



# Developing Rwanda National Innovation System

NCST Quarterly Newsletter - Issue No: 003 - March 2022

**PREAMBLE:** One of the key future drivers of economic growth in Rwanda is Innovation. In order to boost this, there is a need to develop an effective National Innovation System (NIS). This newsletter highlights the training conducted by NCST in collaboration with national stakeholders and World Bank to strengthen the capacity of National STI actors and stakeholders. It also presents NCST mechanisms to empower Rwandan Women in STEM by means of recognizing and awarding outstanding females engaged in scientific and innovative work. It also pinpoints the role of Monitoring and Evaluation activities and the role public and private sector collaboration in boosting R&D innovative outputs.

## INSIDE THIS ISSUE:



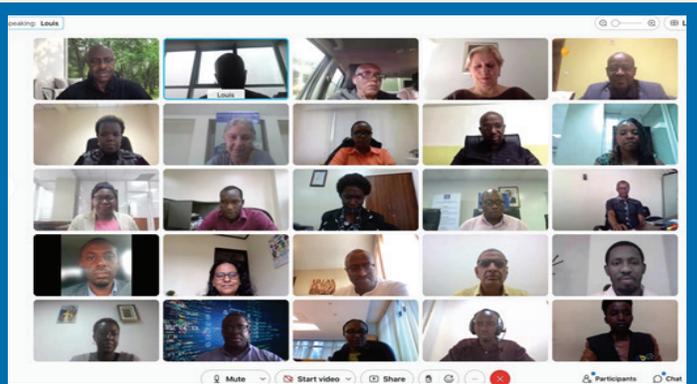
Presentation of Kinyarwanda Dataset by Digital Umuganda



Project team showing domesticated *Tagetes* species at industry collaborator (Sopyrwa)



International Day for Women and Girls in science (IDWGS) 2022 celebration at RBA studio on 11th February 2022



Participants and Trainers attending the 2-days online training workshop for Capacity building in STI system in Rwanda

# Building Capacity for Science, Technology and National Innovation System in Rwanda

Dr. Eugene Mutimura<sup>1</sup> and Dr. Danica Ramljak<sup>2</sup>

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## 1. Background:

Rwanda National Council for Science and Technology (NCST) together with national stakeholders is posed to implement a series of capacity building workshops to strengthen the capacity of science, technology and research and development (R&D) actors and stakeholders. The ultimate goal is to evaluate existing National Innovation System (NIS) opportunities, and to strengthen coordination of all important stakeholders to realize tangible innovative outputs. One of these trainings took place on 8-9 March 2022, and was facilitated by Dr. Danica Ramljak, STI Technical Expert, the World Bank (Figure 1). Other facilitators or trainers involved professionals from Rwanda's national institutions including universities, research institutes, technology park, government agencies and private sector representatives (Figure 1). These facilitators were nominated based on their role in policy, financing and implementation of R&D, technology absorption and diffusion, use of technology for improved business profitability and use of technology for better entrepreneurship and creative outputs.

Promoting innovation requires appropriate national STI policies, financing and collective collaborations of national and international institutions, professionals and citizens. One of Rwanda's national STI policy objective underscores the need for increased scientific and technology output. This is critical pathway to improve, strengthen and optimize the performance of NIS to ensure sustainable and better economic climate. Functional and well-coordinated NIS is essential for Rwanda's continues improvement in innovation development and ascends ranking on Global Innovation index (GII). The capacity building workshop is intended to empower STI actors to better understand the role of each institution in the NIS and to use technology created as a result of knowledge as a key driver of economic growth. Functional NIS is an important prerequisite for strengthening Rwanda readiness to better deal with societal challenges. Again, the global paradigm shift provides opportunities for Rwanda in terms of technology and economic continuum change offering a window of opportunity for 'newcomers' to leapfrog and bypass competition and become leaders in specific technologies.

Figure 1: Profiles of professionals for 8-9 March 2022 Capacity Building Workshop on National System of Innovation

<p><b>Dr. Esperance Munganyinka</b> Department Head, National Research and Innovation Fund (NRIF), NCST</p>  <p>Chair on STI policy, academia, industry and financial investment, potential of science and technology for business profitability and Rwanda's Achievements and Prospects.</p>	<p><b>Dr Danica Ramljak</b> Technical Expert on STI and R&amp;D, The World Bank</p>  <p>Rwanda's Achievements &amp; Prospects, Strengthening R&amp;D Performance for national Global Index Competitiveness.</p>	<p><b>Dr. Louis Sibomana</b> Department Head, Science and Technology Development &amp; Outreach</p>  <p>Chair on STI on actors' capacity to innovate, Academia-industry Collaborations, entrepreneurship &amp; Innovation competitiveness.</p>
<p><b>Professor Nosa O. Egiebor</b> Deputy Vice Chancellor in charge of Academics Affairs and Research, University of Rwanda</p>  <p>Rwanda perspective on Development of Human STI actors' competences and capacity to innovate.</p>	<p><b>Dr. Eugene Mutimura</b> Executive Secretary, National Council for Science &amp; Technology</p>  <p>Features of Rwandan STI Policy and Knowledge Transfer to enhance Technology, Innovation and business collaborations.</p>	<p><b>Ms. Tesi Rusagara</b> Managing Director, Kigali Innovation City (KIC)</p>  <p>The role of academia, industry and financial investment to strengthen national innovation impact.</p>
<p><b>Dr. Tapas R. Bandyopadhyaya</b> Chief Metallurgist Rwanda Engineering and Manufacturing Corporation (REMCO)</p>  <p>Strengthening Academia-industry Collaborations to innovate: Achievements, Challenges and prospects.</p>	<p><b>Dr. Ir. Jimmy NSENGA</b> Technical Lead, Software Engineer, Lecturer and Research Scientist</p>  <p>Utilizing the potential of science and technology for business profitability.</p>	<p><b>Mr. Serge Tuyihimbaze</b> CEO-LEAPR LABS,</p>  <p>Technology and entrepreneurship for improved business innovations.</p>

## 2. Purpose and context:

The overarching goal of the capacity building workshops is: a) to build capacity of various STI national stakeholders to better understand and utilize Rwanda's NIS for better contribute to innovation output and b) to understand and leverage national NIS opportunities for better coordination in improving STI and R&D indicators with a focus on improving national GII and economic growth. Rwanda's concerted efforts to strengthen STI capacities and competencies for more robust NIS is prerequisite for a sustainable economy and national competitiveness. One the well-known gap or challenge is access to technology that characterizes developing countries. Overall access to technology is uneven and unequally distributed in most countries, and Rwanda is not an exception, in which access and use of technology is uneven between communities and regions. An example is that overall, 74% of population in developed countries use internet compared to 26% in developing countries of Africa and Asia. Secondly, R&D spending is much less than 1% as a percentage of national GDP in most least developed countries of Africa and Asia. However, the view that technology is developed in the more affluent countries and simply transferred to the least developed may be misleading. Most innovations involve with incremental improvements and adaptations of existing technologies. The purpose of these capacity building efforts is to understand better the available technology applications in Rwanda, and how widespread these technologies are. After improved understanding, STI actors will be in a better position to be more coordinated and responsible to adapt a growing share of global R&D spending in Rwanda's industrial and social economic growth. For instance, the drone technology was invested in developed countries but Rwanda has been quick and prompt to use drones to carry blood and save lives of many people including mothers and under five-year-old in rural areas. Drones were also used to complement messaging during COVID-19 pandemic crisis but also for destroying mosquito larva and preventing malaria. The goal of these

series of trainings is to not only to develop domestic technological capacities in Rwanda, but also for various STI actors to underscore the importance of improved interactive learning, information exchange and better coordination. This is critical among public, private firms, academia and research institutions in building innovative economy along the entire innovation value chain. **Table 1** provides some key definitions of NIS and nature of innovation focus in which NIS

<sup>1</sup>UNCTAD Secretariat. Science Technology and allow for better networking and cooperation to initiate or enhance interactions to create, import, modify and diffuse new technology within each nation (**Table 1**)<sup>1</sup>. Interaction among pub-

lic and private entities maybe technical, commercial, social and financial, in the development, protection, financing and adaptation of new science and or technology. The focus is production and use of technology as knowledge, product, service to the nation. Some concrete examples are again related to Rwanda technology application such as use of robotics in management of COVID-19 to perform temperature screening, detect people with no masks and instruct them to use masks, and high use of telemedicine in Rwanda's healthcare system to operate certain cases remotely, overcome geographical barriers, provide better efficient clinical care and improve patient outcome.

**Table 1: Definitions of National Systems of Innovation (NSI) and nature of innovation**

Definitions of NSI	Nature on innovation in focus
"...the network of institutions in the public and private sectors, whose activities and interactions initiate, import, modify and diffuse new technology"	<ul style="list-style-type: none"> <li>• Technology new to the firm</li> <li>• Technology new to the world</li> <li>• Technology as a product</li> </ul>
"...the elements and relationships which interact in the production, diffusion of new, and economically useful knowledge, and are rooted inside the borders of a nation"	<ul style="list-style-type: none"> <li>• Technology new to the world</li> <li>• Technology as knowledge resources</li> </ul>
"... the set of institutions whose interactions determine the innovative performance of national firms"	<ul style="list-style-type: none"> <li>• Innovation at firm level</li> </ul>
"...the national system of innovations is constituted by the institutions and economic structures affecting the rate and direction of technological change in society"	<ul style="list-style-type: none"> <li>• Rate and direction of technological change</li> </ul>
"...a national system of innovation is the system of interacting private and public firms (large or small), universities, government agencies aiming at the production of sciences and technology within national borders. <i>Interaction among these units maybe technical, commercial, legal, social and financial, in as a much as the goal of interaction is in the development, protection, financing and regulation of new science and technology</i> "	<ul style="list-style-type: none"> <li>• Production and use of new science and technology</li> <li>• Technology new to the world</li> <li>• Technology as a product</li> <li>• Technology as knowledge resources</li> </ul>
"...the national institutions, their incentives structures and their competences, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country"	<ul style="list-style-type: none"> <li>• Technology leaning</li> </ul>
"...that set of distinct institution which jointly and individually contribute to the development and diffusion of new technologies, and which provide the framework within which government form and implement policies to influence the innovation process. <i>As such it is a system interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies</i> "	<ul style="list-style-type: none"> <li>• Technology new to the world</li> <li>• Innovation process</li> <li>• Technology as artefact</li> <li>• Technology as knowledge resources</li> </ul>

<sup>1</sup> UNCTAD Secretariat. Science Technology and Innovation Indicators for policy making in developing countries: an overview of experiences and lessons learnt. Trade and Development Board, Investment, Enterprise and developing commission. Multi-year Expert Meeting on Enterprises Development Policies and Capacity-Building in Science, Technology and Innovation (STI). Geneva 20-22 January 2010.

### 3. Expected outcomes

The STI capabilities of Rwanda as a nation depend not only on access to a growing accumulation of science and technology, but also on the quality of interactions among the innovation actors in what is called the 'National Innovation System (NIS)'. One of the major challenges in promoting technological innovation is the lack of an appropriate innovation system to ease and allow better interaction among key actors. Coordination and interaction are critically and much more complex because it involves the formal sector—private sector enterprises, universities, research institutes, the government and the financial system—along with non-for-profit organizations. They also include the informal sector, including grassroots innovators, and local and indigenous knowledge. The trainings engage all stakeholders encourage participation of different stakeholders from academia, industry, government involved in STI and R&D performance to ensure full participation and responsibility (ownership and roles) towards the improvement of the NSI and R&D output performance. The trainings are implemented using participatory training approach including facilitator, co-trainers and trainees' interactions.

The main facilitator is Dr. Danica Ramljak, the World Bank Expert with international experience on Science and Innovation for Development. Dr. Ramljak's role will be to lead the learning and critical thinking processes for each topic and she will prepare learning materials related to the topics that will be presented and an assessment tool for evaluation of expected outcomes. She will present and share international experience as well as guide the training discussion based on Rwanda's national context.

The co-trainers are professionals from representative national STI stakeholders: The National Council for Science and Technology (NCST), University of Rwanda (UR), Private Sector Federation (PSF), Kigali Innovation City (KIC), Norrsken East Africa and LEAPR Labs private sector.

Case studies and exploration of national experience related to the specific topics are presented. The trainees actively participate in the training process where their needs and questions, reflection, analysis and strategies considered. Additionally, the panel discussion with special focused on agriculture

sector was held and involved professionals from agriculture sector from public-private institutions along the whole value chain.

Measuring output of innovation is important as innovations are sources of competitive advantage for companies and national economic growth. Innovations are associated with generating new products or services, or perfecting existing ones. Along these lines, it is particularly important to measure innovation and results associated these innovations. **Table 2** provides some key selected indicators for measuring STI as a result of technology value chain (**Table 2**)<sup>2</sup>. The Report from assessment of the state of STI in Rwanda for the reference fiscal year 2019/2020, indicates considerable achievements of Rwanda in innovation development. The study included in the Report examined STI investment, growth, productivity and environment for better informed decision-making to support improvement of STI status for the public and private sectors.

Based on the results it appears that in technology resources, Rwandan institutions

need to adopt all essential technologies and increase investments in key sectors of the national economy such as agriculture, food science and related fields, health and well-being, environmental science as well as transportation engineering.

Concerning human resources, public, private and high learning institutions need to fill the gap observed in required competitive stock of skills in order to develop the requisite skills for innovation development by generating an increased number of researchers performing the R&D. As per collaboration and communication, in order to moderately collaborate on innovation activities, there is a need for Rwandan institutions to cultivate businesses in developing their own prototypes and improve the speed of reaching customers through digitized solutions. Concerning knowledge resources, more efforts should be put on knowledge exchange s between research institutes, academia and industry mainly national but also encourage and support international collaborations.

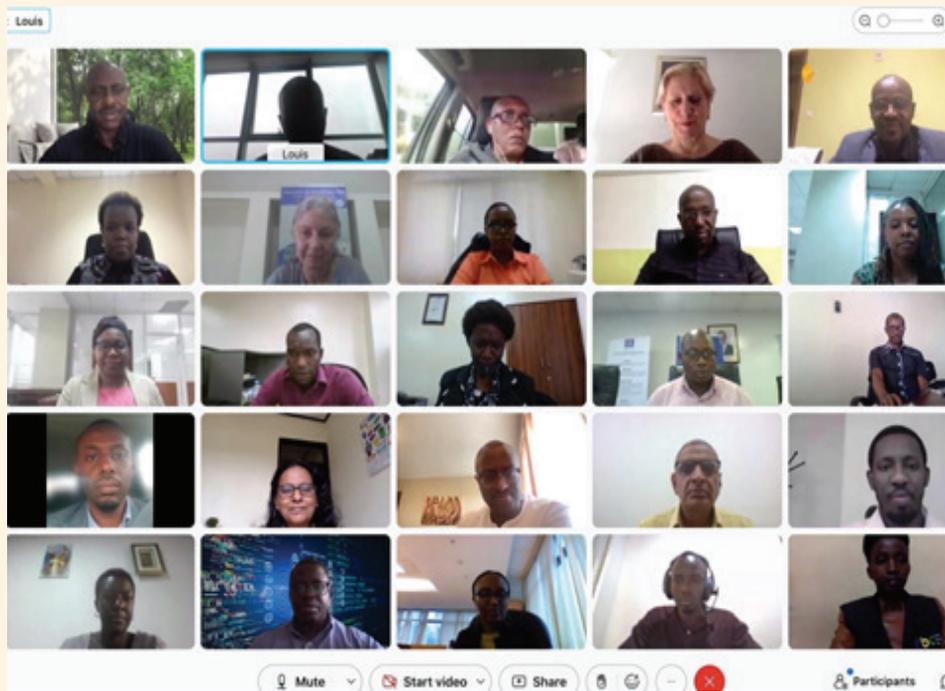


Figure 2: Participants and Trainers attending the 2-days online training workshop for Capacity building in STI system in Rwanda

<sup>2</sup> Measuring Innovation: A New Perspective presents new measures and new ways of looking at traditional indicators. OECD Library available at <https://doi.org/10.1787/9789264059474-en> on 25th May 2010

**Table 2: Definitions of key indicators for measuring Science Technology and Innovation (STI)**

<b>Intellectual Property</b>	An innovation work whose exclusive right to the investor is legally protected
<b>Intangible investment in STI</b>	These are investments with no easily-qualified physical properties. They usually take the form of intellectual property
<b>Patent</b>	The sole right granted by a government to an inventor to market an invention for a period of time. It is a form of an intellectual property that encourages innovative efforts among entrepreneurs.
<b>Bibliometrics</b>	It is a set of methods to quantitatively analyze academic literature. It could be used to measure the number and quality of scientific and technical journal articles in an economy.
<b>Public and private investment in R&amp;D</b>	This shows the expenditure of money and other resources by both government and private firms on R&D.
<b>R&amp;D Intensity of Nations</b>	This is the proportion of a country's GDP ( <i>Gross domestic product</i> ) that is spent on R&D*.
<b>R&amp;D intensity of industries</b>	This estimates an industry's R&D spending (e.g.: in knowledge and technology search efforts) as a proportion of its sales.
<b>High-Tech Industries</b>	Industries that use the most advanced technologies available to manufacture goods or provide services.
<b>High-Tech Exports</b>	These are products with high R&D intensity, such as in aerospace, computer, pharmaceuticals, scientific instruments and electrical machinery.
<b>Output and employment in high-tech and medium-tech industries</b>	This captures total production and the proportion of the labour force absorbed by high- and medium-tech industries in an economy.
<b>Foreign Direct Investment (FDI) as a percentage of GDP</b>	The share of FDI in GDP. It captures knowledge spillover from developed to developing economies.
<b>Technology absorption</b>	An economy or enterprise's capacity and readiness to use the most advanced technology available for productive purposes.
<b>Technology Achievement Index (TAI)</b>	It is used the UNDP to measure how well a country is creating and diffusing technology and building a human skills base, reflecting its capacity to participate in the technological innovation in the network age.
<b>Royalty</b>	The percentage of income accruing to inventors from the sale of their inventions.
<b>License fee</b>	The amount paid or other terms that is needed to be fulfilled before access to intellectual property can be granted.

\*GDP: standard measure of the value created through production of goods and services in a country during a certain period or fiscal year.

#### 4. Future directions

Building sustainable innovation capabilities in Rwanda requires a functional and well-coordinated National Innovation System (NIS) capable of producing, disseminating and using new knowledge. Developing capacity for NIS and improved coordination in utilizing available technology in Rwanda, provides some of the opportunities for a better future of a successful implementation of the national strategic goals outlined in the Vision 2050. Rwanda NIS shows promising progress. The gaps in lack in terms of ensuring better interactions among STI actors and synergies among institutions will continuously be bridged by the current and similar trainings and strategic efforts. It is feasible to build an effective NIS that is well coordinated along the value chain as most institutions and actors seem to play their required roles.

A dynamic and successful NIS requires the involvement of all actors—industry, enterprises or firms, universities and research institutions, the coordination among relevant government line ministries and agencies and the adequate financial support system through well-developed Policy Mix —along with non-for-profit organizations. The role of informal sector such as grassroots innovators, and local and indigenous knowledge generation as supportive players is also important.

One of the current major challenges is inadequate role of industry to invest and engage in R&D output. Yet, industry is the main user of knowledge and technologies produced from R&D as well as a potential investor in R&D. This is particularly relevant for the development of the agro-business sector, which holds a high potential for innovation activities and industrial development.

Efforts are under way such as development of new policy on R&D incentives that are expected to rejuvenate and set up mechanisms for private R&D funding and funds mobilization.

The lack of adequate collaborations that enhance interaction between academia and industry as end-users of innovations will need to be continuously bridged through policy and implementation approaches. Also, there is still a challenge to proceed from incubation to commercialization and utilization of innovations output in society as indicated in **Table 2**.

Incubators are the main instrument for maturing innovative ideas. Some of existing efforts such as over 65% of awardees from the 34 projects have their innovations transitioning to being commercialized. These capacity building efforts enhance collaborations and build up potential synergies of innovation capabilities and industrial development.

# Empowering Women in STEM: One of the priorities for Rwanda to become a knowledge-based economy

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It has become a tradition that on 11<sup>th</sup> February of every year, the National Council for Science and Technology (NCST), in collaboration with various stakeholders join the rest of the World to celebrate the International Day for Women and Girls in Science. This celebration is rooted in the archives of the UN General Assembly which, on 22<sup>nd</sup> December 2015, established an annual International Day to recognize the critical role women and girls in science and technology play for sustainable development. Gender equality was set as a global priority and the support of young girls, their education and their full ability to make their ideas heard are levers for development and peace.

Since 2015, the global community has made a lot of effort in inspiring and engaging 'Women and girls in Science' initiative to improve uptake of girls to science technology, engineering and Mathematics (STEM) education, engage in research and technology development and utilization. However, statistics show that their participation is still low and more actions to promote their full and equal access to and participation in science programs is of paramount importance. The UN Scientific Education and Cultural Organization (UNESCO) report (2014-2016) reveals that fewer than 30% of researchers worldwide are women, and only around 30% of all female students select STEM-related fields in higher education.

In Rwanda, the Statistical Yearbook of the Ministry of Education indicates that the percentage of female students enrolled in STEM disciplines in tertiary education was at 32.1% in 2018/19. The Rwanda

National Research and Experimental Development (R&D) Survey report for 2018/2019 published by the National Council for Science and Technology (NCST) in November 2021 indicates that, of the 3,411 R&D personnel across all sectors, females accounted for 35.73%, a commendable progress from 25.07% in 2015/2016, which makes Rwanda rank fairly well regionally and internationally. This is similar to the increase in number of qualified female researchers over period from 22.6% in 2015/16 to 30.4% in 2018/19. In this regard, the Government of Rwanda is committed to make a strong contribution to increase the number of female students enrolled in STEM, and the number of female researchers as well as to adopt the Women's Empowerment Principles that promote gender equality and women's empowerment in the workplace, marketplace and the community.

Rwandan institutions continue to provide the necessary support to increase women and girls' participation in STEM education, engage in research by promoting women in science through different initiatives. NCST mandates that at least 30% of women participate in all research grant applications. NCST together with other national partners celebrate the 11<sup>th</sup> February Day each year to inspire and motivate women and girls to pursue sciences through awarding and recognizing outstanding women engaged in scientific and innovative work. This initiative is known as the "NCST Women in Science Celebration and Award" event. The goal is also to provide a platform for different organizations to provide support to women already in these fields, in terms of mentorships, increase of visibil-

ity, access to safe spaces, as well as representation.

This "Women and girls in Science" celebration and award aims to empower women in science-related fields and give an opportunity to young scientists to be inspired, and the scientific community at large to learn about the work of successful women scientists in Rwanda has taken place since 2018. The main purpose of the event is to demonstrate the commitment of the Government of Rwanda to promote full and equal access to participation in Science for women and girls and to showcase and recognize the scientific contributions of women in STEM in Rwanda. In this spirit, 3 categories of women and girls have been awarded by NCST: (1) Science Leadership award, (2) Research award, (3) and Rising star award. An additional fourth category of "Champion of science award" has also been included and awarded by the Rwanda Association of Women in Science and Engineering (RAWISE), one of the partners in organizing this event.

The graph below (Figure 3) provides accurate information regarding the amount of money incurred in the form of resources to support women in science career development such as research capacity and development, training, conference attendance.

The celebration of women and girls in science used to be a physical celebration.

However, due to the proliferation of the COVID-19 pandemic in the country since 2020, the celebration of 2020 was not done, and those 2021 and 2022 done lively on RBA Platforms.

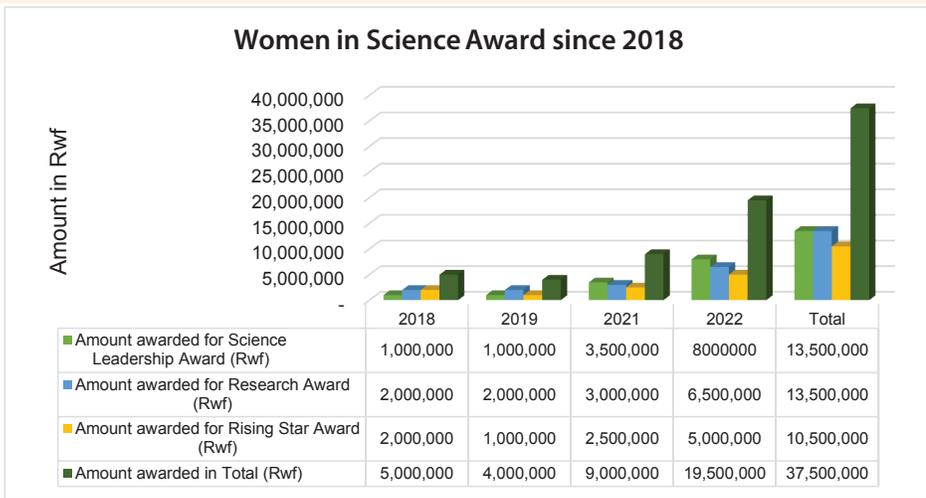


Figure 3 : The amount in Rwanda Francs awarded since 2018



Figure 4: First awarding ceremony in 2018

This year 2022, for the second time, the international day celebration of day of Women and Girls in Science was celebrated while the whole world is still facing the COVID-19, a pandemic which is affecting health, social and economic well-being worldwide, with women at

the Centre. Therefore, this 7<sup>th</sup> International Day of Women and Girls in Science was celebrated under the theme **“The role of Women and Girls in science and their implication in the prevention of COVID-19 pandemic”**.

Various stakeholders joined NCST in the preparation of the day including the Ministry of Gender and Family Promotion (MIGEPROF), Rwanda Association for Women in Science and Engineering (RAWISE), the UR-Sweden program, the Organization for Women in Science for the Developing World Rwanda Chapter (OWSD-Rwanda chapter), Rwanda National Commission for UNESCO (CNRU), and other stakeholders join the rest of the world to celebrate “International Day for Women and Girls in Science”.

In this celebration, four (4) Women in science were awarded for their demonstrated commitment to advance science in the Rwandan society. It was through a live panel discussion presided over by the Honorable Minister of Gender and Family promotion, Prof. Jeannette BAYISENGE on Rwanda TV. Panelists in the live discussion were Minister of Gender and Family Promotion, Hon. Prof. Jeannette Bayisenge, Dr. Eugene Mutimura, Executive secretary NCST and Rita Mutabazi, NCST awardee 2021 . In her intervention, she came back to the vision of Rwanda regarding the women inclusivity/in science and technology. She thanked the National Council for Science and Technology for this push for women to be granted equal participation and leadership in science and technology and innovation for the sustainable development.

Dr. Eugene Mutimura, Executive Secretary of the National Council for Science and Technology (NCST). In his intervention, Dr. Mutimura talked about the three approaches established by NCST to implement the government efforts of increasing women’s participation in science, technology, research an innovation. These are

- The mandatory requirement for at least 30% representation in all research grants funded through NCST.
- The establishment of a specific women grant scheme known as “Women in Science Research and Innovation grant” established to specifically promote

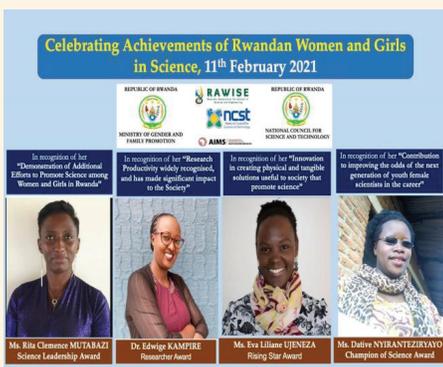


Figure 5: 2021 Awardees



Figure 6: IDWGS 2022 celebration at RBA

the leadership of women in research and development and innovation.

- The third approach is the “Women in science award” implemented since 2018.

Ms. Rita Mutabazi, as the recipient NCST women in science Award 2021, she elaborated on how these awards were very useful. She got leadership in STEM award. With that award, she established the STEM Maker space at GS S<sup>te</sup> Famille School, as safe and creative space for students with a special focus on girls. By creating this, it was a way of demystifying STEM by simple and fun hands on activities in STEM that show real life applications. She added that the choice of the school was also a way of giving back to the school she went to. She emphasized on the fact that she got the award because of a strong network which recognizes the work done by women in STEM and encourages different role models to play a role in inspiring ways which is a very crucial key by highlighting how the mentorship programs that these networks are conducting are contributing to increase females in STEM.



The four categories of award for 2022 included **Category 1 on Science Leadership award** that was awarded to Mrs. Jennifer BATAMULIZA, whose leadership, dedication

and expertise have helped to advance gender equality and women and girls’ empowerment in science and technology in Rwanda. Mrs Jennifer Batamuliza Currently works at the University of Rwanda (UR), College of Business and Economics (CBE) as a lecturer and head of software engineering department. Mrs. Jennifer is a CEO and founder of RWA TECH HUB which is a social enterprise that trains and mentor’s girls in

technology. RWA TECH HUB has trained more than 400 girls how to develop websites, cyber security and machine learning courses. Jennifer remarkable work and outstanding efforts include work with as an Edify Consultant to train girls and primary school head teachers in ICT (coding) and a mentor and Trainer at Rwanda Association for Women in Science and Engineering (RAWISE). Perhaps most important is her work as a Trainer for coding at RWA TECH HUB: Different Trainings for the girls how to code and also mentoring them to join technology field.



**Category 2 Researcher award** for the year 2022 was given to Prof. Eugénie KAYITESI for her achievements in research, and whose research outputs are

widely recognized with significant impact to a woman who is a leader in her field. Prof. KAYITESI is an Associate Professor in Department of Consumer and Food Sciences, Faculty of Natural and Agricultural sciences in the University of Pretoria, South Africa. Prof. Kayitesi has expertise in various research areas of Food Science and Technology, particularly food chemistry, food processing and sensory science. She undertakes fundamental and applied research relating to improved utilization of indigenous, underutilized African plant foods with the goal of attaining nutrition and food security for all in Africa. Prof. Kayitesi has published more than 60 peer-reviewed international journal articles and book chapters and presented her research findings in reputable local and international conferences. She has successfully hosted 5 postdoctoral fellows and supervised 3 PhD students and 10 masters’ students to completion. Prof. Kayitesi has earned several awards in recognition of her contributions to science. She the African Women in Agricultural Research Development

(AWARD) fellowship in 2009. AWARD is a highly competitive fellowship program designed to fast-track the careers of African women scientist/students and professionals showing leadership potential to deliver pro-poor agricultural research and development that benefits the rural communities, especially women. In March 2015 she was named Food Science Educator of the Month by the Institute of Food Technologists (IFT). She is currently a recipient of the world academy of science (TWAS) young affiliation and serves as member of The World Academy of Science (TWAS) Advisory Committee on COVID-19 (2021-2022). She is also a Fellow of the Pan-African Scientific Research Council (PASRC).

Prof. Kayitesi has also been involved in a few community-based projects, she serves as a Board member and chairperson for the Health Equity and rights organization (HERO) a non-government and non-profit organization based in Rwanda. She is also an advisory Board member for the Food Evolution Research Laboratory (FERL). A Johannesburg based virtual laboratory that is an essentially go to guide to direct and influence the thinking, choices and decisions built around health and nutrition.



**Category 3 for “Rising Star award”** for the year 2022” was given to Dr. Claire d’André Hirwa for her innovation in creating a scientific and technological solution useful for the society. Dr. Claire d’Andre Hirwa is currently a Senior Research Fellow in animal breeding, genetics and reproduction at Rwanda Agriculture Board (RAB) with the main duties: coordinating, planning, designing and implementation livestock programs. Dr. Claire d’Andre’s remarkable work and outstanding efforts include the following Innovation technologies. These include

entific and technological solution useful for the society. Dr. Claire d’Andre Hirwa is currently a Senior Research Fellow in animal breeding, genetics and reproduction at Rwanda Agriculture Board (RAB) with the main duties: coordinating, planning, designing and implementation livestock programs. Dr. Claire d’Andre’s remarkable work and outstanding efforts include the following Innovation technologies. These include

Multiple ovulation and embryo transfer. The innovation is called "multiple ovulation and embryo transfer (MOET)". Dr. Claire D'Andre has identified the MOET team to work with; this team has used this technology to flush embryos and introduce embryos from donor to recipient cow. The female calves from these cows are now the source of embryos for rapid multiplication. The bulls are also our local sources of semen for artificial insemination. This capacity shall greatly reduce future costs of importing high yielding cows and semen for artificial insemination. Her work also includes phenotypic characterization of indigenous cattle and chicken. She also works on identification of signature of selection in cattle and poultry through utilization of molecular genetics: I have started working on this innovation by embarking on phenotypic characterization of indigenous cattle and chicken. She is currently working on identification of different markers to be used during selection on Residual feeding intake utilization in cattle. This innovation is being used to identify the best breed which can consume less food and produce more milk under study greening Girinka project. She has co-Authored the NORAD project at RAB with the collaboration between Princeton University (France) and Columbia, we have managed to develop a model for Predicting equations for ruminant livestock productivity and methane gas production called "Ruminant model". She has also worked on "In ELnino project" and managed to develop and test a

tool called "SIDESS "Sustainable Intensification Decision Support System tool to predict the productivity of dairy cattle's in a production system in tropical climate. She has also participated in development of tools modeling and analysis for Rwanda El -Nino and climate change resilient livestock activity and testing the model in village analysis Collaborators: RAB, Columbia and Princeton University.



**Category 4  
"Champion of  
Science award"**

for the year 2022 was awarded to Sr. Laetitia MUSANABAGANWA for her contribution to improving

the odds of the next generation of young female scientists in their careers. The RAWISE Champion of Science award was instituted in 2019, with the purpose to recognize Rwandan women, scientists or not, whose efforts to promote gender equal participation and equal access, might otherwise go unnoticed. That year, the award went to Dr Christine Gasingirwa, the former Applied science analyst at the High education council (HEC) and Co-Chair of Rwanda Academy of Science (RAS), for her continuing advocacy for gender equality in STEM education and careers in Rwanda. She was the first Champion of Science. In 2020, the RAWISE Champion of Science award was given to Josephine Mukarukundo, also a science educator with 14 years

of experience teaching Mathematics and Physics in high school, later turned technical scientist, in 2021, the RAWISE Champion of Science award was given to Dativa Nyiranteziryayo a teacher of Biology and Mathematics with more than ten years of service. Her passion and her dedication to seeing her students succeed has led her to create a female science students club in her school, to better help girls and encourage them to better perform in Maths & sciences in general. Sr Laetitia Musanabaganwa is the head mistress of Maranyundo Girls school, and council member of the Ben-bikira congregation at the Provincial level. Sister Laetitia has a long history in science and education and served as school counselor at MGS before becoming the Head of School. She holds a master's degree of education Planning and Administration, Bachelor degree of science with education in Computer science. She served in different institutions being a Matron and Teacher (computer science) at College Immaculee Conception Save, Head teacher at Gahini FAWE High school. Sr Laetitia Musanabaganwa is very passionate about promoting girls. She believes in motivating girls to strengthen their critical thinking, problem solving, and analytical reasoning skills that will assist them in their further studies and careers. Especially those pursuing STEM. She equips students with the ability to comprehend and acknowledge advances that happen in the world using STEM.

# Monitoring and Evaluation on the Implementation of NCST Funded Projects for Boosting R&D Innovation Outputs

Dr Esperance Munganyinka<sup>\*1</sup>, Dr Didacienne Mukanyiligira<sup>\*2</sup> and Dr Jahet Niyobuhungiro<sup>\*3</sup>

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## 1. Background and rationale

National Council for Science and Technology (NCST) provides funding to competitive innovation and research and development (R&D) projects through National Research and Innovation Fund (NRIF). This funding mechanism was launched in 2018 and to-date 98 projects have been funded with a commitment of approximately 4 billion Rwandan Francs. To ensure the timely completeness and effectiveness of the implementation of these projects, NCST established a Monitoring and Evaluation (M&E) framework to support and inform project implementation progress. The goal is to enhance project outputs and the potential for better impact of the project outcome on the country's economic development and wellbeing of citizens. Key Performance Indicators (KPIs) of the M&E framework use data collection approach, processing data, analysis and reporting data based on M&E tools agreed upon by all stakeholders. Processes and procedures to achieve effective M&E are based on the following established standards: (1) **Monitoring:** Conduct continuous process of collecting and analyzing information on key indicators in order to measure progress toward goals; (2) **Target:** A quantifiable amount of change that is to be achieved over a specified time frame in an indicator (3) **Indicator:** Measure tracked systematically over time that indicates progress toward a target (4) **Evaluation:** Assessment of a planned, ongoing, or

completed intervention to determine its relevance, efficiency, effectiveness, impact, and sustainability (5) **Impact:** A long-term result that is achieved when a series of outcomes is achieved.

The M&E reporting tool is designed as a holistic instrument that is used throughout the funding cycle for each project, and the tool is used during desk and field work assessment. During the M&E activities, a participatory approach of assessment is used in which NCST Staff together with staff from partner institutions assess each project progress based on its objectives, planned activities and expected outcome vis-à-vis current implementation status. The assessment is also based on project implementation progress through submitted quarterly technical and financial reports by the Principal Investigator (PI) from the host institution.

## 2. Monitoring and Evaluation

### 2.1. Quarterly reports

To monitor the implementation progress of funded projects, there is a requirement for the PI and the host institution to submit quarterly narrative reports both technical and financial using the designed M&E tool. The technical section of the report provides a short statement confirming that the tangible output or other project goal included in the proposal has been completed, and whether the project has resulted into any additional outcomes. The submitted report

must also explain how each project goal or objective as set forth in the proposal was met, according to the metrics based on the project indicators. The financial section of the report includes financial statements detailing how all grant funds were expended and account for all categories in the approved budget.

Furthermore, for NCST to improve the management of funding mechanisms, researchers are requested to include in the report a brief explanation on lessons learnt from the current project implementation and to provide their recommendations.

### 2.2. M&E field visits

In addition to quarterly reports from the host institutions, the NCST team conducts regular M&E field visits as part of M&E framework. Currently, the team has conducted the M&E field visits for 17 projects under the Special Collaborative Research Grant to address COVID -19 Pandemic Scheme, 9 projects under Excellence Research Grant Scheme, 5 projects under Academia Industry Collaboration Scheme, 4 projects under Sector Strategic Research Grant Scheme, and 34 projects under Rwanda Innovation Challenge Grant Scheme.

The purpose of the M&E field visits is to assess the progress of research project and specific outputs and achievements, understand data collected and experiments established (Laboratories/Fields work done), and their plans and how

NCST can support current implementation status. In this regard, during field work M&E activities, the process involves the following:

- a) Visit in the Laboratories;
- b) Observations on lab work;
- c) Field visit at the data collection sites;
- d) Review of the work progress/ way forward & plan;
- e) Assess how the project team is working together;
- f) Assess how much time researchers spend on the project;
- g) Assess the budget utilization.

Furthermore, each disbursement of funds instalment from NCST is based on investigators achievement of planned activities, delineated in the outputs for agreed upon indicators. The M&E data for every quarter serve as a tool for results-based planning of activities related to the utilized budgets.

In summary, the data in the reports support decisions on project implementation and improvement. Further, the information in the report demonstrate accomplishments of agreed upon procedures and plans, contribute to better progress of the grant implementation, provide key achievements, challenges, lessons learnt and guide way forward for future project fund disbursement.

### 3. Communication of information

Effective and timely communication of information to the stakeholders is the greatest tool in monitoring and evaluation. After gathering data during the M&E we compile, interpret and present it in a form that conveys the meaning of the progress made. This is done mainly in three ways, namely through an open discussion during the M&E activity where NCST team in the field visit, interacts with researchers, technicians and support staff and provide them with some feedback. It is also done through debrief meetings organized just after the M&E activity. A debrief meeting gathers leaders of the institutions and researchers implementing the project. During

these meetings, NCST team with visited institutions share and interchange information, clarify, stimulate, and seek the best solutions regarding identified project performance challenges. Lastly, the feedback is provided through detailed M&E reports highlighting project details, objectives, methodology used to conduct M&E, achievements, way forward, challenges and mitigation strategies, and recommendations. These reports are submitted to concerned institutions to facilitate corrective decision making.

### 4. Importance of monitoring and evaluation

Based on lessons learnt during the monitoring and evaluation activities, some institutions which did not have guidelines regarding grant funds management for efficient research project implementation, have now put them in place. In addition, researchers have gained experience in grant management in proactively devising strategies to overcome challenges.

Monitoring and evaluation supported and promoted the management of results: Focusing on the measurement of project results using agreed benchmarks or targets, monitoring and evaluation helps to determine if the project is on track or not, facilitate the documentation of lessons learnt to improve the planning of future projects as well as provide enough opportunities to the project team to timely correct project mistakes before it blows out of proportion.

Monitoring and evaluation activities had a great contribution to the success of some project thanks to the routine project monitoring and reporting by different stakeholders, which provided enough opportunities for measuring the performance of the project against targets. This also provided opportunities for adjustments in the implementation strategies based on the feedbacks from the project monitoring field visits.

### 5. Some examples of projects evaluated

As mentioned above NCST team has conducted the monitoring and evaluation field visits for several projects and different schemes. Below we highlight few examples illustrating the impact of M&E activities on funded projects to boost outcomes.

#### ***“Capitalizing on marigold bio-pesticide properties to leverage the output of natural products made in Rwanda”***

This is a 4-year project that started in March 2021 and is expected to complete in February 2025. One of the recommendations given to the researchers during the M&E field visit was to do pre-test extraction of essential oils using available wild *Tagetes* so they can scientifically think ahead while they wait for domesticated plants to be harvested; and due to this recommendation, the research team has already started the pre-test extraction essential oil from already available *tagetes*.



Figure 7: Project team showing domesticated *Tagetes* species and available equipment at industry collaborator (Sopyrwa) which will be used to extract essential oil from *Tagetes*.

**“Bioethanol and hand sanitizer production from sugar cane molasses to quickly respond to their local increasing demand towards COVID-19 pandemic”**

This is a 2-year project that started in November 2019 and is it is completed. Due to the M&Es that have been conducted by NCST team, the project is almost at its end, where the researchers have manufactured the hand sanitizer using bioethanol from sugar cane molasses and extracted Aloe Vera gel (**Figure 8**). Due to the recommendation from NCST team they have managed to bring on Board a private partner that will scale up the production of the hand sanitizer and commercialize it.



*Figure 8: Production of hand sanitizer at National Industrial Research and Development Agency (NIRDA): From Aloe Vera domestica- tion, to distillation of sugar cane molasses using high-end equipment and to the final product.*

# Artificial Intelligence Technology Application for Developing Dataset in Kinyarwanda and Chatbot: The Role Public and Private Sector Collaboration

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## 1. Introduction

Technology and innovation are among the primary engines of nation's growth and economic development, and are playing an increasingly important role in virtually all sectors and in the daily lives of citizens not only in Rwanda, but also around the world. However, this requires innovative approaches and greater levels of multilateral cooperation among key players in different sectors. In particular, the role of the private sector in promoting Science Technology and Innovation (STI) is key for scientific and technology knowledge to ensure Rwanda's future prosperity and competitiveness.

Moreover, the national STI policy emphasizes on the needs to promote research and innovation in new and emerging technologies. These frontiers in technology including the Internet of Things (IoT), Artificial Intelligence (AI), Data Science (DS), Software Engineering (SE), Blockchain, etc., contribute, for example, to improving food security, nutrition and agricultural development; promoting energy access and efficiency; confronting disease and improving healthcare service and delivery; promoting social inclusion; and improving access to educational learning and resources. Thus, it is essential for Rwanda to count on the adoption and use of emerging technologies as well as on the development of local technological solutions that contribute to new ways of inventing, learning, producing, healing and trading as well as creating knowledge.

Furthermore, speech is becoming a preferred way to interact with personal electronics and the future of human-machine interaction lies in voice control. The natural language processing (NLP) is the discipline of AI concerned with the application of computational techniques to the analysis and synthesis of natural language and speech. That is, NLP is the practice of providing computers the ability to understand text or spoken words in as much the same way as human beings do. NLP combines computational linguistics and modeling of human language with statistical, machine learning, and deep learning models. Together, these technologies enable computers to process human language in the form of text or voice data and to understand its full meaning as per the speaker or writer's intent and sentiment. Some of the NLP application includes speech recognition or speech-to-text which involve the task of converting voice data into text data. Speech recognition can be utilized in a variety of applications including virtual assistants or real time text translations. Other widely used NLP applications includes capabilities such as proposing synonyms, grammar check and spelling, and rephrasing sentences.

As global NLP platforms are adopted at a high pace, for example, Google Translate, Google Assistant, Siri, Jose that support visually impaired to navigate and explore the computer and others, there is a need to develop infrastructure (training data) and adequate research.

While major world languages such as English have comparatively abundant text and voice libraries and NLP tools are well developed, computational linguistic resources for KINYARWANDA are in short supply. In Rwanda, a local startup digital UMUGANDA has so far built the largest KINYARWANDA voice dataset with over 1,650,000 Kinyarwanda sentences. Digital Umuganda collects speech data in Kinyarwanda from volunteers during the state-wide, monthly community work day Umuganda. The voice dataset corresponds to over 2,200 hours of recorded voice data collected from over 1,000 speakers.

## 2. Digital Umuganda

Digital Umuganda is an AI and open infrastructure company based in Kigali, Rwanda, with focus on natural language processing including automated speech recognition, speech synthesis (text to speech), automated question answering and information extraction (chatbot) as well as machine translation. According to Mr. Niyonkuru Audace (founder and Chief Executive Officer), Digital Umuganda has been focusing on two main projects, namely Kinyarwanda voice dataset and text and voice Chatbot, to allow local value creation through research and development, and to ensure the advancement of AI applications in Rwanda.

### i) Kinyarwanda data set

Developers, researchers and startups around the globe working on voice recognition technology face a lack of freely

available voice data in their respective language to train speech-to-text engines. Although machine-learning algorithms like Mozilla's Deep Speech are in the public domain, training data is limited. Most of the voice data used by large corporations is not available to the majority of people, expensive to obtain or simply non-existent for languages not

globally spread. Also, for today's Internet and consequently the technologies and services built on top is heavily skewed towards English. If we want technology to become more inclusive, we need to make sure that future technologies especially doors to access information and services exist in local languages such as Kinyarwanda.

- Speech recognition open dataset for Kinyarwanda:** Digital Umuganda has been building open datasets for Kinyarwanda speech to text engines. In 2019 when the dataset creation started there was no dataset for speech recognition in Kinyarwanda. As of today, the dataset has grown to more than 2,000 Hours making it the largest open voice dataset in Africa and the second largest on Common voice repository globally behind English. This has allowed various global researchers as well as Digital Umuganda to start building models on the dataset including the Speech brain team from University of Montreal, Mozilla as well as Digital Umuganda. This is paving the way for voice-based application that will remove barriers rooted from illiteracy, disability, and others to access information.

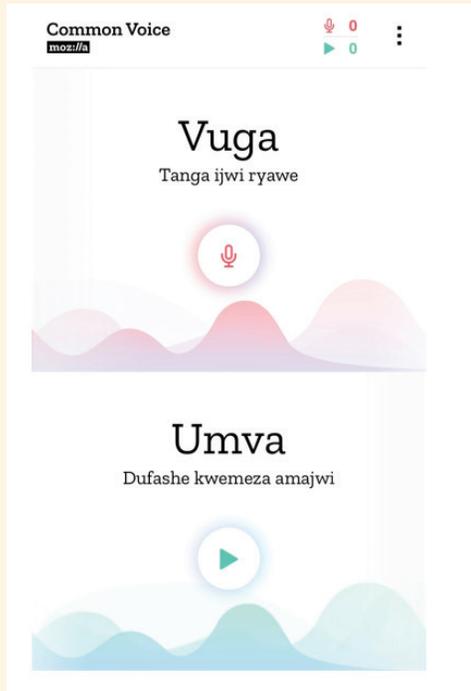


Figure 9: a) Open voice AI infrastructure for Kinyarwanda

b) Presentation of Kinyarwanda Dataset

In this context, Digital Umuganda has developed a voice technology infrastructure for Kinyarwanda AI engines to democratize access to voice technology as shown in **Figure 9**. This was achieved through building productive partnerships with Government of Rwanda, German development agency (GIZ), Mozilla and local communities in Rwanda. The AI infrastructure (Kinyarwanda dataset) being developed will not only allow innovators and researchers to advance and allow transfer learning to other Bantu languages but will also give access to information and services to a large number of Rwandans that might be alienated but transitional text based web based digital solution. Citizens will be able to access automated information in Kinyarwanda on any device. Also, voice tech-

nology serves as a digital bridge to ease access for people living with disabilities to access information, education materials, research and employment. In addition, with voice interaction available in Kinyarwanda we may provide millions of people access to information, make technologies more inclusive and ultimately foster a just, locally rooted yet global digital transformation. Digital Umuganda's success in collecting Kinyarwanda voice and text dataset, and this is evident through Mozilla common voice's platform where the volume of data in Kinyarwanda is second to English as the biggest open voice dataset in the world.

The Kinyarwanda dataset is taking a multifaceted approach to open innovation for speech technologies, including:

- Text to speech dataset for Kinyarwanda:** Text to speech technology has undeniably proven to be a vital technology especially in making Digital tools and solutions become more inclusive. Technologies such as screen readers for people living with visual disabilities all rely on text to speech engines however such technologies are inexistent in Kinyarwanda due to the lack of such infrastructure and R&D work. Digital Umuganda is in the process of finalizing a Kinyarwanda dataset that will be used to train a text to speech engine. So far, Digital Umuganda has collected over 17 hours of highly curated studio data.
- Speech recognition model:** Given the vast amount of collected data, Digital Umuganda has been training voice models. There are currently two versions of automated speech recognition models (1200 hours and 350 hours' models). The training of the third model with 2000 hours is cur-

rently underway. With each new model there is an improvement of the accuracy from low accuracy requirements such as keyword spotter to high accuracy model for live audio and video transcription.

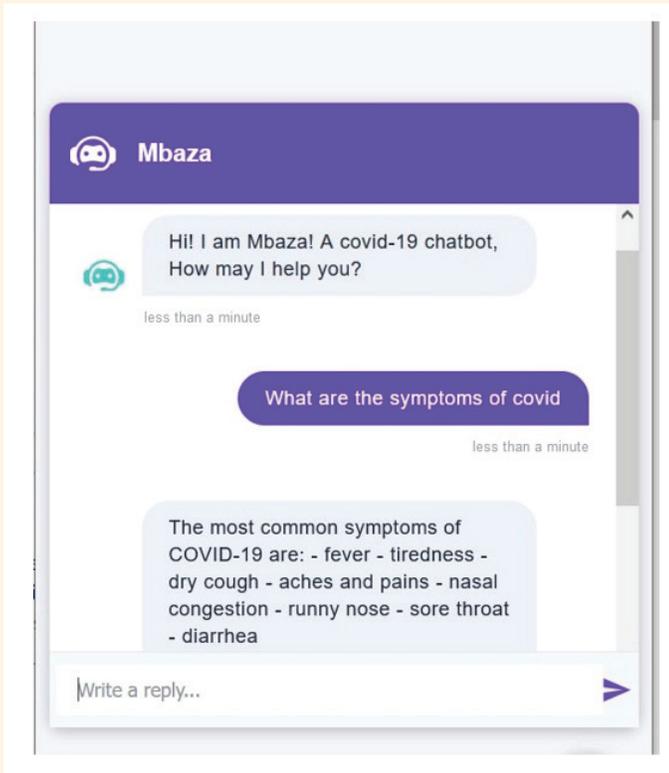


Figure 10: A user interacting with Mbaza AI Chatbot

## ii) Mbaza AI chatbot

Digital Umuganda developed Mbaza AI chatbot with the aim to strengthen Government and citizen communication by providing information as well as services around covid-19 pandemic. Mbaza AI chatbot is an automated voice assistant using natural language processing including voice technology to enable citizens to access information and guidance while using local language and also provides feedback to the relevant authorities for decision making. The chatbot is built in a way to make it easy to scale to other different topics and organization so as to facilitate fast-track and automate information dissemination without the need of large-scale call center operations. This will on one hand ensure that citizens have timely information and on the other hand reduce the resources needed to disseminate information at a large scale. The development of Mbaza AI chatbot is led by Digital Umuganda in partnership with Rwanda Information Society Authority (RISA), Rwanda Biomedical Center (RBC), Mozilla and GIZ. The piloting of the initial rule based chatbot has more than 1,163,000 unique users and is used on average by 15,000 people. **Figures 9,10 and 11** show how a user can interact with the Mbaza AI Chatbot, while **Figure**

**10** shows examples of USSD services such as Covid-19 Test results and vaccination status.

As per **Figure 12**, Mbaza AI chatbot consists mainly of four iterations, starting with rule-based text chatbot and incrementally move towards conversational voice-based chatbot.

- **Iteration 1 (Figure 12.a): Rule-based Text Chatbot:** consists of a rule-based text chatbot, where users can have access to RBC's information and services via USSD, the application is connected to the RBC HMIS service and information are stored in the knowledge base which is updated regularly.
- **Iteration 2 (Figure 12.b): Conversational based Text Chatbot:** AI technology to allow users to have a conversation with the bot, with the options to allow the bot to transfer to an RBC agent at the request of the user or in case it is unable to answer a query.
- **Iteration 3 (Figure 12.c): Web based Voice chatbot:** connect the conversation chatbot to Text-To-Speech (TTS) and Automatic Speech Recognition (ASR) and they are link them to a website portal, allowing users using voice to interact with the voice chatbot
- **Iteration 4 (Figure 12.d): Conversational Voice chatbot:** consists of integration of the work done in the 3rd iteration with the Telephony system, where users using phone call will interact with the chatbot.

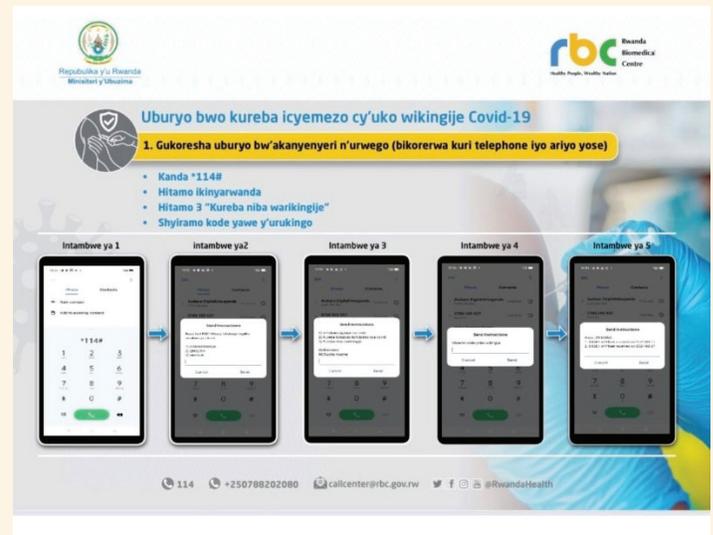


Figure 11: Example of Mbaza rule based chatbot available on 114 national Covid-19line on USSD providing information and services such as vaccination status checking, and Test results

