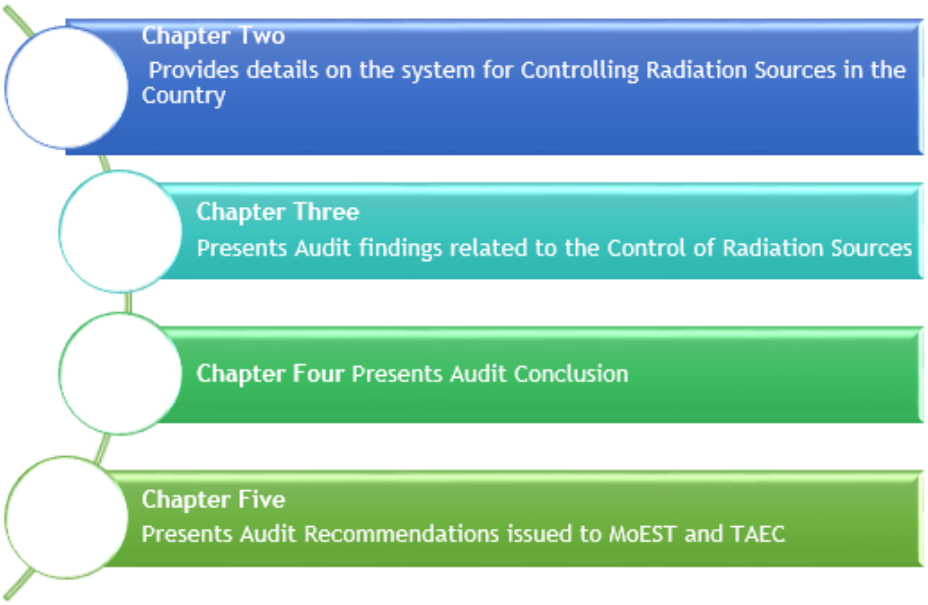
1.5 The Standard Used for the Audit

The audit was conducted in accordance with the International Standards for Supreme Audit Institutions (ISSAIs) on performance audit issued by the International Organisation of Supreme Audit Institutions (INTOSAI).

These standards require that, audit is planned and performed in order to obtain sufficient and appropriate evidence to provide a reasonable basis for the findings and conclusion based on audit objectives.

1.6 The Structure of the Audit Report

The subsequent chapters of this report are as presented below;



CHAPTER TWO

SYSTEMS FOR CONTROLLING RADIATION SOURCES IN TANZANIA

2.1 Introduction

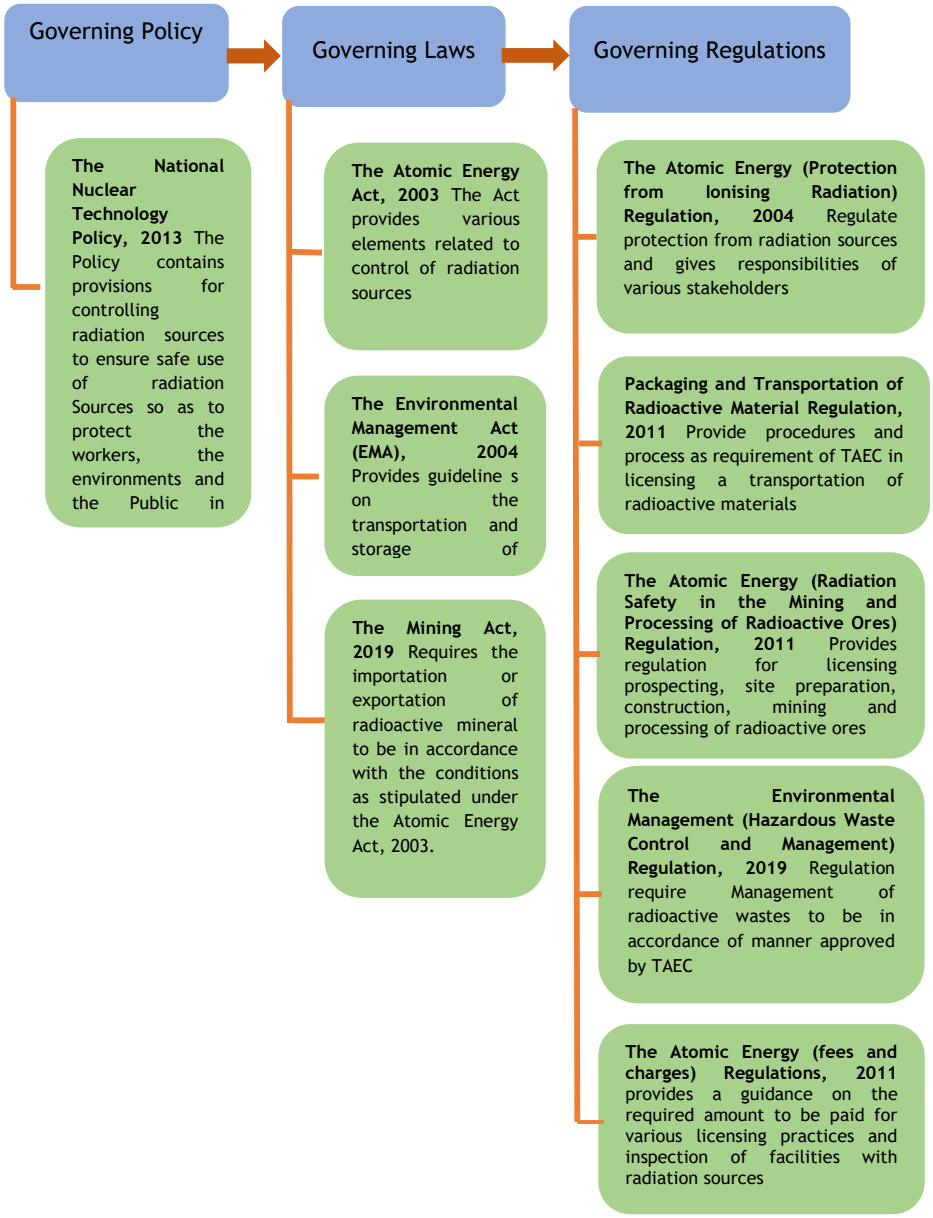
This chapter presents the system for controlling radiation sources in Tanzania. It highlights the governing policies, laws and regulations. Also, it presents roles and responsibilities of key stakeholders, processes and procedures for importation, licencing, and management of radiation sources, categories of radiation sources as well as the resources used for controlling radiation sources in the country.

2.2 Legal Framework Governing Control of Radiation Sources

2.2.1 Policy, Legislations and Regulations

Control of radiation sources is guided by the following policy, legislations, and regulations as presented on **Figure 2.1:**

Figure 2.1: Policy and Legal Framework Governing the Control of Radiation Sources in Tanzania

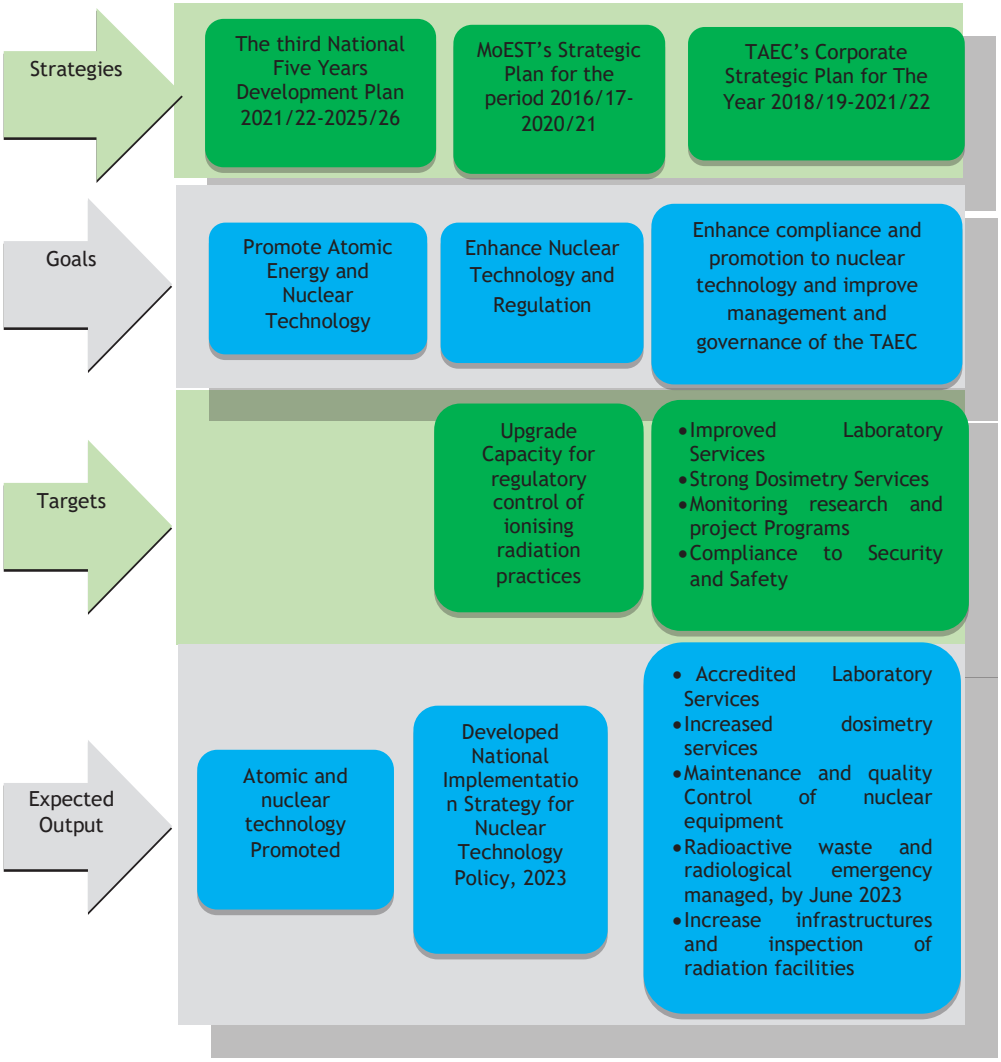


Source: *Auditors' Analysis of Reviewed Policy, Acts and Regulations (2022)*

2.2.4 Plans, Strategies and Goals

The plans and strategies geared on improving control of radiation sources in the country are summarized **on Figure 2.2** below:

Figure 2.2: Summaries of Strategies, Plans and Goals for Controlling Radiation Sources



***Source**: Auditors' Analysis of Reviewed Policy, Acts and Regulations (2022)*

2.3 Roles and Responsibilities of Key Players

2.3.1 Roles of Key Stakeholders

The Ministry of Education, Science and Technology

The Ministry of Education, Science and Technology (MoEST) through its Directory of Science Technology and Innovation play a key role in enhancing the use of radiation sources in the country. The Ministry promote research in areas of radiation sources and widen usability to benefit the public[15].

The Executive Agency Act CAP 245 states that, the Ministry of Education, Science and Technology shall be responsible for the strategic management of the Tanzania Atomic Energy Commission, but not getting to day-to-day management of the Commission. In line with this objective, the Division of Science, Technology and Innovation is responsible to oversee all control and promotion functions of nuclear technology in the country.

The Tanzania Atomic Energy Commission

The Tanzania Atomic Energy Commission (TAEC) has been established under the Atomic Energy Act, 2003 with two prime functions in relation to radiations sources. Firstly, it is a regulatory function on which TAEC is responsible to control safe and peaceful use of radiation sources in the country. This includes natural occurring and man-made radiation sources. Secondly, TAEC is also responsible to design and maintain a system aimed at ensuring an effective and proper promotion of safe and peaceful utilisation of atomic energy and nuclear technology in the United Republic of Tanzania.

Furthermore, according to Section 6(1) of the Atomic Energy Act 2003, the Commission through the Directorate of Technology and Technical and the Directorate of Radiation Control is responsible for controlling radiation sources in the country this includes licensing, carrying out regulatory inspections, holding trainings, seminars and workshops.

[15] http://www.moe.go.tz/sw/menu-item/idara-na-vitengo/idara/sayansi-teknolojia-na-ubunifu

Table 2.1 provides a summary of roles of the Ministry of Education, Science and Technology and the Tanzania Atomic Energy Commission in relation to the control of nuclear technology including radiation sources.

Table 2.1: Summarized Roles of the key Stakeholders

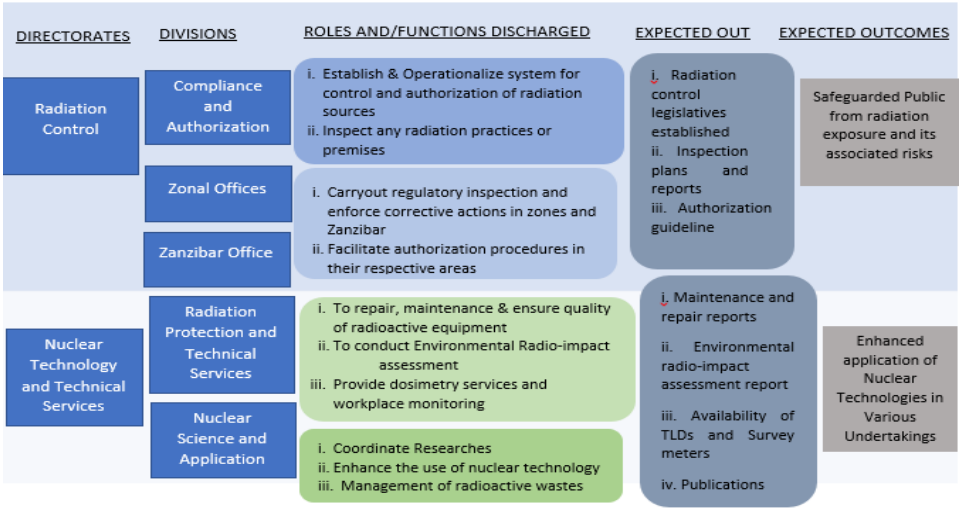
Name of Identified Key Stakeholders	Roles/Functions	Expected Output
The Ministry of Education, Science and Technology (MoEST)	• Monitor and evaluate its Performance and that of TAEC in controlling radiation sources in the country; • Develop national research policy, and agenda and monitor or coordinate its implementation; • Promote the development of research knowledge and human capital in research; and • Promote the appropriate use of research resources.	• Formulation of monitoring and evaluation plan regarding control of radiation sources; • Conduct self-monitoring and evaluation as well as monitoring TAEC's performance; • Formulated national research policy and monitored • Research resources are appropriately utilised and coordinated by means of National Research Agenda. • Research and development strategy is promoted.
Tanzania Atomic Energy Commission	• Establish and operationalise or implement a system for the control and authorisation of radiation sources; • Carry out regulatory inspections and ensure that corrective actions are taken; • Protect users, public and the environment from radiation exposure and its associated risks; • Formulate and operate a national radiological emergency plan and preparedness; • Promote national and international co-operation or collaboration on the applications of atomic	• Control, and promotion system of nuclear technology in place • Users, transporters, importers and exporters of radiation sources are authorized and managed • Issue and calibrate radiation monitoring devices to users of radiation sources; • Formulated and operated national radiological emergency plan and preparedness; • Enter into agreement(s) with national and international institutions/organisations intending to apply nuclear technology in the country; • Establishment of courses and training experts in the area of nuclear technology.

Name of Identified Key Stakeholders	Roles/Functions	Expected Output
	energy and nuclear technology already introduced or intended for introduction in the country; • Liaise with ministries and the appropriate institutions in order to facilitate the incorporation into the syllabi of all relevant and appropriate knowledge in nuclear science and technology for practical application.	

***Source**: Auditors' Analysis of the Reviewed Legislations (2022)*

Further, the functions of the Tanzania Atomic Energy Commission are implemented through various Directorates as summarized on **Figure 2.3**.

Figure 2.3: Directorates Responsible for Control of Radiation Sources

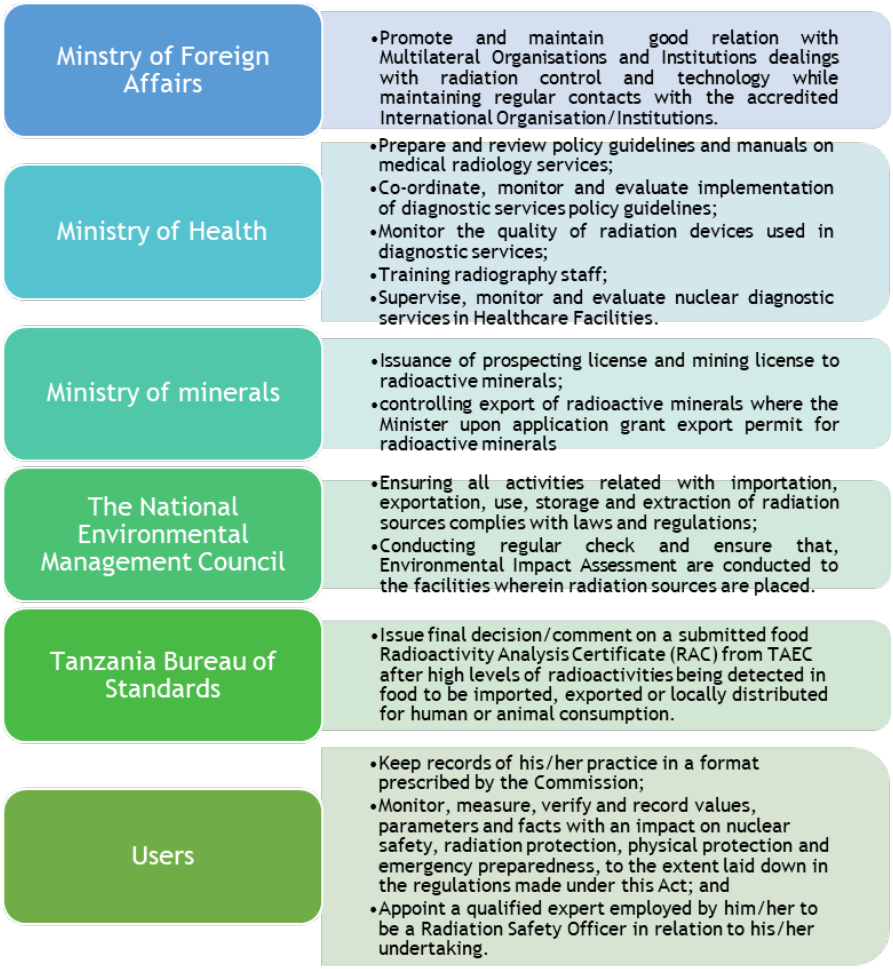


***Source**: Auditors' Analysis from Atomic Energy Act, 2003 and TAEC's Corporate Strategic Plan 2018/19 to 2022/23*

2.3.2 Roles and Responsibilities of Other Players in the Controlling Radiation

The other key stakeholders on the control of radiation sources are Sector Ministries, Regulatory Institutions and Users or Operators of the radiation equipment. The summarized roles of other key stakeholders on the control of radiation sources are also presented under **Figure** 2.4.

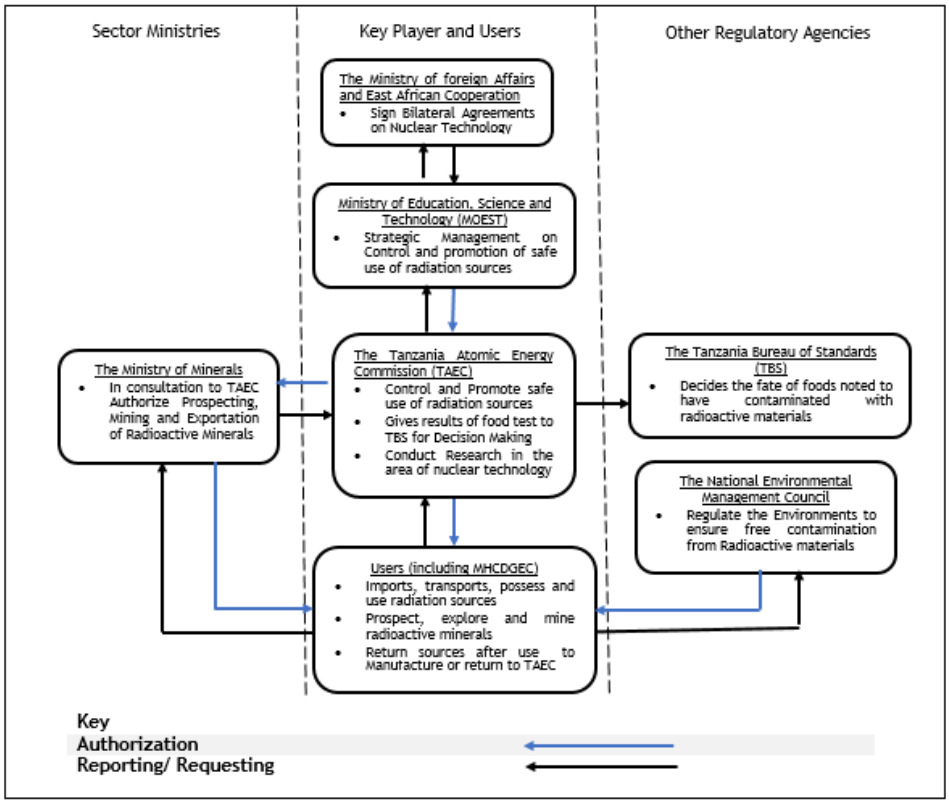
Figure 2.4: Summary of Roles of other Stakeholders in Relation to Control of Radiation Sources



Source: *Auditors' Analysis of Information Extracted from Various Laws and Regulation (2022)*

The relationship between different actors on the control of radiation sources is presented on **Figure 2.5** below.

Figure 2.5: Relationship between Actors in Controlling Radiation Sources



***Source**: Auditors' Analysis of Information Extracted from Various Laws and Regulation (2022)*

2.4 Resources for Managing Controls of Radiation Sources

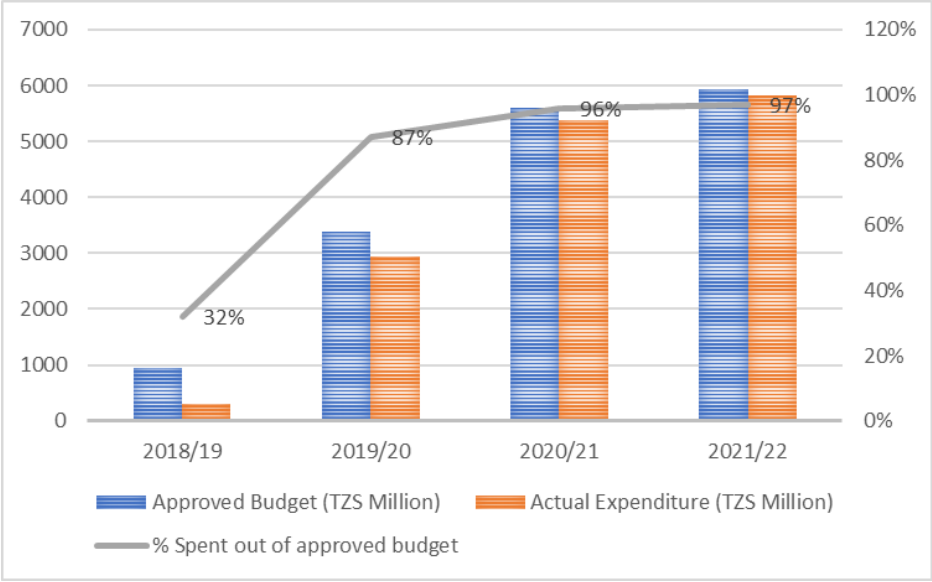
2.4.1 Financial Resources of the Ministry of Education, Science and Technology

The Ministry of Education, Science and Technology similar to other government Ministries, its budget is exclusively financed by the government through the annual budget approved by the Parliament every financial year. The plans and budget for overseeing and implementing activities using nuclear technology

including radiation sources are mainly channelled to the Division of Science, Technology and Innovation (STI) at MoEST.

Figure 2.6 presents approved budgets and actual expenditures for the Division of Science, Technology and Innovation from 2018/19 – 2021/22.

Figure 2.6: Budgets Versus Actual Expenditures for the Division of Science, Technology and Innovation



Source: *Annual Performance Reports from the Financial Year 2018/19 - 2020/21 of the Division of Science, Technology and Innovation*

Figure 2.6 indicates that the actual expenditures out of approved budget for the Division of Science, Technology and Innovation grew from 32% in 2018/19 to 97% in 2021/22.

From financial year 2019/20 to 2021/22 the budget was increased due to introduction of new activity of coordinating an annual event with the objectives of identifying, strengthening, celebrating and developing the innovation spirit among Tanzanians.

2.4.2 Staffing Level at the Division of Science, Technology and Innovation (DSTI)

The Division of Science, Technology and Innovation is categorized into two sections namely, Science, Technology and Innovation (STI) and the Research and Development (R&D) Sections. The Division is headed by a Director assisted by other two Assistant Directors heading the mentioned Sections. **Table 2.2** presents the analysis of staffing positions within the Division of Science, Technology and Innovation as of 30th June, 2022.

Table 2.2: Available Staff at the DSTI as at June, 2022

Section	Professional/Position	Total Required Number of Staff (number)	Total Available number of Staff (number)	Percentage of Available Staff Against the Required
Science and Technology	Assistant Director	1	1	100
	Principal Officers I	1	0	0
	Principal Officers II	2	0	0
	Senior Officers	4	1	25
	Officers I	3	4	133
Research and Development	Assistant Director	1	1	100
	Principal Officer I	2	0	0
	Principal Officer II	1	0	0
	Senior Officer	2	2	100
	Officer I	2	0	0

Source: *Annual Performance Report of the Division of Science, Technology and Innovation for the Financial Year 2021/22*

Table 2.2 indicates that, the two sections under DSTI are fully staffed by the required number of Assistant Directors. However, it also shows that, as of June, 2022, both two sections had no Principal Officers. The Science and Development Section had 25% of the required Senior Officers and was having an extra number of Officer I position.

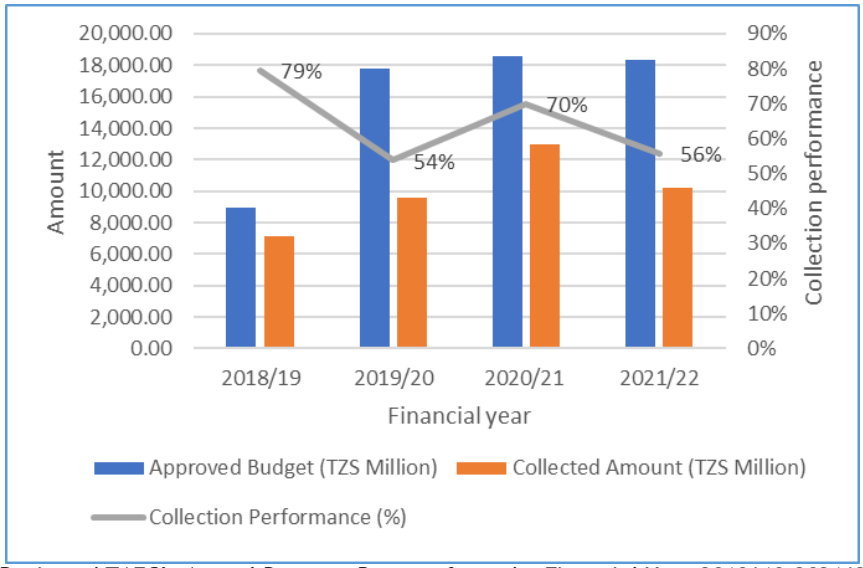
Absence of Principle Officers I&II in both sections of the DSTI was linked to the scarcity of required qualifications in the market when the vacancies were advertised through the Public Service Recruitment secretariat. As a result, the posts for the Principal Officers remained vacant for the reviewed period up to June, 2022.

2.4.3 Financial Resources of the Tanzania Atomic Energy Commission

The TAEC's financial resources for implementing its operations was found to mainly originate from two sources which are internal own sources and from the government budget. Internal sources included revenues obtained from fees and charges for licensing of various services to users of radiation sources and devices.

The internal sources are used to finance the TAEC operations in relation to control of radiation sources in the country. Contribution from the government was mainly used for financing development projects. **Figure 2.7** indicates budgets and actual collection for financing both operational and development activities of TAEC.

Figure 2.7: TAEC's Budget and Collection for Financing Operational - 2017/18-2020/21



Source: *Reviewed TAEC's Annual Progress Reports from the Financial Year 2018/19-2021/22*

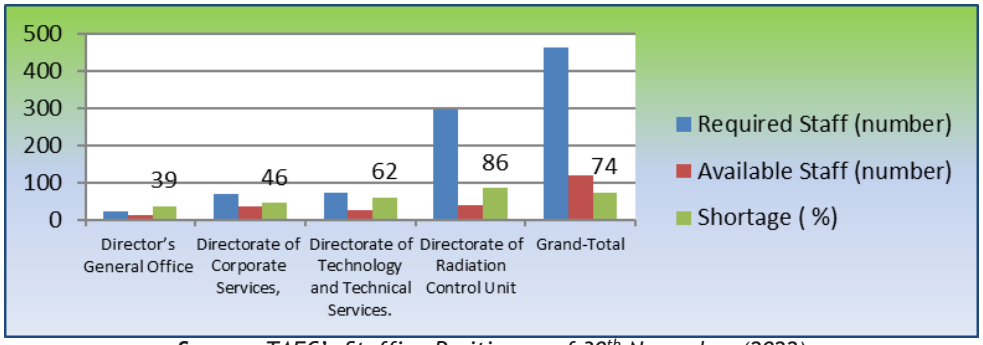
Figure 2.7 indicates TAEC collected 79 % of approved budget in the financial year 2018/19 which dropped to 54 % in 2019/20. Again, for the financial year 2020/21, the actual collection raised to 70 % followed by falling to 56% in 2021/22. Generally, the TAEC'S funds collection performance has dropped by 23% from 2018/19 to 2021/22.

However, the review of the fourth quarter performance report for the Directorate of Corporate Services and Units for the Financial Year 2021/2022, noted that, the main reasons noted for the under collection of revenue were; TAEC had a severe shortage of human resources to its various offices leading into inability to have offices in some of the borders which led into low control of revenues. Another reason was the amendment of the fifth schedule of Regulations 2021 (Fees and Charge) in which the amended provision stated that, the fee shall not apply to food or foods exported to countries that do not require radioactivity analysis certificate. This amendment resulted into the dropping of the food and monitoring fees from TZS 2,083,788,756.0 compared to budgeted amount of TZS 3,251,997,458.00 for the financial year 2021/22.

2.4.2 Human Resources at TAEC

The Tanzania Atomic Energy Commission staffing position has been distributed according to the number of Directorates available in its organisation structure. **Figure 2.8** indicates the staffing position of TAEC as at 30th November, 2022.

Figure 2.8: Staffing Position at TAEC as of 30th November, 2022



***Source**: TAEC's Staffing Position as of 30th November (2022)*

Figure 2.8 indicates that, TAEC is staffed by a total of 121 staff out of 464 required number of staff representing a total shortage of 74% country wide. The Directorate of Radiation Control Unit is much affected whereby the shortage amount to 86% staff despite of being the Directorate responsible for managing the TAEC Zonal Offices.

Inadequate number of staff especially researchers and Radiation Inspection Officers hindered the implementation of TAEC activities especially in research and expansion of laboratory services in various regions.

2.5 Categories of Radiation Sources

Radiation sources are categorised based on their nature of existence or occurrence; according to their use in daily human being activities; or according to nuclear material aggregates as detailed as follows:

2.5.1 Categories of Radiation Sources According to their Nature of Occurrence and Use

The categories of radiation sources according to their use and occurrence is as indicated on Table 2.3:

Table 2.3: Categorisation According to Nature and Use

Base of Categorization	Nature/use	Details
According to Nature of Occurrence	Natural Radiation Sources	Natural radiation sources are all around the earth and are present in the earths, crust, the food we eat and drink, in the air we breathe or in the bodies of human beings or animals whereby their muscles, bones, and tissues-contain naturally occurring radioactive elements[16].
	Artificial Radiation Sources	Artificial radiation sources are man-made sources. These sources of radiations vary depending on the purposes/application/use. These are such as X-ray machines and nuclear medicines which are used for medical diagnostic and treatment; and nuclear gauge, density gauge which are industrial sources used in road constructions and measures of material flows through pipes in factories.
According to Use	Medical Use	Radiation sources under this category are used for diagnostic and disease treatment in Hospitals. They can either be devices emitting radiation such as X-rays, CT scan

[16] https://www.iaea.org/Publications/Factsheets/English/radlife

Base of Categorization	Nature/use	Details
		machines for medical diagnostic or nuclear medicines devices/equipment for diseases treatment.
	Non-Medical Use	The Non-medical sources are those sources of radiation which are used in activities such as constructions, industrials, production, nuclear plants as an electrical power generator and many others. Generally, these sources are for other uses other than health diagnostic and disease treatment.

Source: *Auditors' Analysis of the Atomic Energy Act of 2003*

2.5.2 Categorisation According to the Cause of Potential Early Harmful Health Effects

According to the IAEA Safety Standards Series No. RS-G-19, 2005, Radioactive Sources are ranked in terms of their potential to cause early harmful health effects if the source is not managed safely or securely protected. These categories of radioactive sources according to cause of potential/ early/ harmful/ health effects are as described on **Table 2.4**.

Table 2.4: Categories of Radiation Sources

Categories	Potential Early harmful Health Effects	Activity Ratio (A/D)	Example of sources
Extremely Dangerous	• Likely cause permanent injury • Fatal being Closer to this amount of unshielded radioactive material in a range of minutes to an hour	A/D ≥ 1,000	Radioisotope Thermoelectric Generators (RTGs), Irradiators, therapy sources, and fixed multi-beam teletherapy (gamma knife) sources.
Very Dangerous	• Cause permanent injury to a person who handle or otherwise contact it for minutes to hour • Possible Fatal Staying for hours to days in these sources	1,000>A/D≥10	Industrial gamma radiography; and High/Medium dose rate brachytherapy sources
Dangerous	• Could cause permanent injury to a person who handle it or who was otherwise in contact with it for some hours • It could be possibly-although it would be unlikely -be fatal to be close	10>A/D≥1	Fixed industrial gauges that incorporate high activity sources, and well logging gauges.
Unlikely to be Dangerous	• It would be unlikely temporarily injure someone who handled it or who was otherwise in contact with it for many hours	1>A/D≥0.01	Low dose rate brachytherapy (Except eye plaques and permanent implants), Industrial gauges that do not incorporate high activity sources, bone densitometers, and static eliminators
Most Unlikely to be Dangerous	No permanent Injury could be caused by this source	A/D<0.01	Low dose rate brachytherapy eye plaques and permanent implant sources, X-ray Fluorescence (XRF) devices, Electron Capture devices, Mossbauer Spectrometry sources, and positron emission tomography (PET) check sources

Source: *Auditors' Analysis from the IAEA Safety Standards Series No. RS-G-19, 2005*

2.6 Process for the Controlling of Radiation Sources

2.6.1 Licensing of Exporters, Importers and Transporters

This is an initial stage in the control of radiation sources that requires TAEC to ensure that, any person who wishes to import, export, store or transport any apparatus, article, plant, installation or other substance intended to be used for the purposes of undertakings involving the emission of radiation is securing a license issued to him by the Tanzania Atomic Commission (TAEC). A license is

issued upon an application being made to the Commission using the prescribed form and payment of described fees[17].

However, before issuing of the license the Commission is required to make sure that, the applicant apply for either exportation, importation or transportation by filling an application form(s) that states details of an applicant, purpose of which radiation source will be used for, technical details of the source, international standards compliance, means of transportation, point of entry/exit, type of radiation source, availability of qualified experts for operating the source and disposal plan.

Also, at the point of entry/ exit TAEC conduct inspection of radiation sources or devices emitting radiation. During inspections, the Inspectors verify the details filled on the application form before approval of its importation or exportation. In the case of radioactive sources, TAEC inspects transportation plan, emergence and preparedness plan, valid license and the storage container to protect the public and the environment from harmful effects of radiation during transportation.

2.6.2 Inspections of Radiation Sources and Premises

TAEC examines radiation safety and quality control of radiation sources, radiation emitting devices and premises through inspections and quality assurance checks as indicated in Section 56 (1)(g) of the Atomic Energy Act,2003. The Commission conducts three types of inspections. These include pre-authorisation, routine and follow-up Inspections to licensed users of radiation sources on either planned or ad-hock basis.

Pre-Authorisation Inspection

The commission is required to conduct pre-authorisation inspection to radiation premises prior to issue of possess and use license in order to ascertain compliance on radiation safety requirement and presence of qualified experts to operate or use the entire source of radiations. If the facilities pass the pre-authorisation inspection, they are finally issued with possess and use license. This license

[17] Section 17 of the Atomic Energy Act 2003.

allows them to possess and use radiation sources or radiation emitting devices such as X-rays, CT-SCAN and fluoroscope machines.

Routine Inspections

The Commission (TAEC) is responsible for conducting a routine inspection in each fiscal year to all facilities and persons with radiation sources or devices. The routine inspections are carried with the purpose of assessing a licensee's adherence to licenses compliance requirement such as maintaining an up-to-date license, having qualified radiation sources operators, safety protections measure and using qualified premises for radiation operations. The inspections are also intended to assess the operational efficiencies of the radiation devices and sources by testing whether they have a leakage and a required calibration status.

However, TAEC normally categorise the facilities to be inspected into three categories namely; high, medium and low risks facilities. The high risks facilities are those which possess high risks radiation sources such Cobalt-60, Caesium (Cs) and Beryllium used in both medical and non-medical practices. Healthcare facilities that possess radiation emitting equipment such X-rays are also termed as high risks facilities. The second category is medium risks facilities that include those facilities which have medium risks radiation sources such as those used in mining operations that are well controlled.

Lastly, the low risks facilities are those facilities which possess low risks radiation sources that are always contained such as the beverage industries. In planning for inspection, TAEC consider that, all high risks facilities should be inspected at least once per year and once per every two years for the medium and low risks facilities, subject to available resources such as manpower and financial resources.

Following completion of the inspection exercise, the inspected facilities are issued with an inspection report which contains a list of performed tests, findings and recommendations to rectify the noted anomalies in the overall management of possessed radiation sources.

Follow-up Inspections

This is a kind of inspection conducted by the Commission to assess rectification of observed weaknesses during a previous conducted routine, ad-hock or pre-authorization inspections. The inspection aimed to ensure adherence to safe use of radiation sources by rectifying observed weaknesses noted during the pre-authorisation, routine or unplanned inspections. The inspected facility is then issued with the report that contains the revealed weaknesses and recommendations for improvement.

2.6.3 Licensing to Possess or Use Radiation Sources

Under this stage, any person intending to initiate a practice or to possess radiation sources is required to submit a prior notification to TAEC the expression of intention. The notification is purposely for intention to apply for licensing or registration to possess and use radiation sources. The licencing involves authorisation to import, export or transport any radiation sources intended to be used for the purposes that will involve emission of radiation. Licensing is required for an industrial irradiation installation, an installation processing radioactive substance, medical or industrial radiography facility or for any use of source of which TAEC has not designated as appropriate for registration.

Moreover, the facilities where the radiation sources are installed and issued with license to possess and use are subject to renewal for an interval of one year after fulfilment of the safety requirements within a period of three months prior to the expiry date[18]. TAEC is also required to license any qualified expert intending to carry-out a practice that involves administering ionising radiation to any person for purposes of diagnosing or treating diseases.

2.6.4 Management of Disposal of Radioactive Wastes

According to the Atomic Energy Act of 2003, disposal of radioactive waste means the emplacement of waste in an approved, specified facility (e.g. near surface or geological repository) without the intention of retrieval. Disposal also include the

[18] Regulation 16 of the Atomic Energy (Protection from Ionizing Radiation) Regulations, 2004.

approved direct discharge of effluents (e.g. liquid and gaseous wastes) into the environment with sub-sequent dispersion.

The Commission is responsible to ensure that, no person shall accumulate radioactive waste on his/her premises with an intention of disposing it except in accordance with an authorisation granted to him/her by the Commission. Further, any person who keeps any mobile radiation device for the purpose of its being used in the provision of services is prohibited to dispose any radioactive waste arising from any such apparatus except in accordance with an authorisation granted to him/her by the Commission. The Commission is also mandated by the Atomic Energy Act, 2003 to require the licensee to obtain adequate facilities for the safe management of radioactive waste.

Generally, in Tanzania disposal of radioactive wastes is done by two ways. Firstly, is returning the waste to the manufacturers in accordance with the supplier-customer purchasing contracts, required to be verified and indicated in the importation license granted to the importer by the Commission. Secondly, involve collecting the radioactive waste to the Central Radioactive Waste Management Facility (CRWM) owned and managed by TAEC at the Head Office in Arusha. The CRWM has been established to serve as a National Centre for the collection, characterisation, conditioning, segregation and generally the safe management of radioactive wastes.

2.6.5 Monitoring of Radiation Sources

The Tanzania Atomic Energy Commission after issuing licenses to users for either importation, transportation or possessing and using radiation sources in the country, it is required to ensure that, the conditions on the issued licenses are frequently monitored. This is done in order to ensure users of radiation sources are complying with governing legislations to protect the public and the environment on harmful effect of radiation sources if mishandled by users.

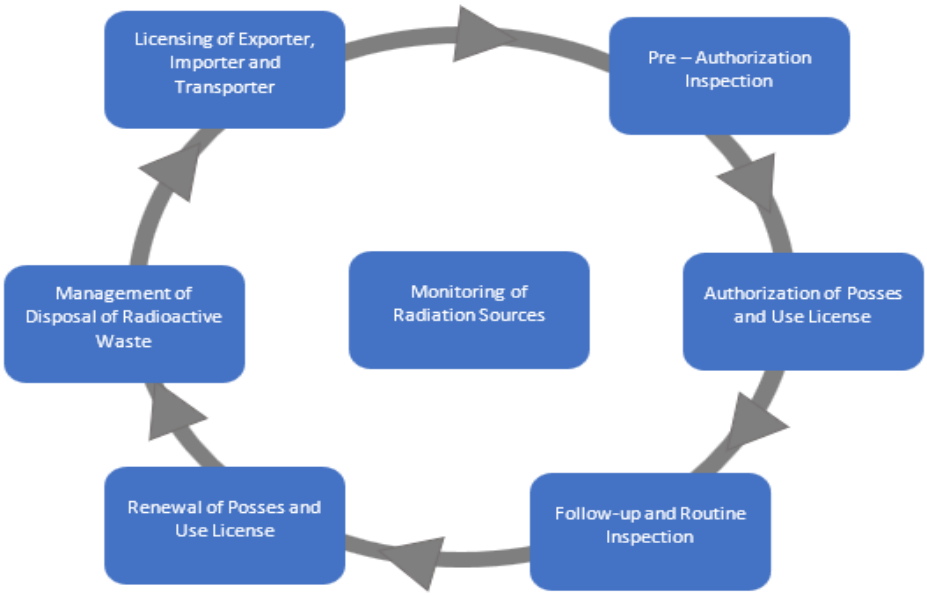
Therefore, TAEC monitors premises with radiation sources to ensure that they comply with the required standards before and after issuing of possess and use licences to those premises storing and using radiation sources. The commission is also monitoring users working with radiation sources by ensuring that they wear

radiation measuring devices and possess radiation survey equipment for area monitoring.

However, movement of mobile radiation sources from one place to another is also the responsibility of TAEC. It ensures that, the mobile radiation sources are adequately monitored through tracking them so as to minimise risks to the public and environment in general. Tracking of mobile radiation sources should be done through frequently maintenance of proper records on type, quantity and status of available mobile sources in the country.

Figure 2.9 provides a pictorial summary of the process for controlling the radiation sources.

Figure 2.9: The Process for Controlling Radiation Sources in Tanzania



***Source**: Auditors' Analysis from the Reviewed Atomic Energy (Protection from Ionizing Radiation) Regulations (2004)*

2.7 Process of Promotion of Safe Use of Radiation Sources

The promotion of Atomic Energy and Nuclear Technology is governed under Part VIII of the Atomic Energy Act, 2003. So far there is no specific regulation or

guideline that have been issued to govern promotion of atomic energy and nuclear technology. On that basis, promotion of safe use of atomic energy and nuclear technology processes depend on the nature and type of technology that is required to be researched and put into use. For example, for food irradiation and road construction technologies would require different approaches. The aim of promotion is to ensure that, the available technology is adapted in the country without causing harm to the people, nation and the environment. Generally, the processes for promotion of safe use of radiation sources/atomic energy and nuclear technology include but not limited to the following:

2.7.1 Conducting Feasibility Study on the Application of Proposed Technology

MoEST through TAEC in collaboration with the government institution that would finally benefit from the project or own the project conduct feasibility study on the application of proposed nuclear technology for the intended use. This stage involves conducting cost-benefit analysis between the proposed technology and the expected running costs to be incurred if the technology will be adopted for use.

This stage also includes searching for the location where the technology would be resided as a centre of production. For example, for a food irradiation technology the center of production shall be the places where huge production of fruits like oranges are available.

It further includes analysis of whether there are adequate experts to run the technology or it would require hiring of experts from outside the country. Also, it assesses the availability and readiness of stakeholders to invest in the identified technology at the existing market opportunities. The output of the conducted feasibility studies is normally a feasibility study report which would suggest whether the project is feasible or not.

2.7.2 Coordination of Key Stakeholders involved in the Control of Radiation Sources

In doing its mandatory activities of controlling and promoting nuclear technology in the country, TAEC was required to coordinate with IAEA and other key stakeholders such as the Higher Learning Institutions and sector Ministries in planning and implementation of its control of radiation sources. TAEC coordinate

with IAEA through its involvement and participation into the international forums on nuclear technology organised by IAEA. These forums provide opportunities for organising and discussing various issues regarding the control and promotion of nuclear technology around the world. The Commission also facilitates coordination of national projects involving nuclear technology with sector Ministries in the country through provision of required expertise, training and awareness programme.

Moreover, these programmes involve seminars, trainings and awareness campaign with key stakeholders possessing radiations sources in both medical and non-medical practices. TAEC also collaborates with Higher Learning Institutions in the country to research on various areas of nuclear technology to enhance training and development of academicians in the field of nuclear technology.

2.7.3 Introducing the Proposed Technology to the Government

Following successful completion of the feasibility study, the entire technology is then presented to the responsible authorities in the country for acceptance, endorsement and obtaining political will on the proposed new technology. This is necessary due to the fact that, acceptance and approval of the proposed technology would mean the government is ready to fund that technology. The authorities can be Ministry, Institution or government agency where the base of the proposed nuclear technology would be established.

2.7.4 Raising Awareness to the Users and the Public

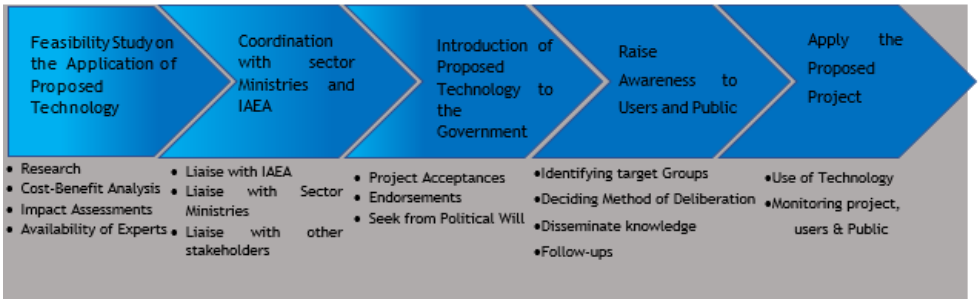
The need and importance of the proposed technology is then communicated by MoEST through TAEC to users and experts in order to raise awareness on its usage and impacts such as health and environmental effects. Awareness is done through training and seminars to the intended users of the technology and the public in general. This is done in order to enhance know-how on the use and impact of the proposed technology to the users and the public. For example, if it is a cancer treatment technology, the health experts are provided with required usage and protection knowledge to themselves and the potential patients so as maximise the potential and minimise the risks associated with the application of the new technology in treatment of cancer cases.

2.7.5 Application of Proposed/New Technology

The proposed technology after being accepted by the government, users and stakeholders finally put into use to meet the intended objective. This involves importation, installation and monitoring of the entire technology, users and the public. For example; if it is cancer treatment technology, would include installing the technology to the earmarked health facilities and monitoring its usage over time. The responsible entity to ensure the technology is put into use depend on the natures of the technology. For instance, if it is a health related technology, the responsible authority would be the Ministry of Health and if it is an agricultural technology it would be under the Ministry of Agriculture.

The process for promotion of safe use is presented on **Figure 2.10** below:

Figure 2.10: Process for Promotion of Safe Use of Radiation Sources



Source: *Auditors' Analysis from Interviews and Document Reviews (2022)*

CHAPTER THREE

AUDIT FINDINGS

3.1 Introduction

This chapter presents the audit findings on the performance of the Ministry of Education, Science and Technology through the Tanzania Atomic Energy Commission in controlling radiation sources in the country. The findings focused on assessing control of radiation sources based on the audit objectives presented in Section 1.3 of the first chapter in this report.

The audit findings are presented below:

3.2 The Extent of Control of Radiation Sources in the Country

The effectiveness of the control of radiation sources is influenced by the adequacy in regulation and licensing user(s) or person or party(ies) intending to use radiation sources for various practices, presence of mechanism for tracking and monitoring disused sources, regular inspection of radiation sources and the facilities to validate if they conform with the intended use and personnel operating them meets the minimum required qualification.

Despite efforts such as licensing users of radiation sources, inspection of facilities possessing sources of radiation, construction of a central waste management facilities at TAEC HQ in Arusha, and the construction of a dosimetry laboratory at TAEC HQ, the audit noted some weaknesses related to licensing, improper disposed radiation sources and inadequate inspection of radiation sources in the country and registering and licensing of qualified experts. These weaknesses indicated ineffectiveness in the control of radiation sources as follows:

3.2.1 An average of 66% of the Registered Radiation Facilities in the Country were not licensed by TAEC to Possess and use Sources of Radiation

Analysis of information of licensed radiation facilities revealed that, from the financial year 2018/19 to 2021/22, the percentage of unlicensed facilities by TAEC were 68%, 69%, 63% and 64% respectively of all registered radiation facilities in the country. This represents an average of 66% facilities with radiation sources

not licensed by TAEC four the reviewed four financial years from the year 2018/19 to the year 2021/22. The percentage of unlicensed radiation facilities for each financial year is as presented in **Figure 3.1** below: -

Figure 3.1: Percentage of Registered Radiation Facilities Not Issued with Possess and Use License by TAEC

Source: *Auditors' Analysis of Possess and Use Licenses and Database (Register) of all Radiation Facilities in the country (2018/19 to 2021/22)*

Figure 3.1 shows that, the percentage of unlicensed radiation facilities increased from 68% in the financial year 2018/19 to 69% in the financial year 2019/20 and lowered to 63% in the financial year 2020/21. However, it risen to 64% in the financial year 2021/22.

Also, it indicates that, the highest percentage of unlicensed facilities was 69% attained in the financial year 2019/20 while the lowest percentage was 63% attained in the financial year 2020/21.

This implies that, the percentages of licensed radiation facilities in the financial years 2018/19 was 32%, 31% in 2019/20, 37% in 2020/21 and 36% in 2021/22 respectively. The findings further indicate that, the percentage of licensed radiation facilities was gradually increasing to the maximum of 37% in the financial year 2020/21 amounting to an increase of 5% for the reviewed period of four years.

Moreover, the review of Suspension Letters and Inspection Reports from TAEC addressed to facilities with radiation sources from financial years 2018/19 to 2021/2, noted that for the case of medical facilities, TAEC suspended some facilities from provision of X-ray services. The reasons for suspension were due to absence of possess and use licenses, inadequate shielding of main door leading to x-ray room and lack of qualified x-ray machine operators (Radiographers). While for the case of non-medical facilities, were suspended from using radiations sources due to the fact that they had no valid licenses for possessing and using radiation sources.

However, the Audit Team noted that, the enforcement actions of suspending radiation facilities found without possessing valid possess and use licenses were not adequately implemented by TAEC, since a total of 90% of facilities with those deficiencies remained unsuspended by TAEC for the reviewed period of four financial years from 2018/19 – 2021/22 as illustrated in **Table 3.1** below.

Table 3. 1: The Extent of unsuspended facilities with radiation sources without possess and use licenses

Financial Year	Suspended Facilities	Number of Unlicensed facilities	% Unsuspended Facilities out of unlicensed facilities
2018/19	114	649	82
2019/20	48	745	94
2020/21	81	692	88
2021/22	48	745	94
Total	**291**	**2831**	90

***Source**: Auditors' analysis of TAEC's Suspension Letters and Inspections Reports to facilities possessing and using radiation sources from financial years 2018/19 – 2021/22.*

From **Table 3.1,** it can be noted that, from 82% to 94 % of unlicensed facilities by TAEC were not suspended from possessing and using radiation sources despite of the fact that were not possessing a valid possess and use license. Whereas in in total, 90 % of facilities with radiation sources were not suspended from possessing and using radiation sources despite the fact that they were not licensed by TAEC for each of the reviewed period of four financial years from 2018/19 to 2021/22.

The Mismatch between the Reported and Actual Data for the Issued Licenses by TAEC

Review of TAECs' Annual Implementation Reports for years 2018/19 to 2021/22 indicated that, there was a significant discrepancy of data on licence reported by TAEC compared to the actual number of licenses issued to users of radiation sources in the country. The reported number of licenses issued was higher than the actual number. The discrepancy ranged from negative seven to 32 of the actual number of licenses issued for the period of years 2018/19 to 2021/22. **Table 3.2** below provides the differences noted between the reported and actual licenses issued.

Table 3. 2: The Difference between the Reported Licensing of the Radiation Facilities from TAECs' Annual Reports and the Actual Issued License

Financial Years	Number of Posses and Use Licenses as per TAEC's Annual Reports (A)	Actual counted number of Licenses issued (B)	Discrepancy (A-B)
2018/19	304	311	(7)
2019/20	368	336	32
2020/21	412	400	12
2021/22	453	424	29

Source: *Auditors' Analysis of information from reviews of TAEC's Annual Implementation Reports and physical counting of issued possess and use licenses (2018/19-2021/22)*

Table 3.2 indicates that, discrepancies of 32, 12, and 29 of a number of licensing for possess and use of radiation sources were exaggerated in the TAEC Annual Reports for the financial years 2019/20, 2020/21 and 2021/22 respectively. This is due to the fact that, the reported number of issued possess and use licenses in the TAEC Annual Implementation Reports were higher than the actual licenses issued by TAEC in the respective years as verified by the Audit Team through physical counting.

The variations on the extent of licensed radiation facilities were due to poor record keeping by TAEC on the number of issued licences that resulted into mismatch between annually reported numbers of licensed facilities versus the actual licenses issued to users of radiation sources. In fact, this situation was evidenced by the Audit Team through reviewed actual number of copies of licenses for the reviewed period at TAEC HQ.

The Presence of Radiation Facilities Operating without Updated License in the Visited Regions

During the visit made by the Audit Team to the radiation facilities in selected 7 regions, 13 out of 21 facilities were not having updated possess and use license for the whole period under the audit. This is equivalent to 62% of the facilities visited. **Table 3.3** shows the number of facilities for each category noted to have expired licenses.

Table 3.3: Visited Facilities Noted to Possess Expired License from 2018/19 – 2021/22

Facility	Radiation Source	Total Number of Facilities Visited	Total Number of Facilities found with Expired License
TANROADS	Nuclear Density Gauge	6	6
Tanzania Airports Authority	X-rays	7	5
Medical Facilities (RRHs)	X-rays	8	2

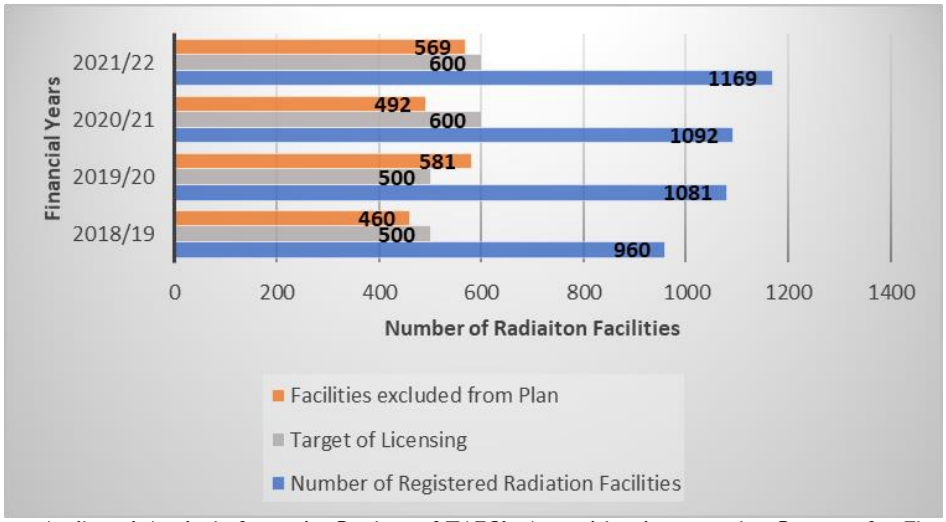
***Source**: Physical verifications of possess and use licenses at the visited facilities with radiation sources (2022)*

From **Table 3.3** above it can be seen that all 6 visited facilities possessing nuclear density gauge under TANROADS were noted to have expired licenses for the whole period of four financial years starting from the year 2018/19 to the year 2021/22, while 5 out of 7 airports had expired licenses and 2 out of 8 medical facilities had expired licenses. Senior Officials from the 2 visited medical facilities found with expired licenses, which were Mbeya and Dodoma RRH stated that they had paid for such licenses but they were not delivered by TAEC up to the time of the visit by the Audit Team which were August, and September, 2022 respectively. The stated reasons were later confirmed with TAEC, whereby the Senior Official from TAEC submitted the license for Mbeya RRH for the financial year 2021/22 which was not available at the respective facility during the time of the Auditors visit in August, 2022. Ineffective licencing was caused by various factors, such as:

Unrealistic Targets set for Licencing of Registered Radiation Facilities/Sources

The Audit Team noted that, inadequacy in licensing for possess and use was attributed to unrealistic licensing plan of TAEC that was not in-line with the total number of registered radiation facilities in the country. This is because TAEC has set targets for licensing far below the actual number of radiation facilities in the country. Analysis made by the Audit Team revealed the difference between the set target and the actual number of radiation facilities ranging from 492 to 581 as detailed in **Figure 3.2**:

Figure 3.2: The Unrealistic Targets of Licensing for Possess and Use of Radiation Sources



***Source**: Auditors' Analysis from the Review of TAEC's Annual Implementation Reports for Financial year 2018/19 to 2021/22*

Figure 3.2 indicates that 460, 581, 492 and 569 radiation facilities were not included in the TAEC's plan for licensing for possess and use of radiation sources for the years 2018/19, 2019/20, 2020/21 and 2021/22 respectively. This is contrary to Section 18 of the Atomic Energy Act, 2004, which requires TAEC to ensure that all operating radiation facilities have been issued with possess and use licence.

Inadequate Functioning of Online Licencing System for the reviewed period of financial years 2018/19 to 2021/22

Further, interviews with Officials from TAEC revealed that, inadequate licensing of possess and use of radiation sources was also caused by the absence of functioning online licensing system that could be used to assist the process of identifying and interacting with users who are not yet licensed; hence simplify the licensing procedures, application and issuance of licenses. Therefore, in the reviewed period of four financial years from 2018/19 – 2021/22, TAEC did not establish the online licensing system due to inadequate strategies and plans focusing on enhancing licensing processes.

However, in January 2023, the Officials from TAEC responded that, TAEC has recently established an online License Application System within the Electronic Documents Management Systems (EDMS) operationalized in November, 2022 that can be accessed on its website which is www.taec.go.tz. Through this system, the users of radiation sources can register, apply and being issued with licenses via an online platform.

Moreover, the Auditor's analysis of the established system found that, the system has already deployed only four categories of licenses out of 11 expected to have been deployed in the system by TAEC. The deployed and functioning categories are; authorisation to possess and use medical diagnostic X-ray equipment, authorisation to possess and use radiation devices/radioactive materials for non-medical, registration to administer ionizing radiation to persons or patients and registration to install/operate/maintain or repair radiation device/plant or apparatus.

However, the inadequate licensing has contributed into having users of radiation sources who were not complying adequately to radiation safety requirements such as absence of well shielded radiation premises, presence of unqualified users of radiation sources and poor storage of radiation sources as well as registered qualified experts.

Furthermore, it was estimated that, TAEC also did not manage to collect fees amounting to TZS 424.650 million, by not licensing 2,831 facilities for authorisation to possess and use of radiation sources for the period from 2018/19

to 2021/22. The estimated licensing fees that were not collected by TAEC was a minimum amount that was to be collected at the rate of TZS 150,000 per source out of 2,831 facilities as per the requirements of the Atomic Energy (Fees & Charges) Regulations, 2011.

Despite, Senior Officials from TAEC stating that, the focus is not on collection of fund but ensuring safety and security of human life. It was evidenced by the confirmation from the Officials that TZS 43.122 million was recovered from the financial years 2018/19 to 2021/22 out of the estimated amount of TZS 424.650 million established by the Audit Team during the review period.

3.2.2 The Presence of Undisposed Radiation Sources

According to Sections 34 and 35 of the Atomic Energy Act, 2003, TAEC was required to ensure that, no person is permitted to dispose any radioactive waste on or from any premises which were used for the purposes of an undertaking carried on by him without an authorisation granted to him by the Commission.

Section 37(2) of the Atomic Energy Act, 200, also states that, there shall be established a Central Radioactive Waste Management Facility known by its acronym as CRWMF which shall serve as a National Centre for the collection, characterization, conditioning, segregation and generally the safe management of radioactive wastes.

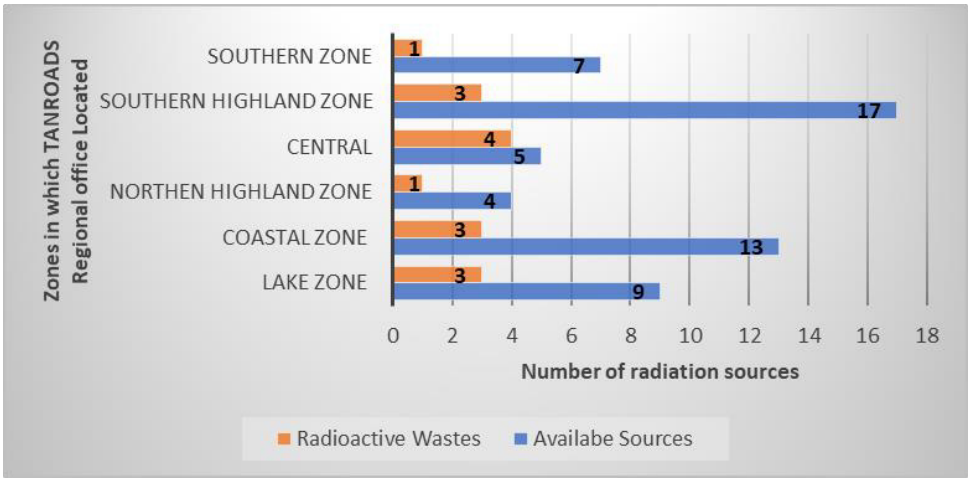
The review of TAEC database for dis-used and defective radiation sources, revealed that, TAEC lack national data on the status of disused sources national wide.

The Audit Team sampled radiation facilities in the construction sector and noted that, TANROADS possess 15 defective radiation sources[19], while at the same time had 40 radiation sources which were not in use (and were supposed to be disposed-off) which are situated in its Regional Offices.

[19] Defective radiation sources stands for a source of radiation at its half-life or at a state that no longer emits desired amount of radiations for a specified purpose.

The details of existing radiation sources which are defective and not safely disposed-off are as presented in **Figure 3.3**.

Figure 3.3: The Extent of Undisposed Radiation Wastes by TANROADS Regional Offices

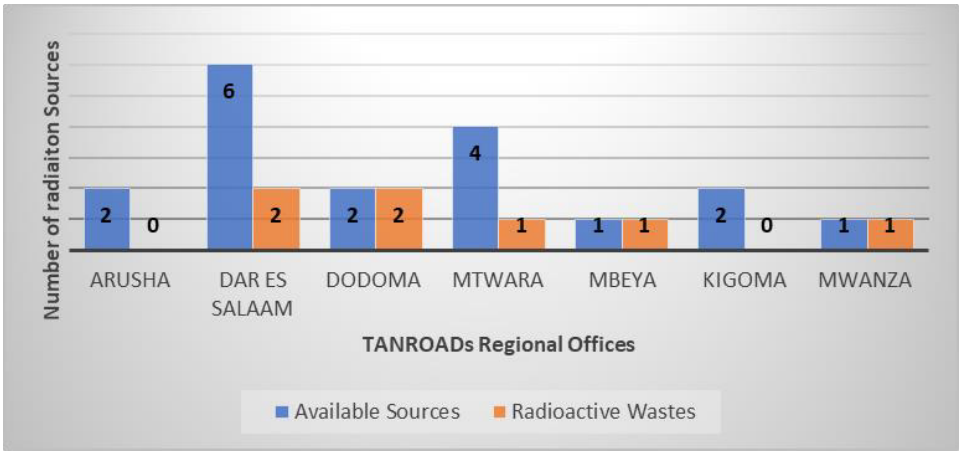


***Source**: Auditors' Analysis of Radiation Sources Status in TANROADS Regional Offices (2022)*

Figure 3.3 indicates that, 4 radioactive wastes were found in TANROADS' Regional Offices located in Central zone, while 3 radioactive wastes were found in Lake Zone; Coastal Zone; and Southern Highland Zone respectively and 1 radioactive waste was located in Southern Zone and Northern Highland zone each.

Further, in five out of the seven visited TANROADS' Regional Offices, the Audit found seven radioactive wastes as presented in **Figure 3.4.**

Figure 3.4: The Undisposed Radiation Wastes by TAROADS in the Visited 7 Regional Offices



***Source**: Auditors' Analysis of Radiation Sources Status in TANROADS Regional Offices (2022)*

Figure 3.4 indicates that, two (2) was the highest number of radioactive wastes and was found in Dar es Salaam and Dodoma TANROADS' Regional offices, while Arusha and Kigoma regions were not having undisposed off radioactive wastes.

The reasons for the existence of disused sources in user's premises was attributed to a lack of contractual agreement for returning back to manufacturers or TAEC radiation sources which are no longer in use. This was contrary to Regulation 62 (1) a & b; and (3) of the Atomic Energy (Protection from Ionizing Radiation) Regulation, 2004. The Regulation requires TAEC to ensure that, licensees contractually agree on return of radiation sources to manufacture of supplier after being used and otherwise make prior arrangement with TAEC to manage and dispose radioactive waste at the end of its useful life.

Through the review of TANROADS list of radiation sources, the Audit Team noted an existence of 55 radiation sources (Troxler) without agreement of neither returning them back to manufacturers nor to the TAEC for being managed as radioactive wastes at the end of their useful life. This was attributed to the fact that, TAEC lack effective system for managing importation of radioactive sources into the country. As a result, proper database does not exist in TAEC for easier follow-ups.

The Audit Team noted that, the available database/register does not capture key information for disposal off radioactive sources such as requirement/mode and time/period for the disposal of each registered radiation source. The Senior Officials from TAEC responded that, at the end of the financial 2021/22, the database (Central Radioactive Waste Management Facility) which serves as a national data base had 150 dis-used sealed radioactive sources. Out of which 87 sources have been conditioned, 55 not conditioned and 8 are scams and yellowcake.

3.2.3 Registered Radiation Facilities were not adequately Inspected by TAEC

According to Section 6 (1) (h) of the Atomic Energy Act, 2003, TAEC is required to carry out regulatory inspections and ensure that corrective actions are taken if unsafe or potentially unsafe conditions are detected.

Moreover, the IAEA Standard on Inspection of Radiation Sources and Regulatory Enforcement (Supplement to IAEA Safety standards series No. GS-G-1.5) requires inspection to radiation sources to be conducted after every one year to five years depending on relative risk associated to each type of radiation practice or sources within a practice. For example; inspection is required to be conducted every year for radiation sources for industrial radiography, Irradiators, radiotherapy, and well logging. While the Operational Policy and Procedures of TAEC requires inspection to be done after every one year to radiation sources used for radiotherapy, industrial radiography, Irradiators, radioactive waste facilities, and cargo scanner. For this case, TAEC was expected to have inspected a wide range of radioactive sources. However, the following weaknesses were found: -

TAEC Achieving its Inspection Targets

In its Corporate Strategic Plan of 2018/19 – 2022/23, TAEC targeted to conduct 30 inspections to radiation sources by June 2023, in order to increase compliance of licensees, registrants of radiation facilities. For this case, TAEC was expected to conduct 6 compliance inspections on annual basis.

Our analysis of the extent of achievement of inspection targets indicated that TAEC managed to achieve 130%, 111% and 112% of its set annual target inspection in the financial years 2018/19, 2020/21 and 2021/22 respectively. However, it

was also noted that TAEC did not achieve its inspection target for the financial year 2019/20 by 13%. This is as presented in **Table 3.4** below:

Table 3.4: The Extent of inspections of radiation facilities as per the set annual inspection targets

Financial Year	Target for Inspection (Number)	Conducted Inspections (Number)	%of inspection Conducted
2018/19	500	650	130
2019/20	620	538	87
2020/21	600	666	111
2021/22	600	670	112
Average Achievement			110

Source: *Auditors' Analysis of information from TAEC's Annual Plans and Implementation Reports, 2018/19 to 2021/22*

Table 3.4 indicates that, TAEC inspected radiation facilities beyond her set target by 30%,11% and 12% in the financial years 2018/19, 2020/21 and 2021/22. However, for the financial year 2019/20 TAEC did not achieve its target for the inspection of radiation facilities by 13%.

Through interview with officials from TAEC it was stated that, the inspection of radiation facilities for the year 2018/19 exceed the target by 30% this resulted from the inadequate plan for the inspections due to lack of basis for the plan of inspection resulted from non-conducted inspection by TAEC for the preceding financial years 2014/15 to 2017/18.

An average of 83% of *Registered Radiation Facilities were not Inspected by TAEC as of 2021/22*

Through reviews of the Inspection Reports conducted by TAEC for a period of four financial years starting from 2018/19 to 2021/22, it was noted that the percentage coverage of inspections conducted ranged from 7% to 17% of all registered facilities with radiation sources in the country. The details of the inspection coverage are presented in **Figure 3.5** as follows:

Figure 3.5: The Coverage of Inspections of Facilities with Radiation Sources from 2018/19 to 2021/22

***Source**: Auditors' Analysis of TAEC's Inspection Reports and Register of Radiation Facilities from 2018/19 – 2021/22.*

Figure 3.5 indicates that, in the financial year 2018/19, 72 out of 960 equivalents to 7% radiation facilities in the country was inspected by TAEC, while in 2020/21, TAEC inspected 463 out of 1092 (equivalent to 42%) of all facilities holding radiation sources. It also shows that, for the year 2021/22 inspection coverage declined to 16% whereby TAEC managed to inspect 185 out of 1169 registered radiation facilities in the country. This means that, 83% of the registered facilities were not inspected by TAEC.

TAEC's performance trend on the inspection of radiation sources varied over a period of four financial years from 2018/19 to 2021/22 as shown on **Figure 3.6.**

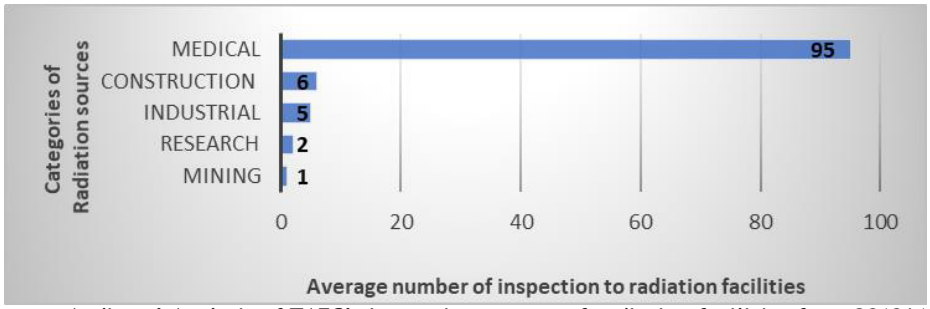
Figure 3.6: Performance trend on Inspection of Facilities with Radiation Sources

***Source**: Auditors' Analysis of TAEC's Inspection Reports and Register of Radiation Facilities from 2018/19 to 2021/22.*

Figure 3.6 indicates that, there was a decrease of conducted inspections from 8% to 4% from the financial years 2018/19 to 2019/20 respectively. While there was a noted increase to 42% in the financial year 2020/21 from 2019/20, followed by a decline to 16% in the financial year 2021/22. The decline of percentage of facilities inspected in the financial years 2019/20 and 2021/22 was attributed by the increased number of radiation facilities in the TAEC register of radiation sources which were not inspected in the respective financial years.

Further review of the inspection reports conducted by TAEC for a period under the audit noted that, the inspection to radiation facilities was highly conducted to medical facilities than in other practices such as construction, research, mining, as well as industrials applications. This is as presented in **Figure 3.7**.

Figure 3.7: The Extent of Inspection of Radiation Sources in Different Practices



***Source**: Auditors' Analysis of TAEC's Inspection reports of radiation facilities from 2018/19 - 2021/22.*

Figure 3.7 indicates that, for the period of four years 2018/19 to 2021/22 TAEC mostly inspected medical facilities, whereby an average of 95 medical facilities were inspected per annum, while the least inspected facilities were for the mining with an average of one facility inspected per annum.

Reasons for inspection favoring more on medical facilities than others included:

(a) Presence of large number of medical facilities that are already identified and registered by TAEC into its register of radiation sources. The reviewed register indicated that, the number of medical facilities with radiation sources i.e. in the financial year 2021/22 the TAEC register of radiation sources shows that number of medical facilities are 798 while the rest of radiation facilities for other practices were 371; and

(b) Radiation sources in medical facilities are mainly exposed to human being, thus requires inspections to be conducted in order to avoid adverse results that might happen from unexpected amount of radiation exposure of human body to impair their health.

Moreover, in the visited 12 facilities with radiation sources, Arusha, Dar es Salaam, Mtwara, and Mbeya Regions, the Audit Team noted that, the inspection was not adequately conducted for the period from 2018/19 to 2021/22 as detailed in **Table 3.5**.

Table 3.5: Extent of Inspections by TAEC in the Visited 12 Facilities with Radiation Sources

Category of Facilities	Number of Facilities Visited by the Audit Team (N)	Number of Inspected Facilities by TAEC /Financial Years (N)			
		2018/19	2019/20	2020/21	2021/22
Airports	4	0	1	4	2
Medical	5	2	2	4	1
Construction	3	0	0	1	0
Total	12	2	3	9	3
Inspected Facilities by TAEC (%)		17	25	75	25

Source: *Auditors' Analysis on TAEC Inspection Reports in the Visited Facilities (2022)*

Table 3.5 indicates that for the financial year 2020/21, TAEC inspected 75% of the visited facilities, while in the year 2018/19 only two of the visited facilities equivalent to 17% were inspected and for the year 2019/20 and 2021/22 the inspection conducted was 25% respectively. Further, the **Table** indicates that the lowest inspection was the construction sector whereby in visited 3 facilities only one facility was inspected by TAEC in the financial year 2020/21.

Interviewed Senior Officials from TAEC stated that, the inadequate inspections conducted to facilities possessing radiation sources was mainly attributed to shortage of human resources specifically the Radiation Safety Inspectors and Assistant Radiation Safety Inspectors at TAEC as indicated in **Table 3.6** below:

Table 3.6: Percent of Shortage of Radiation Inspectors at TAEC as of June, 2022

Designation	Total Positions Required	Total Number Available	Vacancies	Vacancies (%)
Radiation Safety Inspector	80	0	80	100
Assistant Radiation Safety Inspector	140	11	129	92

***Source**: Auditors' Analysis on TAEC Human Resources Plan 2021/22-2024/25 as of 4th April 2022*

Table 3.6 indicates that, TAEC lack radiation Safety Inspectors while at the same time it has a shortage of Assistant Radiation Safety Inspectors by 92%.

Insufficient number of inspections conducted by TAEC contributed to the inadequate implementation of safety requirement in the facilities with radiation sources. This was confirmed in the visited facilities in the construction sector whereby, inspections were conducted at the radiation sources were poorly handled with no radiation warning signs, absence of trained safety officers, inadequate shielding of premises and poor storage of the radiation sources as detailed in **Table 3.7.**

Table 3.7: The Summary of Weakness Noted in the Visited Radiation Facilities in the Construction Sector

Noted Weaknesses	No. of Radiation facilities with the noted weaknesses
No radiation warning signs	6
Absence of trained Safety Officers	6
Inadequate shielding of premises	6
Poor storage of the radiation sources	6

***Sources**: Auditors' Analysis of information from site visit to TANROADS Regional Offices (2022)*

Table 3.7 shows that, all 6 visited TANROADS' Regional offices were found without radiation warning signs, trained Safety Officers, well shielded premises for radiation sources and with poor storage of the radiation sources as shown in **Photo 3.1 (a & b):**

Photos 3.1: (a) & (b) Radiation Facility without Warning notice and symbols, and improperly placed density gauge devices at TANROADS -Dodoma Region

(a) Door without Radiation warning sign/symbol nor notice at TANROADS -Dodoma Region, photo taken on 15th September,2022

(b) Three density Gauge devices placed on top of a table while other activities commence at TANROADS -Dodoma Region, photo taken on 15th September,2022

Source: *Photo was taken by the Auditors during the Audit Verification at TANROADS -Dodoma Region on 15th September, 2022*

Furthermore, inadequate inspection of facilities using radiation sources in the country increases safety risks to users of radiation sources and the public at large. Also, non-conduction of inspection to radiation sources is contrary to the requirement of the supplement to IAEA safety standard series No. GS-G-1.5 and the Operational Policy and procedures of TAEC of October 2021.

Therefore, the installed radiation sources or mobile radiation sources that remain uninspected for a long time than prescribed time in the IAEA standards and the Operational Policy of TAEC can have leakage that emit radiations to the nearby surroundings which are harmful to the users.

3.3 Inadequate Functioning Mechanisms for the Control of Radiation Sources

The Audit Team noted that, TAEC took various initiative towards controlling and promoting safe and peaceful use of nuclear technology as required by Part III of the Atomic Energy Act of 2003. The functioning of control mechanism was assessed based on the analysis of established strategies and plans, procedures for

authorisation of radiation sources, presence of qualified experts operating radiation emitting devices and adequacy of inspection tools for controlling radiation devices.

The results of the analysis revealed weaknesses which indicates inadequate functioning of control mechanisms as detailed below: -

3.3.1 The Inadequate Preparedness for Response to Nuclear and Radiological Emergency

Through the review of Corporate Plan of TAEC, the Audit Team noted that, TAEC has included aspects related to control of radiation sources in its strategic Objective C and D. Under the Strategic Objective C focusing on enhancing promotion of nuclear technology, whereby among other targets, TAEC has a strategy to improve laboratory services through establishing the Quality Management System and accreditation for ISO 17025, strengthen dosimetry services and develop the National Emergency Policy and Plan. Similarly, under Objective D focusing on enhancing compliance to nuclear safety, security and safeguards of radiation sources for protection of the public and environment, TAEC set a strategy to provide assurance of safety performance through inspections, audits, investigations and taking enforcement action for identified non-compliances.

Despite TAEC having these strategies in place, the analysis of the Audit Team revealed the weaknesses regarding preparedness as detailed below:

Delays in the Preparation and Roll out of National Radiological Emergency Plan

Section 6(1) & (V) of the Atomic Energy Act, 2003, requires TAEC to formulate and operate a National Radiological Emergency Plan. The objective was to establish an organized emergency response capability for timely and provide coordinated actions of the authorities in a peaceful response to radiological incident or emergency. Review of TAEC Annual Action Plan of 2019/20, indicates that, TAEC was expected to have established and rolled out the National Radiology Emergency plan by June, 2020.

The Audit noted that, although TAEC managed to develop the National Nuclear and Radiological Emergency Response Plan up to June 2022, the plan was approved two years later by TAEC Board in the 18th meeting of the Board held on 11th February, 2022. This indicates a delay of 2 years.

Further, through the interviews held with TAEC Senior Officials and physical verifications conducted by the Audit Team, it was noted that, all seven visited facilities with radiation sources did not have emergency radiological response plan as a standard operating procedure at the facility level. This was contrary to the requirement of Regulation 34(1)(V) of the Atomic Energy Regulations, 2004, that requires each Institution or Facility possessing radiation sources to establish occupational protection, safety and security measures, including local rules and procedures that are appropriate for controlled areas.

That means, there were no functioning mechanism as a preparedness towards emergency response on nuclear and radiological emergency, despite of the widespread use of radiation sources in medicine, industry, research and mining sectors involving the use of strong radioactive materials like Cobalt-60 and Caesum-137. The absence of a functioning mechanism with the currently growing potential on the use of radiation sources in different practices poses risks of illicit trafficking of radiation sources for illegal purposes.

The absence of radiological emergency plan and local rules and procedures at Facilities level despite available risks in poor handling of radiation sources and presence of disused radioactive materials indicates the risks for presence of uncontrolled accidents involving radiation sources.

3.3.2 Inadequate Functioning of Authorisation Procedures for Authorising Qualified Experts

Regulation 18(1) of the Atomic Energy (Protection from Ionizing Radiation) Regulations, 2004, requires every qualified expert intending to carry out a practice that involves administering of ionising radiation to any person for the purposes of diagnosing or treating a disease to apply for an authorisation to the Tanzania Atomic Energy Commission.

Section 25 (1)) of the Atomic Energy Act, 2003 also requires TAEC in collaboration with any competent institution to keep and maintain a register of qualified

experts operating apparatus, installations and plants in undertakings owned by a user.

Review of licensing status for qualified experts registered by TAEC to administer ionising radiation to persons for the purpose of diagnosing or treating disease, the Audit Team noted that, TAEC has insufficiently managed to register adequate number of radiographers. This is because a number of registered radiologists' experts by the Tanzania Medical Radiology and Imaging Professional Council from 2018/19 to 2021/22 were more than the number of experts registered and licensed by TAEC for the period under review. **Table 3.8** analyses the number of registered radiologists by the Professional Tanzania Radiologist Board versus number of licensed Radiologist by TAEC from 2018/19 – 2021/22.

Table 3.8: The Extent of Registration of Qualified Experts to Administer Ionising Radiation by TAEC

Registration calendar year	Number of registered radiographers by the professional Board[20]	Number of registered radiographers by TAEC	% Registered by TAEC
2018	150	0	0
2019	272	0	0
2020	403	241	60
2021	593	389	66
2022	614	458	75

***Source**: Reviewed Radiographers Registration and Licensing Reports from both Tanzania Medical, Radiology and Imaging Professional Council and TAEC from 2018/19 – 2021/22*

From **Table 3.8,** it can be noted that, TAEC did not provide license to the qualified Radiographers registered by the Tanzania Medical, Radiology and Imaging Professional Council for two consecutive years from January 2018 to December 2019. However, for the calendar years 2020, 2021, and 2022 the licensing by TAEC was done by an average of 67%

Inadequate registration of qualified experts mainly Radiographers who are responsible for administering ionising radiation to persons was mainly contributed by late implementations of the requirement of the Atomic Energy Act, 2003 and its Regulations of 2011 by TAEC for the period under review. This is because TAEC

[20] Tanzania Medical, Radiology and Imaging Professional Council

began to register qualified experts in financial year 2020/21 which was 17 years since it was mandated to do so by *Section 25 (1)) of the Atomic Energy Act, 2003*.

Absence of online qualified experts' registration system was also a contributing factor for the inadequate registration, due to the fact that, TAEC uses manual registers that are difficult to be retrieved when updating the licensing status. As a result, the Commission did not collect an estimated revenue amounting to TZS. 47.2 million, which could have been obtained from the 944 unlicensed qualified experts at the rate of TZS 50,000/ per person for the period under review.

Consequently, inadequate licensing of qualified experts by TAEC has also resulted into existence of unlicensed personnel administering ionising radiation to persons for diagnosing or treatment purposes. This situation has been observed by the Audit Team through the visit made to the selected Regional Referral Hospitals as detailed in **Table 3.9.**

Table 3.9: Analysis of the Existence of Unlicensed Experts in the Visited Medical Facilities as of June, 2022

Name of Visited Region	Name of Visited Medical facility	Number of available radiographers	Number of licensed radiographers	Number of unlicensed radiographers
Arusha	Arusha Regional Referral Hospital	7	4	3
Dar es salaam	Amana Regional Hospital	7	5	2
Mtwara	Lugula Regional Referral Hospital	5	2	3
Mbeya	Mbeya Regional Referral Hospital	5	0	5
Kigoma	Maweni Regional Referral Hospital	8	8	-
Mwanza	Sekou toure Regional Referral Hospital	6	6	-
Dodoma	Dodoma Regional Referral Hospital	5	5	-
Total		43	30	13

Source: *Physical Verification and Reviewed Licensing Certificates from the Visited Healthcare Facilities (2022)*

Table 3.9 indicates that, in four out of seven visited Regional Referral Hospitals equivalent to 57% out of all visited Regional Referral Hospitals (RRH) by the Audit Team, there were Radiographers administering ionising radiation to patients without being licensed by TAEC. It can be further be noted that, at Mbeya RRH, the radiographers were not licensed to the tune of 100% as of June, 2022 contrary

to the requirement of Regulation 18(1) of the Atomic Energy (Protection from Ionizing Radiation) Regulations, 2011.

The Officials from Mbeya RRH stated that, they had paid for the required licensing fees but were not issued with the licenses by TAEC. This situation was confirmed by TAEC Senior Officials by later submitting to Auditors all the five missed radiographers' licenses at Mbeya RRH following Auditors' visit at the facility. Generally, the total number of licensed Radiographers was 30 out of 43 equivalents to 70% of available Radiographers while the total number of unlicensed Radiographers was 13 out 43 equivalents to 30% of the available Radiographers in the visited facilities.

It was further insisted by Officials from the visited facilities that, among the causes of non-possessing of operating licenses by the Radiographers in the visited RRH was non-issuing of the entire license by TAEC following receipt of the required payment from the respective healthcare facility. This situation was noted in three out of seven visited RRH which are Mbeya, Mwanza and Dodoma RRH whereby the facilities applied and paid the required licensing fee but TAEC did not deliver the respective licenses.

Interviewed TAEC Senior Officials stated that non-issuing of licenses following payment made by the respective healthcare facility was due to inadequate filling of the required applications form by the healthcare facility. This situation shows that TAEC does not have an effective system for providing feedback to its clients.

3.3.3 TAEC has not Adequately Ensured Radiation Emitting Devices are Operated by Qualified Experts

TAEC was expected to ensure radiation emitting devices are operated by qualified experts as per the requirement of Regulation 18(1) of the Atomic Energy (Protection from Ionizing Radiation) Regulations, 2004.

For non-medical facilities, the Officials responsible for operating radiation sources in the visited facilities were expected to have attended radiation safety and protection training offered by TAEC together with being issued with training certificates. This is because the Senior Officials from TAEC stated that, since nuclear science and technology is one of the emerging fields, many countries in Africa including Tanzania have no long term curricular for producing qualified

experts that would be operating radiation facilities particularly in non-medical applications.

However, it was noted that, TAEC has not adequately ensured the radiation emitting devices present to both medical and non-medical facilities are operated by qualified experts as described under Section 3.3.2 of this report. This is because TAEC did not manage to license all qualified radiographers registered by the Tanzania Medical, Radiology and Imaging Professional Council for two consecutive years from January 2018 to December 2019.

Further analysis for non-medical facilities specifically Tanzania Airports Authorities and TANROADS noted that some of the Officials responsible for operating the radiation emitting devices were not qualified since they have not attended the required radiation safety trainings organised by TAEC. This situation was noted to both seven airports and five TANROADS Offices that were visited by the Audit Team whereby not all Radiation Operators and Safety Officers attended training provided by TAEC. As a result, the radiation emitting devices were operated by untrained personnel not issued with training certificates by TAEC. **Table 3.10** indicates percentage of attendance of training by operators of radiation emitting equipment in non-medical facilities.

Table 3.10: The Extent of Availability of trained Radiation Safety Officers in the Visited Non-medical Facilities by June, 2022

Name of visited facility	Number of available operators/radiation safety officers	Number of operators/radiation safety officers attended TAEC training	% Trained by TAEC
Arusha Airport	24	2	8
JNIA Airport	300	3	1
Mtwara Airport	10	0	0
Songwe Airport	29	1	3
Kigoma Airport	10	0	0
Mwanza Airport	54	0	0
Dodoma Airport	18	1	6
Five Regional TANROADS Offices[21]	5	1	20

Source: *Interviewed radiation safety officers and reviewed training certificates from visited Airports and Regional TANROADS Offices, 2022*

Table 3.10 indicates that, to the large extent the official responsible for operating radiation emitting devices were not trained by TAEC in both seven visited airports authorities and five TANROADS Regional Offices. From the **Table 3.10** it can be seen that, in three airports which are Mtwara, Kigoma and Mwanza no officials were trained by TAEC. Further, for the five visited TANROADS Offices only one Official was trained by TAEC for the period under review. Generally, the training to operators working with radiation emitting devices in non-medical facilities was not satisfactory, as the percentage of official trained was below 20 percent.

Moreover, Interview with Senior Officials from both the visited Airports and Regional TANROADS Offices revealed that, the reasons for not attending the TAEC training was contributed by inadequate awareness on the training calendar from TAEC and also non-prioritisation of such training by their responsible Institution.

As a result, the Officials were found working with radiation sources such as troxlers and baggage scanners with minimal safety precaution measures. For example, all of the radiation safety officers at the five visited TANROADS Offices were working with troxlers without safety precaution measures.

[21] The five Regional TANROADS Offices visited by the Audit are Mtwara, Mbeya, Kigoma, Mwanza and Dodoma Regional TANROADS Office. Each Regional TANROADS Office had one appointed radiation safety officer

3.3.4 The TAEC Lacked Adequate Scientific Equipment for Inspecting Radiation Sources

For the purpose of protecting the public and environment, TAEC's Corporate Strategic Plan of 2018/19 – 2022/23, requires TAEC to establish and improve regulatory infrastructures for safety and control of ionising and non-ionising radiation sources by June, 2023. The targeted improvements include equipping and re-tooling the existing TAEC's Offices with radiation detector equipment, laboratory equipment and special vehicle for transportation of radiation sources, wastes and construction of new 5 laboratories.

Interviewed Senior Officials from TAEC Headquarters and the visited TAEC's Zonal and Regional Offices revealed that, the Commission was experiencing a shortage of inspection tools such as survey meters, quality control tool kit, pager, beam alignment test tools and collimation test tools. These tools are considered as the minimum requirements of scientific inspection tools that every TAEC's Offices at either head quarter, zonal, regional level are expected to possess as an essential equipment to facilitate inspections activities to be conducted by TAEC in the premises and facilities possessing radiations sources. This means that, for a particular TAEC's Office to efficiently conduct inspections, it is required to possess a minimum of 5 scientific inspection tools which are survey meter, quality control tool kit, pager, beam alignment test tools and a collimation test tool.

However, reviewed Scientific Inspection Tools Analysis Report submitted to the Audit Team by TAEC together with Auditors' analysis of available TAEC Offices categorized in zone wise, it was noted that, the number of available scientific inspection equipment was insufficient compared to the requirement based on the number of TAEC Offices established in the country.

Table 3.11 Presents the extent of shortage of scientific inspection tool in the visited TAEC's Zonal Offices.

Table 3.11: Percentage of Shortage of Scientific Inspection Tools within TAEC Offices as of 30th June, 2022

Location of office in Zone	Number of offices available in each Zone (including OSBP[22])	Quantity (number) Minimum required scientific inspection equipment[23]	Number of Shortage (number)	% Shortage
Eastern	31	155	129	83
Southern	4	20	14	70
Zanzibar	3	15	10	67
Northern	7	35	23	66
Central	1	5	3	60
Lake	9	35	14	40
Southern Highland	2	10	4	40
Total		275	197	72

Source: *Auditors' Analysis of Reviewed TAEC Scientific Inspection Tools Status Report, Physical Verification to TAEC Regional Offices and TAEC Offices Establishment Report as of June (2022)*

Table 3.11 indicates that in total, TAEC has a shortage of 72% of the required inspection tools in all of its Offices in the country as at 30th June, 2022. The highest shortage of 83% was noted in the Eastern zone.

Despite of this shortage of equipment, the Audit Team noted that not all equipment in the respective zone were calibrated to ensure their proper functioning as presented in **Table 3.12**.

[22] OSBP refers to Outstation Boarder Post Offices

[23] Each TAEC Office is required to possess at least a single scientific inspection tool among the 5 identified types which are: survey meter, quality control tool kit, pager, beam alignment test tools and a collimation test tool.

Table 3.12: The Percentage of Calibrated Scientific Inspection Tools within TAEC Offices as of 30th June, 2022

Location of office in Zone	Number of offices available in each Zone (including OSBP[24])	Number of available equipment in each zone	Number of Equipment that were not Calibrated	% Equipment that were not calibrated
Eastern	31	26	10	38
Southern	4	6	2	33
Zanzibar	3	5	2	40
Northern	7	12	4	33
Central	1	2	0	0
Lake	9	21	7	33
Southern Highland	2	6	2	33
Total		78	**27**	**35**

Source: *Auditors' Analysis of Reviewed TAEC Scientific Inspection Tools Status Report, Physical Verification to TAEC Regional Offices and TAEC Offices Establishment Report as of June (2022)*

From **Table 3.12,** it can be revealed that, an average of 35% of scientific inspection equipment available in the seven TAEC Zonal Offices in the Country were not calibrated contrary to the requirement of Regulation 30(2)(b) of the Atomic Energy (Protection from Ionising Radiation) Regulations, 2004. Inadequate calibration of available scientific inspection equipment despite of their shortage, had resulted into risks of absence of a reasonable assurance in the outputs of various measurement undertaken using the uncalibrated equipment.

Further analysis made by the Audit team revealed that, the most commonly missed equipment in all zones included quality control tool kit, pager, beam alignment test tool and collimation test tools. **Table 3.13** present the commonly missed equipment and their associated impact to the control of radiation sources.

[24] OSBP refers to Outstation Boarder Post Office

Table 3.13: The Summary of Commonly Missed Equipment and their Impact in Control Activities

Name of the Equipment	Function of the Tool	Number of Affected Zones	Responsible Zones	Name of affected Offices	Associated Impact to the control Activities
Survey Meter	Detection of radioactive materials	1	Lake	Kibirizi Port	Detection of radioactive materials not performed
Quality Control Tool Kit	For detection of radiation sources	3	North, Lake and Eastern	Namanga, Kigoma, Manyovu, Bukoba, KIA, Tanga, Horohoro, Bagamoyo, Mbweni and Kibirizi Port	Inefficiencies in detection of radiation sources
Pager	An X-ray and gamma radiation detector for detection and location of radioactive materials	3	North, Lake, and Southern Highland	Namanga, Mwanza, Manyovu, Rusumo, Bukoba and Kibirizi	Failure to locate and detect radioactive materials on continuous basis
Beam alignment test tools	Ensure accurate X-ray beam alignment	5	North, Southern, Southern Highland, Central, Lake and Zanzibar	Tanga, Dar es Salaam, Mwanza, Kigoma, Mbeya, Dodoma, Zanzibar and Mtwara	Inefficiencies in testing X-ray beam alignment
Collimation test tool	Verification of proper alignment of the X-ray beam	5	North, Southern, Southern Highland, Central and Lake zone	Mwanza, Kigoma, Mbeya, Mara, Mtwara, Songwe, Tanga and Zanzibar	Inefficiencies in the verification of proper alignment of X-ray beam alignment

Source: *Auditors' Analysis of Common Missed Scientific Inspection Equipment (2022)*

From **Table 3.13** above, the beam alignment test and collimation test tools were not available in five zones namely North, Southern, Southern Highland, Central and Lake Zone. The noted shortage of inspection tools was attributed to the following reasons:

(a) ***Absence of Conducted Needs Assessment of the Requirement of Inspection Tools:*** The Audit Team noted that TAEC did not conduct needs assessment on the type and quantities of inspection equipment required to facilitate the inspection activities. As a result, the Commission kept reporting to have a shortage of inspection tools while it has not conducted the analysis of the requirements.

(b) ***Inadequate Release of Approved Budget for Acquisition of Inspection Equipment***: The reviewed TAEC's Annual Implementation Report for the period of 2018/19 – 2021/22, revealed that, the released funds were not sufficient to implement the planned procurement of targeted inspection equipment as detailed in **Table 3.14.**

Table 3.14: The Percent of Released Funds for Purchasing Inspection Tools from 2018/19 – 2021/22

Financial year	Approved budget (Million TZS)	Released funds (Million TZS)	% Released
2018/19	353.8	273.8	77
2019/20	136.9	331.9	242
2020/21	19.5	3.7	19
2021/22	209.9	143.7	68

Source: *Auditors' Analysis of Reviewed TAEC Annual Implementation Reports from 2018/19 – 2021/22.*

Table 3.14 indicates that, in the financial year 2018/19, TAEC received 77% of the approved funds while in 2019/20 received 242% of approved funds. This situation implies that, there was over release of inspection equipment funds for the financial year 2019/20. For the remaining financial years of 2020/21 and 2021/22, TAEC was allocated between 19% and 68% of its approved budget for purchasing scientific inspection equipment. However, the fund was not enough compared to the actual requirement of inspection tools in terms of quantity and total cost required to acquire them.

However, interviews with Senior TAEC Officials provided an example that, a single Quality Control Kit could cost up to TZS 34.4 million, Survey Meter from

TZS 3.4 – 34.4 million and a Pager TZS 3.4 million. This implies that, for the Commission to re-tool only the 31 offices available in the Eastern Zone would require to have at least TZS 1.066 billion.

(c) ***Centralization of Inspection Activities at TAEC HQ:*** This was identified as a contributing factor to the shortage of scientific inspection tools in the TAEC's Zonal, Regional and the Out Stationed Border Post Offices ***(OSBs)***. It was revealed that, there were no inspectors allocated in the other Offices of TAEC other than the Headquarters whereby the inspection plans and budget were prepared and coordinated from the TAEC HQ only. As a result, TAEC did not find the need to allocate adequate budget to capacitate the Zonal, Regional and Out Stationed Border Post Offices ***(OSBs)*** to plan and conduct inspections in their areas of jurisdiction.

(d) Non allocation of inspectors to both Zonal and Regional level together with non-decentralization of inspections activities have also contributed into the observed shortage of scientific inspections equipment for the period under review.

Consequently, the shortage of radiation detection equipment resulted into ineffective inspection of radiation sources to exporters, importers and users that were planned to be conducted at the Regional, Border posts and Zone wise in the country. On the other hand, insufficient number of scientific and technical equipment has also contributed into failure to detect radiation sources timely by the affected TAEC Offices. It also contributed to inefficiencies in testing radiation emitting devices during inspections including testing of an X-ray beam alignment, undetected radioactive materials or incomplete measurement of radiations which in turn did not lead to conclusive results.

3.4 Inadequate Monitoring of Radiation Sources

The Audit noted that, the Tanzania Atomic Energy Commission performed various initiative towards monitoring of radiation sources. These includes conducting monitoring of quality compliance of premises with radiation sources; monitoring of personal occupationally exposure from radiation sources; enhance calibration and possession of survey meters for radiation facilities monitoring.

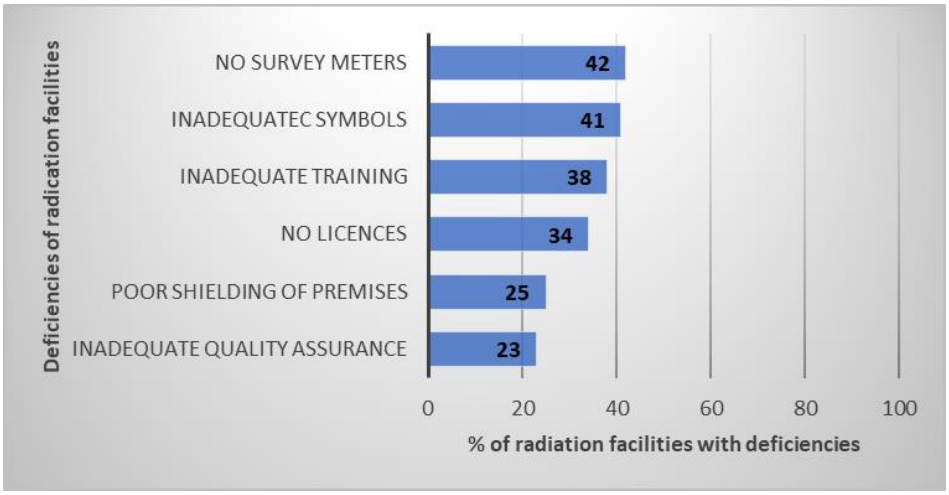
However, the Audit Team noted the following performance weaknesses regarding monitoring of radiation sources:

3.4.1 Inadequate Monitoring of Premises with Radiation Sources

According to Section 56(1) of the Atomic Energy Act, 2003, TAEC is required to conduct examination of all premises in respect of which a licence to install or use apparatus emitting radiation is in force and all places in respect of which authorizations have been granted for the accumulation or disposal of radioactive waste.

The review of TAEC's Inspection Reports from the financial year 2018/19 to 2021/22, revealed the presence of radiation facilities with deficiencies that resulted from inadequate monitoring of premises with radiation sources by TAEC. The identified deficiencies were such as inadequate shielded premises, lack of survey meters, lack of quality assurance programme, lack of warning symbols and notes and the presence of operators who did not attend radiation safety training as detailed in the **Figure 3.8**.

Figure 3.8: Common Weaknesses Noted by TAEC in the 123 Inspected Radiation Facilities for the Financial Year 2018/19 to 2021/22



Sources: *Auditors' Analysis from TAECs' Inspection Reports 2018/19-2021/22*

Figure 3.8 indicates that, the most common weakness of radiation facilities identified by TAEC in its inspections was lack of survey meters. Whereby 52 out of

123 facilities which is equivalent to 42% did not have survey meters. It also shows that TAEC noted that 50 out of 123 of radiation facilities had inadequate symbols and warning notes.

Despite of the efforts made by TAEC towards conducting inspections of radiation facilities, the Audit Team noted weaknesses related to the effectiveness and coverage of the inspections as explained below:

(i) Ineffective Inspections Conducted by TAEC

The audit noted that, the inspections conducted by TAEC were not effective as evidenced by the presence of facilities that were previously inspected by TAEC, but were still having the same weaknesses. This was verified by the Audit team through its audit to the Eight medical facilities and 13 non-medical facilities, whereby the Audit Team observed similar weaknesses pertaining to deficiencies of radiation facilities that were previously identified by TAEC.

Further, through its verification visit, the Audit Team also noted that 8 out of 13 visited medical and non-medical facilities were not possessing radiation monitoring devices (survey meters), lacked adequate and legible radiation signs and symbols.

Lack of radiation monitoring devices and warning symbols is detailed in **Table 3.15** below:

Table 3.15: The Common Non-Compliance Weaknesses Noted in the Visited Facilities with Radiation Sources

Common Non-Compliance Weakness Noted	Total number of visited facilities	Number of visited facilities with common non-compliance weaknesses
The absence of patient waiting areas for medical facilities	8	4
The absence of survey meters for radiation facilities monitoring	21	17
The absence of Established working rules and procedures	21	8
Lack waste Management Plan	21	21
Inadequate safety gears (gonad shield, vests, gloves, goggles) for safe operation of sources of radiation	21	10
Non display of licenses by licensees inside the premises	21	13
Absence of trained radiation safety officers	21	12

***Source**: Auditors' Analysis from Information Obtained from Audit Physical Verification to Radiation Sources Facilities (2022)*

Table 3.15 shows that, for all 21 visited radiation facilities, they did not have waste management plan, 17 facilities found without survey meters, 10 out of 21 found with inadequate safety gears such as gonad shields, vests, gloves and goggles and 4 out of 8 visited medical facilities found without a patient waiting area.

Existence of such weaknesses indicates that, the inspections conducted by TAEC were not adequately enforcing the facilities to conform to the required quality and other safety requirements.

According to the interview conducted to the Officials from the visited facilities, in particular the visited non-medical facilities, the identified deficiencies were attributed to inadequate training on safe use of the radiation sources conducted by TAEC. This led into Officials applying only their professional background skills and knowledge to use and store radiation sources. This situation was not health to officials since they did not have adequate knowledge on safe use of radiation sources.

However, interviews with TAEC Officials and review of TAEC's Inspection Reports revealed that, TAEC has not made follow-up on the implementation of the issued recommendations by TAEC during its inspection to the radiation facilities. This has contributed to a prolonged existence of a number of facilities with the same deficiencies.

Similarly, the existence of deficiencies in the radiation premises has a risk of exposing people and environment to unintended radiation doses that may result into either short term or long-term adverse effects. These impacts are such as cancers and ultimately deaths.

(ii) The Inadequate Coverage of Inspection (s) conducted were focused more on Medical Radiation Sources than other.

The review of TAEC's inspection reports for the period from 2018/19 to 2021/22, revealed that TAEC has not managed to cover all premises for inspections as required by Section 56(1)(b) &(g) of the Tanzania Atomic Energy Act, 2003. This was based on the analysis of the inspections conducted by TAEC in relation to the number of facilities registered in TAEC's register of radiation facilities in the country as detailed in **Figure 3.9**.

Figure 3.9: The Coverage of Inspection of Facilities with Radiation from 2018/19 to 2021/22

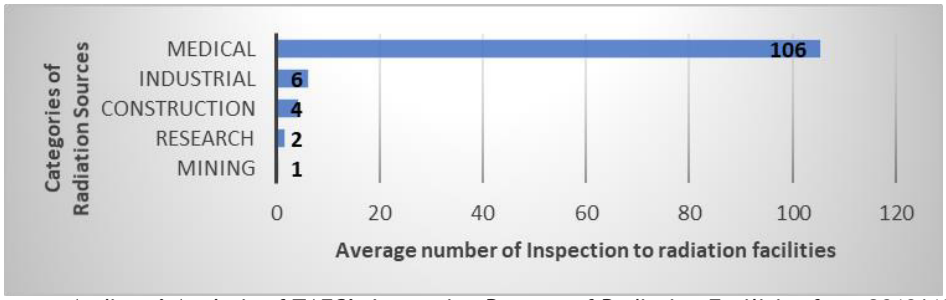
***Source**: Auditors' Analysis of TAEC's Inspection Reports and Register of Radiation Facilities from 2018/19 – 2021/22*

Figure 3.9 indicates that, in the financial year 2018/19, 72 out of 960 equivalents to 7% radiation facilities in the country was inspected by TAEC, while in 2020/21, TAEC inspected 463 out of 1092 (equivalent to 42%) of all facilities holding radiation sources. It also shows that, for the year 2021/22 inspection coverage

declined to 16% whereby TAEC managed to inspect 185 out of 1169 registered radiation facilities in the country. This means that, 84% of the registered facilities were not inspected by TAEC.

Further, the review of inspection reports conducted by TAEC for a period under the audit noted that, the inspection to radiation facilities was highly conducted to medical facilities rather than in other sectors such as constructions, research, mining, as well as in industrial applications. This is detailed in **Figure 3.10** below:

Figure 3.10: The Extent of Inspection of Radiation Sources in different Practices



Source: *Auditors' Analysis of TAEC's Inspection Reports of Radiation Facilities from 2018/19 - 2021/22*

Figure 3.10 indicates that, for the period of four financial years i.e from the year 2018/19 to 2021/22, TAEC mostly inspected medical facilities, whereby an average of 106 medical facilities were inspected per annum, while the least inspected facilities were for the mining with an average of one facility inspected per year.

This implies that, TAEC inadequately conducted inspections to all of the assessed sectors including; Medical, Mining, Industrial, Construction and Research sectors despite of the existing exposure risks to radiation sources in those sectors as analysed in **Table 3.16.**

Table 3.16: The Level of Risks of Exposure to Radiation on the Assessed Sectors

Sector	Practices/Application	Radionuclides used	Level of Risks
Medical	• Blood/Tissue Irradiators • Teletherapy • Gamma Knife Radiosurgery	Co-60 and Cs-137	High Risk
	• XRF • LDR • Brachytherapy	Co-57, Fe-55, Cd-109 and Pd-103	Most unlikely to be Dangerous (Low risk)
Industrial	Irradiators, Sterilization and food preservation	Co-60 and Cs-137	High Risk
	• Level Gauge • Thickness gauge • Conveyor gauge	Cs-137, Co-60, and Am-241	Medium Risk
Mining	• Well logging	Cs-137, Am-241/Be and Cf-252	Medium Risk
Construction	• Level Gauge • Moisture/ Density Detector	Cs-137, Co-60, Am-241, Am-241/Be, Cf-252 and Ra-226/Be	Medium Risk
Research	• XRF • Mossbauer spectroscopy	Co-57, Fe-55, Cd-109	Most unlikely to be Dangerous (Low risk)

Source: *Auditors' Analysis from the IAEA Safety Standards Series No. RS-G-19, 2005*

Key Abbreviations from Table 3.16

Item	Abbreviation
Co-60	Cobalt-60
and Cs-137	Caesium -137
Co-57	Cobalt-57
Fe-55	Iron-55
Cd-109	Cadium-109
Pd-103	Palladium-103
Am-241	Americium-241
Am-241/Be	Americium-241 Beryllium
Cf-252	Californium -252
Ra-226/Be	Radium-226/Beryllium
XRF	X-Ray Fluorescence
LDR	Light Dependent Resistor

Source: *Abbreviation of Radionuclides (2022)*

Table 3.16 indicates that, the level of risks exposure to radiation sources applied in medical and industrial sectors are of both high and low risks depending to the source of radiations used to a particular practice as illustrated in **Table 3.16**. For the case of remaining sectors which are mining, construction and research, it can be revealed that, the levels of exposure are medium and low, respectively. In that regard, the level of inspections conducted by TAEC in all the five assessed sectors were not adequate to enable addressing the level of risks of exposures of radiation sources available in those sectors.

3.4.2 Ineffective Monitoring of Persons Exposure to Radiation Sources

Section 56 (1) (a) & (2) (a) of the Atomic Energy Act, 2003 requires TAEC to provide personal radiation measuring devices to be worn by individuals occupationally exposed to radiation. It also requires TAEC to establish a system to facilitate the determination of extent of exposure to radiation workers, students, and personnel employed in research and teaching and hospitals.

Interviews with Senior Officials from TAEC revealed that, it is the requirement that, doses of radiations occupationally received to workers monitored on monthly and after every three months. Whereby TAEC provides badges named Thermoluminiscent Dosimeters (TLD) to every individual working with radiation sources which are used to keep record on the amount of radiation an individual receives from his undertakings.

However, the minimum acceptable number of exposure an individual can receive per annum must not exceed 20 millisiervert (mSv). In case of over exposure beyond the determined range, a person involved is entitled to be given a leave from his work. This is in according to para.III.1 of Part 3[2] of the General Safety Requirements (GSR) of the International Atomic Energy Agency.

From the review of dosimetry records from TAEC, the Audit Team noted various deficiencies regarding monitoring of the amount of exposure from radiations to officials working in the radiation sources emitting devices for both practices of medical and non-medical facilities as detailed as follows:

(a) Inadequate Monitoring of Amount of Radiation Exposure to Workers in Non-medical Facilities

TAEC targeted to strengthen dosimetry services in order to successfully monitor the amount of radiation exposure. Its targets were to increase dosimetry services for persons and environment from 1800 to 2200 radiation workers by 2023.

Also, it planned to evaluate 920 Thermoluminescent Dosimeters (TLDs) for personal dosimetry, to update the National Personal Dosimetry Registry and 40 environmental TLDs for external radiation, to perform onsite ambient dose rate measurements at 40 centers, update the background radiation database and prepare a radiation map of the United Republic of Tanzania, and to acquire 200 personal TLDs and 2 radiation survey meters per year.

The Audit Team noted that, there was inadequate monitoring of the extent of radiation exposures to workers occupationally exposed to radiation sources working in non-medical sector including security, mining, construction and industrial sectors. It was further established that, for the period of four financial years from 2018/19 to 2021/22, an average of 96.5% of non-medical facilities in the country were not supplied with TLDs to record and monitor level of exposures that every individual occupationally receives working in environments that involves uses of radiation sources.

Figure 3.11 shows the status on the provision of TLDs to non-medical facilities in the country.

Figure 3.11: Non-Medical Facilities with Radiation without Possessing TLDs

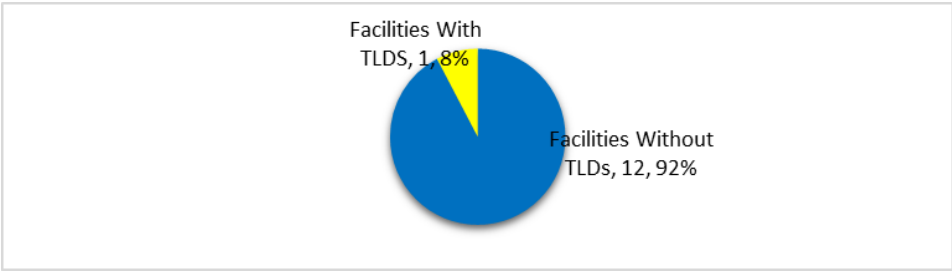
Source: *Auditors' Analysis of TLDs from TAECs Received TLDs Records Book and List of Registered Facilities (2018/19-2021/22), 2022*

Figure 3.11 indicates that, for the financial year 2018/19 to 2020/21 TAEC managed to provide TLDs to 3% of all registered radiation facilities in the country while in the year 2021/2022 the provision of TLDs was 5% of all the registered radiation facilities indicating an improvement of only 2% for the reviewed period of four financial years.

The improved provision of TLDs caused a decrease to the percentage of non-medical facilities not supplied with TLDs from 97% in the financial year 2020/21 to 95% in 2021/22. However, the improvement in percentage of facilities receiving TLDs services was attributed to decreased number of non-medical facilities from TAEC's register of radiation facilities in the country from 612 in year 2020/21 to 376 in the year 2021/22. The actual provision of TLDs to non-medical facilities decreased from 21 facilities in the financial year 2018/19 to 19 facilities in 2021/22.

Similarly, the status of TLDs provision to non-medical facilities was established in the course of audit through the physical verification made to the selected TANROADS offices and TAA. The verification was conducted to non-medical radiation facilities for 7 Airports and 6 TANROADS Regional Offices in seven regions, the results are presented in **Figure 3.12** below:

Figure 3.12: Status of TLDs Provision in Non-medical Radiation Facilities



Source: *Auditors' Analysis on Provision of TLDs in Non - medical Radiation Facilities (2022)*

Figure 3.12 shows that, 1 out of 13 visited non-medical facilities found having supplied with TLDs, while the rest 12 facilities equivalent to 92% did not possess TLDs. All Seven visited airports were not supplied with TLDs while one TANDROADS regional office out of six visited regional offices was supplied with TLDs.

Moreover, interview with Senior Officials from 13 visited non-medical facilities revealed that, their operators working with the radiation emitting devices commonly the X-rays and equipment for non-destructive test namely Troxler which contain radioactive materials, were neither possessing nor wearing TLDS devices due to the fact that, they were not aware of that requirement. This is because they were not instructed by TAEC in either during training or official visit to their premises on TAEC's routine inspections.

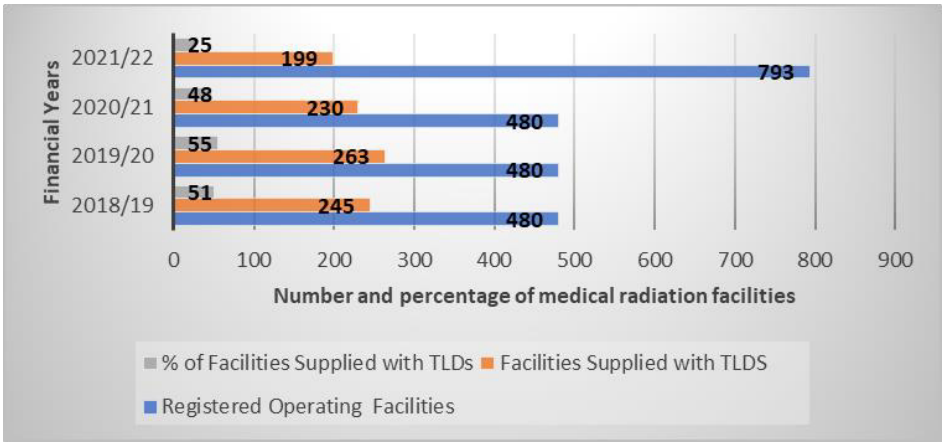
Non provision of TLDs to workers exposed occupationally to non-medical sources of radiation, risk their health since the amount of radiation exposure received while interacting with radiation sources was not established. Additionally, the Audit Team found that, there was no any recommendation made to them regardless of being exposed to un-recommended dose of radiation in their daily practices.

(b) Inadequate Monitoring of the Amount of Radiation Exposure to Workers in Medical Facilities

Regulation 32(2) (d) of the Atomic Energy (Protection from Ionising Radiation) Regulations, 2004, requires Licensees and employers to ensure that all workers engaged in activities that involve or could involve occupational exposure to radiation, are provided with adequate personal monitoring equipment.

Through a review of the TAEC's TLDs Receiving Record Book for the financial years 2018/19 to 2021/22, the Audit Team noted that, 199 out of 793 medical facilities which is equivalent to 25%, were supplied with TLDs for the financial year 2021/22 this marked the least supply of TLDs to medical facilities for the whole period under the audit. On the other hand, 263 out of 480 medical facilities equivalent to 55% were supplied with TLDs for the year 2019/20 and this was the year whereby TLDs were mostly supplied for the period of four financial years covered under the audit. Detailed information of the facilities that received dosimetry services to workers is presented in **Figure 3.13** below.

Figure 3.13: Medical Facilities Supplied with TLDs for the Period of Four Years, 2018/19 to 2021/22



Source: *Auditors' Analysis of TLDs from TAECs receiving TLDs Records Book and List of Registered Facilities (2018/19-2021/22), 2022*

Figure 3.13 indicates that the maximum number of facilities not supplied with TLDs was at 75% for the financial year 2021/22, while the minimum number of facilities not supplied with TLDs was at 45% in the financial year 2019/20. For the financial year 2018/19 and 2020/21 the facilities not supplied with TLDs were at 49% and 52% respectively, this implied that, for the financial year 2019/20, the coverage of healthcare facilities to the supply of TLDs was higher while the lowest supply was noted in the financial year 2021/2022.

TAEC did not Monitor Medical Facilities provided with TLDs

The audit verification in the medical facilities noted that, 2 out of 8 visited medical facilities were found to have all their workers being supplied with TLDs from TAEC, while 6 out of 8 visited medical facilities were found with workers occupationally exposed to radiation sources without the provision of monitoring services from TAEC as detailed in **Table 3.17** below:

Table 3.17: The Number of Personnel Occupationally not Monitored from Radiation Exposure in Visited Facilities

Name of Facility	Total Number of Workers	Workers not Receiving TLDs
Arusha Regional Referral Hospital	7	2
Muhimbili National Referral Hospital	34	-
Amana Regional Hospital	15	2
Mtwara Regional referral Hospital	5	3
Mbeya Regional Referral Hospital	8	2
Maweni Regional Referral Hospital	9	9
Sekotoure Regional Referral Hospital	5	-
Dodoma Regional Referral Hospital	10	3
Total	**93**	**21**

Source: *Auditors' Analysis on the Number of Personnel Occupationally not Monitored from Radiation Exposure in the Visited Facilities (2022)*

Table 3.17 shows that, 21 out of 93 workers equivalent to 23% found to operate in the radiation facilities without provision of TLDs from TAEC to ensure them are properly working in an acceptable range of exposure to radiation sources.

Through the interviews with officials from TAEC, it was noted that, inadequate provision of TLDs to users of radiation sources were attributed to shortage of human resources at TAEC dosimetry laboratory which was evidenced through review of Human Resources Analysis of respective Directorates at TAEC, 2021. The analysis indicated a shortage of laboratory technicians and nuclear instrumentation technicians as detailed on **Table 3.18** below:

Table 3.18: The Shortage of Human Resources at TAEC Dosimetry Laboratory

Designation	Personnel Available	Personnel Required	Gap
Nuclear Instrumentation Technician III	0	5	5
Nuclear Instrumentation Technician II	3	4	1
Laboratory Technician II	8	17	9

***Source**: Auditors' Analysis of information from Human Resources Analysis of Required, Available and Shortages from the respective Directorates (2022)*

Table 3.18 shows that, the demand for nuclear instrumentation Technician III is high since none were at TAEC, while the demand for Laboratory Technician II was 9 staff.

Therefore, the non-provision of TLDs to the staff working with radiation sources leads to difficultly from presuming that whenever a physical or mental disability occurs in a person resulted from exposure to radiation sources from a source of strength sufficient to give rise to such disability as referred in Section 22(4) of the Atomic Energy Act No.7, 2003.

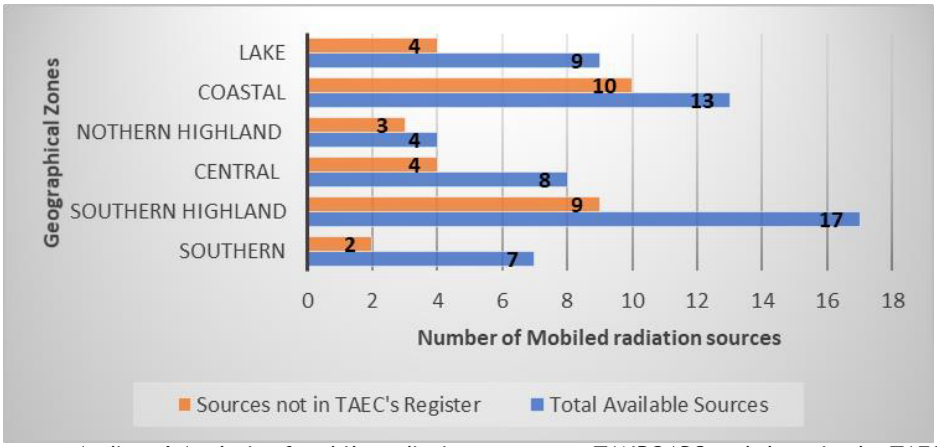
3.4.3 Ineffective System for Tracking of Mobile Radiation Sources Following Registration

According to Section 24(6) of the Atomic Energy Act, 2003, TAEC is required to keep and maintain a register of mobile radiation sources.

Through the review of TAEC's general excel register of facilities with radiation sources in the country, it was noted that TAEC did not have an adequately maintained register for mobile radiation sources. This was further stated in interviews held with Senior TAEC officials who stated that, TAEC did not have an updated register for all mobile radiation sources in the country.

Nevertheless, TAEC has in possession an excel register of facilities with radiation sources which indicates facilities registration number assigned by TAEC, number of radiation sources in the respective facilities in the country and their location. However, through the visit made to TANROADS by the Audit Team it was noted that, there was insufficient inclusion of mobile radiation sources in TAEC list and the presence of untraced mobile radiation sources as detailed in **Figure 3.14**.

Figure 3.14: Untraced Mobile radiation Sources at TANROADS by TAEC



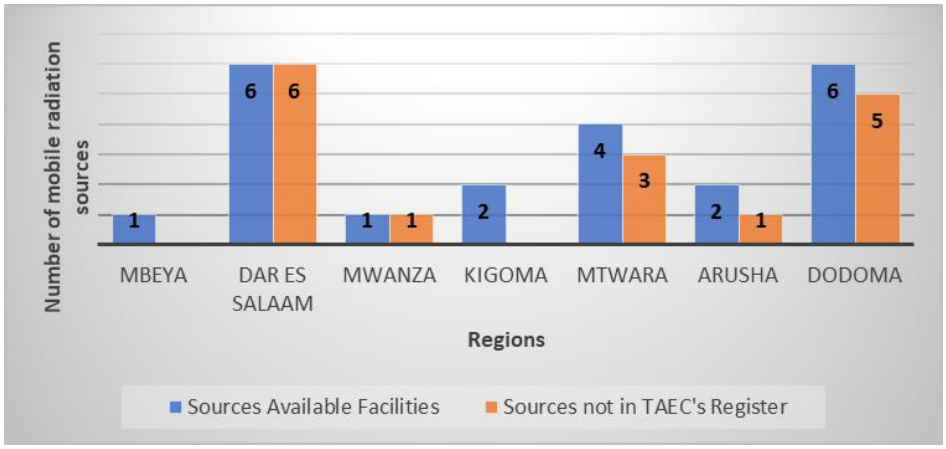
***Source**: Auditors' Analysis of mobile radiation sources at TANROADS and those in the TAECs Register of radiation facilities (2022)*

Figure 3.14 indicates that, TAEC did not manage to track a total of 32 mobile radiation sources whereby the largest number of un-registered mobile radiation sources in TANROADS offices were in Coastal Zone. It was found that, 10 out of 13 mobile radiation sources equivalent to 77% were neither unrecognized nor registered by TAEC. Also, the minimum number of unregistered mobile radiation sources were in Southern Zone, whereby 2 out of 7 mobile radiation sources equivalent to 27% were not in TAEC's Register.

Presence of untraced mobile radiation sources in visited TANROADS facilities

The Audit Team visit to 7 TANROADS regional offices revealed the presence of mobile radiation sources in 5 Regional offices not registered in TAEC's register of radiation facilities. This is detailed in **Figure 3.15**.

Figure 3.15: Mobile Radiation Sources not in TAEC's Registers of Radiation Facilities in the Visited 7 TANROADS Regional Offices



Sources: *Auditors' Analysis from Physical Verifications Mobile Radiation Sources in Comparison with TAEC's register (2022)*

Figure 3.15 shows that, TAEC did not track and register 16 mobile radiation sources found in seven visited TANROADS Regional Offices in the country. It can be noted that, none of the mobile radiation sources in Dar es Salaam and Mwanza regions were registered by TAEC, while for the other regions, namely Mtwara, Arusha and Dodoma whereby sources were 4, 2 and 6 respectively but only one source in each region was in TAEC's register.

Further, the unregistered mobile radiation source was improperly stored contrary to Section 20 of the Atomic Energy Act, 2003 that requires no person shall keep, or cause or permit to keep, mobile ionising radiation devices of any description for the purpose of its being used in delivery by him of services, use, lend or let on hire or cause or permit to be used mobile ionising radiation devices of any description in the course of the delivery by him or any such services, unless he is registered by TAEC in respect of that apparatus.

It was observed that, absence of adequately maintained register for mobile radiation sources was due to a reason that, TAEC did not have an effective mechanism of tracing movements of the mobile radiation sources in the country which led to a number of sources locally transported, lent and transferred to different users without notice of changes made to TAEC.

Failure to maintain up to date register of mobile radiation sources has led to the presence of poorly managed mobile radiation sources. This was revealed through the visits made to TANROADS' Regional Offices, whereby mobile ionising radiation sources were found improperly stored in unshielded facilities. Meanwhile the facilities where the sources were stored were used for other purposes than only being the storage of radiation sources as shown in **Photos 3.2 (a&b)** below:

Photo 3.2 (a) & (b): Poorly stored mobile ionizing radiation sources at TANROADS' MCL and Mtwara Regional Managers Office

(a) MCL-TANROAD HQ photo taken on 3rd August 2022

(b) MTWARA TANROADS REGIONAL MANAGER photo taken on 10th August 2022

Source: *Photo was taken during the Audit Team Site Visit in Dar es Salaam and Mtwara Regions (2022)*

Photos 3.2 (a) & (b) show 4 mobile ionising radiation sources improperly stored at Central Material Laboratory (CML) TANROADS HQ whereby in the same facility on Photo 2(a) other activities for the Laboratory were carried on. Similarly in the Photo 2(b) taken from Mtwara TANROADS Regional Manager's Office, the mobile radiation sources were stored in a container which was found unshielded with 4 sources of radiation.

Inadequate management of mobile radiation sources, may cause a potential risk to both users and the public through exposing them to radiations that exceeds the minimum amount of radiation that is allowed for individuals per annum.

3.4.4 Inadequate Possession of Radiation Detection Instruments by Users with Radiation Sources

According to Section 30(1) & (2) of the Atomic Energy Act, 2003, monitoring and measurements are required to be conducted by licensees of the parameters necessary for verification of compliance with requirements of these regulation and license. For the purpose of monitoring and verification of compliance, every licensee is required to have adequate number of survey instruments for area monitoring at radiation workplace; and send the radiation survey instruments to an approved dosimetry laboratory at least once a year and after its maintenance or repair for calibration.

The review of TAECs survey meters services for the period from financial year 2018/19 to 2021/22 noted that, Facilities that possess sources of radiation in different practices such as medical diagnostics, mineral processing, research and construction sector rarely have survey meters in their premises for area monitoring. **Table 3.19** narrates the number of facilities with radiation in the country that do not have survey meters.

Table 3.19: The Percent of Facilities Lacking Radiation Detection Equipment as of June, 2022

Category of facility	Number of registered facilities	Number of registered facilities with survey meters	Number of registered facilities without survey meters	Percentage of facilities without survey meters out of total registered (%)
Mining	23	2	21	91
Industrial	35	3	32	91
Research	46	2	44	96
Medical	793	3	790	99
Others	158	149	9	100
Construction	114	0	114	100

Source: *Auditor's Analysis from Survey Meters Maintenance Records of TAEC, 2018/19 to 2021/22*

Table 3.19 shows that, the percentage of facilities that lack survey meters for facilities premises monitoring ranged from 91% to 100% of facilities on each category of facilities. In the construction sector, none of its facilities possess survey meters, while for medical practices 99% of facilities do not possess the

survey meters, 96% of facilities in research practices, 91% in Industrial and 91% in mining did not possess survey meters for their facilities monitoring.

Further, through the audit verification in the visited facilities for medical, constructions and airports it was noted that, none of the 8 facilities for the medical and 6 for the construction sector were possessing radiation survey meters, while in the visited airports 4 out of 7 were found to possess radiation survey meters. Through the interviews with officials in the 19 out of 21 visited radiation facilities, it was noted that, radiation users lacked awareness that are required to have survey meters for monitoring purpose to their premises in case of radiation leakages.

Despite that, through Section 6(1) of the Atomic Energy Act, 2003, TAEC is required to formulate and implement programmes for the training of persons to become qualified experts in the development and practical application of atomic energy, nuclear technology and the use of radiation sources and radiation protection. It is also required to hold and facilitate the conducting of seminars, workshops or short training courses including education to the public for the safe and peaceful uses of atomic energy and nuclear technology.

Moreover, radiation facilities without survey meters may experience attenuation to radiations that may result from misbehaved sources of radiation, such incidence has already occurred at JNIA whereby one of the X-ray machines misbehaved until when TAEC inspected the facility and noted that, the X-ray already had been producing radiation above 0.5 microsieverts per hour to personnel working in the facility.

3.4.5 Inadequate-Calibration of Radiation Survey Instruments

Regulation 30(2)(b) of the Atomic Energy (Protection from Ionising Radiation) Regulations, 2004, requires TAEC to ensure that every licensee send the radiation survey instrument to an approved dosimetry laboratory at least once a year and after every maintenance or repair for calibration.

Interviewed TAEC's Senior Officials from Headquarters stated that, calibration of radiation detection equipment mainly survey meters are done based on customers' requests and not in compliance with the requirements of Regulation

30(2)(b) of the Atomic Energy (Protection from Ionising Radiation) Regulations, 2004. This is because TAEC charges calibration fees amounting to TZS 350,000 required to be paid by the customer that became an obstacle to some of the customers.

On the other hand, the review of TAEC's Annual Action Plans and Implementation Reports for the period from 2018/19 to 2021/22 noted that, the Commission calibrated the survey meters from users as per pan and the targets were achieved by more than 100 percent as indicated in **Table 3.20.**

Table 3.20: Performance of TAEC's Calibration Targets (2018/19 – 2021/22)

Financial year	Calibration target (number)	Calibrated survey meters (number)	Performance (%)
2018/19	10	23	230
2019/20	10	11	110
2020/21	30	31	103
2021/22	30	34	113

Source: *TAEC's Annual Action Plans and Implementation Reports from 2018/19 – 2021/22*

Table 3.20 indicates that TAEC managed to calibrate the survey meters by more than 100 percent out of planned target for each reviewed financial year. The calibration performance for the financial year 2018/19 was twice more than the set target because it was in that year when TAEC began to enforce licensees to send their survey meters to TAEC for calibrations, resulting into the response being higher. On the other hand, calibration target set by TAEC was not realistic, because a target of 10 equipment annually is relatively very low number as compared to the number of radiations centers in the country.

Despite this achievement, the Audit Team noted that, TAEC has not managed to enforce the requirement of the law that require every licensee with radiation survey instrument to send it to TAEC for calibration at least once per year. This is because the survey meters were not calibrated according to the number of facilities with survey meters as identified by TAEC. As a result, some of the radiation survey instruments remained uncalibrated for the period under review as shown in **Table 3.21** below:

Table 3.21: Calibration of Survey Meters by TAEC from Identified Facilities Possessing Survey Meters (2018/19 – 2021/22)

Financial year	Number of survey meters available to facilities	Number of calibrated survey meters	% age Compliance
2018/19	9	9	100
2019/20	18	9	50
2020/21	27	7	26
2021/22	32	10	31

***Source**: Reviewed TAEC's List of Organization/Institute for Calibration Dosimeters from 2018/19 – 2021/22*

Table 3.21 indicates that for the financial year 2018/19, TAEC calibrated all survey meters from the identified facilities because this activity was conducted for the first time in 2018/19. For the following financial years from 2019/20 to 2021/22 TAEC calibrated survey meters from 26% to 50% of the identified total survey meters from the facilities which were calibrated in the previous financial year.

The performance trend for calibration of survey meters was decreasing because TAEC did not ensure that, the survey meters are consistently calibrated. This is through ensuring that, those calibrated in the previous year are also calibrated in the current year in accordance with the requirement of Regulation 30(2)(b) of the Atomic Energy (Protection from Ionising Radiation) Regulations, 2004.

In addition, the inadequate calibration of survey meters led to risks of the presence of undetected radiation in case of occurrence of leakages thus, posing risks to health and the environment as well. This is due to the fact that, uncalibrated survey meter may provide unreliable results on the extent of exposure to radiation sources by users and to the surrounding environment.

Moreover, the Audit Team conducted further verifications in both the medical and non-medical facilities that were visited in order to assess the extent of compliance to the frequency of calibration of survey meters and found that, 4 out of 21 visited facilities possessed survey meters. However, no facility sent the survey meters to TAEC for calibration for the period under review. This situation was due to inadequate enforcement made by TAEC to ensure that, all facilities that are possessing radiation detection equipment are identified and frequently monitored to ensure that calibration are done as per the requirements of the Atomic Energy Act, 2003.

3.5 Ineffective Coordination between TAEC and other Stakeholders in Controlling Radiation Sources

The Audit Team noted some weaknesses on the mechanism for coordination, regarding raising awareness to users and the general public on the application of atomic energy and nuclear technology. This is contrary to the requirements of Section 6(1) (p) of the Atomic Energy Act, 2003 that demand TAEC to promote national and international co-operation or collaboration on the applications of atomic energy and nuclear technology.

The details of noted weaknesses regarding coordination are presented as follows:

3.5.1 Inadequate liaising with Appropriate Institutions on Enhancing Practical Application of Atomic Energy

According to Section 6(1) (q) of the Atomic Energy Act, 2003, TAEC is required to liaise with Ministries and the appropriate Institutions in order to facilitate the incorporation into the syllabi of all relevant and appropriate knowledge in Nuclear Science and Technology for the practical applications of atomic energy and the related safety and protection during utilisation.

Reviewed Memorandum of Understandings (MoUs) between TAEC and Higher learning Institutions showed that, TAEC has signed a five years MoU from 2022/23 – 2026/27 with The Nelson Mandela African Institution of Science and Technology (NM-AIST), the University of Dodoma (UDOM) from 2020/21 – 2024/25. These MoUs between TAEC and NM-AIST and UDOM intend to collaborate in academics, research, consultancy and outreach activities through establishing of Postgraduate studies related to nuclear technology. Other cooperation include; exchange of visits students and/or staff, exchange of knowledge through joint research, conferences, publications, seminars, workshops and training.

The Audit Team further noted that, TAEC has also signed MoU with the University of Dar es Salaam (UDSM) on 30th January, 2006 for the purpose establishing and hosting a Radionuclide Monitoring Station at the University of Dar es Salaam.

However, the Audit Team noted that, the extended collaboration between TAEC and Universities covered only 3 out of 30 approved and accredited Universities in Tanzania by the Tanzania Commission for Universities (TCU) as of May, 2022[25].

The Senior Officials from TAEC responded that, despite of not having signed MoUs with other Universities, the Commission collaborates with other Universities in various research and practical activities some of them are Mbeya University of Science and Technology (MUST), Muhimbili University of Health and Allied Sciences (MUHAS) and St. Augustine University of Tanzania (SAUT).

Moreover, during the audit, interview with the Senior Officials at TAEC revealed that, among the reasons that limited TAEC to extend cooperation and coordinate with other Higher Learning Institutions was insufficient learning infrastructure in various Universities that would enhance cooperation in academic and research.

Consequently, this situation hinders early dissemination of nuclear science technology to many scholars in Tanzania that would ultimately affect the country strategic objectives of promoting peaceful use of atomic energy.

3.5.2 Inadequate Provision of Awareness to Users of Radiation Sources

Objective D of TAEC's Corporate Strategic Plan of 2018/19–2022/23 requires the Commission to enhance compliance to nuclear security, radiation safety and safeguards of radiation sources for protection of the public and the environment through conducting training and seminars on awareness, compliances and radiation controls.

Interview with the Senior Officials from TAEC Headquarters and in the visited TAEC's Zonal Offices stated that, training and seminars to both medical and non-medical practitioners are always conducted every year as part of the core activity of the Commission of providing awareness and enhancing safe and peaceful use of technology in the country.

However, reviewed TAEC's Annual Action Plans for the period 2018/19 – 2019/20 revealed that, the Commission did not incorporate training to nuclear technology

[25]https://www.tcu.go.tz/sites/default/files/LIST%20OF%20UNIVERSITY%20INSTITUTIONS%20IN%20TZ%20AS%20OF%2012%20MAY%202022%20FINAL.pdf

users for implementing Objective D of its approved Strategic Plan 2018/19 – 2022/23 for two financial years of 2018/19 – 2019/20. Instead TAEC prepared a separate plan on the National Training Courses on Radiation Protection and Safety for the financial year 2019/20, 2020/21 and 2021/22 while for the financial year 2018/19 training and seminars plan was not prepared.

However, for the financial years 2020/21 and 2021/22, training to nuclear technology users were incorporated into TAEC's Annual Actions Plans. Whereby the Audit Team noted that for the financial years 2020/21 and 2021/22, TAEC conducted 12 National training and tailor-made courses to nuclear technology users in Tanzania as planned in the Annual Action Plans for the financial years 2020/21 and 2021/22 respectively.

The Audit Team also noted that, TAEC implemented awareness programs through various media as planned. On the other hand, a review of TAEC's Annual Implementation Reports for the period 2018/19 – 2021/22 revealed that, the Commission did not adequately report on the level of implementation of its training and awareness plans. This is because TAEC only reported that, it has trained various category of beneficiaries including students, securities organs and radiation workers for both medical and non-medical facilities without indicating the target in each category of training covered.

Inadequate provision of awareness to the users of radiation sources led to insufficient knowledge of the users on safety standards requirement while working with radiation sources. As a result, physical verification made by the Audit Team revealed that, all Officials in the visited non-medical facilities which were 7 airports and 5 Regional TANROADS Offices working with the radiation emitting devices were found not wearing protective gears due to insufficient awareness on risks associated with unsafe working with radiation emitting devices.

3.5.3 Lack of National Strategy for Coordinated Radioactive Waste Management

According to Section 56(1) & (f) of Atomic Energy Act, 2003, TAEC is required to establish a system which will facilitate the operation of a national coordinated radioactive waste management strategy. In this case, TAEC was expected to

develop and operationalise the National Coordinated Radioactive Waste Management Strategy by June, 2019. The intention for developing this strategy was to provide the framework for the development and implementation of a comprehensive, integrated, improved and sustainable system for radioactive waste management at national level.

However, review of the National Policy and Strategy for Radioactive Waste Management of January 2017, revealed that, the Policy and strategy intend to provide a solution of having a national coordinated radioactive waste management strategy was still in draft for 5 consecutive years since, 2017.

Interview with the Senior Officials from TAEC Head Office stated that, non-approval of the draft Policy and Strategy was attributed by absence of appointed Board of Directors at TAEC since 2018/19 up to June, 2022. Up to the time of this audit, the Policy was still not submitted to the Ministry of Education, Science and Technology for review and approval.

Consequently, the non-functioning of the National Policy and Strategy for Radioactive Waste Management resulted into absence of clear and comprehensive procedures for managing dis-used radiation sources that are available in various category of users including medical, mining and industrial sectors. Hence, risks of unmonitored disposal could exist due to absence of established and organized coordinated mechanisms in managing the radioactive wastes.

3.6 Ineffective Monitoring and Evaluation of the Performance of TAEC by MoEST

MoEST has done several activities aimed at improving safe use of nuclear technology in the country. These include participating in the Annual meetings arranged by the International Atomic Energy Agency (IAEA) every year, reviewing and translating the National Nuclear Policy of 2013 and preparation of Nuclear Policy Implementation Plan.

However, the Audit team noted, a number of weaknesses related to planning, establishment of guiding documents in radiation sources, implementation of monitoring and performance evaluation which indicates ineffectiveness in monitoring and evaluation of performance of both TAEC and MoEST. These noted weaknesses are presented as follows:

3.6.1 Ineffective Monitoring and Evaluation Plans Established by MoEST to Monitor the Performance of TAEC

According to the Strategic Plan of the MoEST of 2016/17-2020/21, the Division of Science, Technology and Innovation at MoEST was required to develop monitoring, reviewing and evaluation plan of its various strategic objectives. With regards to control of radiation sources, objective F of MoEST's Strategic Plan of 2015/16-2020/21 is to enhance nuclear technology promotion and regulation in the country. The audit noted the following gaps:

MoEST lacked a Comprehensive Monitoring and Evaluation Plan for Promotion and Regulation of Nuclear Technology

Based on the review of the MoEST's Education Sector Monitoring and Evaluation Plan of 2015/16-2020/21, it was noted that, the Plan did not include activities related to the control of safe use of nuclear technology. The plan was mainly focused on monitoring and evaluation of basic education programme.

Moreover, the Officials from MoEST stated that, the Education Sector Monitoring and Evaluation Plan was part of the Education Sector Development Plan that was developed before the Division of Science, Technology and Innovation was transferred to the Ministry of Education from the Ministry of Communication Science and Technology. Otherwise, the subsequent Education Sector Monitoring and Evaluation Plan (2021/22 – 2025/26 has included the aspects of science, technology and innovation in which nuclear science and technology is included.

However, reviewed Education Sector Development Plan (2021/22 – 2025/26)-Monitoring and Evaluation Framework, noted that, under Outcome F - Science, Technology and Innovation, MoEST set targets to prepare National Skills Inventory Report and developing science, technology and innovations guidelines only while under Output F1–increased access to science, technologies and innovations, MoEST set a target for developing a framework for sharing research and development infrastructures whereas indicators and targets on promotion and regulation of nuclear technology are not described by the plan.

Further, Implementation Matrix of the MoEST's Strategic Plan of 2016/17 – 2020/21, under objective F for enhancing nuclear promotion and regulation of radiation technology, the Ministry planned to upgrade physical and human

capacity for regulatory control of ionizing radiation practices by June, 2021, conduct technical training and awareness campaign in areas of radiation hazards and measurements by June, 2021.

However, MoEST did not include promotion and regulation of nuclear technology activities in its Evaluation Plan presented in its Strategic Plan of 2016/17 – 2020/21. The Evaluation Plan aimed to conduct evaluation studies to obtain evidence as to whether the interventions and outputs achieved have led to the achievement of the outcomes as envisioned in the Strategic Plan. The Plan was also expected to indicate the performance indicators, timeframe needed for achieving the stated performance indicators, mechanisms and frequency of reporting, and the responsible unit/section for monitoring and for data collection.

Officials from MoEST also stated that, this was due to inadequate planning for the monitoring and evaluation activities and low capacity in terms of human resources in monitoring and evaluation at the Ministerial level. As a result, the Ministry did not effectively monitor and evaluate the achievement of its set objective for enhancing nuclear promotion and regulation of nuclear technology including radiation sources.

Similarly, the current MoEST's Strategic Plan of 2021/22 -2025/26 lack monitoring and evaluation plan for assessing its performance on the implementation of objective E for enhancing the mechanisms for promoting science, technology and innovation for socio-economic development. Although, under this objective, the Ministry planned to strengthen linkages between industries and researchers; promotion of grassroots innovators; and putting in place mechanisms for local government authorities to enhance innovation, also lacked the plan for monitoring its achievement.

MoEST did not have a Plan for M&E on the Performance of TAEC

Interviews with Officials of the MoEST, revealed that the Ministry lacked M&E Plan for assessing the performance of TAEC. Officials stated that, this is because the mechanisms for monitoring is through reviewing of submitted performance reports from TAEC to MoEST on a quarterly, semi-annually and annual basis. However, the Audit noted that, MoEST did not have indicators and targets that

could be reported by TAEC to enable the Ministry to assess its performance. Despite the fact that, in its Strategic Plan it is clearly indicated that, monitoring was to be done through internal mechanisms of systematic collection of data using specified indicators, baseline data and indicators target values as illustrated in the monitoring plan[26].

Despite the submitted TAEC reports, the Ministry had neither reviewed those reports nor issued recommendation as a result of their reviews for the period from 2018/19 to 2021/22. The Audit noted that, absence of effective monitoring and evaluation plan hinders MoEST to effectively assess the performance of TAEC in controlling radiation sources.

The Officials from MoEST responded that, MoEST do review and approve TAEC's annual budgets, work plans and performance reports (quarter, semi-annual and annual) before submission to the Ministry of Finance and Planning (MoFP). Furthermore, MoEST-DSTI annual work plan has supervision component (on-site visits) and annual meetings with all STI institutions, including TAEC, to monitor their performance. Despite of this explanation, the Ministry did not submit the reports showing the implementation of its plan.

3.6.2 MoEST has not established the National Research Policy, Guidelines and Standards for Controlling Radiation Sources

MoEST through its Division of Science and Technology and Innovation is required to formulate and review Science, Technology, Innovation and Research policies, guidelines and standards and monitor their implementation[27]. This includes promoting research in areas of radiation sources and widen usability to benefit the public.

Interviews with Officials from MoEST revealed that, the Ministry has not established the National Nuclear Research and Development Policy, Guidelines and Standards.The current used policy is the National Research and Development Policy of the year 2010, whose implementation ended in the year 2020. Also, this

[26] MoEST Strategic of 2021/22-2025/26

[27] http://www.moe.go.tz/sw/menu-item/idara-na-vitengo/idara/sayansi-teknolojia-na-ubunifu

Policy of 2010 lacked information that emphasise on research in nucler technology areas.

On the other hand, the review of the National Nuclear Technology Policy of 2013, noted that, Learning and Research Institutions are required to engage in training experts and conducting research in nuclear technology and the Tanzania Commission of Science and Technology (COSTECH) to engage in coordinating research and dissemination of research outcomes as well. Moreover, the same Policy is silent on the roles of TAEC in guiding, coordinating and conducting research in the area of nuclear technology which is among of its function executed by the Research and Development Section within TAEC. The Policy also does not provide guidance, cooordinating mechanisms and priority areas of research in the area of nuclear technology.

Furthermore, the non establishment of nuclear technology research aspect in the National Research and Development Policy of 2010 and inadequate coverage of nuclear research activities in the National Nuclear Research Policy of 2013, resulted into absence of a clear National Framework for guidance, coordinating and management of nuclear technology research at the national level. There is also absence of short, medium and long-term national research priorities in the areas of nuclear technology due to weaknesses in the available Policies guiding research activities at the national level.

3. 6.3 Inadequate Number of Publications in Area of Radiation

According to TAEC's Corporate Strategic Plan for the period 2018/19-2022/23, MoEST through TAEC has set a target to ensure national and regional projects and research on nuclear science and technology are formulated, coordinated, implemented and monitored by June, 2023. For this case MoEST was expected to ensure that, TAEC fulfils its strategic plan, which was not the case.

Through the review of the approved TAEC's Annual Action Plans, Annual Progress Reports and Published Publications for the period of 2018/19-2020/22, the Audit Team noted that, from 2018/19, TAEC planned to develop research concepts and publish the research on the area of nuclear technology. However, it was noted that, TAEC with exception of the financial year 2019/20 exceeded its target of developing research concepts papers. Despite of this achievement, TAEC did not

achieve its target for the planned number of publications by achieving 52% of planned number of publications for the reviewed period.

Table 3.22 presents the performance of TAEC on the development of research proposals and papers:

Table 3.22: The Performance of TAEC in Developing Research Concepts and Publications

Financial Year	Number of Research Concept			Number of Publications		
	Planned	Developed	Gap	Planned	Published	Gap
2018/19	3	3	-	2	3	-
2019/20	8	3	5	15	6	9
2020/21	11	11	-	10	6	4
2021/22	12	13	(1)	15	7	8
TOTAL	**34**	**30**	**4**	**42**	**22**	**20**

Source: *Auditors' Analysis from Annual Action Plans, Annual Progress Reports and Published Publications from TAEC, 2022*

Table 3.22 indicates that, TAEC in the past four years managed to develop 30 research concepts papers compared to 34 research concepts that were planned, this means that, TAEC did not manage to develop 4 research concepts papers for the reviewed period. For the case of research publications, TAEC has published 22 out of 42 planned publications. This means TAEC did not manage to publish 20 out of 42 papers that were planned, equivalent to 48% of set target.

Senior Officials from TAEC emphasised that, the major reason for not achieving the research papers publication targets was due to the fact that, completion of research work does not lead into immediate publication due to time-consuming paper review process undertaken by the respective journals. As a result, even funding from the Ministry for supporting researching and publications were also disbursed based on approved research proposals. Given such situation, our analysis of funds released for research activities indicated that, the percentage of disbursed funds was less than the planned budget as elaborated in **Table 3.23.**

Table 3.23: The Extent of Disbursement of Budgeted Fund for Radiation Research Activities

Financial Year	Annual Budget (Millions TZS)	Amount disbursed (Million TZS)	Deficit Amount (Millions TZS)	Percentage of undisbursed amount (%)	Percent of Published Research Papers (%)
2018/19	10	3	7	70	0
2019/20	10	3	7	70	0
2020/21	534	57	477	89	33
2021/22	180	91	89	49	47

Source: *Auditors' Analysis on Annual Plans and the Annual Implementation Reports (2022)*

Table 3.23 indicates that, the percentage for undisbursed funds for the research decreased from 70% in financial year 2018/19 to 49% in financial year 2021/22. In other way, it can be noted that, the amount of disbursed funds increased from 30% in financial year 2018/19 to 51% in financial year 2021/22. Despite of improvement in funded research works, TAEC did not manage to attain its target of publishing publications by 48% as indicated in **Table 3.22** of this report.

Consequently, less published papers in the field of radiation safety or/and nuclear security will hinder the dissemination of information on radiation control to potential stakeholders, resulting into the country not making much contribution or progress on the field of radiation worldwide.

3.6.4 Inadequate Monitoring and Evaluation of TAEC's Performance by MoEST

According to Sections 5(1), 6(1) & 16 (1) & (b&c)) of the Executive Agency Act, Cap 245 of 1997, MoEST is responsible for the strategic management of the Tanzania Atomic Energy Commission. In that regard, MoEST was expected to monitor and evaluate TAEC performance through the Division of Science, Technology and Innovation charged with those mandate.

However, the analysis of information from the reviewed Annual Implementation Reports of the MoEST for the years (2018/19-2021/22), revealed that, MoEST through the Directorate of Science, Technology and Innovation monitored implementation of sponsored development projects that are implemented under TAEC. It has also conducted three meetings (a single meeting in each year from 2019-20 to 2021/22) with the Science, Technology and Innovations Institutions

(STI) regarding the overall achievement and challenges facing those Institutions under MoEST of which TAEC was among those Institutions.

Furthermore, the Division of Science, Technology and Innovation (DSTI) through the visit made to TAEC by Deputy Permanent Secretary and the deputy minister for MoEST also visited TAEC twice in financial year 2018/19 and 2020/21 whereby DSTI did not monitor given instructions to TAEC in the respective visits by the Senior Officials from MoEST. DSTI did not monitor the promotion and control activities that are the main roles of TAEC. **Table 3.24** shows monitoring activities performed by MoEST in the last four years (2018/19-2021/22).

Table 3.24: Covered Monitoring Activities for the Financial Year from 2018/19 to 2021/22

Financial Year	Issue Monitored
2018/19	Monitoring Construction of TAEC laboratory building
	Meeting with Science, technology and innovations institutions which are under MoEST
	Supervision visits to TAEC with the Deputy Permanent Secretary – MoEST
2019/20	Monitoring of 10 IAEA sponsored projects in Tanzania
	Meeting with Science, technology and innovations institutions which are under MoEST
2020/21	Monitoring of 10 IAEA sponsored projects in Tanzania
	Supervision visits to TAEC with the Deputy Minister –MoEST
2021/22	Monitoring of 10 IAEA sponsored projects in Tanzania
	Meeting with Science, technology and innovations institutions which are under MoEST

***Source**: Annual Performance Reports, STI Meetings Reports and Supervision Reports for Financial Year 2018/19-2021/22*

Table 3.24 shows that, the Ministry managed to monitor the performance of TAEC on the implementation of projects in the reviewed financial years from 2018/19 to 2021/22. From Table 3.24, it can be deduced that, DSTI managed to conduct two supervision visits to TAEC in the financial year 2018/19 and 2020/21 while for the financial year 2021/22 no supervision visits to TAEC were conducted by MoEST. TAEC also met with the STI institutions in all of the reviewed four financial years from 2018/19 – 2021/22.

However, reviewed Onsite Supervision Reports for supervision made by MoEST to TAEC for the financial years 2018/19 and 2020/21 noted that, the supervision visit

made by either Deputy Permanent Secretary or the Deputy Minister of MoEST were of very higher level focusing monitoring development projects implemented under TAEC and other administrative issues rather than focusing on assessing the achievement of each key performance indicators as indicated into both TAEC's Strategic and Annual Actions Plans for the reviewed financial years from 2018/19 to 2021/22. These activities included radiation control activities such as licensing, inspection and waste management that were also expected to have been monitored by MoEST through DSTI during the whole period of the audit.

In addition to that, during the interviews with Officials from MoEST, it was reported that monitoring that is done by the Ministry are through review of submitted reports from entities that are under the Ministry advise accordingly were necessary. However, the Audit Team did not find Review Reports by MoEST for assessing the performance of TAEC and other institutions under the Ministry.

In adequate monitoring of TAEC activities was caused by:

Inadequate Planning for Monitoring and Evaluation of Regulatory Activities of TAEC

In the review of the Annual plans, it was noted that MoEST did not plan to cover the monitoring activities which are under TAEC as shown in **Table 3.25.**

Table 3.25: The Contents of MoEST's Monitoring Plans

Financial Year	Planned Monitoring Activity(ies)
2018/19	Monitoring the performance of the existing STI institution
2019/20	Undertaking supervision and assessment of 10 projects
2020/21	Conducting M&E on 10 research projects under different sectors (Health, Agriculture, Water and Livestock) financed by IAEA and being coordinated by TAEC
2021/22	Supervising performance of STI institutions under the Ministry

Source: *DSTI Annual Action Plans for the Financial Year 2018/19-2021/22*

Table 3.25 indicates that MoEST planned to monitor sponsored development projects implemented under Tanzania Atomic Energy Commission (TAEC) and not regulatory activities that are implemented by TAEC.

Furthermore, during the interviews with MoEST's staff, it was noted that MoEST monitoring activities depends on burning issues such areas as performance challenges, especially budget performance, raised issues from the Parliament, the Controler and Auditor General or from the responsible Minister.

Inadequate monitoring and evaluation of regulatory fuctions performed by TAEC, leads to under performance of TAEC in performing radiation control duties such as licensing users of radiations sources, inspections to radiation facilities and ensuring persons administering ionizing radiations are registered by TAEC.

3.6.5 Inadequate Monitoring of MoEST's Performance on Matters Related to Control of Radiation Sources

Objective F of MoEST Strategic Plan for 2016/17 – 2020/*21* requires the Ministry to ensure that, promotion, training, and regulations of the nuclear technology are enhanced aiming at ensuring the peaceful use of nuclear technology in the country.

Under the Monitoring, Reviews and Evaluation of the implementation of MoEST Strategic Plan 2016/17-2021/22, it was indicated that MoEST was supposed to monitor its performance on the control and promotion of radiation sources based on the set performance indicators despite of the noted weakness on the monitoring and evaluation plan as stated in sub-section 3.6.1 of this report. Furthermore, the Audit Team noted that the performance indicators set by MoEST was one-sided as are mainly based on the promotion and less coverage on the nuclear regulation activities as shown in **Table 3.26:**

Table 3.26: The MoEST Monitoring Nuclear Technology Promotion

Performance Indicator	Nature	
	Promotion	Regulation
Number of people trained on safe nuclear technology use	V	
Guideline and procedure for utilising nuclear technology in place	V	V
Number of programmes applying nuclear technology	V	
Percentage of public aware of use and misuse of nuclear technology	V	
Number of health services using nuclear technology	V	

Source: *Auditors' analysis from MoEST 2016/17-2020/21 Strategic Plan*

Table 3.26 indicates that, MoEST is much focusing in monitoring its performance, promotion of nuclear technology and putting less focus in monitoring regulation and control of nuclear sources in the county. Out of five set performance indicators MoEST had one for regulation and the remaining four performance indicators for promotion.

The Audit team has also noted that MoEST does not monitor its performance in the area of radiation sources due to inadequate planning for activities related to nuclear promotion and regulation enhancement as shown in **Table 3.27**.

Table 3.27: Extent of Implementation of Planned Activities for Radiation Sources

Performance Indicators set under objective F	Plans for their implementation		
	2018/19	2019/20	2020/21
Number of people trained on safe nuclear technology use	X	X	X
Guideline and procedure for utilizing nuclear technology in place	V	X	X
Number of programmes applying nuclear technology	X	X	X
Percentage of public aware of use and misuse of nuclear technology	X	X	X
Number of health services using nuclear technology	X	X	X

Source: *MoEST Strategic plan and annual action plan for the financial year 2016/17 to 2020/21*

Key: V= Planned
X= Not Planned

Table 3.27 indicates that for the period of three financial years from 2016/17 to 2020/21, MoEST has only planned to implement activities covering objective F whereby out of five components the Ministry covered one in the financial year 2018/19.

Furthermore, the review of MoEST's Strategic Plan for the period 2021/22-2025/26 noted that, the Ministry has not planned for Monitoring and evaluation of its perfomance on the control of radiation sources. The ineffective self-monitoring mechanisms on radiation control by MoEST impacts the accountability and transparency on the control of radiation sources in the country.

CHAPTER FOUR

AUDIT CONCLUSION

4.1 Introduction

This chapter presents conclusion of the audit based on the audit objective and specific objectives provided in Chapter One of this report. The conclusion is categorised into two main parts, namely, overall conclusion and specific audit conclusions. These are detailed as follows:

4.2 General Audit Conclusion

The Audit Team acknowledged the efforts made by the Ministry of Education, Science and Technology and the Tanzania Atomic Energy Commission in the controlling and promotion of safe and peaceful use of nuclear technology in the country. These efforts included the construction of complex laboratories in Arusha and five other laboratories in five Regions to facilitate control of radiation sources.

Other noted efforts included an improved cooperation with the International Atomic Energy Agency (IAEA) which improved the implementation of projects such as strengthening and expanding the Cancer Control Programme, established a Graduate School of Nuclear Science and Technology at the Nelson Mandela African Institution of Science and Technology and establishment of a Multipurpose Irradiator Facility supported by the IAEA to enhance industrialisation.
Similarly, there were noted efforts employed by MoEST in increasing TAEC's research budget from zero in 2018/19 up to TZS 180 million in the year 2021/22. These achievements capacitated TAEC as among the science and research Institutions in the country in the area of capacity building on nuclear technology researches and publications.

However, based on the data collected and analysed in the Findings Chapter of this report, it is concluded that, the MoEST through TAEC has not effectively controlled radiation sources in order to minimise risks to the users, the public and the environment. This implies that, more interventions are still needed to further improve the control of radiation sources because our findings revealed that, still

an average of 66% of registered radiation facilities were found operating without licenses during our study period.

The Audit team noted some deficiencies such as inadequate licensing of qualified experts who by virtue of their work administer radiations to patients, many facilities operating without valid licenses, lack of protective gears as outlined in the findings, inadequate number of inspections to facilities using radiation sources, lack or ineffective system of tracking disused radiation sources and lack of an emergency plan and preparedness at the facility level, all these deficiencies call for more intervention by the MoEST through TAEC.

Similarly, the Commission did not manage to provide adequate awareness to the users of radiation sources whereby the situation was worse for non-medical practices such as construction, mining and industrial sectors.

As a result, there might be an increasing heath risk to radiation users and the general public at large from exposure to uncontrolled radiation sources with radioactive materials such as beryllium (Be), Caesium (Cs) and Americium (Am) that emit radiation continuously even when not in use.

TAEC also did not collect an estimated amount of TZS 47.2 million and 424.650 million as a result of non-licensing of 944 qualified experts and 2,831 facilities for authorisation to possess and use radiation sources for the period under review. It is anticipated that if the fund were to be collected, research activities could have been conducted to a large extent and the other part of the fund would be used to purchase nuclear and scientific equipment.

Likewise, MoEST inadequately monitored and evaluated its own performance and that of TAEC regarding the control of radiation sources in the country. The absence of a comprehensive monitoring and evaluation plan for monitoring its strategic objectives was the main contributing factor. This resulted into inadequate control and monitoring of nuclear technology by TAEC.

4.3 Specific Audit Conclusions

4.3.1 TAEC is Lacking Functioning Mechanisms for Controlling the Radiation Sources

The available mechanisms for controlling radiation sources are not effectively functioning as evidenced by the fact that 66% of 1169 of all registered radiation facilities remained unlicensed by TAEC for four years from the year 2018/19 – 2021/22. The absence of online functioning licensing system that could be used to simplify the process of identifying and interacting with users who are not yet licensed, enable them to apply and being issued with licenses was also the major contributing factor for inadequate licensing of the users of radiations sources. As a result, it is estimated that, TAEC has not managed to collect licensing fees amounting to TZS 424.650 million, by not licensing 2,831 individuals the possess and use licenses for the period from 2018/19 to 2021/22.

It can also be concluded that dis-used radiation sources which form part of radioactive wastes are not well managed by the Tanzania Atomic Energy Commission. This is based on the fact that, TAEC as a Regulatory authority has not established a functioning National Coordinated Radioactive Waste Management Strategy aimed to provide the framework for the development and implementation of a comprehensive, integrated, improved and sustainable system for radioactive waste management at national level. As a result, there is no clear and comprehensive procedures for managing dis-used radiation sources that are available in various category of users including medical, construction, mining and industrial sector that resulted into dis-used sources to remain /uncontrolled.

TAEC is also lacking established working system to identify, register and track the existing radiation sources in the country in order to know their status including life span to facilitate their disposal when they are out of use. This was manifested in the findings of the Audit Team who found that, there were 15 disused mobile radiation sources namely troxler found in the construction industry which continued being uncollected by TAEC up to June, 2022, despite TAEC being aware that troxler contains high risks radioactive materials which keep on emitting radiations regardless of being in use or not in use.

4.3.2 The Ineffective Functioning Control Mechanism of Radiation Sources

TAEC as a regulatory agency, was expected to ensure person administering ionising radiation to patients are registered by the Commission. However, based on the audit findings, TAEC did not manage to adequately register all experts specifically radiographers who are required to be issued with operating license subject to renewal on annual basis. That being the fact, TAEC managed to license from 60% to 75% of registered experts by the Tanzania Medical, Radiology and Imaging Professional Council for the three calendar years from 2020 to 2022. This licensing effort was equivalent to an annual increase of only 6% to 9% per annum. As a result of inadequate efforts applied by TAEC to ensure that all person administering ionising radiation are licensed as per the requirement of the Atomic Energy Act, 2003, it was found that, all the radiographers who were working on contractual basis from 1 year and above were not licensed by TAEC. Consequently, the Commission did not collect an estimated revenue amounting of TZS. 47.2 million, as a result of leaving individuals unlicensed for the period under review.

Moreover, based on our audit findings, we also conclude that, TAEC has managed to have strategies and plans as a Preparedness for Emergency response in case a nuclear and radiological emergency occurs. This emanates from the fact that, TAEC prepared a draft of the National Nuclear and Radiological Emergency Response Plan but it was not disseminated and operationalised up to the facility level up to the end of this audit on June, 2022. Despite the currently growing potential on the use of radiation sources in different practices and risks of illicit trafficking of radiation sources for illegal purposes. Absence of operationalised emergency response plan on nuclear and radiological emergencies at the facilities level result into the risk of uncontrolled nuclear disasters if occurs.

It was further expected that, TAEC would have established requirement for radiation inspection tools so as to identify shortage to be considered for being purchased so as to fill the observed gaps. However, based on the audit findings, it can be concluded that, TAEC did not conduct Needs assessment on the category and quantity and clearly set a budget required to facilitate acquisition of potential radiation inspection tools such as inspection quality control kit and survey meters. Consequently, there were irrational allocation of inspection tools without being able to establish the basis of that allocation. This situation also

implies that, there was no realistic budget set aside as a strategy to minimise the complaint of shortage of radiation inspection equipment. From the Finding Section it can be noted that, for example in financial year 2019/20 TAEC set aside only TZS 19.5 million to retool the existing offices with inspection tools which was found to be an insignificant budget that cannot even enable the purchase of a single inspection quality control kit that was estimated to cost around TZS 60 million.

4.3.3 The Inadequate Monitoring of Radiation Sources

TAEC did not adequately ensure all radiation premises meet safety requirements such as presence of survey meters for dosimetry monitoring, ensure premises are properly shielded, presence of adequate and legible radiation symbols and warnings signs, and ensure all premises are licensed for possess and use of radiation sources. This is because as noted in the audit findings, over 91% of radiation facilities in different areas did not possess survey meters, such that 40% of facilities did not have control of radiation sources at their workplace and 66% of facilities did not have valid license of possessing and using radioactive sources. This was due to ineffective enforcement of inspection made by TAEC into radiation facilities.

Similarly, TAEC did not ensure mobile radiation sources and radiation users are adequately monitored, this resulted into presence of 53% of mobile radiation sources owned by TANROADS not identified and included into TAEC database for radiation sources in the country. Besides that, an average of 53% and 97% of facilities with radiation sources for both medical and non-medical were not provided with radiation measuring equipment (TLDs) for measuring personal exposure to radiation for workplace radiation exposures.

The above shortcoming in monitoring of radiation sources were attributed by a lack of follow-ups mechanisms on the extent of implementation to the recommendation that TAEC has issued to users of radiation sources during routine inspection in order to be assured that, all issued recommendations were implemented. This was based on the fact that, 6 out of 8 visited facilities with radiation sources did not implement these recommendations that required them to acquire survey meters for monitoring their facilities premises with radiation sources.

On the other hand, inadequate monitoring of mobile radiation sources is caused by a lack of adequate mechanisms for tracking mobile radiation sources from the time they are imported to the time they become out of use. In addition, the Audit noted the presence of 32 out of 58 equivalents to 55% of mobile radiation sources in TANROADS premises obtained from different construction projects without involvement of TAEC. As a results those mobile radiation sources were not identified by TAEC in its database.

4.3.4 Ineffective Coordination between TAEC and other Stakeholders

The Audit Team conclude that, TAEC has not provided sufficient awareness to various users of radiation sources such as medical, industries, mining and construction sectors. As noted in the audit findings, this situation was mainly attributed to a lack of a comprehensive awareness plans and strategy that could take into account all categories of players in the use of radiation sources or radiation emitting devices such as X-rays for medical and non-medical use. As a result, most of the practitioners were found to have very low awareness on compliant issues such as possessing radiation detection devices like survey meters and ensuring that they are licensed by TAEC to administer ionising radiation to patient.

The Audit Team also conclude that, the situation of inadequate awareness on the overall management including taking safety and precautions measures were worse to non-medical practitioners compared to medical practitioners. This was due to the fact that, this category of users were not given much attention by TAEC in the awareness programmes. This resulted into health and environmental risks due to inadequate knowledge to handle the possessed radiation sources.

4.3.5 MoEST has Ineffectively Monitored and Evaluated its Performance and that of TAEC in Controlling Radiation Sources

Ministry of Education, Science and Technology has not effectively monitored and evaluated its performance and that of TAEC in the control of radiation sources. This problem was caused by Ministry reliance on the quarterly and annual reports submitted to the MoEST from TAEC as a means of accessing and assessing TAEC performance. Additionally, the Ministry lacked an effective Monitoring and Evaluation plan. Despite the Ministry developing performance indicators for

monitoring and evaluating nuclear promotion and regulation enhancement objective, the developed Monitoring and Evaluation plan was one-side since it covered only the aspects of promotion while ignoring issues regarding regulation activities.

Furthermore, MoEST has not ensured establishment of nuclear technology researchaspect in the National Research and Development Policy of 2010 .Meanwhile the current National Nuclear Research Policy of 2013 does not have adequate coverage of nuclear research activities . This situation resulted into the absence of a clear National Framework for guidance, coordinationand management of nuclear technology research at the national level. Furthermore, the weaknesses in the available Policies guiding research activities have resulted into the absence of short, medium and long-term national research priorities in the areas of nuclear technology at the national level.

Generally, the noted weaknesses were mostly caused by inadequate monitoring plan that does not properly address the key performance indicators such as time frame of the implementation and the responsible department for monitoring its implementation. Consequently, MoEST has not managed to measure performance of TAEC due to absence of effective tools that could be used to measure the performance and recommend for improvements.

CHAPTER FIVE

AUDIT RECOMMENDATIONS

5.1 Introduction

The audit findings and conclusions pointed-out some weaknesses on the effectiveness of controlling radiation sources in Tanzania. Thus, as per audit objectives presented in Chapter One, four major areas require improvements. These areas are: control mechanisms of radiation sources, monitoring of radiation sources, coordination between TAEC and other Institutions and monitoring and evaluation of performance of the Ministry and that of TAEC in controlling the radiation sources.

The National Audit Office believes that, the recommendations that have been given in this Report need to be fully implemented so as to improve the overall control of radiation sources held in both medical and non-medical practices including health facilities, constructions, mining, research and industrial sectors. The recommendations will also ensure that, the Ministry of Education, Science and Technology effectively performs its oversight functions regarding the control of safe and peaceful use of nuclear technology in the country.

5.2 Recommendations to the Ministry of Education, Science and Technology

5.2.1 To improve Monitoring and Evaluation of the Performance of MoEST and that of TAEC on the Control of Radiation Sources

The Management of the Ministry of Education, Science and Technology is urged to:

(i) Develop and implement a comprehensive and effective Monitoring and Evaluation Plan capable of periodically assessing its performance and that of TAEC in relation to the control of radiation sources and radioactive materials in the Country;

(ii) Ensure timely review of the National Research Policy and the Research Policy Implementation Plan to ensure that, they address matters related to nuclear technology; Radioactive wastes; and

(iii) Strengthen and empower TAEC's research section for researchers to conduct research in different sectors and publish research papers for the national economic development to increase the application of nuclear sciences/technology in the country.

5.3 Recommendations to Tanzania Atomic Energy Commission

5.3.1 To Improve the Mechanisms for Controlling Radiation Sources

The Management of Tanzania Atomic Energy Commission is urged to:

(i) Develop mechanisms for licensing that would ensure that, qualified experts responsible for administering ionising radiation to patients are adequately licensed as per the requirements of the Regulation 18(1) of the Atomic Energy (Protection from Ionising Radiation) Regulation, 2011. Also, the mechanism should enhance periodical tracking of licensing status of each person, facilities and radiation emitting devices;

(ii) Develop inspection mechanisms that would ensure that, all radiation facilities are inspected periodically and prior to being granted licenses; and in case of inadequate fund, priorities, should be given to the facilities with category I, II and III sources; and

(iii) Ensure the functioning of the National Coordinated Radioactive Waste Management Programme to ensure that, there clearly and comprehensive established procedures for managing dis-used radiation sources available to both medical and non-medical practices in the country;

5.3.2 To Improve the Monitoring of Radiation Sources to Ensure Safety to the Users, the Public and the Environment

The Management of Tanzania Atomic Energy Commission is urged to:

(i) Ensure drafted National Nuclear Radiological Emergency Plan is rolled out at National and facility level. Also, the rolling out should ensure that, each responsible government agency develop and maintain its

own unique agency plan and detailed reporting procedures to carry out the response;

(ii) Conduct needs assessment to determine the requirements of inspection equipment to establish the available shortage and appropriately cover it. Also, it should facilitate TAEC to know the type, quantity, quality, location and budget needed for acquisition of those inspection tools;

(iii) Ensure that, all equipment available in licensed facilities are calibrated annually in accredited laboratory;

(iv) Develop or improve the personnel monitoring database according to the category of radiation sources in the country;

(v) Develop and issue security guidance to facilities having radioactive materials such as the ones used in well logging, industrial irradiators, disused sources, calibration sources, brachytherapy, etc.;

(vi) Enhance follow-up mechanisms on the implementation of the recommendations ranging from inspections to the users of radiation sources. These are expected enable the users of radiation facilities to comply and facilitate them to work and fix deficiencies in radiation premises to meet the desired quality in provision of radiation services;

(vii) Enhance functional mechanisms for effective tracking of mobile radiation sources in the country. The mechanisms should ensure that, mobile radiation sources are acquired, used, stored, transferred and disposed in accordance with the radiation safety requirement and standards; and

(viii) Ensure that, safety is among its primary objective through taking all the measures, in its mandate, and all the necessary means to protect operators, all members of the public and the environment from the health hazards that could result from the use of both ionising and non-ionising radiations.

5.3.3 To Improve Coordination of Nuclear Technology with other key Stakeholders

The Management of Tanzania Atomic Energy Commission is urged to:

(i) Improve liaising mechanisms with higher learning institutions to ensure that, nuclear science and technology is disseminated to many scholars in Tanzania. This will ultimately help the Country to adequately realise the implementation of Strategic Objectives of controlling and promoting peaceful use of atomic energy.

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APPENDICES

Appendix 1: Responses from the Audited Entities

This part covers responses from the Audited Entities, the Ministry of Education, Science and Technology and the Tanzania Atomic Energy Commission. The responses are divided into two parts, namely General and Specific comments as detailed below:

Appendix 1(a): Responses from the Ministry of Education, Science and Technology

General Comment

The Ministry of Education, Science and Technology (MoEST) through the Division of Science, Technology and Innovation (DSTI) appreciates and commends the audit done by Controller and Auditor General regarding the performance of Tanzania Atomic Energy Commission (TAEC). Furthermore, the Ministry acknowledges that the audit findings and CAG`s recommendations thereof will upon implementation considerable improve the supervision and overall performance of TAEC. Notably, the implementation will ensure robust and efficient monitoring and evaluation (M&E) of TAEC`s core mandates and responsibilities including the control of radiation sources and radiation materials in the country as well as promoting research on nuclear science and technology in favour of the country`s socio-economic development.

Specific Comments

SN	Recommendation	Comments from MoEST	Planned Action(s)	Implementation Timeline(s)
1.	Develop and implement a comprehensive and effective monitoring and evaluation plan capable of periodically assessing its performance and that of TAEC in relation to the control of radiation sources and radioactive materials in the Country	The Ministry agrees with the auditor's observation to develop and implement a comprehensive and comprehensive and effective monitoring and evaluation plan capable of periodically	Ministry through the Division of Science, Technology and Innovation (DSTI), and the Division of Policy and Planning (DPP) will develop and implement a comprehensive and effective M&E as recommended.	The development and implementation of M&E plan will be pursued starting from the financial year 2023/2024

SN	Recommendation	Comments from MoEST	Planned Action(s)	Implementation Timeline(s)
		assessing its performance and that of TAEC in relation to the control of radiation sources and radioactive materials in the Country. This will complement our other existing forms and efforts geared at ensuring that TAEC pursues its mandates and responsibilities as required.		
2.	Ensure timely review of the National Research and Development Policy and its Implementation Plan to ensure they address matters related to nuclear technology and radioactive wastes;	The Ministry agrees with the auditor's observation. However, since there is already a National Nuclear Technology Policy of 2013, which is dedicated for all matter that related to nuclear technology and radioactive	Ministry through DSTI and DPP will start-off with purposeful evaluation of the implementation status of both the National Nuclear Technology Policy of 2013 and National Research and Development Policy of 2010. The findings and recommendations of the evaluation are intended for informing subsequent review of the two policies, and developing their	Given the budgetary implication, evaluation of the implementation status for both policies will start during the financial year 2024/2025; and subsequently their review (per findings and recommendations of the evaluation reports) will start during the

SN	Recommendation	Comments from MoEST	Planned Action(s)	Implementation Timeline(s)
		wastes, the upcoming policy review will ensure that research onto those aspects is well captured. Furthermore, the upcoming review of the National Research and Development Policy of 2010, which provides general research framework and guidelines will ensure the inclusion of provisions that are more accommodative of nuclear and other disruptive technologies.	respective Policy Implementation Strategies.	financial year 2025/2026.
3.	Strengthen and empower TAEC's research section for researchers to conduct research in different sectors and publish research papers for the national economic development to increase the application of nuclear sciences/technolog	The Ministry agrees with the auditor's observation to continue strengthening and empowering TAEC`s research section for researchers to conduct research in different	Ministry through DSTI and TAEC will develop and implement Research Plan on Nuclear Science/Technology in the country. Among other aspects, the Research Plan will entail strategies for promoting nuclear science/research and publication in other Higher Education Institutions (HEIs) and	Given the budgetary implication, the underlined task will commence during the financial year 2024/2025

SN	Recommendation	Comments from MoEST	Planned Action(s)	Implementation Timeline(s)
	y in the country.	sectors and publish research papers for the national economic development so as to increase the application of nuclear science/technology in the country.	Research and Development Institutions (RDIs) in the country. Furthermore, the Research Plan will underline strategies for ensuring sustainable growth of skilled-human resource on nuclear science/technology. Worth noting, the government has already constructed and equipped several state-of-the-art laboratories and other forms of research facilities in view of strengthening TAEC`s research arm.	

Appendix 1(b): Responses from the Tanzania Atomic Energy Commission

General Comment:

In order to provide a real view of performance, the findings would include the achievements that have been attained. This way the audit report would be balanced rather it is now. We request the audit report to include the achievements attained by Tanzania Atomic Energy Commission (TAEC) during the audit period of 2018/2019 to 2021/2022.The findings would include the achievements that have been attained.

It has been observed that the audit did not have a scope included in the National Development Plan and the TAEC Strategic Plan. As such the report might not be focused and have recommendations in the areas which was not given resources because they are not in the plan.

Specific Comments

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
1	Develop licensing mechanisms that would ensure that qualified experts responsible for administering ionizing radiation to patients are adequately licensed as per requirements of the Regulation 18 (1) of the Atomic Energy (Protection from Ionizing Radiation) Regulation 2011. Also, the mechanism should effectively enhance periodical tracking of licensing status of each person, facilities and radiation emitting devices.	TAEC has an effective mechanism for issuing a registration certificate to qualified experts responsible for administering ionizing radiation to patients as per law. To improve the existing mechanisms TAEC has introduced an online information system found at www.taec.go.tz or directly at license.taec.go.tz.	To continue using the existing mechanisms	On going
2	Develop an inspection mechanism that would ensure all radiation facilities are inspected periodically and	The inspection mechanisms exist that has made TAEC to inspect over and above the requirements. The International Atomic Energy Agency	To continue using the existing programme	On going

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
	prior to being granted with license; and priorities, whenever there are inadequate funds, should be given to facilities with category I, II and III sources.	(IAEA) standards (TECDOC1526 (2007)) and TAEC operating procedures for inspection (2021) require that inspection to most facilities be done every 2 to 3 years. This means a maximum of half of projected active facilities need to be inspected each year. Based on the aforementioned standards and operating procedures, TAEC has done over and above the required coverage of regulatory inspections. This is due to the fact that TAEC has put a functioning regular inspection mechanism which is working very well. In general, there has been an increase in regulatory inspections every year. In the financial year 2021/2022, a total of 670 regulatory inspections were carried out compared to 244 regulatory inspections for the year 2016/2017. This is an increase of 174.5 percent. Based on the standards and the TAEC operating		

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
		procedures for inspections the following are the performance of regulatory inspections. Between the year 2018/2019 and 2021/2022, the conducted annual inspections ranged from 162.5% to 227% of all active facilities with radiation source in the country. (i) Specifically, 2018/2019 a total of 650 radiation facilities (equivalent to 227%) of (286) half of the total active radiation facilities in the country were inspected. (ii) In 2019/2020 a total of 538 out of 662 (equivalent to 162.5%) of the half of the total of active radiation facilities in the country were inspected. (iii) While in 2020/2021 TAEC inspected 666 out of 732 (equivalent to 181.9%) of half of the total active radiation facilities in the country were inspected (iv) In the year 2021/2022 TAEC		

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
		inspected 670 out of 773 (equivalent to 173.4%) of the half of the total active registered radiation facilities in the country. In order to raise safety awareness and to ensure safety and security of radiation sources, TAEC put higher targets than those required by the International Standards and procedures. Based on the planned targets, between the year 2018/2019 to 2021/2022 the conducted annual inspections ranged from 81.26% to 113.9% of all active facilities with radiation sources in the country. In particular, 2018/2019 a total of 650 radiation facilities (equivalent to 113%) of active radiation facilities in the country were inspected. In 2019/2020 a total of 538 out of 662 (equivalent to 81.3%) of active radiation facilities in the country were inspected. While in 2020/2021 TAEC inspected 666 out		

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
		of 732 (equivalent to 91%) of active radiation facilities in the country were inspected. In the year 2021/2022 TAEC inspected 670 out of 773 (equivalent to 86.7%) of active registered radiation facilities in the country. Looking at the standards, procedures and the statistics given above, there is adequate coverage of regulatory inspections conducted by TAEC. This is over and above the required. We therefore request the audit team to congratulate TAEC for the great achievement and honestly delete the issues related to coverage of inspections.		
3	Ensure the functioning of the National Coordinated Radioactive Waste Management Programme to ensure that, there clearly and comprehensive established procedures for managing dis-	National Coordinated Radioactive Waste Management Programme exists.	To continue using the existing programme	Ongoing

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
	used radiation sources available to both medical and non-medical practices in the country			
4	Ensure drafted National Nuclear Radiological Emergency Plan is rolled out at National and facility level. Also, the role out should ensure that, each responsible government agency develop and maintain its own unique agency plan and detailed reporting procedures to carry out the response	TAEC to continue implementing the emergency plan as it has been approved.	(i) Stakeholders engagement (ii) Five training modules on radiological emergency implemented (iii) Response teams trained on basic rescue, logistic and telecommunications. (iv) Two evacuation exercises have been conducted (v) Two (2) drilling and simulations exercises to rapid response teams have been conducted (vi) 30 rescue equipment and gears to support rapid response teams have been procured (vii) Ensure each license has developed	2022/2023 and 2023/2024

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
			Radiological Emergency Plan (viii) Resource allocated for implementation of the emergency plan.	
5.	Conduct needs assessment to determine the requirements of inspection equipment to establish the available shortage and appropriately cover it. Also, it should facilitate TAEC to know the type, quantity, quality, location and budget needed for acquisition of those inspection tools	As indicated in serial number 1 TAEC performs over and above the required inspection coverage annually because of the adequacy of the available inspection tools	To continue ensuring equipment are available	On going
6	Enhance follow-up mechanisms on the implementation of the recommendations ranging from inspections to the users of radiation sources. These are expected to enable the users	Mechanisms for follow up issued recommendations that emerges from inspections to users of radiation sources exist these include Follow up inspection, routine inspection and during application of license. Furthermore, the recent introduced E-licensing	(a) To improve the introduced E-licensing information system (b) Amend Act to ensure compounding penalties	On going

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
	of radiation facilities to comply and facilitate them to work and fix deficiencies in radiation premises to meet the desired quality in provision of radiation services	information system is a great tool for follow up.	(c) Recruit more staff	
7.	Enhance a functional Mechanism for effective tracking of Mobile radiation sources in the Country. This will ensure that, mobile radiation sources are acquired, used, stored, transferred and disposed in accordance with radiation safety requirements	A functional mechanism for tracking the radiation sources including mobile exists these includes registration of radiation sources, issuing license to import, export, transport, transfer, store, dispose and possess or use of radiation sources as per law. TAEC has the national register of radiation sources and facilities in accordance with section 24(6) of the Atomic Energy Act, 2003 which is adequately maintained and regularly updated. Until 21 December, 2022, TAEC had registered a total of 1450 of radiation sources and 1289 radiation facilities in which mobile radiation sources are	(i) To recruit staff (ii) To develop information tracking system or add a module to an existing system.	2022/2023-2024/2025

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
		incorporated. The recent introduced electronic information system will assist effective tracking of radiation sources Furthermore, TAEC will continue creating awareness of the requirement of the law and its regulation to users of radiation sources and law enforcers.		
8	Improve liaising mechanism with higher learning institutions so as to ensure nuclear science and technology is disseminated to many scholars in Tanzania that would ultimately be in line with the country strategic objectives of controlling and promoting peaceful use of atomic energy.	There is no any provision in the law that require TAEC to coordinate with higher learning institution on enhancing practical application of atomic energy. However, TAEC has been facilitating various agreements and MoU with various higher learning Institutions. This is a great achieved milestone that TAEC has done. TAEC has 4 MoUs with UDOM, UDSM, NMAIST and SUA through regional/national agreements under IAEA. Furthermore, there are remarkable evidence that TAEC liaises with various relevant institutions such that TAEC has been receiving	(i) To continue with the existing liaising with higher learning institution.	On going

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
		on average 148 students annually for research and practical activities with universities such as MUST, MUHAS and St, Augustine. Development of Medical Physics Master's Program which will be run jointly between the University of Dar es Salaam and the Ocean Road Cancer Institute. For example, TAEC received 4 PhD students from MUHAS since 2019/20-2021/22.		
9	Ensure that all equipment available in licensed facilities are calibrated annually in accredited laboratory	TAEC calibrates all non-TAEC and TAEC equipment as per Regulation 30 (2) (b) of the Atomic Energy (Protection from Ionizing Radiation) Regulation 2004. TAEC will continue recognizing equipment supplier's/manufacturer's calibration and therefore all TAEC equipment available in its offices are either calibrated by TAEC SSDL lab or recognize the supplier's calibration. On average, TAEC calibrated all equipment that are subjected to calibration as per supplier recommendation (refer annual performance report from 2018/19-	(i) To recruit more staff (ii) To develop information tracking system or add a module to an existing system	2023/2024 - 2024/2025

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
		2021/22). TAEC zones and border offices have 62 equipment with supplier/ manufacturer's calibration status that is still valid. TAEC calibrated 12 equipment that need calibration on yearly basis by uses of radiation beams. Some instrument such as pagers cannot be calibrated using radiation beams, alternatively the performance check is done. Consequently, all instruments in use have valid calibration or performance tested. Furthermore, TAEC will continue ensuring that all equipment available in licensed facilities are calibrated annually in accredited laboratory		
10	Improve the personnel monitoring database according to the category of radiation Sources in the Country	TAEC has personnel monitoring database according to the category of radiation sources in the Country, which is being regularly updated and maintained.	(i) To upgrade the personnel monitoring database. (ii) To develop or add a module online tracking of TLD Monitoring Services (iii) To acquire TLD cards (iv) To establish	2022/2023-2025/2026

S/N	Recommendation	Comments from TAEC	Planned Action (s)	Implementation timelines (s)
			dosimetry laboratory in Eastern Zone (2023/2024 and Lake Zone (2024/2025) and Zanzibar Office (2025/2026)	
11	Develop and issue security guidance to facilities having radioactive materials such as those used in well logging; industrial irradiators; disused radiation sources; calibration sources; brachytherapy; etc	The Commission agrees with the auditor's observation to develop and issue Guidance on Physical Protection and Security of Radiological Facilities TAEC is in process of drafting Guidance on Physical Protection and Security of Radiological Facilities	To develop and issue the Guidance on Physical Protection and Security of Radiological Facilities	Within six month 2022/2023
12	Ensure operators of radiation emitting devices are qualified experts	We accept the recommendations.	Operationalize the proposed Tanzania Atomic Energy College	Start enrolling students within a year.

Appendix Two: Main and Sub-audit Questions

This part provides the list of five main audit questions and their respective sub-questions:

Audit Question 1 :	**To what extent the problem of ineffective control of radiation sources exists in the country?**
Sub-Audit Question 1.1:	*To what extent do the users of radiation sources are licensed?*
Sub-Audit Question 1.2:	*Are the disused sources safely disposed-of to protect the public and the environment?*
Sub-Audit Question 1.3:	*To what extent does TAEC monitor/inspect the radiation sources in the country?*
Audit Question 2:	**Does TAEC has functioning control mechanisms of radiation sources?**
Sub-Audit Question 2.1:	*Are there established strategies and plans for control of radiation sources?*
Sub-Audit Question 2.2:	*Are the established procedures for authorisation of radiation sources functioning well?*
Sub-Audit Question 2.3:	*Does TAEC adequately conduct inspection to users of radiation sources to ensure compliance with safety requirements?*
Sub-Audit Question 2.4:	*Does TAEC ensure that the radiation emitting devices are operated by qualified experts?*
Sub-Audit Question 2.5:	*Are there adequate inspection tools for the control oftheradiation sources in the country?*
Audit Question 3:	**Does TAEC conduct adequate monitoring of radiation sources to ensure safety to users, public and minimize environmental risks?**
Sub-Audit Question 3.1:	*Does TAEC monitor the premises with radiation sources to ensure their conforming to the required quality?*
Sub-Audit Question 3.2:	*Does TAEC monitor users of the radiation sources to ensure are adequately protected from exposure to radiation sources?*
Sub-Audit Question 3.3:	*Do users of the radiation sources adequately ensure the public is protected from radiation sources?*
Sub-Audit Question 3.4:	*Do mobile radiation sources available to users adequately tracked to ensure safety is maintained?*
Sub-Audit Question 3.5:	*Does TAEC ensure the users of radiation sources possess survey instruments for area monitoring at radiation work place?*
Sub-Audit Question 3.6:	*Does TAEC ensure users send radiation survey instruments to TAEC for calibration?*
Audit Question 4:	**Is there effective coordination between TAEC and other stakeholders in controlling radiation sources?**
Sub-Audit Question 4.1:	*Does TAEC establish a coordination mechanism with sector*

	Ministries to ensure radiation sources are adequately controlled?
Sub-Audit Question 4.2:	*Does TAEC ensure awareness to the public and users of radiation sources are adequately provided?*
Sub-Audit Question 4.3:	*Does TAEC ensure a National Coordinated Radioactive Waste Management programme is established and functioning?*
Audit Question 5:	**Does MoEST Effectively Monitor and Evaluate its performance and that of TAEC in controlling radiation sources?**
Sub-Audit Question 5.1:	*Does MoEST have effective plan for monitoring and evaluation of the performance of TAEC regarding to control of radiation sources in the Country?*
Sub-Audit Question 5.2:	*Have MoEST established a research policy, guideline and standards in the area of radiation sources?*
Sub-Audit Question 5.3:	*Does MoEST manage to ensure TAEC carry out research in the area of radiation sources in the Country?*
Sub-Audit Question 5.4:	*Does MoEST evaluate the performance of TAEC and take appropriate actions?*
Sub-Audit Question 5.5:	*Does MoEST periodically monitor and evaluate its performance on the matters related to control of radiation sources?*

Appendix Three: List of Reviewed Documents and Reasons for Reviewing them

This part presents the lists of documents that were reviewed and reasons for reviewing them during the execution of the audit.

Category of Documents	Title of the Documents	Reasons for Reviewing
Plans & Strategies	• TAEC's Annual Action Plans from financial year 2018/19-2021/22; TAEC's and MoEST Strategic Plans from financial year 2018/19-2021/22 • Research strategies and plans • Research policies and guidelines	To examine extent of planned activities relating to controls of radiation sources in the country in the respective year and for the period under review from 2018/19 to 2021/22
Performance Reports	• TAEC's Internal Audit Reports from 2018/19 – 2021/22 • Inspection Reports of facilities with radiation sources • Licensing Reports of Users of radiation sources • Annual implementation Reports of TAEC activities from 2018/19 – 2021/22 • TAEC's Awareness and Training Reports from 2018/19-2021/22 • Radiation emitting devices calibration reports from 2018/19-2021/22 • Monitoring Reports for Users of Radiation Sources from 2018/19-2021/22 • Reports on the extent of conducted researches in the area of radiation sources	To examine the performance of TAEC in ensuring controls of radiation sources are executed to protect both users and the public
Monitoring Reports	• Dosimetry Monitoring Reports for workers exposed to radiation sources • MoEST Monitoring reports for TAEC's performance	To assess the effectiveness of monitoring conducted by TAEC to workers exposed to radiation sources to various medical and non-medical facilities with radiation sources

Source: *Auditors' Analysis on the List of Reviewed Documents (2022)*

Appendix Four: Officials interviewed during the audit

This part provides the details of the Officials from various entities who were interviewed during the audit.

Institution Covered	Title of official Interviewed	Reasons for interviewing
Ministry of Education, Science and Technology	Director of science, Technology and Innovation Division Head of Science and Technology Section	To assess the: • adequacy strategic monitoring provided by the Ministry in control of radiation sources • adequacy of allocated budget for the strategic monitoring to control of radiation sources by MoEST
Tanzania Atomic Energy Commission	Director of Regulatory Control Unit	• To understand the status and overall strategies in the control of radiation sources in the country • To understand adequacy authorization to radiation sources in the country • To understand the adequacy of tools for control of radiation sources
	Director of Technology and Technical Services Directory Head of Technical Support and Radiation Protection Section Head of Research and Development Section	• To assess the adequacy of training and awareness programme on control of radiation sources TAEC provides to users and the public in general. • To assess the adequacy of radiation exposures monitoring to people working in radiation facilities • To assess the status of managing repair and maintenance of radiation devices
Selected TAEC's Zonal Offices	• TAEC's Head of Zone • Radiation Inspection Officers • Research Officers	• To understand the procedures followed when managing control of radiation sources. • To understand adequacy of plans and implementation in control of radiation sources

Institution Covered	Title of official Interviewed	Reasons for interviewing
		• To understand adequacy of ensuring that people with radiation sources are authorised
Offices in Regions	• Officer in Charge • Radiation Inspection Officers • Research Officers	• To understand procedures followed when managing control of radiation sources. • To understand adequacy of plans and implementation in control of radiation sources • To understand adequacy of ensuring that people with radiation sources are authorised
Selected Facilities with radiation sources practices in regions (Medical and Non-Medical uses)	• Medical Doctor In-charge • Radiographers, Physician, • TANROADS- Regional Managers • Head of Civil Engineering Laboratory at TANROADS regional offices	To assess the: • Adequacy of radiation facilities in ensuring that operates radiation sources in accordance to safety procedures • Adequacy of radiation facilities from authorizations • Different challenges related to control of radiation sources • Challenges in repair and maintenance of radiation sources in their radiation facilities • Adequacy of shielding facilities in which radiation sources are operated or stored • Status of equipment for monitoring radiation leakage in their facilities

Source: *Auditors' Analysis on the List of Interviewed Officials (2022)*

Appendix Five: Summary of Roles of other Stakeholders in Relation to Control of Radiation Sources

This part presents the roles of stakeholders apart from the main stakeholders involved in the control of radiation sources in the country.

Name of other stakeholder	Roles and responsibilities	Expected output
The Ministry of Foreign Affairs and East African Cooperation	• Promote and maintain good relation with Multilateral Organizations and Institutions dealings with Radiation control and Technology while maintaining regular contacts with the accredited International Organization/Institutions; • Liaison with International Organizations and Cooperations in member countries; • Participating effectively in international peace and security initiatives; • Enhance Cooperation between Tanzania and other countries and Organizations through multilateral framework.	Development, promotion, cooperation and maintenance of good relation between Tanzania and Multilateral Organisations enhanced
The Ministry of Health	• Prepare and review policy guidelines and manuals on medical radiology services; • Co-ordinate, monitor and evaluate implementation of diagnostic services policy guidelines; • Monitor the quality of radiation devices used in diagnostic services; • Training radiography staff; • Supervise, monitor and	• Policy guidelines and manuals on medical radiology services prepared and in use • Nuclear diagnostic services and medical radiation devices monitored • Training to radiographers conducted

Name of other stakeholder	Roles and responsibilities	Expected output
	evaluate nuclear diagnostic services in Healthcare Facilities.	
The Ministry of Minerals	• Issuance of prospecting license and mining license to radioactive minerals; • controlling export of radioactive minerals where the Minister upon application grant export permit for radioactive minerals	Licensing and control of radioactive minerals enhanced by the Ministry of Minerals.
The National Environmental Management Council	• Ensuring all activities related with importation, exportation, use, storage and extraction of radiation sources complies with laws or regulations; • Conducting regular check and ensure that, Environmental Impact Assessment are conducted to the facilities wherein radiation sources are placed.	Activities related with importation, exportation, the use, storage and extraction of radiation are enforced in compliance to applicable laws and regulations; and Environmental Impact Assessments are conducted to the facilities possessing radiation sources.
The Tanzania Bureau of Standards	Issue final decision/comment on a submitted food Radioactivity Analysis Certificate (RAC) from TAEC after high levels of radio activities being detected in food to be imported, exported or locally distributed for human or animal consumption.	Final decision/comment on a submitted food Radioactivity Analysis Certificate (RAC) regularly issued
Users	• Keep records of his practice in a format prescribed by the	Maintained records of practice on ionizing radiation by users and

Name of other stakeholder	Roles and responsibilities	Expected output
	Commission; • Monitor, measure, verify and record values, parameters and facts with an impact on nuclear safety, radiation protection, physical protection and emergency preparedness, to the extent laid down in the regulations made under this Act; and • Appoint a qualified expert employed by him to be a Radiation Safety Officer in relation to his undertaking.	operation of radiation emitting equipment by qualified experts.

***Source**: Reviewed laws and regulations from identified stakeholders (2022)*