AFRICAN UNION
INTERAFRICAN BUREAU
FOR ANIMAL RESOURCES

EUROPEAN UNION

# Compendium of Technologies and Innovations applied in Priority Livestock Value Chains in Africa

*Technologically advancing livestock food systems for prosperity and posterity*



AFRICAN UNION
INTERAFRICAN BUREAU
FOR ANIMAL RESOURCES

EUROPEAN UNION

# Compendium of Technologies and Innovations applied in Priority Livestock Value Chains in Africa

*Technologically advancing livestock food systems for prosperity and posterity*

LiVe2Africa
Sustainable Development of Livestock for Livelihoods in Africa

**Recommended citation:**
AU-IBAR, 2022: Compendium of Technologies and Innovations applied in Priority Livestock Value Chains in Africa: *Technologically advancing livestock food systems for prosperity and posterity*. AU-IBAR Publication.

AU-IBAR
Kenindia Business Park
Museum Hill, Westlands Road
P.O. Box 30786-00100
Nairobi, Kenya

© 2022 African Union – Interafrican Bureau for Animal Resources (AU-IBAR)

**ISBN: 978-9966-077-44-8**

| | |
|---|---|
| **Lead Author:** | Dr. Mary N. Mbole-Kariuki<br>Technology, Innovations and Skill Development Expert,<br>African Union – Interafrican Bureau for Animal Resources (AU-IBAR) - Kenya |
| **Supporting Author:** | Prof. Anne W. Muigai<br>Deputy Vice Chancellor, Academics and Research<br>National Defence University - Kenya |
| **Editor:** | Elizabeth Obel-Lawson |
| **Design & Layout**: | Conrad Mudibo<br>Ecomedia |
| **Production:** | Bernard Bonyo<br>Digital Process Works<br>Email: dpw@cifor-icraf.org |

All rights reserved. Reproduction of material in this publication for resale or other commercial purposes is prohibited without written permission of the copyright holders. However, reproduction and dissemination for educational or other non-commercial purposes are authorized, provided the source is fully acknowledged. Requests for such permissions or additional information should be addressed to:
The Director, AU-IBAR or by email to ibar.office@au-ibar.org

# FOREWORD

Africa is home to a world of diverse Animal Genetic Resources (AnGR) that have contributed significantly to food and nutritional security and livelihoods for millions of people within and outside the continent. She is a livestock-rich continent that hosts approximately one-third of the world's livestock population. A significant proportion of Africa's inhabitants are dependent on livestock, with over 80 percent of the rural poor in agriculture being small holder livestock keepers.

The African livestock sector has been reported to contribute between 30 and 80 percent of countries' agricultural GDP, with over 350 million people being directly dependent on livestock for their incomes and livelihoods, especially in pastoral communities. Livestock products such as milk and meat have been rated as some of the richest sources of protein, contributing up to 13 percent of the world's calorie intake. Indeed, livestock holds promise to alleviate poverty and contribute significantly to food and nutritional security in Africa.

Continental strategic documents such as the African Union Agenda 2063, Livestock Development Strategy for Africa (LiDESA) and The Strategic Plan (2018-2023) of the African Union - Inter-African Bureau for Animal Resources (AU-IBAR) share common visons aimed at transforming Africa into a global powerhouse of the future. Key intervention areas include human and institutional capacity building; promotion of good governance structures, gender equality and youth empowerment; digitalization and private sector engagement; knowledge management and information sharing. The Africa Continental Free Trade Agreement (AfCFTA) aims to embrace digital trade in order to create an integrated and inclusive African market. The adoption of digital technologies across value chains' components will promote harmonization of regulations, standards and best practices.

Through the Compendium of Technologies and Innovations applied in Priority Livestock Value Chains in Africa, the African Union project on Sustainable Development of Livestock for Livelihoods in Africa (Live2Africa) has documented an average of 120 key innovations and technologies existing across priority livestock value chains in Africa. The Compendium is a valuable practical tool that draws on information supplied by all livestock value chain stakeholders drawn from the five African regions. The book aims at guiding national governments and livestock producers on a range of existing and emerging livestock technologies with special focus on their climate-smartness, environmental friendliness and gender inclusivity.

The knowledge published herein is a rich and useful resource to a wide audience including researchers, extension workers, students, policy makers and development practitioners. It is our hope that the untapped opportunities for Africa's development through livestock resources will be unlocked.

I call upon AU Member States, Regional Economic Communities, and technical and development partners to drive the wide dissemination of this publication and adoption of the knowledge shared herein as a way of life to transform the animal resources sector for Africa's prosperity and posterity.

*H.E AMB. Josefa Leonel Correia Sacko*

*Commissioner for Agriculture, Rural Development, Blue Economy*

*and Sustainable Environment (ARBE)*

# ACKNOWLEDGEMENTS

The African Union – Interafrican Bureau for Animal Resources (AU-IBAR) through the Sustainable Development of Livestock for Livelihoods in Africa – Live2Africa Project is grateful to the 55 African Union member states who provided indepth information on technologies and innovations that have been documented in this compendium.

Special recognition goes to all stakeholders who provided information through questionnaires and direct communication, and the technical experts drawn from across Africa who identified and described various gender sensitive, climate-smart and environmentally friendly technologies and innovations that are well suited for Africa's production systems. We greatly appreciate the national institutions, private sector, farmers, women and youth associations amongst others who willingly shared their indigenous knowledge, expertise and novel innovations with us and the continent at large.

In addition, we make special mention of the invaluable technical leadership offered by AU-IBAR's Technology, Innovations and Skill Development Expert, Dr. Mary Mbole-Kariuki, in the inception, drafting and finalization of this pioneer publication for Africa.

Lastly, special thanks goes to the European Union (EU) and African Union (AU) commisions for their financial support. Their personal involvment and dedication were a pre-condition for completing this publication within the expected time.

It is our hope that through this publication, the AU Agenda 2063 vision of "**The Africa We Want**" will be realized and Africa will champion technology and knowledge-based economies.

*Dr. Nick Nwankpa*
*Acting Director*
*African Union Interafrican Bureau for Animal Resources (AU-IBAR)*

# Contents


**Foreword** iii
**Acknowledgements** iv
**Acronyms and Abbreviations** vii
**Definitions and Glossary of Terms** ix
**Executive Summary** xi

**1 Introduction** 1
1.1 The Role of Technology and Innovation in Livestock Value Chains 2
1.2 The Role of Science, Technology and Innovation on Livestock Production 3
1.2.1 Climate change 3
1.2.2 Big Data, Internet of Things and advanced analytics technology 3
1.2.3 Early warning systems 4
1.2.4 Bridging technology adoption gaps 4
1.3 Climate-smart Agriculture (CSA) 4
1.4 Environmentally Friendly Agriculture 5
1.4.1 Agricultural land 5
1.4.2 Climate change 5
1.4.3 Deforestation 5
1.4.4 Soil degradation 6
1.4.5 Environmentally friendly agriculture 6
1.4.6 Waste 6
1.4.7 Irrigation 6
1.5 Impacts of COVID-19 on Livestock Production 7
1.5.1 Conflicts over resources 7
1.5.2 Disruption of supply chains 7
1.5.3 Cessation or reduction of movement of people and vehicles 7
1.5.4 Disruption of provision of veterinary services 8
1.5.5 Disruption of farmers' access to inputs, goods and markets 8
1.5.6 Closure of livestock markets 8
1.5.7 Reduction in number of animals being slaughtered in urban areas 9
1.5.8 Reduced access for farmers to animals 10
1.5.9 Disruption of national transport networks 10
1.6 Regional Priority Livestock Value Chains in Africa 10

**2 The Dairy Cattle Value Chain** 12
2.1 Technologies and Innovations targeting the Processing and Value Addition Components 13
2.2 Technologies and Innovations targeting the Marketing Component of the Value Chain 36
2.3 Technologies and Innovations targeting the Waste Management Component 39

**3 Red Meat and Dairy Livestock Value Chains Cross-cutting Technologies** 51
3.1 Technologies and Innovations targeting the Production Component 52
3.1.1 Breeding and reproduction 53
3.1.2 Feeding 72
3.1.3 Livestock identification and monitoring 95
3.2 Technologies and Innovations targeting the Inputs and Services Components 109
3.2.1 Health 110
3.2.2 Cold chain technologies 118

**4 The Poultry Value Chain 123**
4.1 Technologies and Innovations targeting the Production Component 124
4.1.1 Breeding and reproduction 125
4.2 Technologies and Innovations targeting the Inputs and Services Components 166
4.3 Technologies and Innovations targeting the Housing Component 173
4.4 Technologies and Innovations targeting the Processing and Value Addition Components 185

**5 The Apiculture Value Chain 188**
5.1 Technologies and Innovations targeting the Production Component 189
5.2 Technologies and Innovations targeting the Inputs and Services Components 219
5.3 Technologies and Innovations targeting the Processing and Value Addition Components 242
5.4 Technologies targeting the Trade and Markets Components 264

**6 Digital Innovations and Technologies transforming the Livestock Value Chains in Africa 274**

**7 Appendix 283**
List of Contributors 283

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AfCFTA | Africa Continental Free Trade Agreement |
| AI | Artificial insemination |
| AnGR | Animal Genetic Resources |
| ART | Assisted reproductive technologies |
| ASAL | Arid and semi-arid lands |
| ATM | Automated teller machine |
| AU-IBAR | African Union – Interafrican Bureau for Animal Resources |
| CAGR | Compound Annual Growth Rate |
| COVID-19 | Corona virus disease 2019 |
| CSA | Climate-smart agriculture |
| DLVC | Dairy Livestock Value Chain |
| EAC | East African Community |
| ECCAS | Economic Community of Central African States |
| ECOWAS | Economic Community of West African States |
| ET | Embryo transfer |
| FAO | Food and Agriculture Organization of the United Nations |
| GDP | Gross domestic product |
| GHG | Greenhouse gases |
| GPS | Global Positioning System |
| ICIPE | International Centre of Insect Physiology and Ecology |
| ICPALD | IGAD Center for Pastoral Areas and Livestock Development |
| ICT | Information and communications technology |
| ID | Identification |
| IGAD | Intergovernmental Authority on Development |
| ILRI | International Livestock Research Institute |
| KAGRC | Kenya Animal Genetic Resources Centre |

| | |
|---|---|
| KTBH | Kenya Top Bar Hive |
| LCD | Liquid-crystal display |
| LiDeSA | Livestock Development Strategy for Africa |
| Live2Africa | Sustainable Development of Livestock for Livelihoods in Africa |
| LPG | Liquified petroleum gas |
| LVC | Livestock value chain |
| M&E | Monitoring and evaluation |
| NARS | National agricultural research systems |
| PLVC | Poultry Livestock Value Chain |
| PPR | Peste des petits ruminant |
| PVC | Polyvinyl chloride |
| RECs | Regional Economic Communities |
| RFID | Radio-frequency identification |
| RMLALVC | Red Meat and Live Animal Livestock Value Chain |
| SADC | Southern Africa Development Community |
| SDGs | Sustainable Development Goals |
| SMS | Short Message Service |
| SOP | Standard operating procedures |
| SPIDES | Short Period of Incubation during Egg Storage |
| STI | Science, technology and innovation |
| STISA | Science, Technology and Innovation Strategy |
| SWOT | Strengths, weaknesses, opportunities and threats |
| TTBH | Tanzania Top Bar Hive |
| TUNADO | The Uganda National Apiculture Development Organisation |
| UHT | Ultra-high temperature |
| UMA | Union of Arab Maghreb |
| USD | United States dollar |
| VC | Value chain |
| WHO | World Health Organization |

# DEFINITIONS AND GLOSSARY OF TERMS

**Carbon footprint** refers to gaseous emissions brought about by human production or consumption activities such as carbon dioxide, methane and nitrous oxide that are relevant to climate change[1,2].

**Climate change** is defined as long-term changes in temperature, precipitation, wind patterns and other weather patterns experienced in a region[3].

**Climate-smart agriculture** is defined as agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces or removes greenhouse gases (mitigation) where possible and enhances achievement of national food security and development goals[4].

**Environmentally friendly agriculture** is defined as agricultural practices that reduce the negative impact of agriculture in a sustainable manner.

**Global warming** is defined as the rise in the earth's temperature which persists for a decade or longer[5].

**Greenhouse gases** are gases that absorb infrared radiation emitted from the earth's surface and reradiate it back to the earth's surface, thus contributing to the greenhouse effect.

**Innovation** is defined as the process by which individuals or organizations master and implement the design and production of goods and services that are new to them, irrespective of whether they are new to their competitors, country or the world[6].

An **innovation system** is defined as a network of organizations, enterprises and individuals that are focused on bringing new products, new processes and new forms of organization into economic use, together with the institutions and policies that effect their behaviour and performance[6].

An **innovator** is a person who has invented a gadget or service or used knowledge in a way that has not been used before in order to create value, address a specific need or improve a product or service that is used within the livestock value chain.

**Research** is the diligent and systematic inquiry or investigation that leads to the production of new knowledge.

---

1 Pertsova, C. C. (2007). Ecological economics research trends. Nova Publishers.
2 CHANGE, I P O C. (2005). IPCC expert meeting on emission scenarios.
3 Parry, M., Parry, M. L., Canziani, O., Palutikof, J., Van der Linden, P., & Hanson, C. (Eds.). (2007). Climate change 2007–impacts, adaptation and vulnerability: Working group II contribution to the fourth assessment report of the IPCC (Vol. 4). Cambridge University Press.
4 FAO. 2013a. Climate-smart agriculture: Sourcebook. Rome, Italy: Food and Agriculture Organization of the United Nations.
5 Houghton, J. (2009). Global warming: the complete briefing. Cambridge University Press.
6 Hall, A., Janssen, W. G., Pehu, E., & Rajalahti, R. (2006). Enhancing agricultural innovation: how to go beyond the strengthening of research systems (No. 36346, pp. 1-135). The World Bank. http://documents.worldbank.org/curated/en/492901468197385434/Enhancing-agricultural-innovation-how-to-go-beyond-the-strengthening-of-research-systems

**Technology** in the livestock value chain is a new method, system or device that has been developed through the use of scientific knowledge.

**Sustainable intensification** is defined as an agricultural process that simultaneously increases agricultural production while conserving and protecting the environment[7].

**Value chains** can be defined as a full range of activities that an agricultural product or service undergoes to bring it to a finalized product that is ready for delivery to consumers or for final disposure[8,9].

7 Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., ... & Pierzynski, G. (2018). Global assessment of agricultural system redesign for sustainable intensification. Nature Sustainability, 1(8), 441-446.
8 Kaplinsky, R. & Morris, M. (2012). A handbook for value chain research. IDRC, p. 6.
9 Miller, C. & Jones L. (2010). Agricultural value chain finance: Tools and lessons. Food and Agriculture Organization of the United Nations and Practical Action Publishing, pp. 8-9.

# EXECUTIVE SUMMARY

The five-year African Union project on "Sustainable Development of Livestock for Livelihoods in Africa (Live2Africa)" seeks to sustainably develop Africa's livestock genetic resources through seven components, one of which is the adoption of technology in livestock value chains. The project also seeks to enhance the utilization of technology and innovation in livestock production, and build the capacity of the livestock value chain actors while enhancing their entrepreneurial capacity. Furthermore, the project recognizes the impact of climate change and the need to enhance the utilization of environmentally friendly technologies and innovations that would enhance production while not harming the environment or increasing the impact of climate change.

This compendium is a compilation of technologies and innovations applied in livestock value chains (LVCs) in Africa. It presents technologies and innovations that already exist either in the developed world or in specific parts of Africa. They have been compiled into one document in order to provide a comprehensive reference document for African countries seeking to enhance and improve their LVCs. The compendium should assist national governments and African livestock producers to assess and select emerging technologies and innovations that would be best applied directly or with some modification into their specific LVC. Each technology and innovation was subjected to a strengths, weaknesses, opportunities and threats (SWOT) analysis, its availability in Africa was determined, and the primary users were identified. Suggestions were made on how the technology or innovation could be improved, and strategies were proposed on how they could be adopted by national governments. A deliberate effort was made to assess each technology and innovation so as to determine whether it was climate smart and environmentally friendly, which would not only protect the environment, but also encourage the use of technologies and innovations that would have a greater impact in mitigating the adverse effects of climate change.

The information contained herein was collected through a questionnaire disseminated to stakeholders in all regions of the continent and supplemented through a desktop study.

The report is divided into six sections. Chapter 1 provides an introduction on the role of technology and innovation in LVCs and that of science, technology and innovation (STI) on livestock production, highlighting the emerging roles of climate change mitigation, climate and environmentally smart agriculture. The COVID-19 pandemic was experienced during the compilation of this report and this necessitated a discussion on its impact on livestock production at the end of this chapter.

Chapters 2 to 5 outline technologies and innovations in priority LVCs specifically highlighting those that target the production, input and services, processing and value addition, and trade and markets components.

Chapter 2 outlines technologies and innovations in the dairy cattle VC, while Chapter 3 details the technologies and innovations in the red meat and dairy livestock VCs cross-cutting technologies.

Chapter 4 expounds on the cross-cutting technologies and innovations used across the poultry VC.

Chapter 5 outlines the technologies and innovations in the apiculture VC, and lastly, Chapter 6 focuses on digital innovations and technologies transforming the LVCs in Africa.

# 1 INTRODUCTION

Africa's current population has been estimated to be 1.3 billion based on March 2020 estimates provided by the United Nations[1]. Thus, Africa is the second most populous region of the world after Asia, with 16.72 percent of the world's population[1]. This, combined with an estimated increase in the gross domestic product (GDP) growth rates of African nations, from the present growth rates of 4.6 percent in 2010 to over 5 percent in the coming years[2], has led to projections that in the year 2030, the African GDP will be approximately 20 percent[3] with over 1.5 billion Africans on the continent, of which 48 percent will be living in urban centres compared to 39 percent in 2010[4, 5].

The World Bank estimates that the number of Africans living on less than USD 1.90 per day reduced from 57 percent in 1990 to 43 percent in 2012[6]. However, owing to the rapid population growth experienced, the number of poor people has increased from 280 million in 1990 to 330 million in 2012, with rural areas experiencing more poverty than urban areas[6]. Reports have shown that in the 21st Century, agriculture remains fundamental to reducing poverty, driving economic growth and achieving environmentally sustainable agriculture[7].

Livestock production can play a very significant role in reducing poverty and increasing incomes at the household level[8,9]. Livestock also play a significant role in African nations' economies by contributing to the agricultural GDP, bringing in much-needed foreign exchange earnings, and feeding, employing and providing a source of livelihood to millions of Africans. The "Livestock Revolution" discourse[10] points to rising incomes and urbanization in developing countries including Africa, resulting in an increased demand for livestock and livestock products including meat and milk.

Although African meat and milk markets are not as large as those witnessed in other regions of the world, the African meat and milk market is estimated to reach 34.8 and 82.6 million tons of meat and milk, respectively, in 2050, with an estimated 24.3 and 50.2 million tons of meat and milk being consumed[11]. It has been estimated that the value of agriculture and agribusiness industries in sub-Saharan Africa will grow from USD 313 billion in 2010 to USD one trillion in 2030[11], a greater part of it being contributed by livestock.

1 United Nations, Department of Economic and Social Affairs, Population Division. (2019). World Population Prospects 2019: Highlights (ST/ESA/SER.A/423).
2 Pica-Ciamarra, U., Baker, D., Morgan, N., Ly, C., &. Nouala, S. (2013). Investing in African livestock: Business opportunities in 2030-2050. Livestock Data Innovation in Africa Project. A joint initiative of the World Bank, FAO, ILRI, AU-IBAR with support from the Bill and Melinda Gates Foundation, Seattle, WA. pp. 1-14.
3 Obeng-Odoom, F. (2020). The African Continental Free Trade Area. American Journal of Economics and Sociology, 79(1), 167-197.
4 UN. (2011) World Population Prospects: The 2010 Revision. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, New York.
5 UN. (2012). World Urbanization Prospects: The 2011 Revision. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, New York.
6 Beegle, K., Christiaensen, L., Dabalen, A., & Gaddis, I. (2016). Poverty in a rising Africa. World Bank, Washington, D.C.
7 World Bank. (2008). World Development Report 2008: Agriculture for development. World Bank, Washington, D.C, USA.
8 Food and Agriculture Organization of the United Nations. (2009). The state of food and agriculture: Livestock in the balance. Roma, Itália: FAO.
9 McDermott, J. J., Staal, S. J., Freeman, H. A., Herrero, M., & Van de Steeg, J. A. (2010). Sustaining intensification of smallholder livestock systems in the tropics. Livestock Science, 130(1-3), 95-109.
10 Delgado, C. L., Rosegrant, M. W., Steinfeld, H., Ehui, S. K., & Courbois, C. B. (1999). The coming livestock revolution. Choices, 14(316-2016-7248).
11 World Bank. (2013). Growing Africa: Unlocking the potential of agribusiness. Washington D.C.: World Bank.

There are indications that local demand for livestock products will increase during this period[2], thus presenting a challenge on how to bridge the gap between production and demand for animal-sourced food products.

Available data indicate that Africa will, over time, increasingly become a net importer of meat and animal products, with estimated increases of 0.9 to almost 5 million tons between 2005/07 and 2050 where non-African livestock producers are estimated to contribute between 12 and 15 percent of the meat and meat products consumed within Africa[12].

To address these challenges, approaches that can be used include developing and improving existing livestock value chains (LVCs) and including science, technology and innovation (STI) in all LVCs. This will lead to higher production that will translate into affordable protein-based foods. Investments in livestock production will have direct impacts on the development of agro-industries and VCs that generate alternative employment to farming[13,14,15,16,17,18].

## 1.1 The Role of Technology and Innovation in Livestock Value Chains

Africa is experiencing rapid growth in the demand for livestock and livestock products, fuelled by increases in per capita income and urbanization[19]. The end result is a higher demand for livestock products than can be met by local production[20, 21]. To address this challenge, there needs to be a greater investment in the use of technology and innovation within the livestock value chain (LVC).

Technology and innovation is indispensable for increasing livestock production and is especially important for Africa because it has been shown to drive economic growth. In the agricultural sector, and specifically in LVCs, the use of technologies and innovations cannot be under-estimated. This is especially true because technologies and innovations have been found to be crucial in accelerating benefits across LVCs with the result of bringing significant benefits to livestock producers. Opportunities also exist for technology to strengthen LVCs. Direct benefits of using technology and innovation would be realized when locally produced livestock feeds and materials are used.

With the decreased costs of ICT infrastructure and its rapid expansion into most regions of Africa, ICT could potentially make livestock and their products easily accessible to more people.

12 Pica-Ciamarra, U., Baker, D., Morgan, N., Ly, C. & Nouala, S. (2013). Investing in African livestock: Business opportunities in 2030-2050. Livestock Data Innovation in Africa Project. A joint initiative of the World Bank, FAO, ILRI, AU-IBAR with support from the Bill and Melinda Gates Foundation, Seattle, WA. pp. 1-14.
13 World Bank. (2008). World Development Report 2008: Agriculture for Development. Washington D.C.: World Bank.
14 Christiansen L., Demery, L. & Kuhl, J. (2011). The (evolving) role of agriculture in poverty reduction — an empirical perspective. Journal of Development Economics, 96: 239-254.
15 UNIDO. (2011). Agribusiness for Africa's Prosperity. Wien: UNIDO.
16 World Bank. (2013). World Development Report 2013: Jobs. Washington D.C.: World Bank.
17 APP. (2012). Africa Progress Report 2012. Jobs, Justice and Equity. Geneva: Africa Progress Panel.
18 UNECA. (2012). Report on livestock value chains in Eastern and Southern Africa. Addis Ababa: UNECA.
19 Smith, J., Co-convener, I., & Nouala, S. (2015). African livestock transformation, presented at Feeding Africa, 21-23 October 2015, Dakar, Senegal.
20 Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., & Tempio, G. (2013). Tackling climate change through livestock: a global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO).
21 https://water.unl.edu/article/animal-manure-management/reducing-greenhouse-gas-emissions-cattle-production

The role of STI has been established to be a key driver of economic development. Indeed, STI has been identified as one of the key pillars for achievement of the UN Sustainable Development Goals (SDGs). Africa therefore needs to embrace the STI culture in order to achieve food security. The African Union (AU) recognized the critical role played by STI for Africa's development agenda and adopted a 10-year Science, Technology and Innovation Strategy (STISA-2024). The strategy recognizes that STI are enablers for achieving the AU Agenda 2063 which focuses on the need to diversify African nations' sources of growth, thus ensuring that Africans are lifted out of poverty.

The role of STI in agriculture includes climate change mitigation; Big Data and the Internet of Things; and early warning systems.

## 1.2 The Role of Science, Technology and Innovation on Livestock Production

### 1.2.1 Climate change

Science, Technology and Innovation (STI) for climate change mitigation should be less about developing new agricultural practices and instead entail availing current information and skills that would support sustainable intensification. This would involve technology transfer and adoption of new social and technological skills. Adoption of locally adapted livestock breeds should be emphasized because of their potential to support climate change adaptation in livestock production.

### 1.2.2 Big Data, Internet of Things and advanced analytics technology

Emerging agricultural technologies and applications such as farmer decision support, precision farming, insurance, and access to market information can harness the power provided by Big Data, the Internet of Things and advanced analytics technology[22]. The most common applications in this area include:

- **Sensor-based systems.** These are real time sensor-based systems that have direct application along livestock value chains and are able to monitor production parameters.
- **Smart agriculture.** This is agriculture that employs the use of vehicles, drones, vehicles, autonomous robots and actuators.
- **Smart agricultural spaces.** Examples include those involved in smart fodder production systems found in greenhouses and hydroponics.
- **Data visualization, management and collection systems.** These provide statistics and data that have not been previously possible to collect.
- **Animal health and welfare.** This can be improved through leveraging on ICT and the Internet of Things, thus mitigating effects that may be experienced through intensifying livestock farming systems.

Stakeholder concerns on data security, data ownership, transparency[23] and access to internet should be resolved at regional and international levels in order to maximize benefits to small-holder African farmers.

22 UNCTAD. (2017). The role of science, technology and innovation in ensuring food security by 2030. United Nations.
23 UNCTAD. (2017). The role of science, technology and innovation in ensuring food security by 2030. United Nations.

### 1.2.3 Early warning systems

Global climate information plays a crucial role in providing accurate and reliable climate information. This includes early warning systems for drought, famine, floods or other unfavorable weather. Such information when fed into livestock production has a great impact on increasing productivity and mitigating against livestock losses.

### 1.2.4 Bridging technology adoption gaps

The adoption of livestock production as a path for resource-poor farmers to get out of poverty and food insecurity is hindered by the farmers' inability to increase the production of their animals and their slow pace to adopt new livestock production methods that use new and emerging technologies and innovations. Capacity building for farmers needs to be a continuous process that integrates entrepreneurship training, market information, and technical training, targeting women and youth.

## 1.3 Climate-Smart Agriculture (CSA)

The negative effects of climate change are already being experienced in many parts of Africa where reduced crop yields and shrinking grasslands are affecting production. This is compounded by the fact that agriculture and livestock generate 19-29 percent[24,25] and 14.5 percent[26] of the total greenhouse gases respectively.

The three goals of climate-smart agriculture (CSA) are: first, to increase agricultural productivity that would result in increased incomes, increased food security and development; second, to reduce risks faced by farmers while increasing their ability to adapt to stresses; and third, to reduce GHG emissions and increasing carbon sinks.[27]

Livestock production is responsible for the production of greenhouse gases (GHG) estimated at 7.1 gigatons of carbon dioxide-equivalents per year accounting for 14 percent of all human-induced emissions[28]. Adopting CSA for livestock production involves reducing GHG emissions from livestock. Strategies that have been proposed for this include: first, adopting new types of feeds developed for the growth stage and needs of the animals, thus reducing losses of nutrients in manure; second, increasing the digestibility of the feeds; third, reducing the potential of feeds to produce GHG by adding specific additives; and fourth, managing livestock waste, especially manure and urine to reduce GHG emissions by adopting measures such as covering the manure, composting, aeration, adding additives to reduce GHG emissions, and installing anaerobic digestors to produce biogas[29].

24 US-EPA: United States Environmental Protection Agency. (2011). Global anthropogenic non-CO2 greenhouse gas emissions: 1990 – 2030 EPA 430-D-11-003. (Draft.) Office of Atmospheric Programs, Climate Change Division. Washington, D.C.: US Environmental Protection Agency. (Available from http://www.epa.gov/climatechange/EPAactivities/economics/nonco2projections.html)

25 Vermeulen, S.J., Campbell, B.M., & Ingram, J. S.I. (2012). Climate change and food systems. Annual Review of Environmental Resources 37. (Available from http://www.annualreviews.org/doi/abs/10.1146/annurev-environ-020411-130608)

26 Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., ... & Tempio, G. (2013). Tackling climate change through livestock: a global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO).

27 Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., ... & Hottle, R. (2014). Climate-smart agriculture for food security. Nature Climate Change, 4(12), 1068-1072.

28 Grossi, G., Goglio, P., Vitali, A., & Williams, A. G. (2019). Livestock and climate change: impact of livestock on climate and mitigation strategies. Animal Frontiers, 9(1), 69-76.

29 Garnett, T. (2009). Livestock-related greenhouse gas emissions: impacts and options for policy makers. Environmental Science & Policy, 12(4), 491-503.

## 1.4 Environmentally Friendly Agriculture

Agriculture is a human activity that has great potential to destroy the environment. The environmental impact of agriculture is measured according to agriculture's impact on water, soil, air, animal and plant diversity, and the quality of food itself.

The adverse effects of agriculture and food production on the environment include the following:

### 1.4.1 Agricultural land

Agriculture occupies approximately 50 percent of the world's habitable land, the rest being taken up by forests (37 percent), grasslands and shrubs (11 percent) fresh water coverage (1 percent) and the remaining 1 percent is urbanized built-up areas. The land occupied by livestock can take up to 77 percent of agricultural land if crop and grazing lands are combined. Expansion of agricultural land poses the greatest threat to the environment with its destruction or transformation of the ecosystem causing the biggest impact on the earth's biodiversity.

### 1.4.2 Climate change

Agricultural practices have been shown over time to have significant impacts on the climate and to be drivers of climate change. This occurs mainly through the production and release of greenhouse gases such as carbon dioxide, methane and nitrous oxide, the use of fertilizers, land tillage, and use of agro-chemicals, especially pesticides[30]. All these factors have been found to affect the environment, water and air quality. They also remove, repel or kill naturally occurring plants, animals and insects, thus affecting natural biodiversity. It is well documented that the overuse of pesticides in agriculture has resulted in the drastic reduction of the worldwide bee population, raising concerns on the impact of this on agricultural production[31]. As mentioned above, agriculture has been reported to be the main contributor to methane and nitrous oxide concentrations in the earth's atmosphere[32].

### 1.4.3 Deforestation

Increasing the land under agriculture for both pasture and crop production is a way of increasing agricultural production. Reports indicate that subsistence farming contributed to 48 percent of deforestation, while commercial agriculture contributed 32 percent, logging, 14 percent, and fuel wood removal, up to 5 percent[33]. Impacts of deforestation include habitat loss for millions of plant, animal and microbial species. Deforestation also results in the loss of trees, which remove carbon dioxide and other greenhouse gases from the environment, therefore intensifying climate change[34].

30 Van der Werf, Hayo M.G., & Jean Petit. Evaluation of the environmental impact of agriculture at the farm level: a comparison and analysis of 12 indicator-based methods. Agriculture, Ecosystems & Environment 93.1-3 (2002): 131-145.

31 Woodcock, B. A., Bullock, J. M., Shore, R. F., Heard, M. S., Pereira, M. G., Redhead, J., ... & Peyton, J. (2017). Country-specific effects of neonicotinoid pesticides on honey bees and wild bees. Science, 356(6345), 1393-1395.

32 Awuchi, C. G., Awuchi, C. G., Ukpe, A. E., Asoegwu, C. R., Uyo, C. N., & Ngoka, K. E. Environmental Impacts of food and agricultural Production: A Systematic Review.

33 United Nations Framework Convention on Climate Change. (2007). Investment and Financial Flows to Address Climate Change.

34 Awuchi, C. G., Twinomuhwezi, H., Awuchi, C. G., Igwe, V. S., & Amagwula, I. O. (2020). Industrial waste management, treatment, and health issues: Wastewater, solid, and electronic wastes.

### 1.4.4 Soil degradation

Soil degradation is defined as the decrease in soil quality as a result of human activity. Most of the earth's biodiversity is found in soils, and healthy soils are necessary for the production of food, agricultural activities, including availability of grasslands for livestock, and the supply of water[35]. Agriculture has been found to be the main reason for soil degradation through agricultural practices that lead to erosion, compaction, pesticide contamination, salting, waterlogging, fertility loss, and changes in soil pH – alkalinity, acidity or salinity[36].

### 1.4.5 Environmentally friendly agriculture

Environmentally friendly agriculture is defined as agricultural practices that reduce the negative impact of agriculture in a sustainable manner. Agricultural practices that only emphasize intensification have been found to have the highest adverse effect on the environment[37]. However, those with a focus on "sustainable intensification", where there is an increase in production without adverse effects on the environment – through the incorporation of the better use of land, water, biodiversity, labour, knowledge and technology – have a better impact on the environment.

### 1.4.6 Waste

Agriculture used an estimated two percent of the global plastic production in 2010[38] and plastic use is reported to be on the steady increase. Applications of plastics in agriculture include plastic pots, greenhouse covering, tunnel lining, irrigation systems, silage production, mulching, plastic water reservoirs, crates for crop collection, and nets for greenhouse shading, fishing, wind breaking and fruit picking, among others[39].

The use of plastics in agriculture provides many benefits. However, these plastics cause serious pollution of the environment. Its use on farms encourages a high rate of rain runoff containing fertile soils and pesticides towards wetlands and rivers that can cause heavy silting of rivers and death of fish and other marine and fresh water fauna. The disposal of plastics waste from farms presents a challenge, with most of it ending up on landfills[40]. The use of biodegradable plastics also presents a challenge owing to the time it takes to degrade[41].

### 1.4.7 Irrigation

The primary effects of irrigation can be classified as direct[42], for example, reduction of downstream river flow, increased evaporation of water on the irrigated land and increased

35 Awuchi, C. G., Twinomuhwezi, H., Awuchi, C. G., Igwe, V. S., & Amagwula, I. O. (2020). Industrial waste management, treatment, and health issues: Wastewater, solid, and electronic wastes.
36 Awuchi, C. G., Twinomuhwezi, H., Awuchi, C. G., Igwe, V. S., & Amagwula, I. O. (2020). Industrial waste management, treatment, and health issues: Wastewater, solid, and electronic wastes.
37 Collier, W. L., Wiradi, G., & Soentoros. (1973). Recent changes in rice harvesting methods. Some serious social implications. Bulletin of Indonesian Economic Studies, 9(2), 36-45.
38 Vox, G., Loisi, R. V., Blanco, I., Mugnozza, G. S., & Schettini, E. (2016). Mapping of agriculture plastic waste. Agriculture and Agricultural Science Procedia, 8, 583-591.
39 Scarascia-Mugnozza, G., Sica, C., & Russo, G. (2011). Plastic materials in European agriculture: Actual use and perspectives. Journal of Agricultural Engineering, 42(3), 15-28.
40 Godswill, A. C., Gospel, A. C., Otuosorochi, A. I., & Somtochukwu, I. V. (2020). Industrial and community waste management: Global perspective. American Journal of Physical Sciences, 1(1), 1-16.
41 Hemphill, D. D. (1993). Agricultural plastics as solid waste: What are the options for disposal? HortTechnology, 3(1), 70-73.
42 Rosenberg, D. M., McCully, P., & Pringle, C. M. (2000). Global-scale environmental effects of hydrological alterations: Introduction. BioScience, 50(9), 746-751.

water table level through groundwater recharge; or indirect, for example waterlogging, soil salination, ecological damage and socio-economic impacts.

## 1.5 Impacts of COVID-19 on Livestock Production

The COVID-19 pandemic presents an international emergency that has brought grave danger to the society. Parts of this society are African livestock producers who have directly and indirectly experienced the negative impacts of COVID-19. African livestock contribute directly to food security at the household and national levels and the effects of the pandemic on this continue to be felt and need to be mitigated in order to avoid producing permanent adverse effects. The following areas have been reported as those that have been impacted by COVID-19.

### 1.5.1 Conflicts over resources

The restriction of movement of people imposed by most Africa nations has resulted in transhumant pastoralists overstaying in areas where they would not normally be found during the particular season. This has led to overgrazing and conflict over water with local semi-sedentary pastoralists[43]. Other long-term effects that will continue to be felt include overgrazing and potential destruction of the environment around the camps made by the transhumanists.

#### Mitigation strategies

Mitigation in this area will need the intervention of local and community leaders to preach tolerance and peace during this time of the COVID-19 pandemic. The pastoralists should also be encouraged to leave these areas as soon as possible.

### 1.5.2 Disruption of supply chains

Supply chains of most of the veterinary supplies including medicines and vaccines were disrupted owing to the closing of borders and the reduction or cessation of international flights into many African nations[44]. This caused spikes in local prices for most of these goods, making them too expensive for many farmers.

#### Mitigation strategies

Supply chains involving veterinary drugs, feed and vaccines should be identified and classified as essential services. Transport of such essential goods across borders should also be facilitated.

### 1.5.3 Cessation or reduction of movement of people and vehicles

The reduction and cessation of the movement of people and goods across localities and borders has interrupted the movement of supplies, occasioning long delays at border points[45]. This has resulted in higher delivery costs of feed, veterinary drugs and vaccines.

43 https://icpald.org/effects-of-covid-on-livestock/
44 https://icpald.org/effects-of-covid-on-livestock/
45 https://icpald.org/effects-of-covid-on-livestock/

### Mitigation strategies

National governments need to develop protocols that can facilitate the movement of goods and lorries across borders.

## 1.5.4 Disruption of provision of veterinary services

In many regions, veterinary service providers have been unable to access farmers and their animals and have consequently stopped providing veterinary services[46]. In many countries, vaccination programmes have also been brought to a halt, exposing many livestock to diseases. This is a concern because African countries are at risk of disease outbreaks of Foot and Mouth Disease, Lumpy Skin Disease, African Swine Fever, Rift Valley Fever (RVF) and Peste des Petits Ruminants (PPR).

### Mitigation strategies

Veterinary services and veterinary service providers need to be listed as essential service providers. This would allow them to continue with vaccination exercises and provide veterinary services to farmers.

## 1.5.5 Disruption of farmers' access to inputs, goods and markets

The cessation of movement has prevented farmers from accessing farm inputs including animal feed[47]. This has left farmers vulnerable and open to exploitation especially with regard to livestock products with a short shelf life such as milk and eggs.

### Mitigation strategies

- The effects of this disruption can be mitigated if the national governments could develop procedures on how goods can move seamlessly across their borders.
- The governments should also consider lowering government-imposed taxes on all farm goods and products in order to cushion the farmers against high transport costs.
- Veterinary services and veterinary service providers in many countries have not been categorized as essential services. Doing this would facilitate their movements, allowing them to provide services.

## 1.5.6 Closure of livestock markets

To enforce social distancing, most livestock markets in Africa were closed. With these closures, perhaps one of the greatest effects of the pandemic is that the farmers are unable to sell their livestock in open markets where good prices are almost guaranteed. The prices of livestock dropped drastically, with reports of prices dropping by between 40 and 60 percent in certain regions[48]. A decrease in livestock prices at a time when the prices of grains, cereals and household commodities have drastically increased means that pastoralists have to sell more animals to enable them buy the same amount of food that they purchased in previous years.

46 https://icpald.org/effects-of-covid-on-livestock/
47 https://icpald.org/effects-of-covid-on-livestock/
48 https://icpald.org/effects-of-covid-on-livestock/

### Mitigation strategies

- African pastoralists, who are already vulnerable, need to be cushioned against any reduction in household incomes through the establishment of national funds that can provide support to pastoralists, either through cash-for-work programmes or including them in other social protection funds.
- Governments and private sector need to work together with livestock farmer organizations and establish virtual, electronic trading platforms that would allow traders and aggregators in private farmers to interact on virtual platforms. This would enable trading by transporters, slaughterhouses and other value chain actors with access to livestock.
- Some African countries, namely Egypt, Tunisia and Morocco have planned to give one-time payments to informal workers and sellers in local markets[49].
- Some countries, for example, Morocco have established virtual markets for local producers who were affected when agricultural fairs were cancelled[50].

## 1.5.7 Reduction in number of animals being slaughtered in urban areas

Reports indicate that many slaughterhouses are operating at less than 50 percent of their previous capacity[51]. In Kenya, the IGAD Center for Pastoral Areas and Livestock Development (ICPALD)[52] reports that major slaughterhouses in Kenya are operating at between 40 and 60 percent capacity, with some reporting that they are operating at between 30 and 40 percent capacity. This is caused by the cessation of movement that has disrupted the slaughterhouse supply chain of live animals. However, it is also important to note that many urban households have reported reduced income, thus affecting their ability to afford meat and other livestock products. Demand for meat and other livestock products has decreased owing to closure of hotels and restaurants, collapse of tourism – both domestic and international – and a general slowdown of national economies.

### Mitigation strategies

- African economies rely heavily on agriculture including livestock production. Strategies on how African economies can be supported to recover need to be developed. Such strategies should include national efforts to open up economies and support small-scale livestock producers and pastoralists.
- Slaughter houses should be established in areas inhabited by pastoralists. Thus, governments need to encourage private sector and other investors to establish these slaughter houses.
- Governments should develop seamless cold-chain supply chains where chilled and/or frozen carcasses can be transported from these slaughterhouses to urban centres.

49 FAO. (2020). Mitigating the impacts of COVID-19 under a CC BY-NC-SA 3.0 IGO licence on the livestock sector. Rome. https://doi.org/10.4060/ca8799en
50 FAO. (2020). Mitigating the impacts of COVID-19 under a CC BY-NC-SA 3.0 IGO licence on the livestock sector. Rome. https://doi.org/10.4060/ca8799en
51 https://icpald.org/effects-of-covid-on-livestock/
52 https://icpald.org/effects-of-covid-on-livestock/

- Governments should develop export strategies where live animals and frozen carcasses can be exported to external markets, especially the Middle East countries.

### 1.5.8 Reduced access for farmers to animals

Cessation of movement has reduced the farmer's contact with his animals, especially if the animals were kept in a separate area to where the farmer resides. Cessation has also resulted in increases in hired labour costs owing to labour shortages[53].

#### Mitigation strategies

National governments need to outline COVID-19 measures that can allow farmers access their animals.

### 1.5.9 Disruption of national transport networks

The restriction of movements has resulted in a disruption of national transport networks, leading to a reduced supply of livestock and livestock products.

#### Mitigation strategies

The provision of food, including of livestock and livestock products should be listed as an essential service. This would allow the movement of these goods into markets, thus providing farmers with some income.

## 1.6 Regional Priority Livestock Value Chains in Africa

As earlier stated, the number of Africans who live on less than USD 1.90 and have been classified as poor is increasing in rural areas. Poverty is mainly a rural phenomenon and in sub-Saharan Africa it accounts for 75 percent of the extremely poor[54]. These poor households are mainly livestock keepers and pastoralists who keep some livestock such as cattle, goats, sheep and chicken. Therefore, any strategy adopted should include these livestock species because of their potential to impact these vulnerable groups.

In renewing their commitment to agriculture-led economic growth and inclusive development, African Union Heads of State and Government underscored the importance of elevating the livestock sector so as to harness its full potential. This led to the development of the Livestock Development Strategy for Africa (LiDeSA) in order to raise the profile of the sector, and to attract commensurate investment to the potential contribution of the livestock sector to Africa's economic growth and development objectives.

To kick start its continental contribution to the implementation of the 20-year LiDeSA (2015-2035), AU-IBAR launched the Live2Africa Project which expounds the four pillars of LiDeSA into seven results. The Live2Africa Project seeks to deliver catalytic action that will trigger both commercialization and an inclusive livestock sector transformation at continental scale. The Live2Africa project takes a livestock value chain approach that has the greatest transformation potential to address areas of weakness as well as establish intervention areas that will generate value at each segment.

53 https://icpald.org/effects-of-covid-on-livestock/
54 AfDB. (2013). African Statistical Yearbook 2013. Tunis: African Development Bank.

Through continental prioritization exercises held in 2018, three regional priority livestock value chains across the six Regional Economic Communities (RECs) were identified as follows:

i. **Dairy Livestock Value Chain (DLVC)** - the East African Community (EAC) and the Union of Arab Maghreb (UMA)+Egypt

ii. **Poultry Livestock Value Chain (PLVC) (Egg and Meat)** - the Economic Community of West African States (ECOWAS) and the Economic Community of Central African States (ECCAS)

iii. **Red Meat and Live Animal Livestock Value Chai (RMLALVC)** - the Intergovernmental Authority on Development (IGAD) and the Southern Africa Development Community (SADC)

Currently, the need to drive the adoption of a market-oriented value chain approach has risen. It has been emphasized that through this action, interventions that are demand driven and meet market requirements should be promoted. This approach will encourage greater productivity, improve supply linkages, strengthen relationships among suppliers, and attract investment across the whole value chain, ultimately leading to increased incomes for all actors. Therefore, to enhance value chain efficiency, there is need to embrace the use of technologies and innovations across each segment. This publication provides insights to member states in the use of various technologies and innovations across the three priority value chains.

# 2 The Dairy Cattle Value Chain



# 2.1 Technologies and Innovations targeting the Processing and Value Addition Components

## 2.1.1 Technology options for small-scale processing of milk into yogurt and cheese for Africa

African pastoral communities have for thousands of years produced cheese and yogurt as sources of food and as a way to preserve milk. Pasteurization and commercial dairy industries are recent developments and are not as old as traditional milk preservation practices performed by indigenous communities. Present day milk preservation products include pasteurized milk, yogurt, cultured milks and cheese. To make these, several technologies have been developed. These include:

- Cream separator
- Butter churn
- Milk yogurt
- The manual yogurt cup filler and separator

# The portable milking machine

### Primary use of the technology/innovation

Milking machines are machines used to harvest milk from the udders of cows. They have been in use for the last 25 years in the developed world where shortages of skilled labour, high labour costs and concerns about milk quality have driven their use. In Africa however, where the herds are small and labour is cheap, the adoption has been slow.



AU-IBAR

*A portable milking machine*

## SWOT analysis of the technology/innovation

### Strengths

The portable milking machine is easily available, easy to install and use and has low maintenance costs. It ensures the fast milking of cows, thus improving efficiency and this could encourage farmers to increase their herd sizes. It also ensures the rapid milking of many cows, thus saving time, while guaranteeing the quality of milk. The technology has the advantage of reducing labour costs and greatly reduces a farmer's dependency on manual labourers. It allows for the effective management of milking, thus reducing stress on the cows.

### Weaknesses

The system is not fully automated and still needs a skilled technician to operate it and to move the machine in between animals. Animals are required to wait their turn for milking and this has the negative result of creating high stress levels that can affect the quality and quantity of milk. The technology is also heavily dependent on a reliable source of electricity, which is not available in many parts of Africa. When electric power is not available the farmer has to resort to manual milking. The portable milking machine also calls for a strict cleaning regimen to prevent the spread of pathogenic microorganisms.

### Opportunities

The steady increase in the international world prices for milk and milk products creates a tremendous opportunity for African farmers. Milk production in Africa is on the increase, with Eastern Africa being the leading milk producing region in Africa, producing 68 percent of Africa's milk. The dairy sector is one of the fastest growing agricultural sub-sectors in Africa, creating high economic returns and employment opportunities along the dairy value chain.

### Threats

The high cost of the portable milking machine threatens its widespread use. It requires a strict cleaning regimen which if not followed leads to milk spoilage. This may be a challenge in parts of Africa where water shortages are experienced.

## Local availability of the technology/innovation and potential suppliers across Africa

Portable milking machines are locally available for purchase in most regions of Africa from local or international sellers.

## Primary users of the technology/innovation

The primary cattle owners in Africa are the men and hence make the decisions on the cattle. They are also the ones who often have the resources to purchase the equipment. While the men may be the owners of the technology, it is often the responsibility of the women to milk the cows and manage the labour on the farm. This equipment would therefore be of special interest to women due to the advantages it offers in saving time and labour. However, women are not often in a position to purchase this equipment.

### Climate-smart status of the technology/innovation

This technology is climate smart because it promotes locally adapted breeds and breeding programmes, especially breeds with important traits such as those linked to milk and meat production, disease resistance and heat tolerance. It therefore supports the breeding and sustainable use of indigenous breeds. It also supports herd management and herd age structure.

### Environmentally friendly status of the technology/innovation

The portable milking machine milks more milk per cow than manual milking, thus reducing wastage. Its use also ensures high milk quality, thereby reducing milk loss arising from contamination and poor handling.

### Suggestions for improvement of the technology/innovation

Development of portable milking machines that can be implemented in small-holder farms, with two to four animals would be a great improvement to this technology. These would need to be integrated with alternative energy sources such as batteries, for use in regions where there is no electricity.

### Strategies that can be adopted by national governments to promote the uptake of portable milking machines

To increase milk production at the local level and hence spur investments in the dairy sector, including the purchase of portable milking machines (popularly referred to as milk ATMs (automated teller machine), national governments should create an enabling environment within the dairy sector through strategies such as:

- Developing clear policy framework and regulations that would create an innovative, productive and profitable dairy sector
- Developing regulations detailing safety, quality and animal welfare standards
- Creating an environment for private sector investment to drive growth in the dairy sector, create employment and spur innovation along the dairy value chain
- Direct investments by national governments in the dairy sector
- Developing intra-Africa trade of dairy products through development of partnerships
- Active engagement of pastoralists and crop farmers with a view to reducing conflicts experienced between pastoralists
- Developing financing options that target farmers and farmer organizations

# Voluntary milking machine

## Primary use of the technology/innovation

A voluntary milking system is a farm milking system that allows for voluntary visits by the cow for milking. A cow can visit more than twice a day, with some cows visiting up to four times a day. Their motivation is the special feed waiting for them at the milking station. Sensors and weighing scales prevent cows from repeatedly going just for the special feed when their udders are not full. These systems have been found to milk approximately 15 percent more milk than the breed average, with higher protein and butter content. This outcome has been attributed to the fact that cows are very contented and stress free, thus allowing more milk to be let down. This system differs from the portable milking machine in that the system, from cleaning the teats, attaching milking equipment to the teats, massaging the udder to release milk, to directing the cow out of the parlour, is fully automated. Newer systems integrated with Artificial Intelligence (AI) offer the additional benefit of collecting data from individual cows on milk production, cow health and activity.



AU-IBAR

*Voluntary milking station with feeding troughs*

## SWOT analysis of the technology/innovation

### Strengths

The voluntary milking machine encourages a cow to follow her natural biorhythm, thus encouraging her to go for milking when she is ready rather than following the strict schedule on a farm. The regular milking has been found to increase udder health, decrease mastitis and to reduce the cow's stress level, thus ensuring a higher milk production. The milking process is completely automated with limited human intervention at the milking stations. It frees up manual labour which has been estimated to be about five hours a day. Milk is hygienically collected, stored and disbursed without human intervention, thus reducing the risk of contamination and loss through spillage. The entire system is also automatically

cleaned and sterilized hence ensuring that it is pathogen free. Integration of AI and electronic tagging allows for identification of the cow and enables valuable information to be collected for example, amount of milk produced, quality, cow activity and cow rumination data.

### Weaknesses

One major weakness of this technology is that it is expensive to purchase. It also requires expensive infrastructure and once implemented it may be difficult to use on on-farm or with older animals that may not easily adjust to a new milking programme. The technology also is heavily dependent on a reliable source of electricity, which is not available in many parts of Africa. Owing to the risk of power outages causing damage to the machines, farmers are often required to install back-up power systems which are expensive. The machine needs to be monitored closely to ensure that it has latched onto the teats properly, and this requires a different type of personnel not usually found at the farm. Some animals' phenotypes can prevent a robot attaching to the udder for example, long hair, dark teats, tilted udder or teats that touch each other.

### Opportunities

The steady rise in milk consumption in Africa presents an opportunity to large scale producers to increase production on their farms. Many African countries are not able to meet their demand for milk consumption, thus presenting opportunities for intra-African trade for milk and milk products.

### Threats

A major concern is that the voluntary milking machine eliminates the need to use farm hands who need to either be reassigned to other parts of the farm, or released from employment, which is a disadvantage to the surrounding community. The technology requires highly skilled technicians to monitor the equipment on a 24-hour basis. It is also dependent on reliable internet connectivity for the systems to work effectively while a great part of Africa is not covered by internet.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology/innovation is not locally available. It is, however, available from international suppliers.

## Primary users of the technology/innovation

The primary users of the voluntary milking machine are large commercial farms.

## Climate-smart status of the technology/innovation

The voluntary milking machine would largely be installed in large commercial dairy farms that have the resources to invest in it. These farms, however, mainly keep breeds that are exotic to Africa, which would produce large amounts of milk to guarantee its investment. This model does not promote locally adapted breeds and breeding programmes and therefore, the technology may not be considered to be climate smart.

### Environmentally friendly status of the technology/innovation

This technology improves productivity of milk and meat animals at the farm level thus it helps farmers to keep only few productive animals. It helps to reduce pressure of animals on natural resources/grazing areas thus reducing the environmental impact of keeping large herds of animals.

### Suggestions for improvement of the technology/innovation

The system is ideal for use in high production, zero-grazing environments, where cows are housed indoors for most of the lactation period. It can therefore be improved by making versions that can be used in pasture systems, where cows graze in fields and then walk to the milking parlour. It has been found that in these systems cows have a lower milking frequency because they find it challenging to keep walking to the milking parlour, especially if the distances are long, thus raising issues on animal welfare.

### Strategies that can be adopted by national governments to promote the uptake of the voluntary milking machine

To increase milk production at the local level and hence spur investments in the dairy sector, including the purchase of portable milking machines, national governments should create an enabling environment within the dairy sector through strategies such as:

- Developing clear policy frameworks and regulations that would create an innovative, productive and profitable dairy sector
- Developing regulations detailing safety, quality and animal welfare standards
- Creating an environment for private sector investment to drive growth in the dairy sector, create employment and spur innovation along the dairy value chain
- Direct investments by national governments in the dairy sector
- Developing intra-Africa trade of dairy products through nurturing of partnerships
- Active engagement of pastoralists and crop farmers with a view to reducing conflicts between pastoralists
- Developing financing options that target farmers and farmer organizations

# Portable milk pasteurizing equipment

## Primary use of the technology/innovation

Milk pasteurization involves the heating of milk at pre-determined temperatures (usually between 72 ˚C and 74 ˚C for 15 to 20 seconds) for a specific time needed to kill pathogens found in raw milk. The portable milk pasteurization machine is a pasteurizer that has the capacity to pasteurize milk in quantities ranging from one to 40 litres. This innovation caters to smaller and perhaps non-commercial individuals, farms and farmer cooperatives handling significantly lower quantities of milk compared to commercial processing plants.



Meishu Machinery Technology

*Milk pasteurizing equipment*

## SWOT analysis of the technology/innovation

### Strengths

The innovation is economical, portable, pasteurizes a range of quantities considered to be small scale, is simple to use and operate, and is made of few components that are easy to clean and maintain. This portable milk pasteurizing equipment supports processing and value addition at the farm level.

### Weaknesses

The innovation uses electricity, requires a large amount of water for cleaning, and may not be easily available in parts of Africa.

### Opportunities

The growing demand for relatively small-scale milk pasteurizing equipment is growing, especially with the increase in the number of livestock hubs, farmer associations and cooperatives engaging in milk processing.

### Threats

Commercial milk pasteurizing plants require large quantities of milk and hence may offer attractive prices to farmers that smaller milk processing hubs would not be able to compete with.

### Local availability of the technology/innovation and potential suppliers across Africa

The technology/innovation is locally available.

### Primary users of the technology/innovation

The primary users are milk collection centres/hubs, farmer cooperatives and individual farmers.

### Climate-smart status of the technology/innovation

Indigenous cattle breeds produce less milk compared to exotic breeds, producing 200 litres of milk per year compared to over 12,000 litres per cow in some developed countries. Installation of pasteurizers with smaller production capacities supports the processing of milk from these local breeds. It also supports breeding of indigenous animals for milk production, thus ensuring their sustainable utilization.

### Environmentally friendly status of the technology/innovation

This technology has a low impact on the environment when being installed and produces less waste compared to larger installations.

### Suggestions for improvement of the technology/innovation

The technology may be improved by designing and manufacturing models using green energy as a power source.

### Strategies that can be adopted by national governments to promote the uptake of portable milk pasteurizing equipment

National governments can promote this technology through strategies such as:

- Developing appropriate policies, for example, the law in Kenya prohibits the sale of raw milk (see the Dairy Industry Act (2020) and Dairy Industry Regulations (2020).
- Where these policies exist, there should be strict enforcement. This would reduce the risk of the milk-drinking population from contracting diseases arising from the consumption of raw milk. However, it would increase the need for smaller and portable pasteurizers.

# Ultra-High Temperature (UHT) milk

## Primary use of the technology/innovation

Ultra-high temperature milk (UHT), also known as ultra-pasteurization of milk is a technology that heats milk to temperatures above 135 ˚C. This process kills all the bacteria and other pathogens contained in the milk. Once packaged and stored unopened, the milk has a shelf life of six to nine months.



Egerton University

*UHT milk pasteurization system*

## SWOT analysis of the technology/ innovation

### Strengths

Normal pasteurized milk has a very short shelf life of one day if not kept under refrigerated conditions. The UHT milk on the other hand, can keep for as long as six to nine months. The UHT process is the best method for increasing the lifespan of milk. Excess milk produced can be ultra-heat treated, thus ensuring that it is not lost. It has also been found to boost the nutrient level especially natural protein and calcium, while reducing natural sugars. It is a cost-effective way of adding value to the product. The UHT process results in the removal of lactose and hence this type of milk can be consumed by people who are lactose intolerant.

### Weaknesses

The process of making UHT is costly and requires expensive infrastructure. This therefore favours the big dairy companies and may not be a good business option for small and medium dairy companies. It also changes the colour and taste of milk; thus, regular milk consumers may prefer not to use it. The UHT milk costs more than normal pasteurized milk and this may prevent people from purchasing it.

### Opportunities

The global UHT market is growing steadily and is expected to reach 124.77 million tons by 2024 with increases of compound annual growth rates (CAGR) of 4.57 percent between 2019 and 2024[1]. This growth is driven by increasing urbanization and concerns on the safety of fresh milk in urban centres, rising demands for quality packaged milk products with a longer shelf life, lack of a continuous cold supply chain for fresh milk, and a fragmented fresh milk supply chain.

### Threats

The nutritional value of fresh and pasteurized milk is higher than that found in UHT. The raw milk market is large in Africa and this poses a threat to the consumption of UHT milk.

## Local availability of the technology/innovation and potential suppliers across Africa

UHT milk pasteurizers are locally available.

## Primary users of the technology/innovation

The primary users are the large dairy companies.

## Climate-smart status of the technology/innovation

The production of UHT milk by small holder dairy enterprises ensures that the milk is not wasted. UHT milk is a high value product which increases earnings to famers. This enables them to provide for their families thus ensuring their resilience against climate change.

## Suggestions for improvement of the technology/innovation

Development of UHT pasteurizing equipment that has a green energy alternative is recommended.

## Strategies that can be adopted by national governments to promote the uptake of ultra-pasteurization of milk

National governments need to develop strategies to promote the consumption of UHT milk especially in regions where the cold chain supply is not available.

1 Global UHT Milk Market Growth, Size, Share, Price Trends, Report and Forecast 2020–2025 (https://www.supermarketresearch.com/2020/07/13/uht-milk-market-size-report/)

# Solar milk pasteurizing

## Primary use of the technology/innovation

The solar milk pasteurizer is a milk pasteurizing equipment that uses solar energy as a power source. This makes it very suitable for use in remote regions especially where pastoralists live and graze their animals. These regions are often not connected to electricity and are usually too far from large scale commercial processors.



AU-IBAR

*Solar-powered milk cooler*

## SWOT analysis of the technology/innovation

### Strengths

The solar pasteurizer uses solar energy, which is a freely available and clean renewable energy source. It has a low energy requirement, is economical, durable and easy to install, and it ensures the health of the population by ensuring that the milk they consume is safe.

### Weaknesses

The solar milk pasteurizer may not be locally available. The solar panels are expensive. It has been estimated that farmers would take about four years to recoup their investment in a solar pasteurizer. This could be mitigated if farmers pooled resources to purchase the pasteurizer.

### Opportunities

In Africa, solar energy is freely available throughout and the year and is largely underutilized and underexploited. Milk losses across the milk value chain in pastoral communities are high owing to lack of strong marketing systems that are supported by reliable pasteurization thus guaranteeing milk quality. The use of a solar milk pasteurizer would strengthen the milk marketing strategy and ensure pastoralists generate income from their cattle.

### Threats

Solar milk pasteurizers may be difficult to sell to farmers due to lack of adequate knowledge of their operationalization.

### Local availability of the technology/innovation and potential suppliers across Africa

The technology/innovation is locally available. However, it would require concerted efforts to ensure that it is fully commercialized and disseminated.

### Primary users of the technology/innovation

The solar milk incubator is still at fabrication stage. The target market would be the small-scale milk producers, livestock and milk hubs, farmer cooperatives and pastoralists.

### Climate-smart status of the technology/innovation

The primary energy source for this technology is solar energy which is a renewable energy source.

### Environmentally friendly status of the technology/innovation

The solar milk pasteurizer can be used in arid and semi-arid Lands (ASALs) where milk is usually boiled using firewood, which raises concerns on the degradation of an environment that is already fragmented and seriously degraded. The solar milk pasteurizer prevents wastage of milk and increases farmers' incomes.

### Suggestions for improvement of the technology/innovation

The technology needs to be fabricated with parts that are simple to assemble and clean, using the most efficient amount of water.

### Strategies that can be adopted by national governments to promote the uptake of solar milk pasteurizing

Strategies promoting the use of green energy such as solar energy are key to ensuring that these technologies are widely utilized. Locally fabricated solar milk pasteurizers should be designed, patented and commercially produced. Policies that encourage innovation, dissemination and financing of these innovations would ensure that local and cost-effective innovations reach the end users.

# Mazzi™ container for milk distribution

## Primary use of the technology/innovation

The Mazzi™ (http://www.mazzican.com) can is a plastic container that was developed to ensure the safe collection, storage and transport of milk in developing countries. It has a unique design that facilitates the handling of milk, hence reducing waste through spillage and spoilage. The design contains a mountable sieve and funnel for milking. The back funnel has a technology that allows for the detection of mastitis. The Mazzi™ can be stacked, making it easy to transport. Single containers can be transported using hand, bike, truck or animals. The container is calibrated to measure the amount of milk collected. By maximizing the yields on the farm, the farmer has more income from the milk.



GLOBAL GOOD

*Mazzi™ container – for safe collection, storage and transport of milk*

## SWOT analysis of the technology/innovation

### Strengths

The Mazzi™ can is made using food grade plastic. It is multi-functional and can be used for milking, storage and transportation. It has a wide funnel that can be attached, enabling milking to be done directly into the container. This funnel can then be removed, converting the can into a milk storage and transportation container. This reduces the need for having multiple containers, thus reducing the risks of milk contamination. The funnel assists farmers in the diagnosis of mastitis. Mazzi™ can is durable. It is designed with a wide mouth and groves that are easy to clean. The container is leak proof.

### Weaknesses

The Mazzi™ can is expensive. The farmers may not follow instructions of thoroughly cleaning the container using hot water before putting milk inside it. It requires clean, fresh water which may not be readily available in most regions of Africa.

### Opportunities

Post-harvest milk losses in Africa are high, mainly caused by unhygienic milk handling. Transportation of raw milk to processing plants is unreliable. Most small-holder farmers in Africa deliver milk using unhygienic milk containers that are not usually made to contain milk. With government and private sector support there are opportunities for the Mazzi™ can to be taken up by farmers.

### Threats

The farmers need to be well trained so that they can use the Mazzi™ can properly. The Mazzi™ can may be considered expensive and farmers and farmer cooperatives may not have cash to buy it immediately. There is therefore, a need for a check off system to be developed.

## Local availability of the technology/innovation and potential suppliers across Africa

The Mazzi™ can is locally available from Ashut Engineers Limited Kenya.

## Primary users of the technology/innovation

The primary users of the technology/innovation are women. They are the majority of the small-scale farmers who milk livestock and transport milk.

## Climate-smart status of the technology/innovation

The container is easy to clean and hence saves on water. It increases production, allowing farmers to earn more from milk, thus improving their livelihoods.

## Environmentally friendly status of the technology/innovation

The Mazzi™ can uses or produces materials that are recyclable or can be recycled. It also has a low impact on the environment when being installed.

## Suggestions for improvement of the technology/innovation

The Mazzi™ can may be improved by modifying the design to include a flexible handle at the top to enable easy carrying and handling. It currently comes only in a 10-litre design. Smaller designs for 2 litres and 5 litres would target even smaller producers. The design can be improved so that it does not spill milk during transportation on rough roads.

## Strategies that can be adopted by national governments to promote the uptake of the Mazzi™ can

National governments can promote this technology through strategies such as:

- Developing partnerships to assist farmers to acquire the Mazzi™ can through check-off systems, grants from government, or private sector financing
- Training farmers on how to prevent, reduce and detect mastitis in their herds, as mastitis in cows continues to be a big challenge experienced by African farmers

# Cream separator

## Primary use of the technology/innovation

The cream separator is equipment used to separate cream from fresh milk. Cream is used to make butter, cheese and ghee. The cream separators use the concept of centrifugation to separate the skim from the cream. During centrifugation, the lighter portion, which is the cream, moves to the centre of the bowl, enabling its collection. Cream separators can be either manual or electric.



www.chinanc.en.made-in-china.com

*Small-cale electric milk cream separator*

## SWOT analysis of the technology/innovation

### Strengths

The cream separator ensures purity of the product. Using the cream separator has been found to remove all bacteria, especially the tuberculosis bacteria. This is because the centrifugation process moves all the bacteria into the slime, a sticky mass that remains on the sides of the separator and this is easily removed and disposed of. The cream separator produces a high-quality cream as a result of removal of all impurities. It also produces high quality skimmed milk that can even be directly fed to calves because it does not cause fermentation in the calves' stomach. Using the cream separator aerates the skimmed milk and cream, thus removing any animal odours that may contaminate any end products like butters and cheese. It is a fast and efficient method of obtaining cream and it reduces the workload and effort required to obtain cheese. It is easy to use and clean.

### Weaknesses

Both the manual or electric cream separators are considered expensive. Their parts are also expensive and may not be easy to obtain. The electric cream separators can only be used in regions where electricity is available. Some manual cream separators produce skimmed milk containing a lot of foam.

### Opportunities

There is slow but significant growth in the dairy sector in Africa. The dairy sector is considered an important sector of agricultural production and has a huge potential to reduce poverty and improve food security and nutrition.

### Threats

Lack of favourable policies and infrastructure are changing the landscape of milk processing in Africa.

## Local availability of the technology/innovation and potential suppliers across Africa

The cream separators are locally available.

## Primary users of the technology/innovation

The primary users of the cream separators are small local processors.

## Climate-smart status of the technology/innovation

These small cream separators do not require a large amount of milk. They therefore can be used by small-scale milk producers especially those keeping indigenous breeds and crosses that do not produce large amounts of milk.

## Environmentally friendly status of the technology/innovation

This technology supports indigenous breeds that are locally adapted. The manual cream separators can be utilized in rural environments and by pastoralists because they do not require electricity.

## Strategies that can be adopted by national governments to promote the uptake of cream separators

National governments can promote this technology through strategies such as:

- Developing policies that recognise the role played by small holder dairy producers in the dairy value chain
- Creating and implementing sustainable dairy value chains
- Enhancing value addition and processing through incorporating this into any small holder capacity-building forums that exist
- Developing comprehensive policies for the dairy sector to enhance processing of milk
- Developing laws that prohibit the sale and marketing of unprocessed (raw) milk
- Disseminating information to farmers on the benefits of processing milk

# Butter churn

## Primary use of the technology/innovation

The butter churn is equipment that converts cream into butter by vigorously stirring the cream. This vigorous stirring causes the membranes of the fat molecules to break up, making the fat molecules clump together to form a butter.

Traditional butter churners used by pastoralist communities included gourds and pots. Butter churns can be manual or electric.



SHANGAI BEYOND MACHINERY

*Manual butter churn*

## SWOT analysis of the technology/innovation

### Strengths

The use of butter churns ensures purity of the product. Using the butter churn has been found to remove all bacteria especially the tuberculosis bacteria. This is because the centrifugation process moves all the bacteria into the slime, a sticky mass that remains on the sides of the separator and this is easily removed and disposed of. The butter churn produces a high-quality cream owing to removal of all impurities. It also produces high quality skimmed milk that can even be directly fed to calves because it does not cause fermentation in the calves' stomach. Using the butter churn aerates the skimmed milk and cream thus removing any animal odours that may contaminate any resulting products like butters and cheese. It is a fast and efficient method of obtaining cream and it reduces the workload and effort required to obtain cheese. It is easy to use and clean.

### Weaknesses

Both the manual and electric butter churns are considered expensive. Their parts are also expensive and may not be easy to obtain. The electric butter churn can only be used in regions where electricity is available.

### Opportunities

The dairy sub-sector is one of the fastest growing agricultural sub-sectors in Africa. It generates high economic returns for the producers, providing employment along the entire dairy value chain.

### Threats

The illegal trade in raw milk threatens the growth of the processing industries.

## Local availability of the technology/innovation and potential suppliers across Africa

The butter churns are locally available.

## Primary users of the technology/innovation

The primary users of butter churns are small-scale milk processors.

## Climate-smart status of the technology/innovation

Butter churns provide small holder dairy farmers with additional income, thus improving their resilience in the face of climate change.

## Environmentally friendly status of the technology/innovation

This processing of milk into butter reduces the wastage of milk and facilitates the sustainable use of livestock including indigenous breeds.

## Suggestions for improvement of the technology/innovation

The manufacture of green technology butter churns ensures that they can be utilized in environments where there is no electricity.

## Strategies that can be adopted by national governments to promote the uptake of butter churns

National governments can promote this technology through several strategies including:

- Developing policies that recognise the role played by small holder dairy producers in the dairy value chain
- Developing sustainable dairy value chains
- Enhancing value addition and processing by incorporating this into any small holder capacity-building forums that exist
- Developing comprehensive policies for the dairy sector to enhance processing of milk
- Developing laws that prohibit the sale and marketing of unprocessed (raw) milk
- Disseminating information to farmers on the benefits of processing milk

# Milk yogurt processing

## Primary use of the technology/innovation

Milk yogurt is a milk product developed by the natural fermentation of milk. Yogurt making requires the use of high quality fresh milk.




JKUAT

*Labelled and packaged yogurt, produced in small-scale industry*

## SWOT analysis of the technology/innovation

### Strengths

Making yogurt is easy. It does not require any equipment. It is high in protein content and is an excellent protein source for the family.

### Weaknesses

The initial batch of yogurt requires a yogurt culture, which can be a small quantity of yogurt from a commercially sold yogurt or from a neighbouring farm that makes yogurt. The yogurt culture needs to be renewed every two weeks thus it requires one to retain a small amount of yogurt from a batch.

### Opportunities

The demand for yogurt is steadily growing and is expected to grow by compound annual growth rate (CAGR) of 5.1 percent between 2020 and 2025[2].

### Threats

The threat of substitute products and low purchasing power of consumers in certain regions of Africa threaten the growth of the yogurt producers.

2 https://www.mordorintelligence.com/industry-reports/africa-yogurt-market

### Local availability of the technology/innovation and potential suppliers across Africa

Yogurt production is locally available in Africa.

### Primary users of the technology/innovation

The primary makers of yogurt are pastoralists who have a tradition of making yogurt.

### Climate-smart status of the technology/innovation

Making yogurt encourages the value addition of milk, thus reducing its wastage and providing small-scale livestock producers and pastoralists with more income. More income in the hands of small-scale producers and pastoralists cushions them against climate change, helping them adapt and making them more resilient.

### Environmentally friendly status of the technology/innovation

Yogurt making is an environmentally friendly practice that uses the natural fermentation process to prevent the spoilage of milk.

### Suggestions for improvement of the technology/innovation

Development of new flavours could attract new non-yogurt consuming individuals.

### Strategies that can be adopted by national governments to promote the uptake of yogurt production

Yogurt production can be promoted through capacity building for farmers through training on how to make different flavoured yogurts.

# The manually-operated yogurt cup filler and sealer

## Primary use of the technology/innovation

The yogurt manual cup filler and sealing machine is a manually operated machine used to package yogurt by filling plastic cups and sealing them with a removable aluminium foil paper.



Mizlho Machinery

*Yogurt cup filler equipment*

## SWOT analysis of the technology/innovation

### Strengths

The yogurt cup filler and sealer machine fills and seals plastic yogurt containers without any direct handling and touching by humans. It therefore reduces risk of contaminating the yogurt with microbial contaminants. This product can also be used to package other products such as creams. It is a manual machine and therefore does not require electricity for its use.

### Weaknesses

The manual yogurt cup filler and sealer is expensive. The machine is compatible with the use of plastic containers which are not considered to be environmentally friendly. The manual yogurt cup filler and sealer might be labour intensive and time consuming for large quantities of yogurt.

### Opportunities

The dairy sub-sector is one of the fastest growing agricultural sub-sectors in Africa. It generates high economic returns for the producers, providing employment along the entire dairy value chain.

### Threats

The illegal trade in raw milk threatens the growth of the processing industries.

### Local availability of the technology/innovation and potential suppliers across Africa

The manual yogurt cup filler and sealer are locally available.

### Primary users of the technology/innovation

The primary users of manual yogurt cup filler and sealer are small-scale milk processors.

### Climate-smart status of the technology/innovation

The manual yogurt cup filler and sealer provide small-holder dairy farmers with additional income, thus improving their resilience in the face of climate change.

### Environmentally friendly status of the technology/innovation

The processing of milk into yogurt reduces the wastage of milk and facilitates the sustainable use of livestock including indigenous breeds.

### Suggestions for improvement of the technology/innovation

The manual yogurt cup filler and sealer can be improved by manufacturing high throughput models.

### Strategies that can be adopted by national governments to promote the uptake of the manual yogurt cup filler and sealer

Governments can promote this technology by:

- Developing policies that recognise the role played by small holder dairy producers in the dairy value chain
- Developing sustainable dairy value chain
- Enhancing value addition and processing by incorporating this into any small holder capacity-building forums that exist
- Developing comprehensive policies for the dairy sector to enhance processing of milk
- Developing appropriate policies, for example, the law in Kenya prohibits the sale of raw milk (see the Dairy Industry Act (2020) and Dairy Industry Regulations (2020).
- Disseminating information to farmers on the benefits of processing milk

# 2.2 Technologies and Innovations targeting the Marketing Component of the Value Chain

# Milk dispensing machine (milk ATM machine)

## Primary use of the technology/innovation

The milk dispensing machine commonly known as the milk ATM is an innovation that allows for the mechanized sale of pasteurized milk. The customer comes with a container for the amount of milk that they want to purchase, keys in that amount and the ATM dispenses the milk.




AU-IBAR

*Milk dispenser ATM*

## SWOT analysis of the technology/innovation

### Strengths

The machine enables the direct marketing of milk, thereby bypassing middlemen and ensuring that the farmer maximizes profits. It facilitates the bulk selling of pasteurized milk and allows for hygienic and efficient delivery of milk to consumers. It reduces the packaging expenses for the producer and the consumer, thus reducing costs, which makes the milk affordable. It is simple to use and the process is automated with no direct handling of milk. It preserves the milk at optimal cool temperatures. It also facilitates the bulk selling of pasteurized milk and has low operational costs. It can be moved to new locations depending on the projected sales of milk.

### Weaknesses

The milk ATM is easily vandalized, so needs to be installed in a safe place to ensure its security. It only uses electricity and this may limit its distribution to areas that are connected to electricity. Initial investment costs may be high. The mechanism for collecting and returning used milk cans is not efficient. The machine is not tamper proof and milk can be adulterated.

### Opportunities

The milk ATM's potential has not been realized and currently remains underexploited. The milk ATM offers a new way of marketing and selling milk hence providing huge opportunities for private sector investment and financing.

### Threats

The cost of acquiring the machine and providing its security may eat into the investor's profits. There is a possibility of fraud by the customer who may not make the due payment for the milk dispensed.

## Local availability of the technology/innovation and potential suppliers across Africa

The milk ATMs are locally available from local manufacturers.

## Primary users of the technology/innovation

The primary users are small business owners including youth who are quick to adapt to new technologies.

## Climate-smart status of the technology/innovation

This milk ATM supports the sale and consumption of milk in Africa.

## Environmentally friendly status of the technology/innovation

The milk ATM has a low impact on the environment when being installed. It promotes the recycling of milk containers thus reducing accumulation of waste materials. It promotes the use of biodegradable plastic as milk containers.

## Suggestions for improvement of the technology/innovation

The milk ATM can only be used in areas served with electricity, thus integrating green energy power sources would widen its distribution. Designing milk ATMs that are tamper proof would improve the security and quality of the milk. It would also be necessary to look into how the security of the ATM can be improved and how to reduce customer fraud.

## Strategies that can be adopted by national governments to promote the uptake of the milk ATM machine

National governments can promote this technology by:

- Developing and enforcing policies and legislation that prevent the sale and consumption of raw milk
- Improving the design of the milk ATM to make it difficult to vandalize. It should also be tamper proof.
- Promoting the consumption of fresh milk for health reasons

# 2.3 Technologies and Innovations targeting the Waste Management Component

# Biogas technology

## Primary use of the technology/innovation

Biogas is a combustible gaseous fuel collected when organic matter – usually farm waste products from livestock, for example manure, sludge or droppings – is degraded in anaerobic conditions. The principal gas in biogas is methane gas. Biogas has numerous applications that are suitable for use in Africa, including providing heat, light, electricity generation, and vehicular fuel and as a piped gas to homes to provide cooking fuel.



AU-IBAR

*Biogas slurry and digester*

## SWOT analysis of the technology/innovation

### Strengths

Biogas is a renewable green energy; it is clean and safe to use for domestic and industrial applications. It reduces a household's dependence on trees and other fossil fuels for cooking. It transforms waste material into an important energy source and solves the problem of waste disposal at the farm level. It reduces dependence on fossil fuels and creates jobs. It produces digestate which can be used as organic manure. It is a simple and low-cost technology to implement at the farm level.

### Weaknesses

The biogas technology is still developing and as such it is still not efficient enough to be used on a larger scale. The production of biogas is dependent on temperatures, so during the cold seasons lower amounts of biogas would be produced. There are various methods in which the generated biogas can be stored, but sustainable technologies for Africa need to be developed.

### Opportunities

The primary source of energy in Africa is fossil fuel and wood fuel for cooking. The purchase of this fuel forms a huge component of family finances and rural families spend a lot of time looking for firewood. The consequence of this has been the rapid deforestation of African forests which has resulted in an increasing scarcity of firewood. The worldwide interest in renewable energy is growing steadily. Most of rural Africa is not connected to electricity. Consequently, the use of biogas in Africa will become more prevalent as it becomes more popular.

### Threats

Readily available fossil fuels and availability of charcoal or firewood threatens the uptake of the biogas technology.

## Local availability of the technology/innovation and potential suppliers across Africa

The biogas technology is readily available locally.

## Primary users of the technology/innovation

The primary users of the technology are small-scale farmers.

## Climate-smart status of the technology/innovation

The production and use of biogas is considered to be carbon-neutral. Although when biogas is burned it produces $CO_2$, a greenhouse gas, the carbon in biogas comes from plants which originally fixed this from atmospheric $CO_2$. Also, the use of biogas results in a decreased use of fossil fuels, which reduces the amount of $CO_2$ going into the environment.

## Environmentally friendly status of the technology/innovation

The production of biogas is considered to be environmentally friendly owing to its potential in replacing fossil fuels. It is also a renewable energy. It reduces the dependence on wood as fuel in rural communities, therefore protecting forests while providing a cleaner environment by reducing pollution from waste energy[3].

## Suggestions for improvement of the technology/innovation

Biogas production can be improved by:

- Research into how more biogas can be produced
- Conditioning the biogas to remove excess water, $CO_2$ and toxic hydrogen sulphide

3 Al Seadi, T., Rutz, D., Prassl, H., Köttner, M., Finsterwalder, T., Volk, S., & Janssen, R. (2008). Biogas Handbook. BiG> East project. University of Southern Denmark Esbjerg, Niels Bohrs Vej, 9-10.

## Strategies that can be adopted by national governments to promote the uptake of the biogas production technology

National governments can promote this technology through several strategies including:

- Developing a biogas value chain for Africa, with full mapping of the actors involved along the chain
- Designing biogas digestors made from locally produced materials and implementing their use
- Developing, supporting, patenting and commercializing technologies applied in the livestock value chain that use biogas as a fuel
- Determining the motivation for stakeholders to take up biogas generation and distribution
- Carrying out full stakeholder mapping to determine who the stakeholders are, what role they play, what interest they have in biogas and what their interventions are
- Developing legal instruments that govern the generation, use and dissemination of biogas
- Identifying financing for the biogas sector within their economies, including sourcing for funding, investors and actors who can benefit from this funding
- Capacity building of the various stakeholders in this sector

# Composting

## Primary use of the technology/innovation

Composting is the aerobic decomposition of organic waste. On a livestock farm any waste including manure, stall waste and run off can be composted. A composting area should be created on the farm but not close to where livestock graze. Carrying out composting close to grazing areas exposes livestock to the risk of infestation with larvae and worms from the manure. The compost pile is routinely aerated so as to introduce oxygen which stimulates aerobic microorganisms that feed on the organic material. The composting process produces heat which destroys pathogens and weed seeds. Composting can also be safely used to dispose of dead animals and has been used safely to compost livestock[4].

The waste needs to be managed in a sustainable manner and when managed well, produces compost that has a high market value and demand. Composting is done by creating a composting area, which is routinely aerated so as to introduce oxygen which stimulates aerobic microorganisms that feed on the organic material.



AU-IBAR

*Preparation of compost heap*

## SWOT analysis of the technology/innovation

### Strengths

Composting produces numerous nutrients that have wide application in crop agriculture. Composting has been shown to produce stronger plants with higher yields compared to conventional fertilizers. The composting process adds organic matter to the soil, nitrogen and other critical trace elements. These elements and especially nitrogen is released slowly and over time, making them available to plants over a long period, hence the plants have a long growing season. Composting increases water retention and aeration in soils, hence

4 Morrow, W. M., O'Quinn, P., Barker, J., Erickson, G., Post, K., & McCaw, M. (1995). Composting as a suitable technique for managing swine mortalities. Swine health and production: the official journal of the American Association of Swine Practitioners (USA).

reducing the effect of wind erosion because the water in the soil makes it heavy. Composting promotes recycling of materials.

### Weaknesses

Composting takes up space that cannot be used for other farm activities such as grazing. It produces an unpleasant odour and the composting time is greatly affected by external factors such as ambient temperature and moisture content. It could therefore take a long time if these are not controlled. Composting may not be able to get rid of all chemicals especially agro-chemicals. Compost that is not well sifted may introduces glass and plastic into grazing fields and injure animals. Composting reduces the burning of agricultural crop by-products like sawdust, straw and stovers.

### Opportunities

The demand for fertilizer in Africa is increasing together with its cost of purchase.

### Threats

The following factors threaten the uptake of composting:

- Availability of cheap fertilizer obtained from fertilizer subsidy programmes
- Lack of waste management and recycling programmes in many African countries
- Technical constraints stemming from lack of training programmes on proper composting and waste management procedures
- Poor policy environments jeopardize the availability of compost for use

## Local availability of the technology/innovation and potential suppliers across Africa

The composting technology is locally available.

## Primary users of the technology/innovation

The primary users of this technology are all farmers ranging from small scale to large scale.

## Climate-smart status of the technology/innovation

Waste management through composting reduces greenhouse gases by reducing the amount of waste that is burnt. It is a sustainable method of getting rid of waste while reducing the waste's ability to pollute the environment. Composting provides employment opportunities including waste collection, the recycling process, and the sale and distribution of the finalized product.

## Environmentally friendly status of the technology/innovation

Composting is an environmentally friendly strategy for recycling waste. The process produces organic waste, nutrients and organic fertilizers that are environmentally friendly. Composing reduces the need for dumping waste in landfills, hence reducing the size of land that has become unusable.

## Strategies that can be adopted by national governments to promote the uptake of composting

National governments can promote this technology through strategies such as:

- Developing business linkages with importers in coastal countries
- Improving regional trade cooperation
- Realizing the economies of scale
- Improving access to finance
- Improving infrastructure and transportation arrangements
- Increasing private sector involvement

# Vermicomposting

Vermicomposting is the composting of organic waste using earthworms (*Eisenia fetida*). When earthworms eat organic material, the material passes through their digestive system producing a granular cocoon known as vermicompost. Nutrients available in the organic material are converted into soluble forms that have been found to be more available to plants. Vermicompost has been found to be a rich source of nitrogen, phosphorus and potassium[5].



wikipedia.org

*Earthworms in a vermicompost*

## SWOT analysis of the technology/innovation

### Strengths

Vermicomposting is a cheap method of recycling organic waste and is considered to be a better form of recycling when compared to composting. Vermiculture enriches the soil, increases plant growth and results in strong healthy plants. Vermiculture has been found to repel pests such as bugs, aphids and spider mites. Earthworms can be used as a source of protein for livestock.

### Weaknesses

Vermicomposting requires more space than composting. It also requires more care especially when harvesting, in order to separate the earthworms from the vermicompost, making the process time consuming and labour intensive. The process of making vermicompost is very expensive thus limiting the number of farmers who can have access to it.

5 Sorathiya, L. M., Fulsoundar, A. B., Tyagi, K. K., Patel, M. D., & Singh, R. R. (2014). Eco-friendly and modern methods of livestock waste recycling for enhancing farm profitability. International Journal of Recycling of Organic Waste in Agriculture, 3(1), 50.

### Opportunities

Livestock farms generate a lot of waste that can prove difficult to manage. In the USA, intense livestock farms were said to produce 369 million tons of manure annually. Fertilizer costs continue to increase. While no data information is available on the contribution of vermicompost, it can lessen the farmer's fertilizer costs incurred.

### Threats

Farmers' low acceptability of the value of vermicompost in farming poses a threat to its uptake.

## Local availability of the technology/innovation and potential suppliers across Africa

Vermicomposting is done at the farm level and hence is locally available.

## Primary users of the technology/innovation

The primary users of this technology would be all types of livestock farmers.

## Climate-smart status of the technology/innovation

Vermiculture recycles organic waste and reduces the reuse of hazardous livestock waste. Vermicomposting results in the production of more worms, hence increasing the recycling of organic waste and boosting the quality of the soil present in the environment.

## Environmentally friendly status of the technology/innovation

Vermicomposting is an environmentally friendly technology that produces an organic fertilizer thus reducing dependence on, and use of, chemical fertilizers. It also recycles waste and reduces practices that are not environmentally friendly like burning and incineration of waste which increases local and general greenhouse gas concentration. It also reduces the amount of waste that ends up in landfills

## Suggestions for improvement of the technology/innovation

Vermicomposting can be improved through provision of training programmes.

## Strategies that can be adopted by national governments to promote the uptake of vermicomposting

National governments can promote this technology through several strategies including:

- Advocacy and awareness raising on manure management
- Developing policies and legislation that provide guidelines on the management of manure at local and national levels

- Developing centres where information on vermicomposting can be obtained, shared and exchanged
- Providing farmers with access to earthworms
- Providing farmers with access to financing to start vermicomposting at the farm level
- Providing incentives to investors, experts and other resource personnel that can provide project financing

# Livestock-fish integrated farming for waste management

## Primary use of the technology/innovation

Livestock-fish integrated farming involves the use of fresh livestock manure in fish farming[6]. Livestock farming produces manure, urine, and spilled livestock feed that all can be used as fish feed. The organic matter when incorporated into fish ponds stimulate natural food webs in the fish ponds. Basically, the organic matter produces planktons that fish feed on.



ICAR-CCARI/ Manju Lekshmi

*Integrated livestock fishpond*

## SWOT analysis of the technology/innovation

### Strengths

This technology solves the livestock waste problem for farmers at no additional cost. The livestock waste is converted into a rich protein source. Livestock feed waste is used as fish feed. The bottom silt and water in fish ponds can be used as an organic fertilizer and is a rich source of nutrients.

### Weaknesses

The chemicals used on the farm might kill the fish. Putting too much manure into the fish pond may reduce the water quality and oxygen levels in the water, causing fish death.

### Opportunities

Aquaculture is a fast-growing food production sector in Africa. The incomes of livestock farmers venturing into fish farming has grown tremendously, resulting in an increase in the number of farmers venturing into this area. In western Kenya for instance, 90 percent of households depend on fish as a source of income.

6 Little, D. C., & Edwards, P. (1999). Alternative strategies for livestock-fish integration with emphasis on Asia. Ambio (Sweden).

### Threats

Cultural beliefs and other practices prevent people from eating fish produced in this manner.

### Local availability of the technology/innovation and potential suppliers across Africa

The technology and its supplies can be easily accessed from fishing bays, fish processing plants, fish mongers and aquaculture farms.

### Primary users of the technology/innovation

The primary users are small-scale livestock farmers with a few animals producing a significant amount of waste.

### Climate-smart status of the technology/innovation

Integrated livestock fish farming gives small-scale livestock farmers new sources of income, provides high quality protein sources for the family, and enhances their resilience in the face of climate change.

### Environmentally friendly status of the technology/innovation

Integrated fish livestock farming results in the efficient use of land and water resources. It also promotes recycling of nutrients.

### Suggestions for improvement of the technology/innovation

Sustainable production models for small-scale farms should be developed especially to reduce the risk of disease and contamination.

### Strategies that can be adopted by national governments to promote the uptake of livestock-fish integrated farming

National governments can promote this technology through several strategies including:

- Enhancing government funding in aquaculture
- Providing stimulus to promote private sector investment in aquaculture
- Developing comprehensive policies on aquaculture that will ensure coordinated and streamlined promotion of aquaculture
- Mapping and developing the aquaculture value chain
- Disseminating information to farmers on the benefit of keeping fish and conducting training programmes to enhance livestock farmers' skills on aquaculture
- Developing strategies to disseminate clear and correct information on livestock-fish integrated farming
- Using extension officers to promote the recycling of animal waste through the integration of livestock farming
- Designing sustainable livestock-fish integration models that are environmentally friendly and economically sustainable.

# 3



# RED MEAT AND DAIRY LIVESTOCK VALUE CHAINS CROSS-CUTTING TECHNOLOGIES

# 3.1 Technologies and Innovations targeting the Production Component

# Artificial Insemination (AI)

### Primary use of the technology/innovation

Artificial insemination (AI) is an assisted reproductive technology (ART) used to deposit semen from males directly into a female uterus for the purpose of conception. A bull can sire an average of 15 to 50 calves per year. AI makes it possible to maximize the vast number  a genetically superior bull.



AU-IBAR

*1: Electro ejaculator and artificial vagina*



AU-IBAR

*2: Mounting and collection of semen*



AU-IBAR

*3: Collected raw semen*



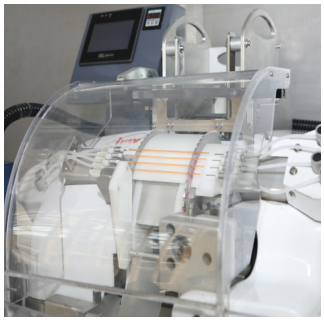
AU-IBAR

*4: Semen concentration analysis*



AU-IBAR

*5: Semen motility test*



AU-IBAR

*6: Semen straw filling machine*



AU-IBAR

*7: Filled semen straws stored in liquid nitrogen*

## SWOT analysis of the technology/innovation

### Strengths

The technology is cheap, easily available, easy to transport, has a high success rate and it eliminates the need to keep breeding males. It also allows for the use of germplasm from breeding males with good genetics and desired traits. AI produces immediate results of animals with desired traits of high meat and milk production. It facilitates the breeding of animals from different geographical locations, thus eliminating the need for transporting animals from one place to another.

### Weaknesses

The technology's success rate may be hampered by the farmer's inability to detect when a breeding female is on heat. It also requires the use of trained technicians who may not be easily available in regions where the services are required. AI also necessitates infrastructure including cryopreservation centres that are served by electricity, a sustainable source of liquid nitrogen, AI equipment, and high quality semen (that has been tested and undergone quality controls) which is expensive and not easy to acquire. Good record keeping is also necessary to prevent inbreeding which would compromise the desired gains.

### Opportunities

The demand for AI in Africa is great where there is a need for animals with good genetics. Africa also has a large population of indigenous breeds with good traits that can be disseminated using AI. The decrease in land sizes across the continent discourages the small-scale farmers from keeping breeding males, thus providing an opportunity to use AI. With proper planning there is an opportunity to disseminate good genetics to places where there is need. Africa is endowed with youth, many of who are unemployed; some are graduates who can be supported to become technicians or take up AI as a business. Immediate benefits offered by AI provide an opportunity for private sector support. The farmers have a high level of awareness especially of the benefits and results.

### Threats

Farmers in some regions of Africa have low acceptance of using AI and prefer to use breeding males. In these regions the proportion of natural mating in use is higher than that of AI. There is also a cultural opposition to the use of female technicians in some regions of Africa, with the belief that the insemination will not be successful. This technology carries the risk of inbreeding where a few animals, whose semen is widely used, become the parents of the next generation. The risk also exists of disseminating livestock diseases should the quality controls of the semen not be up to internationally prescribed standards. The shortage of trained AI staff and cryopreservation centres is a threat. The cost of AI has been found to be high and may hinder its use especially where resources are constrained.

### Local availability of the technology/innovation and potential suppliers across Africa

The technology/innovation is locally available from local breeding and government stations and institutions, for example, Kenya Animal Genetic Resources Centre.

### Primary users of the technology/innovation

The primary users of the technology/innovation are men who often procure the AI services. However, the women are the ones who are left home to take care of the cattle and they are the ones the AI technicians would often interact with.

### Climate-smart status of the technology/innovation

This technology is climate smart because it promotes locally adapted breeds and breeding programmes especially those breeds with important traits such as milk and meat production, disease resistance and heat tolerance. It also supports herd management and herd age structure.

### Environmentally friendly status of the technology/innovation

This technology improves productivity of milk and meat animals at the farm level, thus it helps farmers keep only few productive animals. It also helps to reduce pressure of animals on natural resources and grazing areas, thus reducing the environmental impact of keeping large herds of animals.

### Suggestions for improvement of the technology/innovation

The technology can be improved through integration with mobile technologies.

### Strategies that can be adopted by national governments to promote the uptake of artificial insemination

National governments can improve this technology through several strategies including:

- Improving the use of AI across Africa at the farm level by training farmers to be able to accurately detect when an animal is on heat
- Capacity building forums aimed at improving conception rates of AI. These forums can be used to educate farmers on benefits of AI.
- Training more AI technicians including local youth and graduates by recruiting them into formal training programmes or through understudy of AI technicians. Strategies to attract more youth could include providing them with start-up capital for an income generation project.
- Using cooperatives and livestock hubs to provide AI services to their members
- Improving extension services to farmers; building AI centres that are easily accessible to farmers; providing financial services, directly or through cooperative and livestock hubs; ensuring sustainable production of semen that meets quality standards; and ensuring that liquid nitrogen is easily available
- Making the environment suitable for private sector investment
- Protecting the genetic erosion of indigenous animals by providing legislation and policy guidelines

# Embryo Transfer (ET)

## Primary use of the technology/innovation

Embryo transfer (ET) is an assisted reproductive technology (ART) where embryos are removed from the reproductive tract of a donor female and subsequently transferred to one or more recipient females. A calf is born with about 150,000 eggs, each with a potential for reproduction. However, mature heifers produce one calf per year and only eight to ten calves in a lifetime, making the genetic multiplication of the best cows very slow. ET when used in genetically superior females could increase the number of superior calves such heifers produce in their lifetime.



David Kihurani

*1.Loading embryo into straw*



David Kihurani

*2.Transfer guns, sheaths & shields*



David Kihurani

*3.Straw into embryo gun*



David Kihurani

*4.Transfer of embryo*

## SWOT analysis of the technology/innovation

### Strengths

ET maximizes the genetic potential of heifers by increasing the number of offspring they can produce in one lifetime, shortening the generation interval and thus rapidly disseminating animals with superior genetics. Embryos produced through ET are disease free and easily transported, including across borders, thus eliminating risks of cross- boundary disease transmission. ET results in the rapid increase of livestock productivity.

### Weaknesses

The technology is expensive, thus limiting the number of farmers who can access it. It also requires expensive infrastructure, equipment and supplies that may not be easy and cheap to obtain. The technology also requires specialized technical expertise and advanced training. Retention of such personnel in Africa may also prove to be challenging. ET may be difficult to implement on a large-scale and is pegged on the existence of registered animals and their corresponding performance data, which may not exist for many breeds in Africa, especially the indigenous livestock breeds.

### Opportunities

Livestock producers of African breeds have a high interest in ET, including its potential to improve the performance of indigenous African breeds. There is great opportunity to provide the youth of Africa with employment by training them to be ET service providers along the various aspects of the value chain. Again, great opportunities exist for private sector investment. ET can also be used to conserve indigenous breeds, especially those at high risk of being lost.

### Threats

The use of ET to transfer exotic germplasm into Africa can result in the genetic erosion of indigenous breeds and eventually lead to their being lost. Most African states do not have strong legislation guiding the use of ET within their countries, the absence of which can lead to its indiscriminate use, thus leading to loss of indigenous breeds. The cost of ET can be reduced through providing services where numbers of farmers are high. The lack of strong farmer cooperatives that can negotiate for reduced rates for their members is lacking. ET requires the use of highly trained personnel who are not easy to find in most parts of Africa. Animals that have undergone ET need specialized care, including feed and supplements that may not be easy to provide. The use of ET on local breeds is hampered by widespread diseases in Africa. ET practice is threatened by other cheaper technologies such as AI. ET would have great impact in rural Africa; however, access may be limited by poor roads and unavailability of market information.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology/innovation is locally available from local breeding and government stations, universities and research institutions.

## Primary users of the technology/innovation

The primary users of the technology/innovation are men who have the resources to procure the services.

### Climate-smart status of the technology/innovation

This technology is climate smart because it promotes the sustainable use of indigenous breeds, thus leading to their conservation. ET can be used in breeding programmes involving indigenous breeds. It also supports herd management and herd age structure.

### Environmentally friendly status of the technology/innovation

This technology promotes the conservation of indigenous livestock and promotes the breeding of productive animals, thus reducing the need for the farmer to keep many animals. It therefore reduces the pressure of animals on natural resource and grazing areas, thus conserving grazing lands.

### Suggestions for improvement of the technology/innovation

The technology may be improved by integrating the use of ET to collect data on indigenous breeds and disseminate information on the advantages of the technology.

### Strategies that can be adopted by national governments to promote the uptake of embryo transfer

National governments can promote this technology through strategies such as:

- Developing legislation, policies and legal frameworks detailing the management of local and exotic germplasm within regions, including germplasm exchange and sharing, research guidelines, commercialization and ownership
- Creating breed standards for indigenous breeds and their maintenance, and the genetic characterization of local breeds, which are key to the sustainable use of ET in Africa
- Developing ET technology in Africa in tandem with the development, upgrading or construction of easily accessible gene banks, by leveraging on existing infrastructure for other advanced technologies such as ART and cryopreservation. Training of required technical capacity should be incorporated during the initiation phases.

# Estrus control and synchronization technologies

## Primary use of the technology/innovation

The use of Assisted Reproductive Technologies (ART) such as Artificial Insemination (AI) and Embryo Transfer (ET) is dependent on estrus synchronization of the animals. Estrus synchronization involves the administration of reproductive hormones in a group of cattle, making them go on heat at the same time.



David Kihurani

*Estrus synchronization*

## SWOT analysis of the technology/ innovation

### Strengths

Estrus synchronization reduces and in instances, eliminates the need to detect when an animal has gone on heat. This therefore reduces the breeding season, concentrating the breeding activities within a set period. A shorter breeding period results in the effective management of labour during breeding and eventually during the calving period. This results in producing a uniform calf crop that is older and heavier during the weaning season due to the increased growth time, thus increasing the production potential of the calves that would eventually translate into higher profits for the farmer. Estrus synchronization allows for the superior heifers to be bred to superior sires.

### Weaknesses

The technology is usually successful in breeding females that have a sufficient body condition to go on heat, which may be a challenge for indigenous animals. Animals may go on heat and not be detected owing to short estrus periods that last between 12 and 24 hours. It calls for the farmer being keen to recognize when the animal has gone on heat. The AI should be timed accurately for results to be achieved. Thus, the AI technician has to be available when the animals go on heat. The technology is dependent on keeping good records, which may not be a standard practice in rural Africa.

### Opportunities

There is a high demand in Africa for animals with high production traits. There are many institutions conducting research and development in this area. Mobile penetration within Africa is high, increasing the possibilities of accurate estrus synchronization.

### Threats

This technology combined with AI and ET has the potential to cause the genetic erosion of indigenous breeds. The demand for superior exotic breeds is a threat to the conservation and preservation of indigenous breeds. Inconsistent follow up, poor provision of extension services and lack of follow up by government and government agencies hinder the use of this technology. The high potential of this technology is hampered by poor information dissemination among famers of indigenous breeds.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology/innovation is locally available from local breeding stations, government stations, universities and research institutions.

## Primary users of the technology/innovation

The primary users of the technology/innovation are men who have the resources to acquire it.

## Climate-smart status of the technology/innovation

This technology is climate smart because it can be used as a tool to conserve indigenous breeds and promote their breeding, especially of those breeds with unique traits such as disease resistance and heat tolerance.

## Environmentally friendly status of the technology/innovation

Estrus synchronization promotes the birth of animals with good genetics and that are adapted to local environments. The technology is therefore environmentally friendly.

## Suggestions for improvement of the technology/innovation

Integrating the use of estrus synchronization with mobile technologies may yield positive results.

## Strategies that can be adopted by national governments to promote the uptake of estrus synchronization

National governments can promote this technology through strategies such as:

- Supporting estrus synchronization management which is expensive and may not be within the reach of all rural livestock farmers. This can be achieved by developing breeding programmes for indigenous breeds where indigenous livestock with superior genetics would be selected using genetic data, eventually leading to their development.
- Taking advantage of mobile technology penetration to collect data on indigenous breeds and disseminate this information
- Generating policies and legal frameworks, including developing breed standards of indigenous breeds for their conservation, rational utilization and management of indigenous genetic resources
- Identifying and using institutions with required infrastructure as a foundation for training and providing technical expertise

# Cryopreservation technology

## Primary use of the technology/innovation

Cryopreservation refers to the process of freezing semen from breeding males for use at a later date. Spermatozoa have a short viability and when AI cannot be done immediately it is often frozen. To protect the spermatozoa from damage, the freezing process involves the use of a cryoprotectant such as dimethyl sulphoxide or glycerol. Cryopreservation can be used in cryoconservation which is the collection of semen for potential use in future breeding of the livestock. Cryoconservation ensures the storage of semen (and of ova and somatic cells) in gene banks to conserve endangered populations or breeds of interest.



AU-IBAR

*Semen preservation*

## SWOT analysis of the technology/innovation

### Strengths

Cryopreserved semen can be stored and used at a later date. Cryopreserved semen when used together with AI, offers the advantage of selecting the parents. Semen preserved in this way can be stored indefinitely. It is easy to use and has a good success rate. It facilitates the breeding of animals from different geographical locations. Cryopreservation can store sperm from endangered species and this can be used later. It can be used to restore diversity. Cryopreserved semen has been stored for many years, sometimes up to 50, without significant loss of viability.

### Weaknesses

The collection and storage of semen for immediate breeding and/or future breeding is expensive, and requires specialized skills and infrastructure. Cryopreservation of semen from cattle has been successful; however, not all livestock species semen can be used in this way. Biosecurity management is key, to prevent the transmission of diseases to the facility and hence it often requires that the facility be constructed in an isolated area. Animals whose samples are collected should be disease free to protect livestock from getting diseases. Use of cryopreserved material requires clear policies, guidelines and legislation on their distribution to avoid misuse of the material.

### Opportunities

There are enormous opportunities of using cryopreservation for cryoconservation. This would ensure the preservation and breed reconstitution of many livestock breeds, especially those of indigenous breeds that are currently under threat of extinction. Regional genebanks for the preservation of indigenous African livestock are currently being established in Africa, presenting opportunities for the use of this technology.

### Threats

Cryopreservation when not managed adequately can lead to genetic erosion, and the propagation of the genotypes of a few animals.

### Local availability of the technology/innovation and potential suppliers across Africa

Cryopreservation is locally available from local breeding and government stations and institutions, for example, the Kenya Animal Genetic Resources Centre (KAGRC). Cryoconservation is available in regional gene banks such as the National Animal Genetic Resource Centre and Data Bank in Uganda.

### Primary users of the technology/innovation

The primary users of this technology are AI specialists, scientists and breeders involved in breeding and conservation of African livestock.

### Climate-smart status of the technology/innovation

Cryopreservation and cryoconservation technologies are climate smart because they support the conservation and preservation of indigenous African livestock breeds. They also support the re-constitution of breeds whose genetic diversity has become low or that have become extinct.

### Environmentally friendly status of the technology/innovation

Cryopreservation can be used to support the production of breeds that are high producers, thus making it environmentally friendly. For Africa, the focus of this technology would be to combine it with cryoconservation and to ensure that African breeds are not eroded genetically.

### Suggestions for improvement of the technology/innovation

An improvement may be made by integrating cryopreservation with emerging cold chain technology so as to avail it in regions where electricity may not be available.

### Strategies that can be adopted by national governments to promote the uptake of cryopreservation

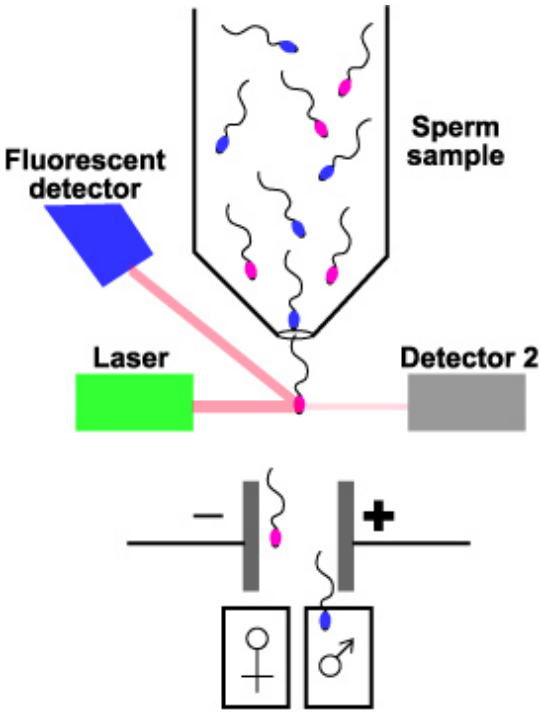
National governments can promote this technology by:

- Coordinating the collection of specimens for cryoconservation, in order to preserve local germplasm
- Supporting the regional genebanks by developing policies and legislation that promote the preservation of breeds' germplasm

# Sexed semen technology

## Primary use of the technology/innovation

Sexing semen is the process where semen is identified as to whether it bears an X or a Y chromosome. This procedure has enormous application in artificial insemination where the desired sex of the calf can be pre-determined.




*Source:* http://www.ansci.wisc.edu/jjp1/equine/technology/spsex.html

## SWOT analysis of the technology/ innovation

### Strengths

The process of sexing semen removes dead, deformed and unviable sperm ensuring that only viable semen is used. This therefore ensures high conception rates of over 90 percent even when the sperm used is at low concentrations. The conception of only healthy calves also guarantees easy pregnancy and births. When female only calves are produced a farmer saves time and resources that would have been used on unwanted male calves. It also ensures that the rapid reproduction of superior females occurs and ensures a constant supply of replacement heifers. Sexed semen provides an essential support to the artificial insemination and embryo transfer technologies, ensuring their success. The sexed semen technology provides an economic method of increasing herd strength without the risk of introducing diseases through the purchase of heifers from external sources, thus improving the bio-security of farms.

### Weaknesses

Purchase of the equipment and intellectual property rights is expensive. The equipment also has a low sorting efficiency and speed. It needs to be operated by highly skilled staff and the procedure results in the destruction and loss of about 50 percent of the sperm processed owing to shear force, electrostatic charge, droplet formation and when the machine stops suddenly. The procedure also results in a reduction of the freezing potential of sorted sperm.

### Opportunities

With the increase in demand for AI services, combining this with the use of sexed semen provides greater opportunities for dairy and beef production. The rapid reproduction of indigenous breeds with good traits can be enhanced through the use of sexed semen combined with artificial insemination and embryo transfer.

### Threats

The use of sexed semen together with AI and ET has the potential of causing the genetic erosion of indigenous breeds especially where farmers prefer exotic germplasm.

### Local availability of the technology/innovation and potential suppliers across Africa

The technology/innovation is locally available from local breeding stations, government and private institutions and universities.

### Primary users of the technology/innovation

The primary users are commercial farmers in high production settings.

### Climate-smart status of the technology/innovation

This technology supports breeding programmes that produce heat and disease-tolerant breeds. It also supports herd management, small herds and herd age structure.

### Environmentally friendly status of the technology/innovation

This technology has a low impact on the environment when being installed. It supports the production of animals that are wanted, thus reducing the cost of keeping animals that will later be culled.

### Suggestions for improvement of the technology/innovation

The technology can be improved through its integration with mobile technologies.

### Strategies that can be adopted by national governments to promote the uptake of sexed semen

National governments can promote this technology by:

- Spurring investment by the private sector in the provision of sexed semen as a service to commercial producers
- Investing in this technology in government stations involved in provision of AI services so as to avoid excluding the benefits of sexed semen to small-scale farmers

# Blood testing for pregnancy diagnosis in cattle

## Primary use of the technology/innovation

Early pregnancy detection is key to preventing losses and mitigating against complications, especially with first calving heifers. It is an essential tool for the management of productive and unproductive cows. Traditional methods of diagnosis of pregnancy in cattle are still in use and involve direct observation or by rectal palpitation. These methods have been enhanced by combining them with the use of rectal-ultra sound diagnosis. However, the methods are not entirely accurate and require the use of specialized staff and equipment. The use of indirect pregnancy diagnosis using blood tests offers early and accurate detection of pregnancy in cattle.



AU-IBAR

*Collection of blood sample for testing pregnancy*

## SWOT analysis of the technology/innovation

### Strengths

Blood pregnancy tests are non-invasive compared to other methods, are fast, efficient, cost effective and safe. The test is done approximately 28 days post breeding, thus offering early detection of pregnant and non-pregnant cows. The technology provides results that are 95 percent accurate in a cost-effective manner.

### Weaknesses

Blood tests work through the detection of pregnancy-specific proteins (PSP) in the animal's blood. However, PSPs can remain elevated for long periods after calving, sometimes up to 60 days and it therefore needs a grace period to avoid false positives. The test confirms the presence or absence of a pregnancy and cannot give information on the gender of the calf. The blood has to be sent to a laboratory for analysis, causing a delay of several days during which a cow has not been separated for specialized care. The technology may be expensive for farmers.

### Opportunities

Increasing awareness of the benefits of early pregnancy detection is creating demand for methods for early detection of pregnancy in cattle. This technology when combined with the use of sexed semen and AI can provide farmers with a highly productive farming system.

### Threats

The delays caused by not getting results immediately thus prompting other invasive pregnancy tests to be undertaken, makes the technology less attractive to farmers.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology/innovation is locally available from local biomedical laboratories.

## Primary users of the technology/innovation

The primary users are commercial farmers in high production settings.

## Climate-smart status of the technology/innovation

This technology supports breeding programmes that produce heat- and disease-tolerant breeds. It also supports herd management, small herds and herd age structure.

## Environmentally friendly status of the technology/innovation

This technology ensures that farms operate at high production levels, resulting in the efficient use of feed, energy and human resources.

## Suggestions for improvement of the technology/innovation

The technology can be improved through its integration with mobile technologies.

## Strategies that can be adopted by national governments to promote the uptake of blood testing for pregnancy diagnosis

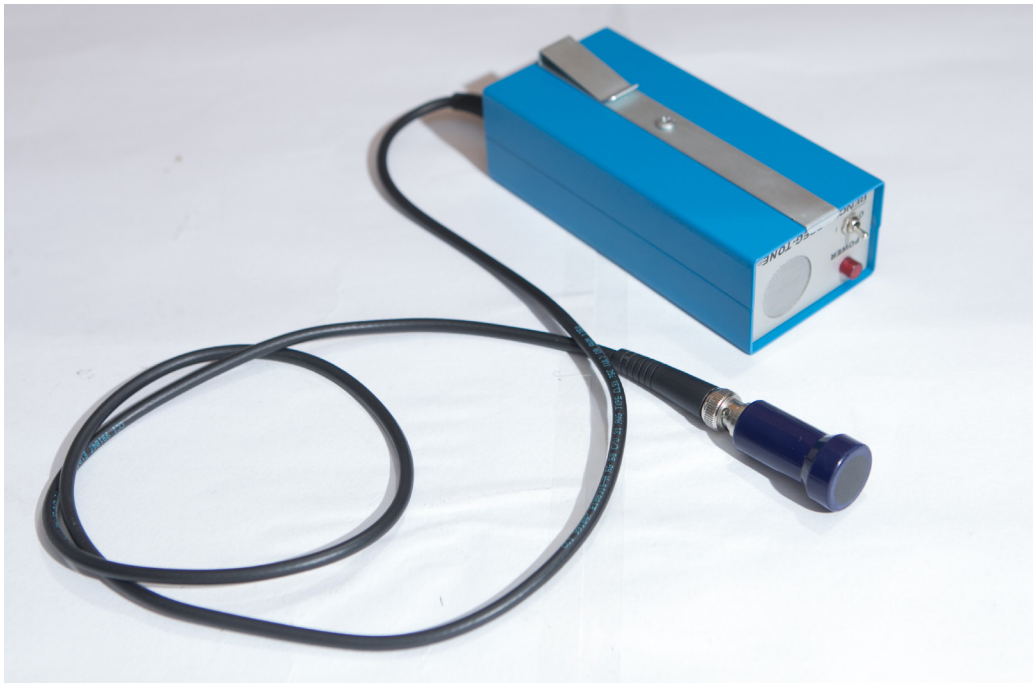
National governments can promote this technology by:

- Encouraging investments in more laboratories offering this service
- Developing policies and legislation that encourages private sector support in this area

# Transrectal real-time ultrasonography

## Primary use of the technology/innovation

Pregnancy diagnosis is an invaluable tool to the cattle producer who is trying to maintain maximum profitability. The use of transrectal real-time ultrasonography has been an effective tool in dairy and beef breeding programmes. This technology is revolutionary in enabling understanding of reproductive biology, key to successful commercial breeding programmes. This early detection tool facilitates real-time reproductive management decisions, such as re-breeding or culling, thus reducing expenses, and increasing profitability.



David Kihurani

*Ultrasound PD test machine*

## SWOT analysis of the technology/innovation

### Strengths

The rectal-sound ultrasound examination has the ability to determine the sex of the foetus after 60 days in gestation, allowing implementation of management strategies. This technology can identify a dying foetus and enable it to accurately pinpoint a dying foetus or one that has recently died, which can then efficiently aid to resynchronize the animal in the reproductive programme. It enables early detection of disease which delays conception such as pyometras. This technology is also more effective in detection of multiple pregnancies and staging age of the foetus. In addition, it has been reported to reduce in embryonic loss associated with rectal palpation conducted early in gestation as well as effective oestrus and ovulation synchronization for effective timed Artificial Insemination.

### Weaknesses

Ultrasound examinations are considerably invasive though not as invasive as the rectal palpation. The technology may be expensive to farmers. Technical expertise is required in the utilization of the equipment and interpretation of the images.

### Opportunities

Increasing awareness of the benefits of early pregnancy detection is creating demand for methods for early detection of pregnancy in cattle. This technology when combined with the use of sexed semen and AI can provide farmers with a highly productive farming system

### Threats

The technology is considered invasive and may not be preferred by small-holder farmers

### Local availability of the technology/innovation and potential suppliers of the technology/innovation across Africa

The technology/innovation is locally available from local biomedical laboratories.

### Primary users of the technology/innovation

The primary users are commercial farmers in high production settings

### Climate-smart status of the technology/innovation

This technology supports breeding programmes that produce heat and disease-tolerant breeds. It also supports herd management, small herds and herd age structure

### Environmentally friendly status of the technology/innovation

This technology ensures farms operate at high production levels, resulting in the efficient use of feed, energy and human resources.

### Suggestions for improvement of the technology/innovation

The technology can be improved through its integration with mobile technologies

### Strategies that can be adopted by national governments to promote the uptake of transrectal real-time ultrasonography

- Investments in more laboratories offering this service needs to be encouraged
- National governments need to develop policies and legislation that encourages private sector support in this area

# Digital scales

## Primary use of the technology/innovation

Weighing livestock plays an important role in tracking their performance, animal health and determining the best time to breed an animal. Digital livestock scales are electronic, having an LCD screen on which the weight is displayed thus providing an accurate weight. The previous generation of scales used springs on the underside of the machine. When a weight was placed on the surface, the springs contracted and initiated a spinning wheel with measurement marks on it. This would then display the weight of the animal.




AU-IBAR

*Digital weight recording*

## SWOT analysis of the technology/innovation

### Strengths

The digital scales are reliable, durable and readings provided are highly accurate. They are easy to use and can be controlled directly or remotely. Readings are generated automatically and are displayed on an LCD screen. The scale can be connected to a computer where all the weights are stored for further analysis. Digital scales reduce or completely eliminate human error. Additional features that can be found on a digital scale include body composition analysis, fat percentage and other readings that can be very useful in a production setup.

### Weaknesses

The technology is dependent on a source of power which can be direct electricity or rechargeable batteries. They cost much more than the analogue scales and besides, they require calibration. They may not be easily available.

### Opportunities

With the increased demand for livestock products, it is necessary to have accurate weighing of the goods. Digitization of livestock production will make a great contribution to sustainable livestock production. The digital scales maximize profits while minimizing the risks farmers face.

### Threats

The use of digital scales can be disadvantageous to small-scale farmers especially when it is more disruptive than enabling to their production methods. The data collected needs to be smart or useful to the farmer directly. If not, the farmer can easily be overwhelmed by the data collection process. Data should be collected and used in a transparent manner.

## Local availability of the technology/innovation and potential suppliers across Africa

Digital scales are available from local suppliers.

## Primary users of the technology/innovation

The primary users are commercial farmers in high production settings.

## Climate-smart status of the technology/innovation

The digital scale supports the sustainable production of livestock. This enables farmers to reap more profits, thus allowing them to make more money from their produce. It empowers farmers to charge accurately for their product and reduces wastage.

## Environmentally friendly status of the technology/innovation

The installation of digital scales has little or low impact on the environment when being installed. It supports the sustainable production of livestock and livestock products.

## Suggestions for improvement of the technology/innovation

To improve the technology, scales that do not only rely on electricity should be developed.

## Strategies that can be adopted by national governments to promote the uptake of digital scales

National governments can promote this technology by:

- Making the digital scales cost effective, robust, simple to use and accessible so that small-scale farmers can adopt and invest in the scales
- Making a concerted advocacy and capacity enhancement drive in order to ensure that small-scale farmers realise the benefits of using scales for their livestock and livestock products production

## 3.1.2 Feeding

# Feed formulation technologies

### Primary use of the technology/innovation

Feed formulation is the process of combining different livestock feed ingredients in specific proportions to provide animals with the required nutrients at each stage of their growth. Determining the ration (the amount of food given to an animal daily) requires precise calculation of the nutrients the animals need, depending on their production stage and an assessment of the feedstuff available. Feed formulation is critical to ensure that the nutritional requirement of the animal is met. The feed formulation process involves calculations that used to be done manually but are now provided by software. This software can be purchased, especially for use in specialized production systems. However, there are many feed formulation technologies that are available on the internet.




AU-IBAR

*A small-scale feed manual feed mixer*

### SWOT analysis of the technology/innovation

#### Strengths

The use of software to formulate feed is an easier method to use than the manual method. It provides precision and uniform formulation of animal feed. It is simple to use, where the farmer only keys in required data and the software calculates the specific proportions. It eases the pressure on farmers to ensure animals have precise nutritional requirements to maximize profits. It also enables precise feed formulation with determination of the quality and quantity of feed.

#### Weaknesses

The development of the feed formulation software requires specialized skills. Unavailability and high cost of feed formulation may deter the accurate constitution of feed.

### Opportunities

The rise in demand for meat, milk and other livestock products has resulted in an increase in the global demand for animal feed. This has been projected at an increase of 15 percent annually from 2018 owing to growth in the livestock sector. Developing country demand for feed concentrates has been rising steadily over the last decades, driven primarily by an increased demand for meat, milk and other livestock products.

### Threats

Rising costs of grain threatens farmers' ability to provide feed for their animals. The competition for grain between humans and animals, and the increasing demand for animal protein threatens the use of food grain for the production of high value animal protein.

## Local availability of the technology/innovation and potential suppliers across Africa

There are many feed formulation software programmes freely available online. Larger commercial entities may opt to purchase tailor-made options; however, it may not always be necessary.

## Primary users of the technology/innovation

Feed formulation software is used by beef and dairy cattle farmers in medium- or large-scale production systems.

## Climate-smart status of the technology/innovation

Feed formulation is a necessary component of sustainable cattle production. It supports the efficient utilization of feed, thus reducing wastage and hence directly contributing to increased livestock production.

## Environmentally friendly status of the technology/innovation

Feed formulations do not require any environmental installations and are hence environmentally friendly.

## Suggestions for improvement of the technology/innovation

Specific feed formulation software for small-holder African farmers should be developed.

## Strategies that can be adopted by national governments to promote the uptake of feed formulation

National governments can promote this innovation through strategies such as:

- Educating small-holder farmers on the importance of accurately determining the feed composition of livestock feed
- Creating awareness through cooperatives and other farmer organizations on the benefits of correct feed composition for their livestock

# Automatic cattle feeding system

## Primary use of the technology/innovation

The automatic cattle feeding system is a robotic feeding system used in feeding cattle. The system can be used in both beef and dairy production. It consists of a robotic feeder that is either manually or automatically loaded with feed that has been specially constituted for the cattle's dietary needs. The robot then travels along a designated path using sensors to distribute feed to animals in a shed. The robotic system detects the amount of feed available in the shed using laser lights and calculates the amount of feed the cattle need.




en.schauer-agrotronic.com

*An automatic cattle feeding system*

## SWOT analysis of the technology/innovation

### Strengths

The automatic cattle feeding system provides the cattle with fresh feed at all times. Its automated system ensures that the cattle do not run out of feed by increasing the feed in lots where the amounts have decreased, and mixing and pushing feed out to cattle in lots where the cattle are shy to approach the feed lots. With this system, there is no rush for feed or bullying from aggressive cattle. The robot feeds the cattle for 24 hours per day so the cattle eat on demand, resulting in higher production.

### Weaknesses

The automatic cattle feeding system is fairly expensive, requires specialized infrastructure and skilled personnel to operate, and can only be used in intensive beef or dairy production systems. The system requires electricity to operate and the farmer has to invest in emergency back-up power supply to ensure that it can operate for 24 hours. It needs large inputs of grain, silage and feed mixes.

### Opportunities

The automatic cattle feeding system guarantees higher production for the farmer, which translates into higher profits.

### Threats

The automatic cattle feeding system is a highly specialized and expensive system to acquire. This together with the expensive infrastructure it requires threatens its adoption. Large-scale beef producers with land would prefer to graze the animals.

## Local availability of the technology/innovation and potential suppliers across Africa

The automatic cattle feeding system is not locally available.

## Primary users of the technology/innovation

The automatic cattle feeding system is mainly used by large-scale commercial beef or cattle producers.

## Climate-smart status of the technology/innovation

The automatic cattle feeding system achieves the sustainable production of beef, milk and other livestock products by reducing wastage and maximizing profits.

## Environmentally friendly status of the technology/innovation

The automatic cattle feeding system requires that specialized infrastructure be set up on farms, the installation of which needs specialized designs and planning in order for it not to destroy the environment.

## Suggestions for improvement of the technology/innovation

The automatic cattle feeding system can be improved by designing systems that can cater for medium intensity production systems.

## Strategies that can be adopted by national governments to promote the uptake of the automatic cattle feeding system

National governments can promote this technology by developing partnerships with the private sector to mitigate the high cost of investment in the system.

# Insects as alternative protein sources of animal feeding

## Primary use of the technology/innovation

The use of insects to feed fish in aquaculture is well established. However, with knowledge on the nutritional value of various insect species becoming available, the use of insects as livestock feed is now being practised.

Analysis of the feed nutritive value and determination of the quality of the protein and content has determined that 15 insect species drawn from five orders have the same protein nutritive content as commercial protein sources. These are listed in Table 1 below:

*Table 1: List of scientific and common names of insects reared for alternative animal feed*

| S/N | Scientific name | Common name(s) | Stage consumed by livestock |
|---|---|---|---|
| *1.* | *Blaptica dubia* (Serville, 1838) | Orange-spotted cockroach | Adult females; adult; nymph |
| *2.* | *Blatta lateralis* (Walker, 1868) | Turkestan cockroach<br>Rusty red cockroach<br>Red runner cockroach | Adult; nymph |
| *3.* | *Eublaberus distanti* (Kirby, 1903) | Bat-cave cockroach | Adult; nymph |
| *4.* | *Alphitobius diaperinus* (Panzer, 1797) | Litter beetle<br>Lesser mealworm | Larvae |
| *5.* | *Tenebrio molitor* (Linnaeus, 1758) | Mealworm beetle | Adult; pupae; larvae |
| *6.* | *Zophobas morio* (Fabricius, 1776) | Superworm | Adult; larvae |
| *7.* | *Hermetia illucens* (Linnaeus, 1758 | Black fly | Pre-pupae; maggot; larvae |
| *8.* | *Musca domestica* (Linnaeus, 1758) | Common housefly | Pupae; maggot; larvae |
| *9.* | *Antheraea assamensis* (Helfer, 1837) | Muga silkworm | Pupae; larvae |
| *10.* | *Bombyx mori* (Linnaeus, 1758) | The domestic silkmoth | Pupae; larvae |
| *11.* | *Galleria mellonela* (Linnaeus, 1758) | The greater wax moth<br>The honeycomb moth | Larvae |
| *12.* | *Samia riciini* (Anderson, 1788) | Ailanthus silkmoth | Pupae; pre-pupae |
| *13.* | *Acheta domestica* (Linnaeus, 1758) | House cricket | Adult; nymph |
| *14.* | *Gryllodes sigillatus* (Walker, 1869) | Banded cricket | Adult; nymph |
| *15.* | *Gryllus assimilis* (Fabricius, 1775) | Field cricket | Adult; nymph |
| *16.* | *Locusta migratoria* (Linnaeus, 1758) | The migratory locust | Adult; nymph |
| *17.* | *Zonocerus variegatus* (Linnaeus, 1758) | Variegated grasshopper | Adult; nymph; pupae |

## SWOT analysis of the technology/innovation

### Strengths

Advantages offered by the use of insects for alternative feed include the fact that they have high protein content; they are easily cultivated on organic waste and industrial by-products; they have a high feed conversion rate; and they have high fecundity. They also have low space and energy requirements to rear. Insects can be produced quickly and throughout the year. Their production has been documented to use less water compared to conventional livestock. The rearing of insects is sustainable and offers a quick solution to bridging the gap in available feed for livestock. Studies have shown that insects have a high palatability. The enzymes found in larvae have been found to be useful aids in livestock gut health[1, 2].

### Weaknesses

Many countries are yet to develop the required regulatory framework to facilitate the development and use of insects as feed. The scaling up of rearing processes remains a real challenge for many insect feed producers. Currently, there is a knowledge gap on the safety of using insects for animal feed especially when chemical and microbiological safety is concerned. Other concerns are on the impact of insects on local biodiversity and the impact of accidental releases of insects into the environment. Managing the inputs given to the insects presents a challenge especially when the main food source being used for the insects is food waste. This is because it is not possible to guarantee the exact composition of food waste needed to generate feed that is homogenous.

### Opportunities

The United Nations Food and Agriculture Organization (FAO) estimates that an increase in production of commercial feed production by 70 percent is needed in order to meet growing demand for protein[3]. Insect rearing offers an attractive solution to the food waste problem where food waste can now become a new alternative for generating revenue.

### Threats

The traditional animal feed suppliers have large scale production systems and this poses a threat to the insect feed producers who are facing challenges in up scaling insect production to meet demand.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology is locally available.

1 Rumpold, B. A., & Schlüter, O. K. (2013). Potential and challenges of insects as an innovative source for food and feed production. Innovative Food Science & Emerging Technologies, 17, 1-11.

2 Urošević, M., Popovic, A., Jajić, I., Petrovič, M., Krstović, S., & Samardzic, M. (2019). The potential and risks of insect usage as animal feed—the legislation in European Union and perspective for Serbia. Ann. Agron, 43, 46-56.

3 FAO. (2018). How to feed the world in 2050. FAO - The Food and Agriculture Organization of the United Nations. Rome, Italy, http://www.fao.org/fileadmin/templates/wsfs/docs/expertpaper/HowtoFeedtheWorldin2050.pdf. Last accessed: 30. Oct 2020.



Commons.wikimedia.org/Dragüs

*Orange-spotted cockroach (*Blaptica dubia)

### Primary users of the technology/innovation

Insect rearing is primarily used by large- and medium-scale alternative feed producers.

### Climate-smart status of the technology/innovation

Insect rearing is climate smart owing to the sustainable model that it utilizes.

### Environmentally friendly status of the technology/innovation

The insects provide an environmentally friendly and nutritious ingredient for animal feed. Insects are able to convert industrial and farm waste into high protein, fat and minerals for animal feed thus offering solutions for waste management. Insects have also been shown to produce less greenhouse gases compared to conventional livestock. For example, pigs have been shown to produce 10-100 times more greenhouse gases per kg of weight compared to mealworms[2].

### Suggestions for improvement of the technology/innovation

To improve this technology, the relevant policy framework needs to be developed.

### Strategies that can be adopted by national governments to promote the uptake of insects as alternative protein sources of animal feed

National governments can promote this technology through:

- Developing relevant regulatory frameworks
- Advocacy with livestock farmers in order to develop their acceptance levels to feeding their livestock insects

# Feed supplementation block-making technology

## Primary use of the technology/innovation

The feed supplementation block-making process follows different approaches in different countries depending on the required amounts of blocks and the individual farmer's needs. Different approaches can be adopted to mix the ingredients, ranging from hand mixing, through using shovels to mechanical mixing using a mixer. This process is followed by compacting which can be done manually using home-made cardboard, wood or metal molds. The feed supplementation block-making technology uses an equipment to mix the feed ingredients and compact them. Feed supplementation block-making machines can be manual or mechanized.



AU-IBAR

*Manual feed supplementation block-making machine*

## SWOT analysis of the technology/innovation

### Strengths

Using a feed supplementation block-making machine is more advantageous because all the ingredients are mixed well to make a well-formed consistency. It also saves a farmer's time and the farmer is able to avoid the hard process of making the blocks manually. The machine is easy to operate and maintain, and is affordable. The block-making machine assists the farmer to gauge the feed requirements of the animals, hence reducing wastage. Using a machine to make feed supplementation blocks is an efficient method of making a large number of feed blocks.

### Weaknesses

The feed supplementation block-making machine may cost more than the farmer is able to afford. It may require to be assembled by skilled personnel and further, technically skilled persons may be needed to operate it. Manual machines require hard labour inputs, while mechanized versions require diesel or electricity to operate, which may not be cheap. These latter versions may pollute the environment.

### Opportunities

The increased demand for meat, milk and livestock products in Africa is projected to rise to an average of 64 kg of milk in 2050, up from 44 kgs in 2013. There are numerous opportunities for the livestock sector to reduce poverty in Africa. The livestock sector contributes between 30 and 80 percent to countries' agricultural and national GDP.

### Threats

Commercially produced farmers' feed blocks have competitive advantage, have the marketing advantage too and are therefore easy to market and promote among the farmers.

## Local availability of the technology/innovation and potential suppliers across Africa

Mechanized feed supplementation block-making machines are locally available.

## Primary users of the technology/innovation

The primary users the feed supplementation block are farmers keeping dairy cattle, sheep and goats.

## Climate-smart status of the technology/innovation

The feed supplementation block machines reduce poverty at the farm level by increasing livestock productivity. The farmer is also able to make many feed supplementation blocks which he can sell to his neighbours, thus diversifying his income.

## Environmentally friendly status of the technology/innovation

The manual feed supplementation block-making machines are environmentally friendly and have no impact on the environment when being installed. However, the mechanized versions of this machine may produce emissions which may be detrimental to the environment.

## Suggestions for improvement of the technology/innovation

The technology could be improved by:

- Developing simple mechanized versions that have a lower impact on the environment, for example, by replacing diesel motors with green energy-operated motors
- Developing designs that are simple, easy to copy and can be fabricated at the community level

## Strategies that can be adopted by national governments to promote the uptake of feed supplementation block-making machines

National governments can promote this technology by:

- Creating partnerships that can finance the acquisition of the feed supplementation blocks
- Developing business models easily adopted by farmers who wish to earn additional incomes from making blocks for sale

# Feed supplementation blocks

## Primary use of the technology/innovation

African livestock are often fed on crop residues and pasture that are lacking essential nutrients like nitrogen, minerals and vitamins. Commercial protein supplements such as seed cakes are very expensive and this has led to farmers making non-protein/nitrogen blocks for supplementation using urea, indigenous forages and legumes. The use of indigenous trees, shrubs, legumes and urea have the potential of alleviating feed shortages and nutritional deficiencies occasioned by the high cost of feed and shortages of grain caused by droughts.

The ingredients often constitute molasses, protein source (which can be from indigenous legumes, trees or forages), urea (which provides a source of nitrogen which livestock convert into usable protein), cement or lime (which supplies calcium and acts as a block hardener), salt (which attracts the livestock to the block and limits the animal's appetite) and a phosphorus source.




AU-IBAR

*Feed supplementation blocks*

## SWOT analysis of the technology/innovation

### Strengths

The farmer-made feed and mineral blocks offer livestock the required nutrients including nitrogen, minerals and vitamins that are lacking in fibrous feeds. They are a simple way of supplying protein to livestock. Easy to make, store and transport, they are also safe for livestock consumption. They are a cheaper protein source compared to commercial protein. These blocks enhance the nutritive content of feed thus increasing milk and meat

production, and higher reproduction, especially in small ruminants. Special medicated blocks (for example, medicated urea molasses blocks) can be made to control some parasites, for example, nematodes. Farmer-made feed and mineral blocks containing urea are very useful because they increase the efficiency of the rumen fermentation and they prevent livestock from selecting the feed they want to consume, leaving the other less favorable ingredients.

### Weaknesses

Farmers may need to invest in a feed block-making device if they have many animals. The formulation of the feed requires precise and accurate constitution of the various nutrients. The formulator needs to take various factors into consideration including the livestock species, the production stage, and the feed substrates that are available. This requirement means there is a danger that the farmer will make one block for all the livestock species and ages that he has, resulting in poor production performance of the animals. The livestock need to be trained to eat or lick the block to ensure a consistent intake of protein across the herd. Blocks can be used for too long especially when feed quantity is low. It is also important for the farmer to understand that the blocks cannot be used as an energy supplement, or given to animals less than six months of age, and should be protected from wet and humid conditions to prevent them from becoming soft.

### Opportunities

The increase in demand for meat, milk and livestock products in Africa is projected to increase to an average of 64 kg of milk in 2050 up from 44 kg in 2013. There are numerous opportunities for the livestock sector to reduce poverty in Africa. The livestock sector contributes between 30 and 80 percent to countries' agricultural and national GDP.

### Threats

Feed supplementation using grain and minerals is in direct competition with human food provision. Shortage of feed and fodders is a major problem in Africa. The quality and quantity of the feed and fodder when available may also be a challenge mainly because of droughts caused by climate change.

## Local availability of the technology/innovation and potential suppliers across Africa

Supplementation of livestock feed using locally produced feed is available in Africa.

## Primary users of the technology/innovation

The primary users of feed supplementation are beef and dairy cattle farmers.

## Climate-smart status of the technology/innovation

Livestock feed supplementation results in increased meat and milk production by livestock. This results in more income being generated by farmers, thus reducing poverty and supporting their sustainable livelihoods.

### Environmentally friendly status of the technology/innovation

The use of locally produced legumes, urea and minerals reduces wastage of these products from the environment.

### Suggestions for improvement of the technology/innovation

The technology could be improved by developing feed supplementation formulas that can be easily adopted for use by small-scale farmers.

### Strategies that can be adopted by national governments to promote the uptake of feed supplementation blocks

National governments can promote this technology by:

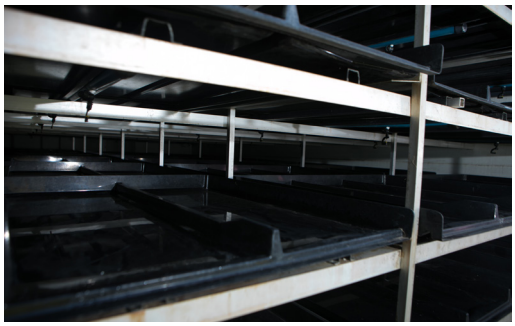
- Improving on the provision of extension services, especially among small-scale farmers to ensure that they are supplementing their livestock feed
- Developing the capacity of farmers to make nutritious blocks individually or within blocks

# Hydroponics for fodder production

## Primary use of the technology/innovation

The hydroponics technology entails the growing of plants without the use of soil. The use of this technology for fodder production has been revolutionary because of the advantages it offers, including producing fodder for livestock production in a short time of about seven days and in small spaces. The fodder is grown in climate-controlled environments where all the plants' requirements of water, temperature, lighting and humidity are maintained at ideal conditions in order to maximize outputs. It has been reported that plants grown in hydroponic systems have 20-25 percent higher yields than field-grown plants with a probability that is 2-5 times higher[4].







AU-IBAR

*A hydroponic system in government-owned farm*

4 Resh, H.M. (2013). Hydroponic food production: A definitive guidebook for the advanced home hydroponic grower. CRC Press, Taylor and Francis Group, Florida, USA.

## SWOT analysis of the technology/innovation

### Strengths

The hydroponic fodder grows in a very short time of seven days while field fodder takes months to grow[5]. Hydroponics fodder production guarantees a stable, consistent and predictable production; it has higher nutritive value compared to traditional fodder; it requires less water, with 3-4 litres of water used to grow one kilogram of fodder compared to 70-100 litres of water needed for traditional fodder. The fodder can be produced on a regular basis throughout the year and is therefore not affected by prevailing climatic conditions. The hydroponics system has complete control over the internal climate. The growth environments are well contained and hence not vulnerable to pest invasions. Hydroponics fodder therefore, does not require any pesticides or chemicals to grow. It is not dependent on soil fertility since it does not need any soil. The fodder does not need a large area to produce, thus is an effective means of using space. The nutrients and pH are optimally calibrated for the specific type of fodder. Thus, the plants effectively utilize the nutrients. Hydroponics systems do not have the challenge of feeds that take long periods to grow, thus saving time and cost of weed control. Hydroponics systems save production time and require a lean staff hence saving on costs of labour.

### Weaknesses

Hydroponic fodder production is sophisticated and expensive to purchase and install. It requires highly skilled technical expertise to operate, install and monitor. It needs real time monitoring. It has the disadvantage of using a lot of water and hence adequate measures have to be made to ensure a constant supply of water, including additional water storage facilities. All water should be applied directly to the roots and any water not used should be recycled. The main power source in a hydroponic plant is electricity. Perhaps a great disadvantage to investors is the slow rate of return on investments.

### Opportunities

There is a high potential for use of hydroponics to grow fodder owing to climate change and challenges of diminishing agricultural land. Global market opportunities for hydroponics were estimated at USD 9.5 billion in 2020 and are expected to grow at a compound annual growth rate of 12 percent to reach 16.6 billion in 2020[12]. Growth in the market is attributed to the increasing acceptance of growing plants in controlled environments. This growth is expected to lead to the development of cheaper and more efficient hydroponics systems that would be more affordable, have higher production rates and thus would be more cost effective.

### Threats

The constant water shortages, power outage, low rate of return, high infrastructure requirements and investment may mean that many farmers will avoid investing in hydroponics for fodder production, preferring instead the simpler and more conventional fodder production systems. The hydroponics system also carries a high risk of water-borne disease outbreaks that would easily spread throughout the system's establishment

5 Research and Markets. (2020). Hydroponics market by type (aggregate systems, liquid systems), crop type (vegetables, fruits, flowers), equipment (HVAC, led grow light, irrigation systems, material handling, control systems), input, region - global forecast to 2025.

as a result of using a common water reservoir and recirculating water. To mitigate against this risk, growers would need to invest in water filtration systems that can prevent the entry of microorganisms into the system.

### Local availability of the technology/innovation and potential suppliers across Africa

The hydroponics system is available from hydroponics distributors.

### Primary users of the technology/innovation

The primary users of this technology are large-scale farmers and investors.

### Climate-smart status of the technology/innovation

This hydroponic technology is a form of climate-smart agriculture that results in higher production of feed and has a direct impact on livestock production. Growing large amounts of feed using considerably smaller amounts of water and space effectively utilizes resources more efficiently, thus reducing the impact of agriculture on climate change.

### Environmentally friendly status of the technology/innovation

This hydroponics technology efficiently uses small land spaces for growth of fodder, which would normally require large tracts of land. It uses liquid systems to grow plants, thus preserving the natural soils. The water used in the hydroponics is recycled, thus is efficiently used and conserved. The crops grown using hydroponics would be considered to be organically grown, which is environmentally friendly.

### Suggestions for improvement of the technology/innovation

The national government and private sector should develop low cost hydroponic systems made up of local materials and locally adapted greenhouses.

### Strategies that can be adopted by national governments to promote the uptake of hydroponics

The hydroponics system for growing fodder is cost effective and sustainable. However, the high costs of investment and infrastructure development means that only a few can enter this market.

National governments can promote low cost hydroponics systems for Africa by developing modified greenhouses with wooden shelves for holding seed trays. The water system could also be modified to use polyvinyl chloride (PVC) pipes.

# Improved indigenous grasses

## Primary use of the technology/innovation

Using indigenous African grasses and forages for dairy production has an enormous potential to increase dairy production in Africa, especially because they are native to the continent[67]. These grasses and forages being native to the continent have the added advantage of being locally adapted. One such grass is *Brachiaria*, a grass that is native to Africa, and is found to grow naturally in large sections of natural savannah landscapes of Africa. *Brachiaria* has been proposed as a dry season compliment to other grasses. Genetically improved *Brachiaria* has been developed and introduced to farmers in Eastern Africa, namely Kenya and Rwanda and this has directly resulted in a 15-40 percent increase in milk production[8].



AU-IBAR

*Improved grass* – Brachiaria *grass*

## SWOT analysis of the technology/innovation

### Strengths

The *Brachiaria* grass is a local grass and indigenous to Africa. It is therefore adapted to the environment and because of this, it has been found to grow fast with less water. *Brachiaria* has deep roots and hence serves the dual purpose of fodder and reducing soil erosion. It is easy to establish by using vegetative propagation. It is drought resistant and is adapted to low fertility soils, thus it can do well with low fertilizer inputs, and is palatable to animals. It also transfers atmospheric carbon to soils, is an efficient user of nitrogen and helps minimize ground water pollution. *Brachiaria* is resistant to many diseases that affect other

6 Raney, T. (2011). The state of food and agriculture. *Women in Agriculture: Closing the Gap for Development*, *2*.
7 Ghimire, S. R., Njarui, D. M., Mutimura, M., Cardoso Arango, J. A., Johnson, L., Gichangi, E., ... & Djikeng, A. (2015). Climate-smart Brachiaria for improving livestock production in East Africa: Emerging opportunities.
8 Mureithi, J. G., & Djikeng, A. (2016). Overview of the climate-smart Brachiaria grass programme. Climate-smart Brachiaria grasses for improving livestock production in East Africa-Kenya Experience, 1.

forage crops like Napier grass, alfalfa and clovers including Napier stunt and smut disease[2]. *Brachiaria* has also been found to be an ideal grass to use in rehabilitating pastures that are environmentally degraded.

### Weaknesses

The uptake and dissemination of *Brachiaria* has also proved to be challenging. Planting *Brachiaria*, especially in small-holder farms, is likely to have the unwanted effect of replacing cash crops to make room for grass, thus reducing the farmers' incomes from these cash crops.

### Opportunities

Small-scale farmers who have planted *Brachiaria* have reported an almost immediate increase in dairy production. Planting *Brachiaria* especially offers small-scale farmers the opportunity to intensify their production system, thus increasing their incomes and so directly reducing poverty.

### Threats

Small-holder farmers in certain regions of Africa, for example Eastern Africa have predominantly fed their dairy animals with Napier grass which offers advantages of high biomass production and can withstand frequent cutting.

## Local availability of the technology/innovation and potential suppliers across Africa

The *Brachiaria* grass is locally available from government stations, national research stations and directly from farmers.

## Primary users of the technology/innovation

The primary users of this technology are farmers, small-scale holders and large-scale commercial farmers.

## Climate-smart status of the technology/innovation

*Brachiaria* can be considered to be a climate-smart technology because feeding it to livestock results in immediate increase in meat and milk production. This directly impacts the incomes of the farmers, improving their livelihoods and reducing poverty.

## Environmentally friendly status of the technology/innovation

*Brachiaria* is indigenous to Africa and its propagation and genetic improvement will support its conservation and sustainable use. Its long roots prevent soil erosion and the grass has been used to rehabilitate degraded pasture lands, thus preventing further erosion and degradation. It uses little water and is easy to establish.

## Suggestions for improvement of the technology/innovation

Developing strategies for its genetic improvement will result in a larger diversity of cultivars that can be easily adapted in a large range of environments.

## Strategies that can be adopted by national governments to promote the uptake of improved indigenous grasses

National governments can promote the uptake of *Brachiaria* through:

- Collection and characterization of all of the indigenous *Brachiaria* of Africa
- Establishing genetic improvement programmes
- Creating awareness throughout Africa on the benefit of growing *Brachiaria*
- Developing dissemination strategies for *Brachiaria* among livestock producers

# Enzymes in animal feed

## Primary use of the technology/innovation

The primary expense for any livestock farmer is feed, which accounts for up to 70 percent of the total costs. To increase the efficiency of the livestock's digestive system and to maximize on the nutrient value of feed, enzymes were introduced to livestock feed. These enzymes include phytase (to decrease phosphate excretion), carbohydrase (to digest fibre, starch and other carbohydrates) and proteases (to improve on the digestion of proteins).

These enzymes help to break down indiscriminating factors such as phytate and fibre that are naturally present in various livestock feed, thus enhancing their digestibility. These enzymes naturally exist and are eventually digested or excreted by the animal and therefore leave no traces in the animal products such as meat or milk.

## SWOT analysis of the technology/innovation

### Strengths

The use of enzymes increases the digestibility of plant-based feed, increases the utilization of the nutrients in feed and increases the flexibility and range of feed sources that can be used to formulate feed. The enzymes increase the feed conversion rate, resulting in faster growth and reduced variability in the nutritive value of feed. This results in herd growth uniformity and an increase in the production of poor animals. Enzyme use has also been found to favorably alter the gut microbiome leading to enhanced digestion and absorption. The use of digestive enzymes produces less animal waste and hence less pollution of the environment.

### Weaknesses

Enzymes, being proteinous in nature are easily denatured. They can only work when the specific moisture, temperature, pH, enzyme and substrate concentrations are used. They digest specific substrates and hence the farmer cannot use one enzyme for all types of feed; the enzymes need to be added to specific substrates. The activity of the enzymes is easily reduced if they are not stored in proper conditions.

### Opportunities

The use of antibiotics has been the leading growth enhancer. However, the limitations put on their use, together with the increase in demand for animal proteins means that livestock producers will turn to the use of enzymes.

### Threats

The high costs of the enzymes together with the very specific way in which they are used make them more suitable for use in large, high intensive commercial establishments and not for the small-holder farms.

### Local availability of the technology/innovation and potential suppliers across Africa

The enzymes are locally available.

### Primary users of the technology/innovation

The primary users of enzymes are commercial and intensive farming establishments.

### Climate-smart status of the technology/innovation

The use of enzymes in animal feed results in increased production, reduced wastage of feed, and faster and more uniformed growth of the animals. This leads to increased incomes for the farmer.

### Environmentally friendly status of the technology/innovation

Enzymes have been found to reduce production of animal waste which can be a huge problem in large commercial production establishments. Enzyme use results in the efficient production of nutrients thus reducing wastage.

### Suggestions for improvement of the technology/innovation

Cheaper and more stable enzymes should be developed.

### Strategies that can be adopted by national governments to promote the uptake of enzymes in animal feed

National governments can promote this technology by:

- Improving technology transfer to small-scale livestock producers through extension networks
- Developing partnerships that would result in cheaper enzymes

# Rain water management technologies

## Primary use of the technology/innovation

Rainwater harvesting involves the collection and storage of runoff water for use in crop and livestock production. Practicing rainwater harvesting is especially key because agricultural production in Africa mainly depends on rain. With climate change being experienced in most parts of Africa, coupled with the change in rainfall patterns, rainwater harvesting is necessary to mitigate against water shortages. To secure water availability especially for small holder farmers, it is important for them to adopt water storage technologies. These technologies include roof rain water catchment, small reservoirs and dams.




AU-IBAR

*Roofrain water harvesting*



AU-IBAR

*Waterpan*

## SWOT analysis of the technology/innovation

### Strengths

Rainwater harvesting provides an independent source of water for the farmer, supplementing rainfall water. During the dry season the harvested water acts as a water source for the farmer. Farmers have multiple needs for water, including domestic, crop and livestock farming, which can all be catered for by the harvested water. The technologies are easy to design, build and maintain.

### Weaknesses

The quality of the stored water should be assessed before being given to animals. While rain is a clean source of water, storage of water can sometimes lead to its pollution. High

use of agro-chemicals in farming can lead to their being washed into the storage reservoirs, making the water unsafe for human or animal consumption. Rainwater harvested from roofs is easily contaminated by dust, moss, lichen, and human or animal faeces.

### Opportunities

Recurring droughts, increased water demand, low supply and high cost of country water supplies presents an opportunity for increasing the number of farmers storing rainwater for livestock production. Availability of water in arid and semi-arid areas presents opportunities for rehabilitation of degraded grasslands. New and cheaper water drilling technologies together with a large variety of water pumps help farmers to increasingly rely on their own water for the storage and management of water.

### Threats

Increased water demand for human and domestic use threatens its availability for livestock.

## Local availability of the technology/innovation and potential suppliers across Africa

Water storage technologies are available locally.

## Primary users of the technology/innovation

The primary users of this technology are the small-scale livestock producers.

## Climate-smart status of the technology/innovation

Adoption of rainwater harvesting technologies acts as a buffer against the variability and uncertainty of rainfall. Having a water source increases the resilience of the farmer against dry spells, rain-fed grass and crop failure, and allows farmers to have water for their animals and for growing livestock feed. With easily available and accessible water, a farmer is less dependent on rainfall and thus is not vulnerable to climatic fluctuations. These farmers are able to increase the number of animals they keep and their feed production.

## Environmentally friendly status of the technology/innovation

Rainwater harvesting technologies are environmentally friendly practices that allow farmers to manage their requirements for water while engaging in farming activities. They mitigate against the loss of livestock and crops.

## Suggestions for improvement of the technology/innovation

Rainwater harvesting can be improved by developing water reservoirs that serve multiple purposes.

## Strategies that can be adopted by national governments to promote the uptake of rainwater harvesting

National governments should develop policies and regulations that support water storage practices among farmers.

# Drones – unmanned aerial vehicles

### Primary use of the technology/innovation

Drones or unmanned aerial vehicles are flying robots that can be remotely controlled using software-controlled flight plans embedded in their systems. Initially only used in the system, now they have wide application including in livestock management. Thermal imaging and high definition cameras in drones enable farmers to track and monitor livestock remotely, hence identifying problems in time. This enables farmers to resolve the problems quickly and efficiently. Drones have also been used to monitor the status of the environment.



AU-IBAR

*Drones for tracking and monitoring livestock*

### SWOT analysis of the technology/innovation

## Strengths

Drones enable real time monitoring of livestock and unlike vehicles that have to follow a road they can fly directly to a required destination. They track and inspect the animals using camera and GPS locators, thus allowing farmers to intervene early should there be a problem. Owing to their low noise levels, drones are able to move quite close to the animal without scaring them, should a farmer need to visually inspect an animal closely. Animals can be tagged with sensors which can then be used to identify and monitor individual animals and also to conduct large scale census activities. Drones can be used to herd animals and drive them into specific areas. They reduce the number of labourers, hence saving costs. Drones can be used to gather and process data on livestock, hence providing an efficient monitoring system for large agricultural enterprises.

### Weaknesses

Drones are expensive to acquire and also need the installation of highly specialized infrastructure. They need fast internet speeds that may not be available in many regions. They run on battery power which is limited to between 10 and 30 minutes flight time.

### Opportunities

Agriculture provides the largest application of drones for monitoring large tracts of land, most of which are very remote. Drones provide an inexpensive and reliable method to do so. This, together with the focus on increasing agricultural production provides an environment for the safe application of drones.

### Threats

By 2017 only 15 out of 54 African countries had laws to govern the use of drones[9].

The rate of return on investment may be too slow to justify their use in agriculture.

## Local availability of the technology/innovation and potential suppliers across Africa

Drones for agricultural use are locally available.

## Primary users of the technology/innovation

The primary users of the drone technology are large-scale commercial farmers.

## Climate-smart status of the technology/innovation

Drones are effective tools to fight climate change through their ability to go to remote areas that are not easily accessible and collect data, thereby reducing research costs while increasing the accuracy of the data provided.

## Environmentally friendly status of the technology/innovation

Drones do not have adverse consequences on the environment. On the contrary, they can inform on the status of the environment. Drones can be used to rehabilitate environments by providing this information. They can also be used to drop tree seeds in these areas, thus planting more trees in one trip than is humanly possible. The use of drones on farms reduces greenhouse emissions associated with farm machinery.

## Suggestions for improvement of the technology/innovation

Drones that have the capacity to fly for longer periods, and have high stability and ability to fly autonomously would benefit farmers more than the versions available now. Also needed is the development of drone management software that is applicable in agriculture.

## Strategies that can be adopted by national governments to promote the uptake of drones

The use of drones in agriculture has developed faster than the required regulations. Concerns are now emerging on the risks of ground or air risks, bio- and national security concerns and the need to safeguard the privacy of citizens. A balance therefore needs to be created through networking and stakeholder engagement to manage these risks, while benefiting from the use of the technology.

9 Jeanneret & Rambaldi. (2016), updated by Soesilo, Meier, Lessard-Fontaine, Du Plessis, and Stuhlberger. (2016) & Guerin. (2017).

# Radio Frequency Identification Technology

## Primary use of the technology/innovation

The radio frequency identification technology (RFID) is a wireless technology that uses radio waves to identify livestock. The RFID has farm application for traceability, farm management, animal tracking and monitoring. This technology is now being used to provide seamless traceability of livestock products from farm to fork.




AU-IBAR

*Radio frequency identification technologies*

regional level, where serious disease outbreaks can be traced, managed and monitored from one source, which could be outside the farm. This offers the advantage of the possibility for authorities to ensure that animals that need to be culled rather than treated are culled by their owners who may be reluctant to do so.

### Weaknesses

The RFID technology necessitates significant investment by the farmer in infrastructure, hardware and software. It also requires specialized staff to be recruited. The farmer also needs to implement alternative power sources to mitigate against power outages and also make arrangements for backup systems for the farm data collected. Concerns have been raised on the security of RFID data.

### Opportunities

The increasing requirements for all livestock products entering certain markets will mean that all African livestock should be tagged at the farm level. This will provide enormous opportunity for this application in Africa.

### Threats

The high cost of the technology may mean that only large farming enterprises will be able to afford it.

### Local availability of the technology/innovation and potential suppliers across Africa

The RFID technology is locally available.

### Primary users of the technology/innovation

The primary users of the technology are medium- and high-intensive farming enterprises.

### Climate-smart status of the technology/innovation

The RFID technology reduces production costs and wastage, and has been shown to contribute to increases in livestock production.

### Environmentally friendly status of the technology/innovation

The RFID technology does not require installations that would be detrimental to the environment.

### Suggestions for improvement of the technology/innovation

The uptake of this technology/innovation within Africa can be improved by:

- Integration with mobile and other digital platforms
- Developing partnerships with local software
- Renegotiating proprietorships

### Strategies that can be adopted by national governments to promote the uptake of the RFID technology

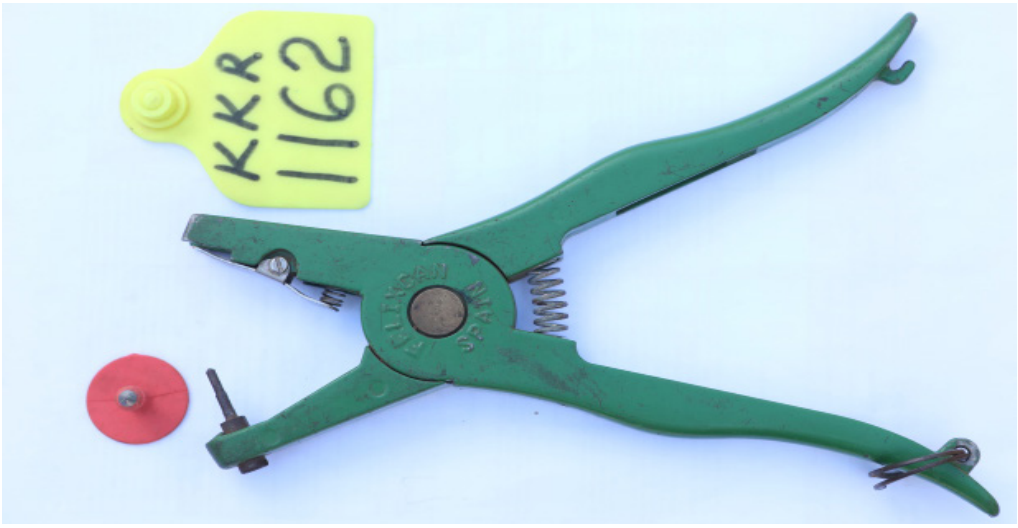
National governments can promote this technology through:

- Developing policies and legislation that manage the use of RFID at country and regional levels
- Implementing the RFID technology to manage the recovery of stolen animals
- Enabling small scale livestock holders and pastoralists to access the RFID technology given that its cost is higher than what most of these stakeholders can afford

# Livestock Identification and Traceability System – LITS

## Primary use of the technology/innovation

This technology allows for an effective livestock identification and traceability system.




AU-IBAR

*Labelled eartag*

## SWOT analysis of the technology/innovation

### Strengths

LITS provides an easy, efficient and reliable traceability system.

### Weaknesses

The technology requires an expensive annual license.

### Opportunities

Traceability of the origin of livestock products is increasingly becoming important to consumers and producers. Enormous potential therefore exists for implementation of digital platforms that can facilitate this.

### Threats

The lack of legislative framework in many African countries is slowing investment into this area. The technology is expensive to implement.

### Local availability of the technology/innovation and potential suppliers across Africa

The technology is locally available.

### Primary users of the technology/innovation

The primary users of the technology are the large-scale commercial farmers.

### Climate-smart status of the technology/innovation

This technology supports the traceability of livestock products, thus increasing production and reducing wastage. Products that can be traced from the farm of origin are expected to fetch better prices, thus increasing profits gained by farmers.

### Environmentally friendly status of the technology/innovation

The technology does not require installations that would be detrimental to the environment.

### Suggestions for improvement of the technology/innovation

This technology can be improved by ensuring integration with mobile and other digital platforms.

The uptake of this technology/innovation within Africa can be improved through:

- Developing partnerships with local software
- Re-negotiating proprietorship with patent owners to make it possible for local companies to purchase it

### Strategies that can be adopted by national governments to promote the uptake of LITS

National governments can promote this technology through several strategies including:

- Developing strategic partnerships with telecommunication companies
- Developing partnership with industry and other stakeholders who will assist in the development, financing, dissemination and use of the technology
- Implementing legal frameworks that integrate traceability of livestock products from farm to fork
- Building the capacity of rural communities to build trust and confidence
- Improving adoption of technology among rural communities
- Investing in developing and improving infrastructure in the rural area

# Pedometers with SMS transmitters

## Primary use of the technology/innovation

A pedometer is a small electronic device that is attached to the leg of an animal and is used to count the number of steps the animal takes over time.



AU-IBAR

*Pedometer fastened on cow's leg*

## SWOT analysis of the technology/innovation

### Strengths

Pedometers are light weight and easy to use. They have been used to detect lameness[10] in cattle even before the problem physically manifests itself. Lameness has been associated with reduced production and hence financial losses. Pedometers have also been used to detect estrus in cows[11,12] where cattle in estrus have been shown to have increased mobility. They are also used to detect sick animals where decreased pedometric activity has been shown to correspond to illness[13], hence enabling early action to be undertaken. These cows are then separated from the rest by triggering a separate gate to be opened for them.

10 Mazrier, H., Tal S., Aizinbud, E., Bargai, U. A field investigation of the use of the pedometer for the early detection of lameness in cattle. Can Vet J. 2006;47(9):883-886.
11 de Mol, RM. Automated detection of estrus and mastitis in dairy cows [Ph.D Thesis]. Wageningen, Netherlands: Wageningen University, 2000.
12 Lehrer, A.R., Lewis, G.S., Aizenbud, E. Estrus detection in cattle: A recent development. Anim Reprod Sci. 1992;28:355–361.
13 O'Callaghan, KA. The control of pain associated with lameness in dairy cattle [PhD Thesis]. Liverpool, UK: University of Liverpool, 2003.

### Weaknesses

The cost of implementing the technology is high and the data system requires a reliable power source to operate efficiently, which is mainly electricity. It also needs a back-up system and mechanisms to ensure that the data is protected and backed up.

### Opportunities

Pedometers offer the opportunity for medium to large-sized dairy establishments to improve estrus detection and hence improve reproduction.

### Threats

The use of pedometers to monitor cattle health is a very new technology and hence it will take some time for farmers and cattle monitors to gain trust in it.

## Local availability of the technology/innovation and potential suppliers across Africa

The pedometer technology is locally available.

## Primary users of the technology/innovation

The primary users of this technology are medium and large-scale cattle producers.

## Climate-smart status of the technology/innovation

Pedometers increase livestock productivity, hence increasing farmers' incomes.

## Environmentally friendly status of the technology/innovation

Pedometers are small devices that are clipped on the cattle's legs. They do not require special installation and hence do not have adverse impacts on the environment.

## Suggestions for improvement of the technology/innovation

An improvement would be the development of cost effective, easy to use pedometers for small scale livestock producers and pastoralists.

## Strategies that can be adopted by national governments to promote the uptake of pedometers

National governments can promote this technology by developing strategies to increase private sector investment in this area as this would ensure that the pedometers are accessible to all livestock farmers, including small-scale farmers and pastoralists.

# Virtual fence technology

## Primary use of the technology/innovation

Challenges faced by farmers include monitoring the status of the grazing land to prevent overgrazing. The use of virtual fences is one tool being used to manage the land carrying capacity. Virtual fences have introduced the concept of no- fence grazing. Cattle are fitted with collars with a device that gives them a small electric shock, a Global Navigational Satellite System receiver and a controller that is linked to a cloud computing system. When animals try to go out of the grazing area, they are given a small electric shock that prevents them from leaving.



Wageningen University

*A cow fitted with a GPS collar to track animal's location and send alerts if the cattle attempt to leave the virtual fence*

## SWOT analysis of the technology/innovation

### Strengths

Virtual fences optimize grazing by holding cattle in the best placed grazing location. They also keep them away from hazardous or no-go terrains, for example, bogs, marshes or neighbour's crops. They can be used to drive animals back to the barns. Virtual fences make it possible to practice rotational grazing without the expense of building new fences. Maintenance costs of physical fences are not necessary. Virtual fences protect the soil and grass from overgrazing. Virtual fences lessen the need for herders, thus reducing labour requirements. The cattle collar can be used to locate the animal's position.

### Weaknesses

Virtual fences necessitate investment in specific infrastructure. They rely on continuous and stable internet availability. This would require the farmer to invest in wireless technology

installation for the farm. Erecting the fences and managing the system in general also need staff with a specialized skill set. Virtual fences cannot keep out wildlife that are determined to enter the enclosures, hence there may still be a need for a perimeter fence.

### Opportunities

The effective management of rangelands and grasslands results in the sustainable management of this important resource and it has a direct impact on increased livestock production.

### Threats

Unavailability of internet and telephone coverage may limit the locations where this technology will be installed. The availability of labour to herd cattle and the easily available wooden posts for fencing make these options more attractive to farmers compared to virtual fences.

## Local availability of the technology/innovation and potential suppliers across Africa

Virtual fences are not available in Kenya.

## Primary users of the technology/innovation

Large-scale commercial farms would be the primary users of this technology.

## Climate-smart status of the technology/innovation

Virtual fences focus on managing range and grasslands effectively for maximum production. This protects land from becoming degraded and can be used in the rehabilitation of degraded landscapes. The virtual fences protect the cattle from entering dangerous terrain. Their continued use leads to increased livestock production and consequently improved incomes for the famer.

## Environmentally friendly status of the technology/innovation

Traditional fences in Africa typically use wood. Using virtual fences protects forests from deforestation. They also preserve grass, optimize its use and contribute to the sustainability of the grasslands.

## Suggestions for improvement of the technology/innovation

Virtual fences technology can be improved by developing versions that use renewable energy.

## Strategies that can be adopted by national governments to promote the uptake of virtual fences

National governments should develop strategies to mitigate the cost of infrastructure development and that of the technology.

# Ingestible cattle bolus

## Primary use of the technology/innovation

The ingestible cattle bolus is an ingestible bolus containing software for location and animal health monitoring. The location monitoring parameters are done using GPS technology or magnetic field information sensors. These are communicated together with an identified animal tag, therefore transmitting the animal's ID and its location. The bolus is also able to collect other animal health parameters including temperature, stress, or disease patterns, allowing for rapid management decisions to be undertaken by the farmer.




www.tracks360.com

*An ingestible cattle bolus*

## SWOT analysis of the technology/innovation

### Strengths

The ingestible cattle bolus is easy to insert and remains in the cow's rumen for the duration of its life. It allows for the early detection of disease, changes in feed quality and nutrition, assesses stress factors and monitors feed absorption. It allows a farmer to make early and better-informed decisions. Insertion of bolus in cattle herds can also be useful to track stolen cattle.

### Weaknesses

Some ingestible boluses are very specific and may be designed for use only in dairy cattle or beef cattle and not both, while others are very specific with regard to the physiological readings that they take and may only take one or two physiological parameters rather than a variety. Many are battery operated. The ideal ones would be those with extended battery life of more than five years. However, those with short battery lives of less than six months or a year may not offer extended service.

### Opportunities

The global demand for meat and other livestock products has more than quadrupled in the last 50 years. To meet this rising demand, a significant amount of innovation has been included in livestock production. The use of the bolus to optimize cattle health and wellbeing is one such innovation that has direct implications on livestock production.

### Threats

The bond between a farmer and his cattle has been reliably used to manage cattle health and well-being. This bond, together with the farmer's experience to directly observe the animals has been reliably used to detect animals that are sick or are on heat. It is a cheaper method and more trusted by the farmer compared to the insertion of the bolus. It may therefore not be easy to convince a farmer to invest in this technology.

### Local availability of the technology/innovation and potential suppliers across Africa

The technology is locally available.

### Primary users of the technology/innovation

The primary users of the ingestible cattle bolus are medium- and high-intensive dairy and beef farmers.

### Climate-smart status of the technology/innovation

The ingestible cattle bolus supports sustainable increase in cattle production through early breeding and disease interventions. These lead to higher incomes for the farmer.

### Environmentally friendly status of the technology/innovation

The ingestible cattle bolus is inserted into the rumen of a cow and remains there for the duration of the cow's life. It is therefore not harmful to the environment. The bolus is non-toxic to the animal and does not emit any harmful emissions.

### Suggestions for improvement of the technology/innovation

The development of locally made boluses would mitigate costs involved in the purchase of imported models.

### Strategies that can be adopted by national governments to promote the uptake of the ingestible cattle bolus

Given that the high cost of the technology may limit the number of farmers who may be able to invest in it, the development of partnerships to mitigate the high cost would be beneficial to farmers.

# Bolus hardware

## Primary use of the technology/innovation

Traumatic reticuloperitonitis or hardware/tyre wire disease is a condition that results from the ingestion of fragments of metal or wire by cattle which can lead to the perforation of the reticulum[14][15]. Cattle do not select their feed and do not completely masticate before swallowing so they can swallow metal objects especially if they are given silage, hay or feed made from fields that contain rusting nails or fences. The insertion of magnets is a popular preventative routine for the prevention of hardware disease especially because cattle rarely recover when their reticulum or other vital object is punctured. The magnet traps all metal objects, immobilizing them and thus preventing their moving around.



AU-IBAR

*Unused magnetic bolus hardware*



AU-IBAR

*Used magnetic bolus hardware with iron and other magnetic materials attached*

## SWOT analysis of the technology/innovation

### Strengths

The bolus hardware has been shown to prevent hardware disease. It is easy to administer and is not expensive.

### Weaknesses

The hardware bolus has to be inserted in young animals for best results. The procedure should be done by a professional to ensure that it is lodged in the rumen. There is a risk that the bolus will move around.

### Opportunities

The treatment of animals with traumatic reticuloperitonitis often requires expensive surgery which carries a risk of loss of the animal. The use of the bolus hardware offers an opportunity for increasing production while preventing the loss of producing animals.

14 Braun, U., Gansohr, B., & Flückiger, M. (2003). Radiographic findings before and after oral administration of a magnet in cows with traumatic reticuloperitonitis.

15 Ibrahim, H. M. M., & Gomaa, N. A. (2016). Traumatic Pericarditis in Cattle: Risk Factors, Clinical Features and Ultrasonographic Findings. J Vet Sci Med Diagn 5: 3. doi: http://dx. doi. org/10.4172/2325, 9590, 7-15.

### Threats

Farmers producing their own feed may not see the need to install the bolus hardware in their animals.

### Local availability of the technology/innovation and potential suppliers across Africa

The bolus hardware is locally available.

### Primary users of the technology/innovation

The primary users of the technology are medium- to high-intensive cattle producers.

### Climate-smart status of the technology/innovation

This technology prevents animals from getting hardware disease which is the cause of sudden death in animals. The death of animals especially the high producers can result in high income losses for farmers.

### Environmentally friendly status of the technology/innovation

The bolus hardware immobilizes metal objects in the rumen of animals. The technology has no adverse effects on the animal or on the environment and does not emit any pollutants into the environment.

### Suggestions for improvement of the technology/innovation

Hardware bolus that can integrate a chip could provide useful data on the types of hardware inside an animal and on the animal's general health.

### Strategies that can be adopted by national governments to promote the uptake of the hardware bolus

National governments can promote this technology through:

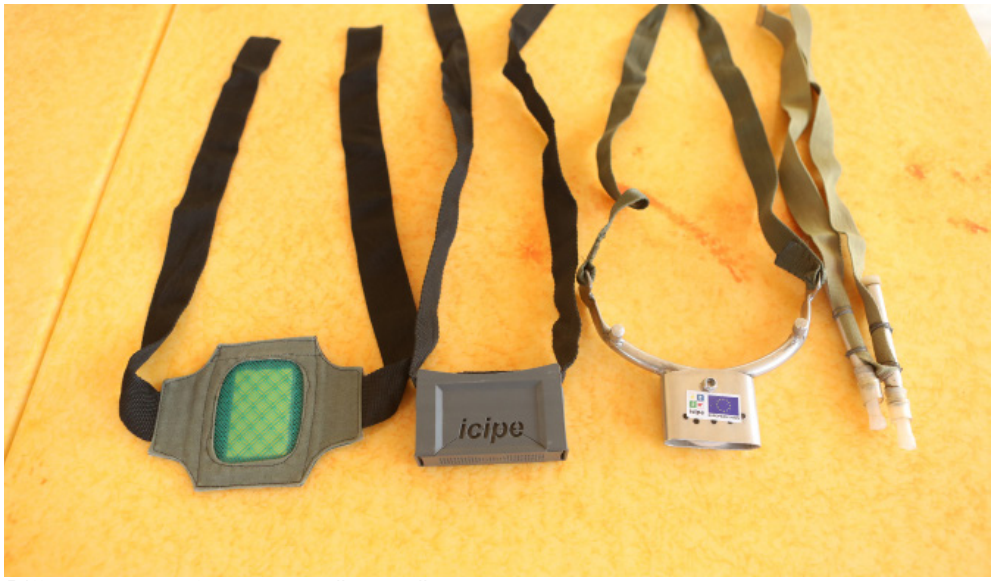
- Advocacy and awareness creation, especially among pastoralist communities whose animals may be at risk
- Encouraging small holder farmers to use the technology
- Providing incentives to local industries to manufacture local bolus hardware that would be cheaper and easier to access
- Training extension service providers and vets on how to install the hardware bolus

# 3.2 Technologies and Innovations targeting the Inputs and Services Components

# Tsetse repellent collars

## Primary use of the technology/innovation

Tsetse repellent collars are now being used to control tsetse flies which are vectors of the African trypanosomiasis disease[16]. This technology comprises a collar containing compounds isolated form the waterbuck which are slowly released. The cows then emit waterbuck odours that repel the flies and turn the cows into non-hosts.




AU-IBAR

*Different types of tsetse repellent collars*

## SWOT analysis of the technology/innovation

### Strengths

The tsetse repellent collars have been reported to be very effective in reducing the disease incidence in regions of Kenya by up to 90 percent[1]. The farmers can continue to graze their animals in their normal habitats, including areas infested with tsetse flies and they can graze their animals for longer, including early mornings and late evenings. The farmers do not have to use high amounts of trypanocides. Animals that wore the collar were found to have increases in weight and milk production and they were calmer when grazing. The collars are easily accepted by pastoralists.

16 Saini R.K., Orindi, B.O., Mbahin, N., Andoke, J.A., Muasa, P.N., Mbuv,i D.M., et al. (2017). Protecting cows in small holder farms in East Africa from tsetse flies by mimicking the odour profile of a non-host bovid. PLoS Negl Trop Dis 11(10): e0005977. https://doi.org/10.1371/journal.pntd.0005977

### Weaknesses

The efficacy of the tsetse repellent collar is dependent on the continued emission of the repellent. Tsetse flies are problematic, mainly to pastoralists who graze their cattle in regions that are predominantly tsetse zones. The collar may therefore not be affordable and easily available to them. There is a risk that the collar may stop working owing to various reasons including damage of the collar by the cow.

### Opportunities

The use of tsetse collars in areas that were not possible because of tsetse fly infestation presents opportunities for increasing cattle production in these areas.

### Threats

The widespread use of trypanocides threatens the full adoption of the tsetse collars. The availability, wide distribution and accessibility of the tsetse collars will also determine the full use of the technology.

## Local availability of the technology/innovation and potential suppliers across Africa

The tsetse repellent collars are locally available.

## Primary users of the technology/innovation

The tsetse repellent collars are mainly used by pastoralists in tsetse-infested regions.

## Climate-smart status of the technology/innovation

The tsetse repellent collar uses naturally derived repellents. The collar increases cattle production and hence reduces losses experienced by the farmers, most of whom are resource poor.

## Environmentally friendly status of the technology/innovation

The tsetse repellent collars are securely tied around the necks of cattle and do not require any environmental installation, hence making them environmentally friendly. The odour produced by the repellent is naturally derived and therefore does not have any adverse effect on the environment.

## Suggestions for improvement of the technology/innovation

The tsetse repellent collar should be fully commercialized by local communities.

## Strategies that can be adopted by national governments to promote the uptake of the tsetse repellent collar

Among the strategies for the promotion of this technology are:

- The national government of Kenya, where this collar was developed, should support commercialization of the product
- The extension service should be fully involved in the technology dissemination and education of the farmers

# Digital Pen Technology

## Primary use of the technology/innovation

The Digital Pen Technology is a technology that allows individuals to collect disease information and transmit it in real-time. The pen consists of a built-in camera, processor, Bluetooth connection and a memory chip. It allows the user to write normally on normal paper while the camera takes images of the text as the user is writing it. It then transmits this information to a pre-configured disease collection database. The pen can also be used as a scanner to scan and send information that is already in print or written form.



AU-IBAR

*Disease surveillance digital pen*

## SWOT analysis of the technology/innovation

### Strengths

The pen allows for the collection and transmission of information in real time. It reduces delays experienced in data collection and transmission, thus it allows for immediate decisions and action to be taken. It is simple to use and its memory allows for the storage of files and audio. It is able to convert handwritten notes into digital text. It can make audio recordings which can also be transmitted to disease collection servers.

### Weaknesses

The digital pen may have challenges transcribing non-printed hand writing. The security of the data on the pen may be easily compromised should the pen fall into the wrong hands. It is an expensive technology especially if it has to be provided to all the vets on the ground.

### Opportunities

Livestock production is the main economic activity of pastoralist communities in Africa. However, disease outbreaks challenge their ability to sustainably engage in livestock production. This is compounded by poor road and telecommunication infrastructure that delay the reporting of disease outbreaks. The digital pen will provide a rapid avenue for the reporting of diseases in these regions, thus leading to their effective control.

### Threats

The cost of the digital pen may limit its access to the required users.

### Local availability of the technology/innovation and potential suppliers across Africa

The digital pens can be easily purchased through local distributors.

### Primary users of the technology/innovation

The primary users of digital pens are veterinary and other livestock health management workers.

### Climate-smart status of the technology/innovation

The technology facilitates the rapid reporting of diseases, thus enabling their early intervention. This saves farmers and livestock keepers from losing their animals to diseases.

### Environmentally friendly status of the technology/innovation

This digital pen is a hand-held device that does not require any special installations. It is therefore environmentally friendly.

### Suggestions for improvement of the technology/innovation

Improvements could include making digital pens that have larger storage capacity together with solar charging capability.

### Strategies that can be adopted by national governments to promote the uptake of digital pens

National governments can promote this technology by:

- Developing polices that facilitate the real time collection of disease outbreak information as this could rapidly result in the uptake of this technology
- Creating mechanisms where the digital pens' cost could be reduced

# Mastitis detection technology

## Primary use of the technology/innovation

Bovine Mastitis greatly impacts animal health, the quality of milk and milk production, and causes huge financial losses to farmers worldwide, including those in developing countries[17]. Early detection and accurate diagnosis of mastitis in animals is a key factor for its prevention, treatment and control[18]. Mastitis is detected using several technologies. These include the detection of changes in inflammatory cell counts in milk caused by their increase as the cow's immune system responds to the disease; measurement of changes in electrical properties of milk owing to changes in the mineral composition in milk brought about by the disease; or detection of heat and swelling in a pattern-like format on the mastitis. Early detection of mastitis saves the farmer money, improves cow productivity, reduces treatment times and decreases the possibility of using antibiotics. Most important is that it protects the quality of milk.




AU-IBAR

*California Mastitis test kit*

## SWOT analysis of the technology/innovation

### Strengths

The mastitis detection technology that uses the detection of inflammatory cells is simple, affordable and rapid to use.

17 Sharma, N., Maiti, S.K. & Sharma, K.K. 2007. Prevalence, etiology and an-tiobiogram of micro-organisms associated with sub-clinical mastitis in buffaloes in Durg, Chhattisgrh State (India). International Journal of Dairy Science, 2(2): 145–151.

18 Down, P.M., Bradley, A.J., Breen, J.E., Hudson, C.D., Green, M.J. 2016. Current management practices and interventions prioritized as part of a nationwide mastitis control plan. Vet Rec. 178(18):449.

### Weaknesses

The electrical conductivity test that detects changes in the electrical properties of milk requires for sensors to be incorporated into the automatic milking machines. This technology may be more adapted to large herds rather than the small-holder system. Testing all the milk on a daily basis using these technologies may not be possible for large herds.

### Opportunities

Mastitis is the cause of huge losses of milk experienced on an annual basis in Africa. Adoption of cost effective and easily implementable mastitis detection solutions can have direct economic gains to farmers.

### Threats

Direct examination of udders is a cheap method for the detection of mastitis in cattle that has been used for a long period. It may not be easy to change farmers' perception on their need to invest in more sensitive tests for mastitis detection.

## Local availability of the technology/innovation and potential suppliers across Africa

The mastitis detection technologies are locally available.

## Primary users of the technology/innovation

The primary users of this technology are high-intensive dairy farmers.

## Climate-smart status of the technology/innovation

Early detection of mastitis followed by intervention directly impacts the farmers' finances by reducing the costs of treating animals and lowering the losses of milk caused by the infection.

## Environmentally friendly status of the technology/innovation

The mastitis detection technology does not require installations that would impact on the environment. The detection and treatment of animals results in good health for the herds.

## Suggestions for improvement of the technology/innovation

Mastitis detection technologies that can be used by small holder farmers and pastoralists should be developed.

## Strategies that can be adopted by national governments to promote the uptake of mastitis detection technology

National governments can promote the uptake of this technology by developing partnerships between developers of the technology and farmer organizations that would enable the technology to be used at milk collection centres.

# Automatic syringes

## Primary use of the technology/innovation

Manual vaccination of animals can be very laborious especially when a large number of animals need to be vaccinated. This is mainly because it involves the use of manual syringes where needles have to be manually replaced. This is compounded by the risk of human error which results in inconsistencies and inaccuracies in the dosages administered, or animal injuries from overused needles, or the skill of the administrator. Automatic syringes offer safe and automatic administration of medication to livestock.



AU-IBAR

*Automatic syringe*

## SWOT analysis of the technology/innovation

### Strengths

The automatic syringe is easy to use, is light weight and allows for fast and efficient use during mass vaccination exercises. It is made from stainless steel and hence is durable. It is easy to clean, assemble and maintain. Its dosage administration is very accurate. Automatic syringes also have safety mechanisms for the safety of animals and the administrator.

### Weaknesses

Automatic syringes need to be calibrated to ensure that correct doses are being administered. Automatic syringes require stringent labelling of the medication or vaccine that is being used in order to prevent mixing up occurring.

### Opportunities

The use of automatic syringes allows for the mass vaccination of African livestock. With more than 300 registered veterinary vaccines worldwide[19], there is tremendous opportunity for the use of automatic syringes.

### Threats

The cost of automatic syringes may limit the use of this technology to large-scale farming enterprises.

## Local availability of the technology/innovation and potential suppliers across Africa

Automatic syringes are locally available.

## Primary users of the technology/innovation

The primary users of automatic syringes are veterinary practitioner and famers.

## Climate-smart status of the technology/innovation

Automatic syringes administer accurate doses of vaccines and medication. This reduces wastage at the farm level.

## Environmentally friendly status of the technology/innovation

Automatic syringes do not require any external installations and are therefore very environmentally friendly.

## Suggestions for improvement of the technology/innovation

Automatic syringes could be integrated with smart solutions for data collection.

## Strategies that can be adopted by national governments to promote the uptake of automatic syringes

National governments can promote this technology through:

- The widespread use of automatic syringes, as this would offer numerous advantages at country level
- Developing policies and legislation that facilitate the widespread use of automatic syringes

19 Barrett, A. D. (2016). Vaccinology in the twenty-first century. npj Vaccines, 1(1), 1-3.

## 3.2.2 Cold chain technologies

Cold chain technologies are technologies that provide cold chain supply for meat, milk and other perishable livestock products. Transportation and storage of perishable livestock products presents a challenge for some regions of Africa not only because many regions are not connected to electricity but also because the high temperatures cause the rapid deterioration of meat, milk and other livestock products. This calls for innovation of new cold chain products. The weak links in the cold chain are associated with chilling of products during storage and transportation, and transfer of products from one actor to another.

# Solar powered vaccine cooler/refrigerators

### Primary use of the technology/innovation

Previous solutions to provide cold chain solutions to the last-mile regions not served by electricity relied on kerosene or gas-powered refrigerators which experienced challenges of safety, pollution and fuel supply. The solar powered vaccine cooler is powered by solar panels that charge batteries. They provide an essential service in the provision of a reliable and continuous cold chain for delivery of vaccines and medicines.



HANDOUT/GAVI/Hervé Lequeux

*A solar powered vaccine cooler*

### SWOT analysis of the technology/innovation

#### Strengths

The solar powered vaccine cooler/refrigerator is built to the World Health Organization (WHO) specifications. It uses solar energy, thus providing a safe and clean source of energy. It is portable and does not require electricity. It can store extra energy to power it for a week. The coolers are energy efficient, requiring only one 250-watt solar panel. The solar powered

vaccine coolers are easily assembled and are easy to use. They do not need any additional source of energy and hence are largely maintenance free. Solar energy is constantly available. The solar powered vaccine cooler is quiet when running. Its performance is very high even in high temperature regions.

### Weaknesses

The solar powered vaccine cooler/refrigerator requires at least five hours of sunlight every day and hence its use is dependent on the climate of a particular region. The solar panels are expensive although once acquired their running costs are low. Solar powered coolers are not as powerful as conventional electric or fuel-run refrigerators. Challenges of battery power failure need to be addressed.

### Opportunities

Large areas of Africa are not connected to electricity. This makes the delivery of vaccinations challenging due to lack of a continuous cold chain. The alternatives of using kerosene and gas-powered refrigeration systems have been found to have numerous challenges of supply chain issues, poor temperature control, frequent breakdowns and maintenance needs. The need to provide cold chain together with the continuous availability of sun throughout the continent provides an opportunity to use the solar powered vaccine cooler/refrigerator.

### Threats

The cost of purchasing the solar powered vaccine cooler/refrigerator, the solar panel, extra batteries and other required accessories may prove to be too expensive for ordinary veterinarians and community livestock health providers.

## Local availability of the technology/innovation and potential suppliers across Africa

The solar powered vaccine cooler/refrigerator is manufactured outside Africa.

## Primary users of the technology/innovation

The primary users of the technology are animal health service providers.

## Climate-smart status of the technology/innovation

The solar powered vaccine cooler/refrigerator uses solar energy, a renewable resource that does not run out or pollute the environment. In contrast to refrigeration systems that use oil or fuel to run, the solar powered vaccine cooler does not make any noise. The panels or the solar cells are silent when running.

## Environmentally friendly status of the technology/innovation

The use of the solar powered vaccine cooler/refrigerator eliminates the need to use electric power or fossil fuels like kerosene.

## Suggestions for improvement of the technology/innovation

Cheaper and affordable solar panels and batteries need to be developed.

### Strategies that can be adopted by national governments to promote the uptake of the solar powered vaccine cooler/refrigerator

The adoption of the solar powered vaccine cooler/refrigerator needs effective strategies to mitigate the high cost of acquiring it. These may include:

- Developing sustainable and viable financing mechanisms to enable animal health service providers to acquire the technology
- Developing mechanisms for long term maintenance and repair
- Providing incentives to encourage training of solar refrigeration professionals
- Addressing battery failure challenges through the manufacture of cost effective and efficient battery packs

# Solar Ice Maker

## Primary use of the technology/innovation

Small holder farmers who do not have access to electricity and have to walk long distances to the milk collection centre, hub or cooperative have a challenge with preserving the quality of their milk. Most times therefore, the trip to the hub or the milk collection centre can only be made once a day. Milk storage thus presents a real challenge. One solution to this has been to use the solar ice maker to make ice cubes[20], which are in turn used at night to refrigerate the milk or other milk products.



*Solar ice maker*

20 http://www.solaripedia.com/13/389/5537/solaricemakerkenya.html.

AU-IBAR

## SWOT analysis of the technology/innovation

### Strengths

Environmentally friendly and cost effective, the ice maker can be used to reduce spoilage in the dairy value chain.

### Weaknesses

The technology is not easily accessible to the farmer, may require government intervention, and another challenge is inaccessibility of the liquid ammonia.

### Opportunities

The Solar Ice Maker™ has great potential for use by fishmongers; it can be also be used to promote efficiency of the cold chain delivery system.

### Threats

The Solar Ice Maker™ has not yet been fully commercialized and disseminated. Farmer perception may be biased towards conventional ice making technologies.

## Local availability of the technology/innovation and potential suppliers across Africa

This is a new technology that has not been fully disseminated.

## Primary users of the technology/innovation

The primary users of the technology are small-scale dairy farmers seeking milk preservation strategies.

## Climate-smart status of the technology/innovation

The Solar Ice Maker™ reduces the wastage of milk, thus increasing incomes accrued to farmers.

## Environmentally friendly status of the technology/innovation

The Solar Ice Maker™ eliminates the need to use electricity or fossil powers, making it an environmentally friendly technology.

## Suggestions for improvement of the technology/innovation

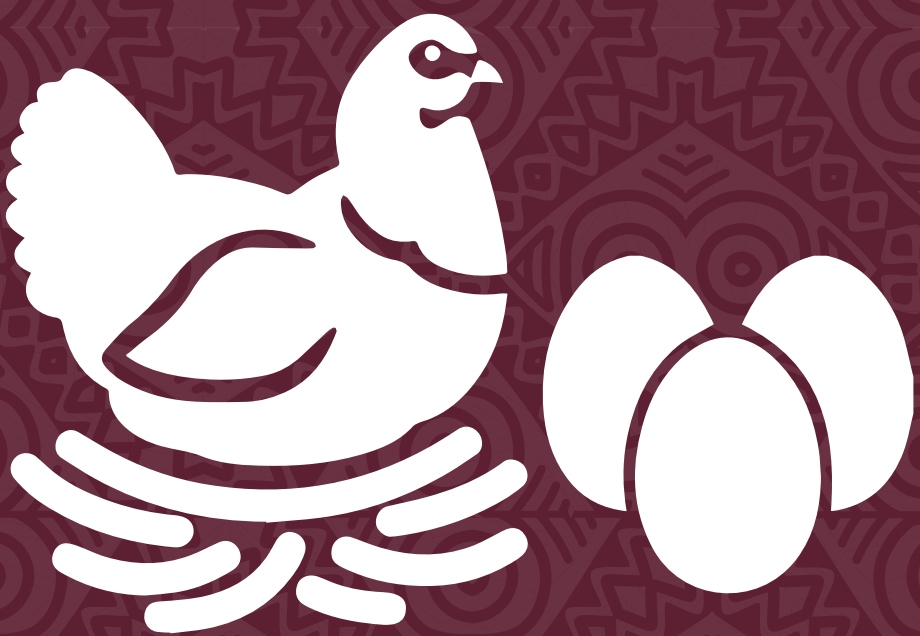
The Solar Ice Maker™ needs to be fully commercialized and disseminated throughout Africa.

## Strategies that can be adopted by national governments to promote the uptake of the Solar Ice Maker™

National governments can promote this technology by:

- Developing legislation and policies promoting the use of solar energy technologies
- Developing microfinancing options for farmers willing to purchase the Solar Ice Maker™.

# 4 The Poultry Value Chain



# 4.1 Technologies and Innovations targeting the Production Component

# Cooperative incubation-brooding and contract farming

## Primary use of the technology/innovation

Poultry farming cooperatives have evolved into providing community incubation, brooding services and contract farming. Contract farming describes situations where community farmers provide the farm, chicken house and labour, while an investor provides the eggs for hatching and the finances to run the operation including funds for medicine and food[1]. In some instances, the investor will also provide the technical support.



AU-IBAR

*Medium-scale electric incubator*

## SWOT analysis of the technology/innovation

### Strengths

The farmers do not have to invest in incubation or brooding of eggs individually but can do it within the cooperative. Investors in contract farming provide the finances for brooding and hatching of eggs. This results in knowledge sharing and transfer, leading to more farmers being armed with the knowledge and skills to carry out the technology. Community incubation and brooding allows for many eggs to be hatched at the same time at a minimum cost.

1 Begum, I. A. (2005). An assessment of vertically integrated contract poultry farming: a case study in Bangladesh. International Journal of Poultry Science, 4(3), 167-176.

### Weaknesses

The literacy levels among the poultry farmers can impact training and knowledge transfer. Cooperatives operating in resource-poor environments will have limited resources available for purchasing adequate incubators.

### Opportunities

Many small-scale poultry farmers at the community level are willing and interested in joining cooperatives that offer community incubation and brooding services. There are many organizations willing to offer poultry production training activities. There are also microfinance organizations willing to support training initiatives that will lead to increased poultry production at the community level.

### Threats

The lack of skilled personnel to train the farmers on incubation and poultry brooding techniques can be a challenge. Politics of the cooperative's governance can threaten the stability of the cooperative. High operation costs for cooperatives, limited availability of finance and competition from large-scale poultry farming enterprises threaten the stability of poultry farming enterprises.

## Local availability of the technology/innovation and potential suppliers across Africa

Cooperative incubation, brooding and contract farming are locally available.

## Primary users of the technology/innovation

The primary chicken producers in Africa are women.

## Climate-smart status of the technology/innovation

Cooperative incubation, brooding and contract farming mainly involve the breeding and propagation of indigenous poultry. This supports the sustainable use of indigenous breeds, resulting in their conservation and preservation. Community cooperatives have the advantage of uplifting the lives of resource-poor poultry farmers, the majority of who are women.

## Environmentally friendly status of the technology/innovation

Contract farming enables farmers to use idle land for production purposes.

## Suggestions for improvement of the technology/innovation

Development of standard operating procedures (SOP) for the manuals would make management easier.

## Strategies that can be adopted by national governments to promote the uptake of incubation-brooding services and contract farming

National governments can promote these methods by:

- Providing opportunities for farmers to form cooperative societies
- Capacity building for the leadership in existing cooperatives
- Capacity building for farmers by training on innovative poultry production practices that include the latest disease and bio-security interventions
- Capacity building for farmers and cooperative management on financial management and records keeping,
- Integrating mobile technologies for data collection and monitoring
- Capacity building for farmers on processing, quality control and standards

# Artificial Insemination (AI) and semen enrichment and dilution

## Primary use of the technology/innovation

Artificial insemination (AI) in poultry is an important technology used to improve the production of poultry. It involves the manual deposition of semen in the reproductive tract of the hen. It requires good knowledge of the anatomy of chicken. Semen is collected from cockerels and assessed for motility, viability and concentration after which it is deposited into the reproductive tract of the hen[2]. The *in vitro* storage of undiluted semen decreases its fertilizing ability after it has been stored for a few hours[3] . To preserve the semen quality and viability, several approaches have been adopted including dilution with saline[4] together with antioxidants for enrichment such as vitamin E[5] oleic acid[6], lycopene[7], and coenzyme Q10[8].



*Preparation for semen collection from a cock*



AU-IBAR

*Collection of semen procedure*



*Transfer of semen into insemination cup*



AU-IBAR

*Insemination of hen*

2 Kharayat, N. S., Chaudhary, G. R., Katiyar, R., Balmurugan, B., Patel, M., Uniyal, S., ... & Mishra, G. K. (2018). Significance of artificial insemination in poultry. Research & Reviews: Journal of Veterinary Science and Technology, 5(1), 15-19.

3 Bellagamba, F., Cerolini, S., & Cavalchini, L. G. (1993). Cryopreservation for poultry semen. World's Poult. Sci. J, 49, 158-166.

4 Clarke, R. N., Sexton, T. J., & Ottinger, M. A. (1982). Effects of holding temperature and storage time on respiratory rate, motility, and fertility of chicken and turkey semen. Poultry science, 61(9), 1912-1917.

5 Kowalczyk, A. M., Klećkowska-Nawrot, J., & Łukaszewicz, E. T. (2017). Effect of selenium and vitamin E addition to the extender on liquid stored capercaillie (Tetrao urogallus) semen quality. Reproduction in Domestic Animals, 52(4), 603-609.

6 Eslami, M., Ghaniei, A., & Rad, H. M. (2016). Effect of the rooster semen enrichment with oleic acid on the quality of semen during chilled storage. Poultry science, 95(6), 1418-1424.

7 Rosato, M. P., Centoducati, G., Santacroce, M. P., & Iaffaldano, N. (2012). Effects of lycopene on in vitro quality and lipid peroxidation in refrigerated and cryopreserved turkey spermatozoa. British poultry science, 53(4), 545-552.

8 Sharideh, H., Zhandi, M., Zenioaldini, S., Zaghari, M., & Sadeghi, M. (2019). The effect of coenzyme Q10 on rooster semen preservation in cooling condition. Theriogenology, 129, 103-109.

## SWOT analysis of the technology/innovation

### Strengths

AI at the farm level only requires a few simple tools namely a 1 cc plastic syringe, a medicine dropper and a glass eye cup. It is therefore cheap. AI increases the mating ratios of high producing males with good genetics. A cockerel would normally breed with six to ten hens, but this ratio can be greatly increased with AI. Males with good genetics can be used for several generations. AI can also be used in males with leg injuries which would not be possible in natural mating. Natural cross breeding programmes have higher success rates with the use of AI.

### Weaknesses

The poultry used for AI have to be disease free so that they do not transmit diseases. Harvesting semen from males requires a special technique. The volume of semen between breeds has been found to vary considerably and this has to be taken into consideration when planning a breeding programme. The volume also varies seasonally and is affected too by the time of day, with more semen being produced at the end of the day. Semen harvesting seems to work better when mature males are used. The production of semen requires expertise in handling the cockerel. The semen should be used as soon as possible because its viability decreases with time.

### Opportunities

The demand for breeding males for use in production is high. For this demand to be met, it is important that AI be used. There are numerous opportunities to improve indigenous chicken through active selection and breeding.

### Threats

The large number of hens that need to be mated weekly would make the use of AI labour intensive because of the large numbers involved. This would result in a high increase in labour costs. AI in poultry is not widespread mainly because of its low acceptance rate and the preference for using natural breeding methods. The high investment requirement poses another threat.

## Local availability of the technology/innovation and potential suppliers across Africa

AI in poultry is locally available.

## Primary users of the technology/innovation

The primary users of this technique are breeders and extension workers.

## Climate-smart status of the technology/innovation

The genetic improvement of indigenous chicken using AI will result in the selection of superior birds with traits that are attractive to farmers. This will ensure the survival of the breeds through their propagation. The use of indigenous chicken breeds to supply meat and eggs will result in their conservation and preservation. One drawback of AI would be indiscriminate crossbreeding of indigenous chicken with exotic birds. This would lead to the genetic erosion of indigenous chicken, thus putting them at risk of loss.

### Environmentally friendly status of the technology/innovation

This technology ensures that poultry are successfully mated, thus increasing the number of fertilized eggs. The technology supports the reproduction of hens that have good genetics.

### Strategies that can be adopted by national governments to promote the uptake of artificial insemination

Currently this technology is only located in a few laboratories in Africa. Efforts should be made to disseminate the technology throughout the continent.

# Poultry sexing

Poultry sexing refers to the identification of the chick to determine whether it is male or female. Egg production needs only female chickens. This therefore requires that chick identification be done rapidly and as soon as possible to save on production costs, thus necessitating that the sex of all hatched chicks be identified as soon as they are hatched. Many methods used to determine the sex of a chick are applied after the egg has hatched and all rely on the physical gender. The methods include:

i. Feather/plumage colour sexing for poultry sexing

ii. Sexing of poultry before hatching

### *i. Feather/plumage colour sexing for poultry sexing*

#### Primary use of the technology/innovation

Feather or plumage sexing refers to the determination of the sex of the bird by carrying out wing feather observation. Female chicks have been observed to have wing feathers before they hatch, while male chicks do not begin to develop their wing feathers until a few days after they have hatched. The process of sexing involves stretching a chick's wing and observing for signs of wing feather development.

#### SWOT analysis of the technology/innovation

##### Strengths

This method is fast and easy to use once the appropriate training has been conducted. The result of this selection process of female chicks only results in reduced costs incurred in the raising of male chicks.

##### Weaknesses

The method is labour intensive since it is conducted manually. The employees need to be trained by skilled personnel. Breed standards have to be availed for accurate comparisons to be made. The unfortunate consequence of this technology is the culling of male chicks, which raises ethical questions.

##### Opportunities

Poultry farming in Africa presents opportunities for income generation, providing food, savings and investment. Most of the poultry farmers in Africa are women. The commercial broiler production industry is also growing at a very fast pace.

##### Threats

The male chicks have use in the African rural setting where they are raised and sold as breeding males or sold for meat. The concept of culling chicken is foreign to Africa and may be difficult to sell.

### Local availability of the technology/innovation and potential suppliers across Africa

Sex selection of chicks is available in Africa.

### Primary users of the technology/innovation

Sex selection is only done in large hatcheries primarily concerned with selling layers.

### Climate-smart status of the technology/innovation

The selection of female chicks for egg production results in reduction of production costs leading to higher incomes for the farmer.

### Environmentally friendly status of the technology/innovation

The selection of males does not involve any specialized installations. Sex selection ensures that farmers make most of the resource that is available to them.

### Suggestions for improvement of the technology/innovation

Sex selection should be implemented in family poultry production units. This would result in a consolidation of their resources thus helping them increase their profits.

### Strategies that can be adopted by national governments to promote the uptake of feather/plumage colour sexing

National governments can promote this method through:

- Implementing capacity building programmes for family poultry producers
- Developing strong extension services to support poultry production at the community level

## *ii. Sexing of poultry before hatching*

The number of day-old male chicks that are culled have been estimated as approximately 90 million and 300 million per year in Germany and the European Union annually[9]. The culling of day-old male chicks has led to ethical debates on animal welfare.

Ova gender identification of male embryos before they are hatched has been successfully done by detecting gender differences either in the DNA content via infrared spectroscopic imaging[10] of blastoderm cells, PCR analysis of blastoderm cells[11,12], spectroscopy[13] or by using endocrine variances between males and females[14].

9 Klein, S., Flock, D., & Ellendorff, F. (2003). Management of newly hatched male layer chicks-current knowledge on sex determination and sex diagnosis in chicken: potential solutions. W. Poult. Sci. J, 59(1), 62-64.

10 Steiner, G., Bartels, T., Stelling, A., Krautwald-Junghanns, M. E., Fuhrmann, H., Sablinskas, V., & Koch, E. (2011). Gender determination of fertilized unincubated chicken eggs by infrared spectroscopic imaging. Analytical and bioanalytical chemistry, 400(9), 2775-2782

11 Petitte, J. N., & Kegelmeyer, A. E. (1995). Rapid sex determination of chick embryos using the polymerase chain reaction. Animal Biotechnology, 6(2), 119-130.

12 Arnold, K. E., Orr, K. J., & Griffiths, R. (2003). Primary sex ratios in birds: Problems with molecular sex identification of undeveloped eggs. Molecular Ecology, 12(12), 3451-3458.

13 Galli, R., Preusse, G., Uckermann, O., Bartels, T., Krautwald-Junghanns, M. E., Koch, E., & Steiner, G. (2016). In ovo sexing of domestic chicken eggs by Raman spectroscopy. Analytical chemistry, 88(17), 8657-8663.

14 Weissmann, A., Reitemeier, S., Hahn, A., Gottschalk, J., & Einspanier, A. (2013). Sexing domestic chicken before hatch: A new method for in ovo gender identification. Theriogenology, 80(3), 199-205.

## Primary use of the technology/innovation

Ova sexing of poultry is used to identify the gender of the fertilized egg before hatching.

## SWOT analysis of the technology/innovation

### Strengths

The detection methods are rapid, easy to use and resolve the ethical question of culling millions of day-old chicks. The methods have a high accuracy rate. These methods save labour and time taken to manually sort through thousands of hatched day-old chicks.

### Weaknesses

The techniques used require specialized staff, laboratories and other infrastructure that may not be cheap. The assays need to be installed at a hatchery. Perhaps the major weakness is that the eggs need to be incubated for between 16 and 18 days to allow for the formation of an embryo.

### Threats

Village farming of poultry is not focused on identification of the sex of the chickens. In most settings, chickens are farmed as layers, while excess cockerels are sold for meat or are consumed in the homesteads.

## Local availability of the technology/innovation and potential suppliers across Africa

Ova sexing is a new technology that is only available in the developed countries.

## Primary users of the technology/innovation

The primary users of this technology are the large hatcheries.

## Climate-smart status of the technology/innovation

Early and rapid sex determination saves time, results in lower emissions and saves the energy that would have been used during the incubation of millions of eggs which translates to higher profits for farmers.

## Environmentally friendly status of the technology/innovation

The techniques are environmentally friendly and are conducted within laboratory setups.

## Suggestions for improvement of the technology/innovation

The techniques can be improved through developing partnerships that will fast track the transfer of technology to Africa.

## Strategies that can be adopted by national governments to promote the uptake of sexing of poultry

National governments can promote this technique by developing incentives for investment in this technology in Africa.

# Electric poultry incubator

## Primary use of the technology/innovation

A poultry incubator is a device used to manage fertilized eggs to ensure the continued development of the embryo by controlling the temperature, humidity and by periodically turning the eggs. Commercially available incubators are expensive. However, simple electric incubators can be constructed using readily available materials[15].



AU-IBAR

*Small-scale electric incubator*

## SWOT analysis of the technology/innovation

### Strengths

The incubators are easy to make using locally available materials. They are easy to use and just require the placing of eggs inside. They can be made with a small window to allow for easy viewing and hatching of eggs. They can be used for a variety of poultry species.

### Weaknesses

These incubators need to be installed in areas that are connected to electricity. Perhaps the greatest challenge facing locally made electric incubators is to ensure that the parameters of temperature and humidity are maintained at the correct temperature. Challenges can also be experienced to ensure that the central water reservoir continuously has water. The incubators run the risk of having a low hatch rate. Some models do not have windows that allow for inspection of the eggs and chicks.

### Opportunities

The rise in consumption of chicken in most parts of Africa[16] has resulted in an increased demand for day-old chicks.

15 Sharma,N., Maiti, S.K. & Sharma, K.K. 2007. Prevalence, etiology and antiobiogram of micro-organisms associated with sub-clinical mastitis in buffaloes in Durg, Chhattisgrh State (India). International Journal of Dairy Science, 2(2): 145–151.

16 Adegbulugbe, T. A., Atere, A. O., & Fasanmi, O. G. (2013). Development of an automatic electric egg incubator. International Journal of Scientific & Engineering Research, 4(9), 914-918.

### Threats

Commercially available incubators that are made with industry standards have a high hatching rate. These are also more familiar to poultry farmers and have been tried and tested by farmers. There are few local fabricators with the technical know-how on how to make the electric incubators.

### Local availability of the technology/innovation and potential suppliers across Africa

Locally manufactured electric incubators are locally available.

### Primary users of the technology/innovation

The primary users of the locally manufactured electric incubator are small-scale poultry farmers and the youth who are interested in taking up egg hatching as a business.

### Climate-smart status of the technology/innovation

Locally manufactured electric incubators provide small-scale poultry farmers with affordable incubators that they can use to hatch eggs and increase their poultry production, ultimately increasing their incomes. These incubators are used to hatch indigenous chicken, therefore promoting the conservation and preservation of this indigenous resource.

### Environmentally friendly status of the technology/innovation

The installation of electric incubators at the farm level is environmentally friendly. They can be fabricated using recycled wood and wood products. They do not produce any emissions that are harmful to the environment.

### Suggestions for improvement of the technology/innovation

The technology may be improved by:

- Developing electric poultry egg incubators that have stable and reliable temperature and humidity control systems, and also consume less electricity.
- Developing models that use green energy as a source of power

### Strategies that can be adopted by national governments to promote the uptake of electric poultry incubators

National governments can promote the technology by:

- Developing standard designs that can be easily adopted by local youth and small fabricators
- Developing partnerships to mitigate the cost of acquiring the technology
- Developing and implementing strategies for provision of power – including electric and solar energy – to rural communities

# Solar poultry incubator

## Primary use of the technology/innovation

The solar poultry incubator allows for the successful incubation of poultry eggs using solar energy, a green energy source.



AU-IBAR

*Solar-powered incubator*

## SWOT analysis of the technology/innovation

### Strengths

The solar poultry incubator is produced using locally available materials. It is easy to use and maintain. It is easily customizable and can be used to hatch eggs from more than one poultry species.

### Weaknesses

The solar poultry Incubator relies on the availability of solar energy which might not be available during adverse weather conditions. It uses solar panels that are expensive and not easy to acquire. Its production capacity is lower compared to commercial electric incubators. The level of manufacture of the incubators is low owing to the fact that they are handmade and the production capacity of the youth making them is low.

### Opportunities

There is a high demand for incubators occasioned by the rise in demand for eggs and chicken meat. Technical skills and materials, including recycled materials to manufacture the electric incubators, are also available.

### Threats

Commercially available incubators have high and reliable production capacity. They are also well known and have been used by farmers for a long time. Solar panels are usually imported and are expensive, making the electric incubator costly to purchase.

### Local availability of the technology/innovation and potential suppliers across Africa

The solar poultry incubators are manufactured locally.

### Primary users of the technology/innovation

The primary users of the solar poultry incubator are small-scale poultry farmers and the youth who have invested in them for income generation.

### Climate-smart status of the technology/innovation

The solar poultry incubator is mainly used to hatch eggs from indigenous chicken, thus promoting, conserving and sustainably using this valuable resource.

### Environmentally friendly status of the technology/innovation

The solar poultry incubator uses solar energy, a renewable resource, making it very environmentally friendly. It produces a lower amount of pollutants compared to the electric incubator. It is manufactured using recycled materials and has a low environmental impact when being installed.

### Suggestions for improvement of the technology/innovation

The solar poultry incubator can be improved by adding a sensor to track the temperature and humidity inside.

### Strategies that can be adopted by national governments to promote the uptake of the solar poultry incubator

National governments can promote this technology by:

- Developing incentives for investment in local fabricators of the incubator
- Providing subsidies for the materials used in its manufacture
- Providing incentives to designers to improve on the design
- Providing business incubation for the youth involved in the fabrication of the incubator
- Setting up a monitoring and evaluation process to continuously improve the quality and standards of the incubators
- Investing in the marketing and sensitization of local poultry producers
- Designing capacity building workshops for small-scale poultry farmers where the use of the incubator can be demonstrated

# Short Periods of Incubation during Egg Storage (SPIDES)

## Primary use of the technology/innovation

Ideally, all hatching eggs should be incubated immediately. However, the availability of hatching eggs together with fluctuations in market demands for eggs affect the manner in which eggs are placed in incubators. Storage of hatching eggs for longer than seven days has been shown to decrease their hatchability and can result in the death of the embryo[17]. The short periods of incubation during egg storage (SPIDES) allows for the storage of eggs for longer than 14 days. The technique involves storing eggs for between 5 and 6 days followed by heating them to 32-38 $^{O}$C on day seven for six hours before returning them to the store. Subsequent heat treatments are given every 5-6 days thereafter. The eggs are moved to the incubator for hatching after the first or second treatment[18].

## SWOT analysis of the technology

### Strengths

The technique facilitates the hatching of eggs without heavy losses of the embryos. The chicks hatched are of good quality. The hatching window is reduced. The technique does not require additional infrastructure since the same machine is used to hatch the eggs. The technique allows for the synchronization of the sale and delivery of day-old chicks with market demand.

### Weaknesses

The SPIDES technology requires that the eggs are continuously monitored. It therefore needs additional labour. The management of the egg flow into the hatchery and incubator is quite complicated and thus may need separate management.

### Opportunities

Demand for day-old chicks, though being high tends to be seasonal.

### Threats

The local demand for day-old chicks may be too high for African poultry farmers to meet

## Local availability of the technology/innovation and potential suppliers across Africa

The technology is locally available.

17 Benton Jr, C. E., & Brake, J. (1996). The effect of broiler breeder flock age and length of egg storage on egg albumen during early incubation. Poultry Science, 75(9), 1069-1075.

18 Benton Jr, C. E., & Brake, J. (1996). The effect of broiler breeder flock age and length of egg storage on egg albumen during early incubation. Poultry Science, 75(9), 1069-1075.

### Primary users of the technology/innovation

The primary users of this technology are large hatcheries.

### Climate-smart status of the technology/innovation

The SPIDES technology allows for the matching of demands with production, thus maximizing profits while reducing losses of eggs that have been fertilized but have not been hatched for lack of demand.

### Environmentally friendly status of the technology/innovation

The SPIDES technology allows for the production of chicks when they are needed. It does not require any additional installations. It is therefore environmentally friendly.

### Suggestions for improvement of the technology/innovation

The SPIDES technology should be implemented in Africa.

### Strategies that can be adopted by national governments to promote the uptake of SPIDES

The SPIDES technology should be optimized for indigenous breeds. This can be achieved through the following strategies:

- Building the capacity of community poultry producers
- Deploying extension service workers
- Developing training programmes and manuals that are easy to follow and can be implemented at the community level
- Developing partnerships with companies that can provide hatcheries to community poultry farmer groups

# Poultry brooders

Chicken brooding is the period between the time the chick hatches to when it is able to take care of itself. It usually lasts for between 0 and 8 weeks, during which time a chick is not able to maintain its body temperature. An artificial brooder is an area where heat, water, food and bedding are provided for the chicks. Large-scale brooders use electricity for heating. This is however not possible in many parts of Africa that are not supplied with electricity. Alternatives to providing heat for the brooders are many, are variable and depend on the locally available resources which include using kerosene, wood, oil, water or gas. However, when considering how climate smart or environmentally friendly they are, the following brooders stand out: solar brooder and artificial hot water brooder.



AU-IBAR

*Commercial brooder*

## Opportunities

Poultry production in Africa is growing at a steady rate. Between 2000 and 2013, African total chicken meat quantities increased from about 28 million tons in 2000 to 47 million tons in 2013[19], with South Africa being the leading African producer. In Africa, women and children play a significant role in the management of poultry with most households keeping between five and 20 birds which are raised on a free-range system and survive mainly as scavengers[20]. This production system has contributed to a very high mortality rate of up to 40 percent under natural brooding conditions[21]. The following brooding methods present opportunities for increasing the brooding success in rural settings.

19 FAO STATS. (2020).
20 Gueye, E. F. (1997). Diseases in village chickens: Control through ethno-veterinary medicine. Ileia Newsletter, 13(2), 20-21.
21 Hoyle, E., 1992. Small-scale poultry keeping in Welaita, North Omo region. Technical pamphlet No. 3 Farmers Research Project (FRP). Farm Africa Addis Ababa.

## Types of brooders

i. Clay pot charcoal brooder
ii. Kerosene brooder
iii. Basket brooder
iv. Hay-box brooder
v. Solar brooder
vi. Infra-red lamp
vii. Artificial hot water brooder
viii. Gas brooder

# Clay pot charcoal brooder

## Primary use of the technology/innovation

The clay pot charcoal brooder is used as a chick brooder in rural settings, especially in places that are not connected to electricity.



African Farm Resource Centre

*A clay pot charcoal brooder*

## SWOT analysis of the technology/innovation

### Strengths

The clay pots are easily available, are easy to make and are cheap. Charcoal is readily available in rural settings and is affordable.

### Weaknesses

The clay pot charcoal brooder produces smoke in large quantities which might affect chicken health. The charcoal takes some time to light and produce heat and may be difficult to use during the rainy seasons.

### Threats

Commercially produced poultry brooders are more accepted, produce predictable results and are preferred by some poultry farmers, especially those with a large number of chicken.

## Local availability of the technology/innovation and potential suppliers across Africa

There may be other brooders that are more reliable to use and are considered to be more environmentally friendly.

### Primary users of the technology/innovation

The primary users of the kerosene brooder are women and rural poultry farmers.

### Climate-smart status of the technology/innovation

The clay pot charcoal brooder produces a lot of smoke which increases greenhouse gases generally and locally.

### Environmentally friendly status of the technology/innovation

The production of charcoal encourages the destruction of natural forests, which may be detrimental to the environment. The process of making the charcoal is also considered to be a non-environmentally friendly process because it produces large amounts of smoke that pollute the environment.

### Suggestions for improvement of the technology/innovation

A more environmentally friendly source of heat to place inside the clay pot should be considered. Suggestions include the use of charcoal briquettes made from recycled products such as wood and paper.

### Strategies that can be adopted by national governments to promote the uptake of the clay pot charcoal brooder

National governments should not promote the clay pot charcoal brooder until it is modified to be a green energy source.

# Kerosene brooder

## Primary use of the technology/innovation

The kerosene brooder plays an important role in poultry farming, especially in rural settings that have no access to electricity. Kerosene brooders are made by mounting kerosene lanterns on small wooden boxes to make them heavier so that the chicks cannot knock them over. They give off adequate heat and can be used continuously for 10 hours when they are completely filled.



www.anamericanhomestead.com

*Kerosene brooder*

## SWOT analysis of the technology/innovation

### Strengths

Kerosene lanterns are easily available in rural settings. They are cheap and easy to set up.

### Weaknesses

Kerosene is expensive and may not be easily available all the time in rural settings. It is prone to adulteration, which raises health and safety concerns. Perhaps the greatest risk of using the kerosene brooder is that of causing a fire as a result of spillage of the kerosene which can easily ignite. The glass on the lantern can get very hot and this can burn the chicks. The smoke emitted by the lantern is also a concern. The kerosene brooder only heats the atmosphere to 10-15 degrees above the environmental temperature and it may not be suitable in very cold settings.

### Threats

Other brooding methods are considered to be environmentally friendly and do not raise many concerns for the health and safety of the chicks and the farm employees.

### Local availability of the technology/innovation and potential suppliers across Africa

The kerosene brooder is readily available in rural settings where the kerosene lanterns are a common method of providing lighting.

### Primary users of the technology/innovation

The primary users of the kerosene brooder are women and rural poultry farmers.

### Climate-smart status of the technology/innovation

The kerosene brooder is not considered to be climate smart on account of the smoke and gas emissions produced by the lantern. These emissions could contribute to local and general greenhouse gases which are not climate friendly.

### Environmentally friendly status of the technology/innovation

The use of fossil fuels including kerosene is not considered to be environmentally friendly, because its production and use may contribute to the destruction of the environment. Kerosene is also not a renewable resource.

### Suggestions for improvement of the technology/innovation

The kerosene brooder can be improved by modifying it so that it can use a green fuel source.

### Strategies that can be adopted by national governments to promote the uptake of the kerosene brooder

National governments should not promote the kerosene brooder until it is modified to be a green energy source.

# Basket brooder

## Primary use of the technology/innovation

A woven basket can be used to provide free range chicken with a brooding area. It can also be used for brooding individual chicks that do not have a hen to provide warmth. The basket brooder is lined with grass, hay or straw and a source of heat such as an infra-red lamp or a charcoal burner is placed next to it.



AU-IBAR

*A woven basket brooder*

## SWOT analysis of the technology/ innovation

### Strengths

The basket can be woven by rural women communities using local grasses which are readily available. The basket is cheap and durable.

### Weaknesses

The straw or grass used to line the basket is prone to parasite and pest infestations such as lice, mites and bed bugs that can attack and infest the chicks. The straw/hay or grass would need to be changed regularly, making it labour intensive. The basket can only hold a few chicks at a time and is therefore only suitable for rural household poultry production.

### Threats

The free-range chicken is adapted to scavenging and may not readily adapt to the basket.

### Local availability of the technology/innovation and potential suppliers across Africa

The technology is readily available and can be made by local carpenters.

### Primary users of the technology/innovation

The primary users of the technology are small-holder farmers.

### Climate-smart status of the technology/innovation

The basket brooder increases the survival rate of indigenous chicks. This results in an increase in production, thus giving the farmer more resources at the household level and provides a buffer for the farmer against poverty.

### Environmentally friendly status of the technology/innovation

The basket brooder is made using local materials and thus it is cheap and easy to make. The wooden parts can be made using recycled materials.

### Suggestions for improvement of the technology/innovation

The basket brooder technology can be improved by:

- Using fire-proof materials that easily available
- Substituting the filler material with pest-repellent material through incorporation of pesticides or locally available pest-repellent plants

### Strategies that can be adopted by national governments to promote the uptake of the basket brooder

National governments can promote the technology through the following strategies:

- Developing training programmes for extension workers on poultry production
- Disseminating the basket brooder using community breeders and extension workers
- Developing sustainable methods, including using the youth, for fabrication and dissemination of basket breeders

# Hay-box poultry brooder

## Primary use of the technology/innovation

It has been observed that rural chicken stop laying eggs for an average of three months in order to rear chicks.

The use of the hay-box brooder has been found to decrease chick mortality. It provides an artificial brooding system that allows a hen to continue laying eggs while brooding, hence increasing production at the rural level[22]. The hay-box poultry brooder box is made from four wooden boards, a small door, a wooden or wire mesh floor, small ventilation holes, a central nest and a wire mesh surrounding a chick run.



AU-IBAR

*A hay box poultry brooder*

## SWOT analysis of the technology/innovation

### Strengths

The hay-box poultry brooder has been found to be as productive as electric brooders. It does not use any artificial source of heat thus saving the farmer expenses that would have been incurred when buying fuel. It is able to maintain the required temperatures of between 34 $^{O}$C and 39 $^{O}$C if the box is built to the required specifications. The brooder has a simple design that can be copied by carpenters in the rural areas. It uses locally available materials of wood and hay; it is portable and can be adapted for different production systems. The hay-box brooder is durable, easy to clean and disinfect.

### Weaknesses

The use of the hay-box poultry brooder may be labour intensive, especially during the first week when chicks have to be removed out of the box four to five times daily for feeding and watering. The door to the box has to be opened in the morning and closed in the evening

22 Solomon Demeke. 2010. Chick Brooder. News article of Spore, CTA. Bimonthly bulletin No.145.

and failure to do this may lead to chick death. The hay and run also have to be changed frequently. The insulating – hay and straw – materials may harbour parasites such as lice, bed bugs and mites that can attack the chicks. It is therefore important that the insulating material is changed frequently.

### Threats

Rural African family poultry farmers are relying on natural brooding systems using free-range chicken. Adoption of this new technology would require advocacy and training.

## Local availability of the technology/innovation and potential suppliers across Africa

The hay-box poultry brooder is locally available.

## Primary users of the technology/innovation

The hay-box poultry brooder is suited for use in rural poultry production systems.

## Climate-smart status of the technology/innovation

The hay-box poultry brooder can be used in rural set-ups where indigenous breeds of chicken are bred.

## Environmentally friendly status of the technology/innovation

The hay-box poultry brooder is environmentally friendly. It does not produce any emissions. It can be made using recycled wood materials. It uses hay or straw, which is easily available at the community level.

## Suggestions for improvement of the technology/innovation

The technology can be improved by incorporating green powered energy.

## Strategies that can be adopted by national governments to promote the uptake of the hay-box poultry brooder

It has been reported that many rural African communities are not aware that artificial brooding methods exist. Hence national governments can employ the following strategies to promote the hay-box poultry brooder:

- Training of extension service officers who would be key in dissemination of this technology
- Forming community farmer organizations in regions where they do not exist
- Disseminating the hay-box poultry brooder to community farmer organizations who can also be used to disseminate this technology
- Developing sustainable methods for the fabrication of the hay-box poultry brooder at community level. This would be ideal if youth are organized into groups and trained on how to make them.
- Exploring financing options

# Solar brooders

## Primary use of the technology/innovation

Solar brooder technology has been used as a source of heat for chicks. This technology uses a black absorber which concentrates sunlight, converting it to heat energy which is used to warm the chicks. The solar radiation is used to charge a battery and hence it can be stored to be used in subsequent days or at night.



*Solar brooder*

## SWOT analysis of the technology/innovation

### Strengths

Solar radiation is used as a source of energy; it is readily available in Africa. Solar is a clean renewable resource.

### Weaknesses

The initial investment that would include building the infrastructure, purchasing and installing the solar panels may be high and out of reach for rural poultry farmers, especially women. It also may require periodic maintenance. During rainy or cold seasons the amount of solar radiation may be limited.

### Threats

Commercially produced poultry brooders are more accepted, produce predictable results and are preferred by some poultry farmers, especially those with a large number of chicken.

### Local availability of the technology/innovation and potential suppliers across Africa

The solar brooder can be constructed at the local level.

### Primary users of the technology/innovation

The primary users of the solar brooder are women and poultry farmers.

### Climate-smart status of the technology/innovation

The primary source of energy for the solar brooder is solar energy, a renewable resource. This technology is therefore considered to be climate-smart.

### Environmentally friendly status of the technology/innovation

The solar brooder does not produce any toxic emissions and is therefore environmentally friendly.

### Suggestions for improvement of the technology/innovation

The technology may be improved by developing designs that are easy to follow and can be constructed at the farm level.

### Strategies that can be adopted by national governments to promote the uptake of the solar brooder

National governments can promote this technology through strategies such as:

- Creating incentives for investors to develop cheaper solar panels
- Spurring investment in the commercial production of solar brooders
- Developing and disseminating locally fabricated solar brooders

# Infra-red lamp

## Primary use of the technology/innovation

The infra-red lamp provides heat to the brooder. It is placed directly over the brooding area. It provides heat using infrared technology. The lamps are used in combination with a reflector system that directs heat to the area where the chicks are located.



AU-IBAR

*An infra-red lamp used in brooder*

## SWOT analysis of the technology/innovation

### Strengths

The infra-red lamps have been shown to use up to 30 percent less electricity and are therefore energy efficient. The lamp is made from a strong type of glass and is therefore durable and has a red glass coating to reduce glare. It produces sufficient heat and is safe for the chicks. It can be used for commercial or domestic poultry production. The heat that it produces can be directed to a specific area using reflectors.

### Weaknesses

The infra-red lamp uses electricity as an energy source and can only therefore be used in regions that have electricity. The bulbs can fall and break and they may be expensive. The reflectors are often sold as separate items and would need to be purchased. Power interruptions can affect production significantly if alternative methods are not in use.

### Threats

The concept of using electric heating for brooders is common with commercial poultry producers. Rural communities may not have electricity hence limiting the area where these can be utilized.

### Local availability of the technology/innovation and potential suppliers across Africa

The infra-red lamps are locally available.

### Primary users of the technology/innovation

The primary users of the infra-red lamp are large-scale commercial poultry producers.

### Climate-smart status of the technology/innovation

While hydro-electric generation is considered to be environmentally friendly, it is considered not climate smart because of the methane gas released into the environment. Methane gas, a greenhouse gas, is produced from the algae growth that occurs in dams or when the dam water submerges vegetation.

### Environmentally friendly status of the technology/innovation

The use of hydro power to generate electricity is considered to be environmentally friendly because hydro generation produces zero carbon emissions. Damming of water saves it from loss and thus provides communities with a source of livelihood. Electric power produced from fuel-based generators are not considered to be environmentally friendly.

### Suggestions for improvement of the technology/innovation

Alternative sources of energy for the lamps could be sought including solar energy.

### Strategies that can be adopted by national governments to promote the uptake of the infra-red lamp

National governments can promote this technology by:

- Developing incentives that support the use of green energy
- Spurring investments into the field of wind and solar energy provision for rural communities

# Artificial hot water brooder

## Primary use of the technology/innovation

Heating large brooding areas especially in large commercial poultry production enterprises can be done using hot water systems. The water is heated in a boiler and circulated throughout the brooding house using a system of pipes that give off heat. The heat from the pipes transfers into the brooding area where the chicks are housed.



www.instructables.com

*Installation of a hydronic heating system*

## SWOT analysis of the technology/innovation

### Strengths

Heating water using a boiler is a simple method and with a good piping system it can warm a large brooding area.

### Weaknesses

The water used has to be pure water so that it does not cause blockages in the pipes. The maintenance costs for boilers are high. Considerations have to be made on the type of heating to be used. If it is electricity it can be very high. The cost of installing these heaters is also high.

### Threats

The availability of clean and cheap water to use for heating buildings may not be easy in many parts of Africa. The cost of using it for heating may also be prohibitive.

### Local availability of the technology/innovation and potential suppliers across Africa

The technology is locally available.

### Primary users of the technology/innovation

The primary users of this technology would be the large-scale poultry producers.

### Climate-smart status of the technology/innovation

Heating water using a green energy method such as solar would be considered to be climate smart and environmentally friendly.

It improves farmers' incomes, making them resilient against climate change.

### Environmentally friendly status of the technology/innovation

Heating water using electricity is not considered to be environmentally friendly.

### Suggestions for improvement of the technology/innovation

Improvements that could be made to the technology include:

- Incorporating solar-powered water heating systems
- Exploring new hydronic heating systems where hot running water is passed under wooden floorboards using pipes or radiators

### Strategies that can be adopted by national governments to promote the uptake of the artificial hot water brooder

National governments can promote the uptake of the technology by:

- Lowering the cost of electricity to encourage small-scale rural poultry producers to use it for brooding
- Developing policies and legislation to increase investments in rural electrification

# Gas brooder

## Primary use of the technology/innovation

The gas brooder uses liquified petroleum gas (LPG) gas as a fuel source to heat the brooding area.



AU-IBAR

*A gas brooder*

## SWOT analysis of the technology/innovation

### Strengths

The gas brooder can be used in areas that do not have electricity.

### Weaknesses

LPG gas supply in rural areas may be problematic. It is an expensive fuel source and the continued increase in its cost may make it an unsustainable source of heat. It requires strict safety procedures to be adopted for its use to prevent accidents from occurring.

### Threats

The cost and availability of LPG gas in rural communities would limit its use to commercial poultry producers.

## Local availability of the technology/innovation and potential suppliers across Africa

LPG gas is locally available.

## Primary users of the technology/innovation

The primary users of LPG brooders are the large-scale commercial poultry producers.

## Climate-smart status of the technology/innovation

Although LPG gas produces carbon emissions when it is burned, it is considered to be a more environmentally friendly source of energy compared to fuel-generated electricity, for example, coal or petroleum.

### Environmentally friendly status of the technology/innovation

The LPG gas is considered to be an environmentally friendly fuel.

### Suggestions for improvement of the technology/innovation

The gas brooder can be made more cost effective if it is manufactured to have sensors, an efficient exhaust system and a control panel that can be used to give feedback on all the parameters. The system if fully automated would be efficient and would mean that there would be less manpower required to monitor the chicken brood house.

### Strategies that can be adopted by national governments to promote the uptake of gas brooders

LPG gas is considered to be an expensive fuel source for rural communities. Developing strategies to lower its cost and increase rural communities' access to it would increase its use in poultry production.

# Ammonia production sensors

## Primary use of the technology/innovation

Ammonia is produced through the bacterial decomposition of chicken droppings[23] and is considered to be a major pollutant of poultry buildings[24]. Exposure of chickens to ammonia causes numerous adverse effects including irritation to the mucous membranes in the eyes and respiratory system, increases their susceptibility to respiratory diseases, and is thought to affect the chicken's food intake, food conversion efficiency and growth rate[2]. To keep ammonia levels low, chicken houses need to be well ventilated and the litter needs to be kept dry and regularly maintained. In addition to this, installation of ammonia sensors gives real time feedback on the levels of ammonia in the chicken houses.



AU-IBAR

*Ammonia sensor*

## SWOT analysis of the technology/innovation

### Strengths

The ammonia sensors accurately capture the levels of ammonia in the poultry houses. They are durable, can detect even small amounts of ammonia and can also be used to detect other gases. The management of ammonia levels in poultry houses results in an increase in poultry production.

### Weaknesses

The ammonia sensor has to be well calibrated to avoid giving false readings. They may be expensive for small-scale poultry producers.

23 Taiganides, E. P., & White, R. K. (1969). The menace of noxious gases in animal units. Transactions of the ASAE, 12(3), 359-0362.

24 Kristensen, H. H., & Wathes, C. M. (2000). Ammonia and poultry welfare: a review. World's Poultry Science Journal, 56(3), 235-245.

### Opportunities

The increase in African poultry production presents opportunities for income generation at the family level. Since poultry are mainly kept by women in Africa, this activity results in poverty alleviation at the family level.

### Threats

The cost of ammonia sensors may be a limiting factor. African poultry production practices may not involve the detection of ammonia levels. However, the implementation of good practices including regular cleaning of poultry houses may keep ammonia levels low.

## Local availability of the technology/innovation and potential suppliers across Africa

Ammonia sensors are locally available.

## Primary users of the technology/innovation

The primary users of ammonia sensors are the large-scale poultry producers.

## Climate-smart status of the technology/innovation

Ammonia is considered to be an environmental pollutant. The detection of the levels of ammonia in local environments is a climate-smart practice because it seeks to reduce the levels, thus managing the quantities in the local and general environment.

## Environmentally friendly status of the technology/innovation

The installation of ammonia sensors is an environmentally friendly process that does not involve the destruction of the environment in any way. Ammonia detection and reduction preserves the quality of the environmental air.

## Suggestions for improvement of the technology/innovation

Ammonia sensors that are smart and can be used to collect data would be useful tools for data collection.

## Strategies that can be adopted by national governments to promote the uptake of ammonia sensors

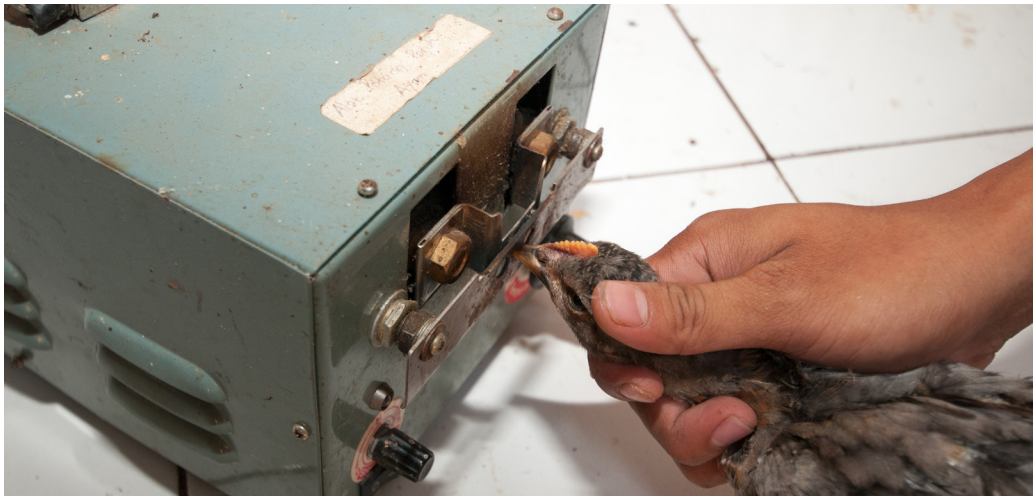
Currently the cost of ammonia sensors limits their use to commercial poultry farms. Developing simple and cost-effective sensors that can be used at the rural community level would increase the uptake of this technology.

# Electric chicken debeaking

## Primary use of the technology/innovation

Chicken debeaking or trimming is the partial removal of the sharp upper and lower mandible tips of the beak[25,26]. It is often done on 5-10-day old chicks to prevent cannibalism, severe feather pecking and aggressive behaviour[27]. Debeaking technologies include:

- **The use of a heated guillotine blade**. This debeaking technique uses a blade heated to 700 $^{O}$C which cuts and cauterizes the beak tissue. It is performed on 4-5-day old chicks. The process can be manual or automatic.
- **Laser, infra-red or microwave debeaking.** This process involves the use of an infra-red beam, an electric currency or microwave beam to direct high energy to the tip of the beak. This causes the tip of the beak to fall off after a few days.



Shutterstock

*Electric chicken debeaking machine*

## SWOT analysis of the technology/innovation

### Strengths

Debeaking prevents cannibalism and aggressive behaviour in chickens, leading to improved animal welfare. It also prevents chickens from eating their own eggs and pecking eggs, thus causing their breakage. The procedure generally results in a reduction in feed consumption as well as improved feed management. Generally, debeaking results in higher production levels.

25 Lonsdale, M. B., Vondell, R. M., & Ringrose, R. C. (1957). Debeaking at one day of age and the feeding of pellets to broiler chickens. Poultry Science, 36(3), 565-571.

26 Nicol, C. (2018). Feather pecking and cannibalism: Can we really stop beak trimming?. In: Advances in Poultry Welfare (pp. 175-197). Woodhead Publishing.

27 Cunningham, D. L. (1992). Beak trimming effects on performance, behavior and welfare of chickens: a review. Journal of Applied Poultry Research, 1(1), 129-134.

### Weaknesses

The debeaking process carries the risk of causing permanent damage to the beak and thus needs to be done professionally. In some chickens the debeaked beak can grow back.

### Opportunities

The debeaking process directly leads to an increase in poultry production.

### Threats

The practice of chicken debeaking is very controversial, with animal welfare groups criticizing the practice because it inflicts pain on the birds and affects the beak nerves. They argue that debeaking goes against animal welfare.

## Local availability of the technology/innovation and potential suppliers across Africa

The practice of debeaking chickens is locally available.

## Primary users of the technology/innovation

The primary users of debeaking are the large-scale poultry producers.

## Climate-smart status of the technology/innovation

The debeaking of chickens has been directly linked to an increase in poultry production, thus increasing incomes of poultry farmers. This increases the resilience of the overall poultry production.

## Environmentally friendly status of the technology/innovation

The debeaking of poultry does not involve the destruction of the environment. The techniques used are manual or use a green energy source such as electricity-powered devices.

## Suggestions for improvement of the technology/innovation

This technology can be improved by developing guillotines that can be used at the rural community level. Commercial guillotines need to be heated to very high temperatures which may not be possible in rural villages.

## Strategies that can be adopted by national governments to promote the uptake of electric chicken debeaking

Current poultry production practices at the community level do not include the debeaking of poultry. Strategies for the uptake of this practice, especially where rural farmers are keeping many chickens, need to be disseminated.

# Poultry identification

## Primary use of the technology/innovation

The identification of chicken is a key production practice for use in traceability of chicken products sold to consumers. It is especially important when a farmer begins to breed chicken for purposes of identifying the top breeders. Several methods can be used for poultry identification including:

**Wing bands:** This is a permanent type of identification. It has a high retention rate and will remain on the chick for life.

**Leg bands:** The leg bands are plastic or aluminium bands that are wrapped around a chicken's leg. They are fitted to size and are often used on mature birds.



AU-IBAR

*Chicken identification bands*

## SWOT analysis of the technology/innovation

### Strengths

The identification bands are proof of ownership and can be used to identify the chickens' products sold to consumers.

### Weaknesses

The wing band requires that the chicken's wing be punctured. The leg band on the other hand requires to be changed as the chicken grows.

### Opportunities

The increasing requirement that all livestock products should be traced from the farm to the consumer expands the opportunities for the application of this technology.

### Threats

In rural poultry production systems, chicken are identified using their phenotype.

### Local availability of the technology/innovation and potential suppliers across Africa

The poultry identification tags are locally available.

### Primary users of the technology/innovation

The primary users of the technology are large-scale commercial poultry farmers.

### Climate-smart status of the technology/innovation

The identification of poultry results in sustainably higher production levels, raising food security levels.

### Environmentally friendly status of the technology/innovation

The tagging of chicken has no adverse effects on the environment.

### Strategies that can be adopted by national governments to promote the uptake of poultry identification

The practice of tagging poultry is not common among family and village poultry production systems. The identification of high producing chickens involves selection and breeding, which requires poultry identification. This practice should therefore be disseminated to these production systems, possibly through the use of extension service providers.

# Trap nests

## Primary use of the technology/innovation

A trap nest is a nest box with a door that automatically closes when a hen enters to lay an egg.

The trap nest allows for the identification of hens that are laying eggs. It allows for tallying of the number of eggs a chicken is laying daily. The advantage of this technology is that it can be used in the production of high producing chicken breeds.



AU-IBAR

*Simple chicken trap nest*

## SWOT analysis of the technology/innovation

### Strengths

The trap nest is simple to make and is durable. It can be made by any carpenter using local materials, thus making it cheap and affordable.

### Weaknesses

The chickens may sleep in the trap nest meaning that it will need to be cleaned out regularly. Some chickens may still not lay eggs in the trap nest despite it being provided.

### Opportunities

The identification of the layers is a critical component of poultry production that should impact the layers' feed management. The need for traceability of poultry products makes it necessary to identify the chickens that are laying eggs.

### Threats

Free range chicken may not easily accept a trap nest but naturally look for a dark quiet place to lay their eggs so as to protect the eggs from a predator.

### Local availability of the technology/innovation and potential suppliers across Africa

The technology is locally available.

### Primary users of the technology/innovation

The primary users of the technology are the large-scale poultry producers.

### Climate-smart status of the technology/innovation

The trap nests simplify the process of egg collection, thus reducing wastage and loss of eggs.

### Environmentally friendly status of the technology/innovation

The trap nests are made from locally produced materials that can be recycled and are therefore environmentally friendly.

### Suggestions for improvement of the technology/innovation

The technology can be improved by installing cameras and sensors to detect the movement of chickens.

### Strategies that can be adopted by national governments to promote the uptake of trap nests

Trap nests are not commonly used in family and village poultry production systems. This practice would lead to an increase in production. It should therefore be disseminated through extension service providers.

# 4.2 Technologies and Innovations targeting the Inputs and Services Components

# Automatic Feed Management System

## Primary use of the technology/innovation

The feeding of chickens is a time-consuming process, especially if the chickens are many and are not free range. The Automatic Feed Management System is an automated system that provides feed to the entire length of the poultry house with chain devices that transfer feed from bins to the troughs.



Hightop Pultry Equipment

*Automatic feed management system transferring feed from bins to the troughs*

## SWOT analysis of the technology/innovation

### Strengths

The Automatic Feed Management System is robust, can use any type of feed, including pellets, mash or crumbles. It distributes feed evenly throughout the chicken house, thus ensuring that the birds get an equal amount. It provides a cost-efficient method for feeding large numbers of birds. It requires low labour and low maintenance. It is durable and provides a long-life service.

### Weaknesses

This feed system technology is expensive, requires skilled personnel to monitor it and can only be used in regions that are connected to electricity.

### Opportunities

The increase in consumption of chicken in most parts of Africa[28] has created high demand for chicken meat and eggs.

### Threats

The low adoption of automation and technology in livestock production is a threat.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology is available mainly in developed countries.

## Primary users of the technology/innovation

The primary users of the technology are intensive chicken producers.

## Climate-smart status of the technology/innovation

The automation of feed management reduces the wastage of feed and labour costs, therefore increasing profits for the farmer.

## Environmentally friendly status of the technology/innovation

The installation of Automatic Feed Management technologies at the farm level is an environmentally friendly process that does not cause any destruction of the environment.

## Suggestions for improvement of the technology/innovation

Integration of the Automatic Feed Management System with sensors and cameras allows for the real time monitoring of the flocks.

## Strategies that can be adopted by national governments to promote the uptake of the Automatic Feed Management System

National governments should promote this technology by:

- Developing incentives that encourage investments in the Automatic Feed Management System
- Developing partnerships that favour the transfer of Automatic Feed Management technology to Africa

28 Adegbulugbe, T. A., Atere, A. O., & Fasanmi, O. G. (2013). Development of an automatic electric egg incubator. International Journal of Scientific & Engineering Research, 4(9), 914-918.

# Automatic water drinkers – nipple drinker

## Primary use of the technology/innovation

Chicken consume a lot of water, owing to their highly active nature. They therefore need constant access to clean drinking water throughout the day. Chickens that do not have direct and easy access to water easily become dehydrated and stop laying eggs. If the condition persists it can lead to their death. Placing water trays or drinking spots in the chicken house can lead to the water getting spilt by accident or contaminated by chicken stepping into it. Automatic water drinkers solve this problem by providing water on demand for the chicken. These can be placed in the poultry house on the Deep-Litter or in the cage system. The automatic drinkers look like nipples and water flows out when they are pressed. One nipple drinker is sufficient to water three layers.



Xian Poultry Equipment

*Automatic water dispensing systems*

## SWOT analysis of the technology/innovation

### Strengths

The automatic water drinkers are self-filling, thus reducing labour requirements for watering chicken. The drinker is made using a simple structure that is easy to clean. The drinker is cheap and easy to assemble, with a design that saves water and reduces wastage; it is also easy to refill. The design prevents dirt and debris from getting into the water.

### Weaknesses

The chickens need training to learn how to get the water to flow out. They require monitoring to ensure water does not run out. Concerns have been raised by animal welfare supporters on the reduced access to water for the chicken.

### Opportunities

The majority of African poultry farmers have access to clean water that they can provide to their chicken.

### Threats

The common practice for small-scale poultry producers is to provide clean water in a trough.

## Local availability of the technology/innovation and potential suppliers across Africa

The automatic water drinkers are locally available.

## Primary users of the technology/innovation

The primary users of the automatic water drinkers are all classes of poultry farmers.

## Climate-smart status of the technology/innovation

The automatic water drinkers reduce water wastage and are therefore climate friendly. Provision of clean and adequate water increases chicken production and thus provides farmers with additional income.

## Environmentally friendly status of the technology/innovation

The automatic water drinkers do not require any special installations and hence do not destroy the environment in any way.

## Suggestions for improvement of the technology/innovation

Integration of sensors on the automatic water dispenser would enhance the technology by collecting data.

## Strategies that can be adopted by national governments to promote the uptake of automatic water drinkers

National governments can promote this technology through strategies such as:

- Developing automatic water drinkers from locally made materials
- Increasing access for small scale poultry farmers to automatic water drinkers by providing mechanisms through which they could easily acquire the technology

# Feed pellet mill

## Primary use of the technology/innovation

The feed pellet mill, also known as a pellet press is feed processing equipment that converts powdered feed into pellets. The process entails the use of heat, moisture and pressure, and produces pellets that have a uniform texture and nutrient composition. This homogeneity provides for a balanced nutrient delivery to the poultry. The feed is thoroughly mixed and each pellet produced has a standard nutritional consistency. Pelleted feed is easy to handle, easy to store and reduces feed wastage.



www.pelletizermill.com

*A pelleting machine*

## SWOT analysis of the technology/innovation

### Strengths

The feed pellet mill sorts the feed before it enters the mill, removing anything that is not digestible by the chickens including metal, paper, stones and string. The pellets are homogenous in nature, and they reduce wastage of feed by the chickens.

### Weaknesses

Feed pellet mill machines are expensive and require specific infrastructure, installation and operation by skilled personnel.

### Opportunities

The increasing demand for livestock feed presents a huge opportunity for use of the feed pellet mill. This demand has had the added advantage of improving the quality and supply of feed raw materials.

### Threats

Demand for feed pellet mills in Africa may not be high enough to spur investment in feed production mills.

### Local availability of the technology/innovation and potential suppliers across Africa

Feed pellet mills are available in Africa.

### Primary users of the technology/innovation

The primer users of the feed pellet mills are small feed industries.

### Climate-smart status of the technology/innovation

This technology is climate smart because it uses local foods and grasses to make feed.

### Environmentally friendly status of the technology/innovation

The use of local grasses and forages for feed makes this technology environmentally friendly.

### Suggestions for improvement of the technology/innovation

Standard feed formulas should be developed by feed experts and shared with small feed industries.

### Strategies that can be adopted by national governments to promote the uptake of feed pellet mills

National governments can promote this technology through several strategies including:

- Awareness creation on the importance of pelleting feed, such as reduced feed wastage, uniform nutrient distribution within pellets, etc.
- Developing strategies for dissemination including use of skilled extension service providers
- Providing youth access to technologies, through strategic partnerships
- Providing entrepreneurs access to microfinance

# 4.3. Technologies and Innovations targeting the Housing Component

# Deep litter

## Primary use of the technology/innovation

Poultry farmers often use a dry absorbent organic material such as straw, hay, or wood shavings as bedding material. The chicken defecates on this material and instead of cleaning it out; the farmer adds new bedding material on top of it. This process is continued and is allowed to build from about 10 cm in height to 1-2 m. The large quantities of carbon present in the bedding locks up gases including nitrogen and ammonia that would be produced through the bacterial decomposition of chicken waste, therefore improving the air quality.



AU-IBAR

*Advanced deep litter system*

## SWOT analysis of the technology/innovation

### Strengths

The deep litter encourages decomposition and composting, processes which provide heat used to keep the poultry houses warm. The deep litter insulates chicken from the cold ground and provides a warm surface for them to walk on. The anaerobic decomposition also promotes the growth of good bacteria that produce vitamins B12 and K and inhibit the growth of bad bacteria. Deep litter keeps levels of ammonia and nitrogen low. Old deep litter is removed from chicken houses and can be used for composting. The materials used to make the deep litter are cheap, easily available and are abundant.

### Weaknesses

The deep litter can become saturated with waste and become wet and muddy. It has been found to contain a range of bacteria, fungi and viruses[29] that are potentially harmful to poultry and humans. Maintenance of deep litter requires regular layering with new bedding material and is labour intensive. This system needs a regular supply of high quality litter, which has economic implications if it has to be purchased by the chicken farmer. Dust from the litter can cause an increase in chicken respiratory diseases.

### Opportunities

Demand for chicken meat has led to an increase in poultry farming. The high concentration of macro-nutrients in chicken manure[30] has been found to enhance soil fertility[31], making it the most sought-after animal manure for use in crop and fish farming[32]. Rising demand for organically produced food and the growing number of urban vegetable farmers has increased the demand for manure.

### Threats

The presence of pathogens such as *Salmonella*, *Campylobacter jejuni*, and *Listeria monocytogenes* in poultry manure and litter may threaten human and other livestock health especially if the poultry meat is contaminated. The heat treatment together with the addition of biological treatments should be considered as methods of pathogen control for chicken deep litter[33].

## Local availability of the technology/innovation and potential suppliers across Africa

Deep litter is locally available.

## Primary users of the technology/innovation

The primary users of deep litter are small- and large-scale poultry and chicken farmers.

## Climate-smart status of the technology/innovation

Chicken and poultry production produces large amounts of ammonia which is a strong greenhouse gas. Deep litter used in poultry and chicken houses absorbs the ammonia gas before it vaporizes, resulting in reduced emissions of local and general ammonia gas.

29 Kyakuwaire, M., Olupot, G., Amoding, A., Nkedi-Kizza, P., & Ateenyi Basamba, T. (2019). How safe is chicken litter for land application as an organic fertilizer?: A review. International Journal of Environmental Research and Public Health, 16(19), 3521.

30 Duncan, J. (2005). Composting chicken manure. WSU cooperative extension. King County Master Gardner and Cooperative Extension Livestock Advisor, Washington State University, Pullman. Retrieved 11 Nov 2017 from hppt://www.scirp.org>references paper

31 Dikinya, O., & Mufwanzala, N. (2010). Chicken manure-enhanced soil fertility and productivity: Effects of application rates. Journal of Soil Science and Environmental Management, 1(3), 46-54.

32 Wilkinson, S. R. (1979). Plant nutrient and economic valus of animal manures. Journal of Animal Science, 48(1), 121-133.

33 Lemunier, M., Francou, C., Rousseaux, S., Houot, S., Dantigny, P., Piveteau, P., & Guzzo, J. (2005). Long-term survival of pathogenic and sanitation indicator bacteria in experimental biowaste composts. Applied and Environmental Microbiology, 71(10), 5779-5786.

### Environmentally friendly status of the technology/innovation

The composting of deep litter into manure recycles essential nutrients back into the environment. Animal manure, including chicken manure, are valuable sources of both macro and micro nutrients, and ploughing this back into pastures and farms is an excellent form of nutrient management.

### Suggestions for improvement of the technology/innovation

Research should be carried out on easy-to-adopt methods for treating chicken manure to remove pathogens.

### Strategies that can be adopted by national governments to promote the uptake of deep litter

National governments can promote this technology through:

- Developing integrated fish farming for chicken farmers to enable them use chicken manure as fish feed
- Assisting chicken farmers to process, market and sell the manure they produce from deep litter

# Slatted raised floor

## Primary use of the technology/innovation

This technology entails the construction of chicken houses that have a slatted floor[34]. The slats comprise pieces of wood of between 2 and 5 cm wide and placed 2-3 cm apart. The slats could also be made from plastic—these form the entire floor of the house. The floor of the chicken house is raised about 1 m above the ground to allow for accumulation of droppings below it.



Plastic https://www.sanislat.com/photos
Wooden (inset) http://indiv.com/

Plastic and wooden (inset) slatted raised floor

## SWOT analysis of the technology/innovation

### Strengths

The poultry houses are durable and easy to construct using locally available materials. No cleaning of the floor is required, therefore reducing labour costs. The slatted floors reduce contact between the chickens and their droppings and litter, hence lower the chances of bacterial and other pathogen infections. Slatted houses can be used in combination with deep litter flooring. These houses can also be partially constructed above fish ponds where the chicken droppings fall directly into the pond. Having open slates increases ventilation, hence reduces the amount of ammonia circulating.

### Weaknesses

The management of the chickens including feeding, watering and gathering of eggs can be managed from outside the house. A bigger house with stronger floors needs to be constructed to allow for passage into the house.

34 Bhadhauria, P. (2014). Different types of poultry housing systems for tropical climate. Linkedin Corporation.

### Opportunities

The demand for chicken manure for crop and fish farming have increased, presenting an opportunity to better manage the collection and processing of chicken manure.

### Threats

While poultry manure contains high amounts of macronutrients and micronutrients such as nitrogen and phosphorus, it also contains bacteria, other pathogenic microorganisms and heavy metals that may be harmful to human health especially when the chicken products are contaminated with them.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology is locally available.

## Primary users of the technology/innovation

The primary users of this technology are both small- and large-scale farmers.

## Climate-smart status of the technology/innovation

Adoption of slatted chicken houses increases production of chicken manure. The adoption of integrated poultry-fish production results in income generation that directly impacts the livelihoods of farmers.

## Environmentally friendly status of the technology/innovation

The integration of fish farming with manure production is environmentally friendly owing to the recycling of nutrients within the environment.

## Suggestions for improvement of the technology/innovation

Development of rubber mats on slatted floors can reduce chicken feet injuries.

## Strategies that can be adopted by national governments to promote the uptake of slatted chicken houses

National governments can promote this technology through strategies such as:

- Capacity building for chicken farmers on the best housing for poultry
- Conducting studies aimed at understanding chicken house preferences in small poultry production systems with a view to developing the best options
- Conducting capacity building for small-scale poultry farmers who want to begin fish farming

# Battery or cage system

## Primary use of the technology/innovation

The battery or cage system for poultry production is a housing system for chicken; it is primarily used in intensive poultry production systems. In this system, chicken are kept in compartments or units. The floor of the battery cage slopes frontwards allowing eggs to roll to the front of the cage for easy collection. Depending on the number of chicken a farmer is keeping, there are different options of battery cages including single, double or triple cages.



AU-IBAR

*Battery cage system*

## SWOT analysis of the technology/innovation

### Strengths

The battery cage system of chicken production uses the smallest amount of land where an estimated 20,000 to 25,000 chickens can be reared per hectare. This reduces the overall cost of housing chickens. The chicken can be housed individually or in groups of two to three, allowing for individual data records to be kept, which is highly advantageous for breeding programmes. Good poultry management practices of feeding, watering and egg collection can be easily maintained. The battery cages do not need litter. The chickens cannot eat the eggs; the eggs produced are clean and the level of egg breakage is reduced. The battery cage system has also been found to be effective in eliminating poultry diseases.

### Weaknesses

Animal welfare associations have raised concerns with the use of battery cages especially when high numbers of chicken of up to six are placed inside each cage. Keeping many chickens together is detrimental to their welfare and can also easily spread diseases.

### Opportunities

The use of battery cages offers opportunities to increase poultry production. Poultry production has been on the steady increase with annual growth estimated at 5 percent per year, with its share of meat production increasing from 15 percent to 30 percent in the last three decades.

### Threats

The increase in animal welfare concerns regarding the space allocation for each hen has impacted the adoption of this technology.

## Local availability of the technology/innovation and potential suppliers across Africa

The battery cages are locally available.

## Primary users of the technology/innovation

The primary users are poultry farmers in small, medium or large production systems.

## Climate-smart status of the technology/innovation

The battery cage maximizes the space for chicken production, resulting in higher incomes for poultry farmers. This reduces poverty levels at the community level and enhances farmers' resilience.

## Environmentally friendly status of the technology/innovation

The battery cages allow for keeping many chickens in a small amount of space.

## Suggestions for improvement of the technology/innovation

To take care of animal welfare concerns, battery cages should have enough spaces for the chickens to be able to move their wings and to generally move around.

## Strategies that can be adopted by national governments to promote the uptake of battery cages

National governments can promote this technology through strategies such as:

- Development of national policies governing animal welfare including chicken welfare
- Adoption of integrated fish-poultry farming

# Natural ventilation for poultry houses

## Primary use of the technology/innovation

Ventilation in chicken houses is key to maintaining chicken health and welfare. Good ventilation reduces the amount of ammonia gas in the poultry house, reduces temperatures increases, regulates the humidity, and controls excess moisture and circulating air and dust. Side wall curtains can also be installed and these are opened to allow air inflow when the poultry house gets warm and they are closed when airflow needs to be restricted. Natural ventilation air supply into the poultry house uses the chimney effect where warm air rises and is let out through vents, doors or flaps. This then creates negative pressure and fresh air is sucked into the house through natural ventilation openings.



AU-IBAR

*Naturally ventilated chicken house using locally available materials*

## SWOT analysis of the technology/innovation

### Strengths

Natural ventilation has low investment because it uses natural resources. It is simple to install and incorporate into the design and structure of the house.

### Weaknesses

The natural ventilation openings require to be manually opened and closed, making them labour intensive. The natural vents when left open for too long can allow pests and predators to enter the chicken house. Windows, vents and chimneys all need regular maintenance. Natural ventilation does not allow for specific poultry house control to be effected. During cold weather the cold air can flow directly to the chickens.

### Opportunities

More demand for chicken eggs and meat has resulted in an increase in chicken production. Managing the environmental conditions has been found to reduce the cost of production.

### Threats

Small- and medium-scale poultry producers do not consider ventilation when building poultry houses. The risk of rodents and other predators is high and the need to keep these out affects the number of openings in the poultry house.

## Local availability of the technology/innovation and potential suppliers across Africa

Natural ventilation is naturally built into the design of a house and is therefore locally available.

## Primary users of the technology/innovation

The primary users of this technology are all poultry farmers.

## Climate-smart status of the technology/innovation

The internal climate of poultry houses contributes to animal health and welfare.

## Environmentally friendly status of the technology/innovation

The diffusion of ammonia and other gases that can accumulate within poultry houses reduces the local and general accumulation of greenhouse gases.

## Suggestions for improvement of the technology/innovation

Integration of natural and simple mechanical ventilation options should be considered.

## Strategies that can be adopted by national governments to promote the uptake of natural ventilation

To promote this technology, national governments should consider the development of poultry housing designs for poultry farmers.

# Mechanical ventilation for poultry houses

## Primary use of the technology/innovation

Mechanically induced air movements become necessary when the natural ventilation does not sufficiently provide quality air in a poultry house. Mechanically induced air exchange can be provided through installation of fans. Fans use negative pressure, usually during warmer seasons, to push out warm air found inside the chicken house. They can also use positive pressure, especially during cooler seasons, to push outside air into the house. In Africa, most of the fans are negative-pressure ventilators used to push warm air outside the house. This process creates a partial vacuum inside the house that causes air to be drawn into the house through vents, windows and openings in the house.



AU-IBAR

*Automated ventilation system*

## SWOT analysis of the technology/innovation

### Strengths

Controlled ventilation controls internal temperatures, preventing them from becoming too high.

### Weaknesses

The fan and air conditioners require frequent maintenance. They are expensive to acquire. The fans have to be calibrated to ensure that they do not adversely affect the internal environment. The fans and openings (vents, doors or curtains) need to be designed and professionally installed for them to work.

### Opportunities

Growing demand for chicken eggs and meat has resulted in an increase in chicken production. Managing the environmental conditions has been found to reduce the cost of production.

### Threats

The mechanical ventilators require electricity to run. They also need specific infrastructure and control. This is expensive and may be out of reach for small- and medium-scale chicken farmers.

## Local availability of the technology/innovation and potential suppliers across Africa

Mechanical ventilators are locally available.

## Primary users of the technology/innovation

The primary users of the mechanical ventilators and fans are large-scale poultry farmers.

## Climate-smart status of the technology/innovation

The mechanical ventilators use electric energy which is not always available. Control of the internal environments of poultry houses results in an increase in poultry production.

## Environmentally friendly status of the technology/innovation

The reduction of ammonia, carbon dioxide and other greenhouse gases is an environmentally friendly practice.

## Suggestions for improvement of the technology/innovation

Solar radiation and other types of green energies should be used for powering the mechanical ventilators.

## Strategies that can be adopted by national governments to promote the uptake of mechanical ventilators

National governments can promote this technology through strategies such as:

- Developing manuals on the management of internal environmental conditions for poultry farmers should be developed
- Developing national and regional policies for the management of greenhouse gases in livestock production

# 4.4. Technologies and Innovations targeting the Processing and Value Addition Components

# Mobile poultry processing units

## Primary use of the technology/innovation

The mobile poultry processing units are portable and mobile set-ups that small- and medium-scale farmers use to process their own chicken. Such farmers previously would have had to sell their chicken to middle men or larger processing plants. The mobile poultry processing unit allows farmers to process and sell their own processed chicken.



www.lancasterfarming.com

*Mobile poultry processing unit*

## SWOT analysis of the technology/innovation

### Strengths

The mobile poultry processing unit travels to the place where the chicken need to be slaughtered and carries out the slaughtering there. It can therefore travel to rural communities and slaughter chicken on site. It therefore has the potential to reach a large number of farmers.

### Weaknesses

The cost of chicken produced through the mobile poultry processing unit is higher because of the smaller number of chicken that the unit processes. The cost of acquiring the unit may initially be high.

### Opportunities

The increasing demand for processed poultry meat against the relatively low supply of chicken provides a great opportunity for investment in this area. The development of cruelty-free and organically raised chicken has increased the possibility of small- and medium-scale farmers producing their own chicken.

### Threats

The high cost of acquiring the mobile poultry processing unit and the lack of skilled personnel to use the equipment may limit the number of users of this technology. The risk of contamination of the chicken meat while it is being processed carries a high risk of financial loss for the famer.

### Local availability of the technology/innovation and potential suppliers across Africa

The mobile poultry processing units are not locally available.

### Primary users of the technology/innovation

The primary users of the mobile poultry processing units are the small- and medium- scale poultry farmers.

### Climate-smart status of the technology/innovation

Processing chickens at the farm level increases profits for the farmer by cutting out costly middle men who would normally buy the chicken and deliver to poultry processing plants.

### Environmentally friendly status of the technology/innovation

The mobile processing unit has a lower environmental impact because the poultry processing is done in a small area.

### Suggestions for improvement of the technology/innovation

This technology should be transferred to Africa through the development of small-scale mobile poultry processin g units for developing countries.

### Strategies that can be adopted by national governments to promote the uptake of mobile poultry processing units

National governments can promote this technology through strategies such as:

- Developing partnerships with manufacturers of the mobile poultry processing unit
- Developing strategies to mitigate the cost of purchasing the mobile poultry processing unit.



# 5



# The Apiculture Value Chain



# 5.1 Technologies and Innovations targeting the Production Component

# The Langstroth Hive ™

## Primary use of the technology/innovation

The Langstroth Hive is classified as a modern type of hive. It is primarily used to produce a diverse set of bee products including honey, beeswax and propolis. It is made up of two parts, a brood chamber located at the bottom of the hive where the queen lays eggs and an upper box also known as a super or honey box. The key feature of this hive is that it is made from frames hung vertically on which bees build honeycombs. These frames can be easily removed and are constructed in a way that bees cannot attach honeycombs that would connect adjacent frames or connect them to the walls of the hive. During honey harvesting, the frames are removed and honey is extracted without destroying the honeycombs so that bees do not have to keep reconstructing them.




AU-IBAR

*Langstroth Hive*



AU-IBAR

*Smoker*

## SWOT analysis of the technology/innovation

### Strengths

The Langstroth Hive produces high quality honey that can be extracted in a fast, easy and efficient manner because the comb is fixed firmly to the four sides of the frame. The strong honey comb that the bees are able to build allows for easy handling of the frame when removing honey or inspecting the bees without damaging the honey comb or killing the bees by crushing when handled. The hive is durable, lasts for a long time, produces a higher yield of honey compared to the traditional hive, is easy to control and manage, and adapts easily to modern processing mechanisms. The Langstroth Hive is able to produce many types of bee products, is easily constructed by local carpenters and is easy to populate with frames from other beekeepers thus saving on production time.

### Weaknesses

The Langstroth Hive is considered to be expensive; it may require technical expertise to manufacture. This hive is considered to have a lower colonization rate compared to other products in the market. Perhaps one of the greatest weaknesses of this hive is that it is easily stolen and thus the beekeeper needs to consider the location of the hive. Another major weakness of this hive is the design where bees at the bottom of the hive can starve off if they have no honey stores there, despite the availability of honey stores in upper boxes. The hive is heavy to lift. With time and as the hive grows and becomes more established, the upper boxes become heavy with honey, and will need to be lifted for inspection.

### Opportunities

There is a huge local and international demand for African honey. Nigeria for example, is only able to meet 10 percent of its local domestic consumption of 380,000 tons and imports the rest. This demonstrates the huge potential for investments in this area of beekeeping. Local communities are interested and willing to take on beekeeping as a commercial activity. Africa is endowed with a large bee genetic diversity that is healthy and active. Africa is also endowed with numerous plants that bees can use for foraging. Africans have a long history of keeping bees and are therefore experienced in the practice.

### Threats

African bees are aggressive and this may be a deterrent for new entrants to beekeeping. Among some communities, this aggression in bees has led to a fear of keeping bees. The threat of bush fires, which destroy hives and kills bees is a major risk to bees. The climate change being experienced in Africa is causing the reduction of forests and threatens the bees that need forage plants.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology/innovation is locally available and can be obtained from APITRADE (Africa), Africa Apiculture Platform, the Uganda National Apiculture Development Organisation (TUNADO) (Uganda), Golden Bees Ltd; ICIPE (Kenya), national agricultural departments, national agricultural research organizations, national governments, national agricultural research stations (NARS), universities, research institutions, NGOs and breeding stations.

## Primary users of the technology/innovation

The primary users of the technology/innovation are men, who are the traditional beekeepers in Africa, and young entrepreneurs who venture into beekeeping for financial gains.

## Climate-smart status of the technology/innovation

Beekeeping is climate smart and supports the conservation of African bees through the breeding of bees. It also supports pollination of plants thus ensuring their survival. The hives can be made using recycled wood products.

### Environmentally friendly status of the technology/innovation

Beekeeping supports the conservation and preservation of environments, discourages the use of agrochemicals which are not only harmful to the environment but also kill bees. The hives can be made using recycled wood products.

### Suggestions for improvement of the technology/innovation

The Langstroth Hive can be improved by integrating digital technologies for traceability of hives so as to enhance their security and collect data on the bees.

### Strategies that can be adopted by national governments to promote the uptake of beekeeping

National governments can promote beekeeping through several strategies including:

- The characterizing, identification and active propagation of indigenous and cultivated bee forages
- Developing apiculture policies and legislation to support beekeepers and beekeeping as a commercial enterprise
- Developing databases for the collection and storage of apiculture data
- Identifying the challenges faced by beekeepers with a view to developing tailor-made solutions
- Developing awareness programmes for communities in order to interest producers; and developing strong beekeeping extension services
- Creating partnerships and financing options that can mitigate costs of acquiring the hives thus increasing access for beekeepers to modern hives
- Developing capacity building programmes that will increase technical skills and business management skills of beekeepers
- Developing early warning systems to detect bush fires that destroy hives
- Developing policies and legislation on the safe use of agrochemicals in order to protect bee diversity and populations
- Developing clear bee and bee product marketing strategies
- Developing clear strategies to deal with pests and predators

# The Flow Hive™

## Primary use of the technology/innovation

The Flow Hive is a hive that is mainly used to produce honey. Its innovation is that the harvesting of honey is direct and into honey jars by simply turning a lever located at the bottom of the hive. The hive therefore does not need to be opened to extract the honey. The bees are therefore not disturbed during this process.




AU-IBAR



AU-IBAR

*The Flow Hive*

## SWOT analysis of the technology/innovation

### Strengths

The strength of the Flow Hive is that it does not need to be opened for removal of honey and requires little monitoring by the beekeeper. This therefore ensures that the honey making process is not disrupted during harvesting, and the hive produces a high quality and quantity of honey. The bees do not need to be smoked thus the harvesters do not need to deal with aggressive bees. Honey is dispensed directly into the honey jars so time is saved. No heavy lifting of the hive boxes is required and transportation of honey in buckets after extraction is not necessary. The Flow Hive produces hygienic honey because it is not handled by people. It requires less labour for processing and harvesting. The Flow Hive is durable and lasts for a long time and is easy to control and manage. A big strength of the Flow Hive is that it is possible to flavour the honey from different frames separately.

### Weaknesses

The Flow Hive is a patented product and has to be purchased directly from the patent holders expensively. It also uses plastic frames which is not a natural product for bees. It has a lower colonization rate compared to other products in the market. The hive does not require close monitoring and this may be a disadvantage in that the beekeeper may not closely monitor the status of bee health within the hive. The hive is also easy to steal.

### Opportunities

There is a tremendous local and international demand for African honey. Nigeria for example, is only able to meet 10 percent of its local domestic consumption of 380,000 tons and imports the rest. This demonstrates the huge potential for investments into this area of beekeeping. Local communities are interested and willing to take on beekeeping as a commercial activity. Africa is endowed with a large bee genetic diversity that is healthy and active. Africa is also endowed with numerous plants that bees can use for foraging. Africans have a long history of keeping bees and are therefore experienced in the practice.

### Threats

The Flow Hive is not readily available to African beekeepers. It is also expensive to acquire and thus may only be available to large commercial producers.

## Local availability of the technology/innovation and potential suppliers across Africa

The Flow Hive is not locally available.

## Primary users of the technology/innovation

The Flow Hive may be available to large commercial honey producers who would be able to purchase it from the patent holders.

## Climate-smart status of the technology/innovation

Beekeeping supports the conservation and preservation of the African bee diversity.

### Environmentally friendly status of the technology/innovation

Beekeeping supports the conservation and preservation of environments, and discourages the use of agrochemicals which are not only harmful to the environment but also kill bees. The hives can be made using recycled wood products.

### Suggestions for improvement of the technology/innovation

Domestication of this technology will ensure that it reaches many African beekeepers.

### Strategies that can be adopted by national governments to promote the uptake of the Flow Hive

National governments should make a critical assessment of the niche market that this hive would fill with a view to exploring options for introducing it into the African market.

# The Thermosolar Hive™

## Primary use of the technology/innovation

The Thermosolar Hive™ is a hive that primarily focuses on the production of honey. It has an innovation that kills Varroa mites. The solar ceiling on the hive heats the hive to temperatures above 40 $^{O}$C. These temperatures do not affect the bees but they have been found to kill the Varroa mites. The hive is fitted with sensors that go off when the required temperature is attained. The heat kills all the Varroa mites inside the hive, including those on the walls of the hive, the body of the bee and in the brooding chamber. Continuous killing of the Varroa mites means that they do not get to reproduce and hence their numbers in the environment where the hive is located reduce.



AU-IBAR

*Thermosolar Hive*

## SWOT analysis of the technology/innovation

### Strengths

The Thermosolar Hive™ kills Varroa mites without the use of chemicals; speeds up the establishment and expansion of bee colonies; produces a higher yield of honey; saves a beekeeper's time; produces high quality honey; is durable and lasts for a long; and is easy to control and manage.

### Weaknesses

The Thermosolar Hive™ is a patented product and is only available for purchase from the patent holders (www.thermosolarhive.com); it therefore may not be easy to acquire. It is expensive; its price may not be affordable to African producers, especially those who are interested in beekeeping for commercial purposes. Its management requires skilled labour. It also needs monitoring to ensure that the hive does not have elevated temperatures that would affect bee health.

### Opportunities

There is a huge export demand for African honey. There is great interest in keeping bees for only honey production. Varroa mites pose an enormous problem for African beekeepers and the Thermosolar Hive™ provides a solution for their eradication from hives and the surrounding environments.

### Threats

Chemical treatment of Varroa mites is the easier solution for African beekeepers. The Thermosolar Hive™ may be not be easy to acquire on account of its cost and distribution, and thus it may not be within the reach of African bee producers.

## Local availability of the technology/innovation and potential suppliers across Africa

The Thermosolar Hive™ is not locally available.

## Primary users of the technology

The primary users are developing world beekeepers with an interest in producing organic honey, produced without the use of chemicals.

## Climate-smart status of the technology/innovation

The Thermosolar Hive™ uses solar energy to control the Varroa mites. The use of solar energy is a climate friendly approach towards eradicating the mites.

## Environmentally friendly status of the technology/innovation

The Thermosolar Hive™ has a low impact on the environment when it is being installed. It uses solar energy which is a green energy source, to heat the hive.

## Suggestions for improvement of the technology/innovation

There are no suggestions for its improvement.

## Strategies that can be adopted by national governments to promote the uptake of the Thermosolar Hive™

The Varroa mites present a huge problem to African beekeepers. National governments should explore how access to the Thermosolar Hive™ can be increased for African producers.

# The Kenya Top Bar Hive ™

## Primary use of the technology/innovation

The Top Bar Hive produced in Kenya as the Kenya Top Bar Hive (KTBH) and in Tanzania as the Tanzania Top Bar Hive (TTBH) is a hive designed to produce honey and a range of bee products, including beeswax and propolis.




AU-IBAR

*Kenya Top Bar Hive*

## SWOT analysis of the technology/innovation

### Strengths

The KTBH and TTBH hives are affordable; produce high quality comb honey; are highly durable; and are easy to make and manage. The hives have a very high bee colonization rate. They have the advantage that they can easily be moved from one location to another and can hence be used to provide pollination services. The top bar on the hive is easily opened for inspection. This enables the beekeeper to work fast when inspecting the hive or when harvesting honey. The hive can be modified by using supers from a Langstroth hive. It allows for easy removal of honeycombs without disturbing combs containing broods. It also allows for the suspension of hives from wires thus protecting the hive from predators and pests. The design of the hive guides the bees into building parallel combs following the top bar. Top bars are also easy to construct compared to frames found in other types of hives.

### Weaknesses

One important weakness is that the hive has to be inspected on a weekly basis. This is necessary in order to prevent bees from building combs that are attached to one another. This hive may produce less honey compared to new designs (for example, Langstroth or Flow Hive). Another weakness is that the hive is located near the ground and is therefore easy to steal. The hives makes the bees construct combs that are suspended from top bars which are more likely to break compared to combs that are built inside the frames. A person willing to invest in making these hives as a business may find installation of the infrastructure too expensive.

### Opportunities

There is a huge demand within Africa for honey and likewise, a high export demand for African honey. There is growing demand for pollination services that can be provided by moving these hives to farms. The demand for honey creates vast opportunities for investment in beekeeping. Africa is endowed with numerous bee-foraging plants that ensure that the bees have adequate food resources. Africans have been keeping bees over many years and there are therefore numerous indigenous beekeepers with indigenous knowledge and experience.

### Threats

The KTBH and TTBH hives face threats from the Langstroth Hive which has several advantages including the fact that it produces more honey and honeycombs not destroyed during honey harvesting.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology/innovation is locally available and can be obtained from APITRADE (Africa), Africa Apiculture Platform, TUNADO (Uganda), Golden Bees Ltd; ICIPE (Kenya), national agricultural departments, national agricultural research organizations, national governments, national agricultural research stations (NARS), universities, research institutions, NGOs and breeding stations.

### Primary users of the technology/innovation

The primary users of the KTBH and TTBH hives are men, who are the primary beekeepers in Africa.

### Climate-smart status of the technology/innovation

The KTBH and TTBH hives are climate smart because they support pollination services offered to large commercial farms. They also produce a variety of bee products, not only honey, thus maximizing the energy utilized by bees.

### Environmentally friendly status of the technology/innovation

The KTBH and TTBH hives have low impact on the environment when being installed. These hives have an advantage in that they can be made using recycled wood products, thus limiting the cutting of healthy trees.

### Suggestions for improvement of the technology/innovation

The technology/innovation can be improved by integrating digital sensors to track and monitor the movement of bees.

### Strategies that can be adopted by national governments to promote the uptake of the KTBH and TTBH hives

National governments can promote the technology through several strategies including:

- Developing international and local markets
- developing strong beekeeping extension services, as this is key for maximizing production of African beekeepers
- Spurring the creation of producer groups and societies that would offer support to African producers
- Creating partnerships, including financing that would promote bee start-ups and encouraging the youth to venture into beekeeping as a solution to the big unemployment problem
- Setting up systems for early detection of bush fires, which pose a huge threat to beekeeping. Such systems should include solutions for putting out the fire using safe and clean methods.

# The Warre Hive

## Primary use of the technology/innovation

The Warre Hive is a top vertical hive that uses bars instead of frames. The hive is made up of boxes that extend downwards. The bees build the honeycomb in the top box and extend downward into the other boxes. New boxes are added to the bottom of the hive. The Warre Hive produces honey and a diverse set of bee products.



AU-IBAR

*Warre Hive*

## SWOT analysis of the technology/innovation

### Strengths

The Warre Hive produces honey of a high quality. It also produces a higher yield of honey when compared to other types of hives. It is able to produce many types of bee products and is very low on maintenance requirements; it has a simple management design where all activities can be contained in one box compared to management by comb design. The hive is designed in such a way that it does not need a queen excluder. It is durable and lasts for a long time. It is also easy to control and manage. The hive is easily adapted to modern processing mechanisms and can easily be constructed by local carpenters. Compared to some hives, it is more temperature, humidity and population self-regulating. Designs for its construction are available online and can be used by local carpenters.

### Weaknesses

The Warre Hive can be expensive if the beekeeper is purchasing a ready-made one. The Warre Hive is not well known in Africa and hence faces competition from other more widespread types of hives. Perhaps the greatest weakness of the hive is that it has a lower colonization rate compared to other hives which are on the market. The hive is made with a small entrance that is ideal for bees; however, it makes it difficult for one to use an entrance feeder. Once the hive gets old and has many boxes at the bottom it can get very heavy, making lifting difficult. The hive is usually placed on the ground and hence it can easily be stolen.

### Opportunities

African beekeepers have the interest and desire to keep bees. They are endowed with beekeeping knowledge some of which is from their indigenous culture. This goodwill, together with the increasing demand for honey worldwide and increasing domestic African consumption, creates a great opportunity to exploit beekeeping.

### Threats

Introduction of this hive to domestic African markets may be difficult owing to the popularity of the Langstroth, KTBH and TTBH hives and the fact that they are easily available and renowned.

### Local availability of the technology/innovation and potential suppliers across Africa

The Warre Hive is not locally available. However, it can be manufactured by local carpenters using designs freely obtained from the internet.

### Primary users of the technology/innovation

The Warre Hive would most likely be used by men, who are the majority of the beekeepers in Africa.

### Climate-smart status of the technology/innovation

The Warre Hive promotes the conservation and preservation of bees. It also promotes pollination services.

### Environmentally friendly status of the technology/innovation

The Warre Hive can be made using recycled materials. It is placed on the ground and hence has little impact on the environment.

### Suggestions for improvement of the technology/innovation

The Warre Hive can be improved by designing and developing a local African design which can then be dispersed for beekeepers to manufacture.

### Strategies that can be adopted by national governments to promote the uptake of the Warre Hive

National governments should conduct studies to measure the output from this hive compared to other types of hives, and in this way, determine whether they should invest in the large-scale production of the Warre Hive.

# The Horizontal (Long) Hive

## Primary use of the technology/innovation

The Horizontal or Long Hive is a modification of the Langstroth Hive, only in this case the hives are expanded horizontally manner rather than vertically as is the case with the Langstroth Hive.



www.africanbeekeepers.co.ke

*The Horizontal or Long Hive*

## SWOT analysis of the technology/innovation

### Strengths

The Horizontal Hive is said to be the more natural version of the Langstroth Hive. Since expansion is horizontal rather than vertical it does not require heavy lifting. This design also makes inspection and cleaning of the hives very easy. It produces a higher quantity and quality of honey than the traditional hive. It is very durable. Modified designs allow for addition of honey supers which are the same type that are used in the Langstroth Hives. The Horizontal Hive can be made from recycled materials by local carpenters. It can be used to make many types of bee products.

### Weaknesses

The Horizontal Hive is slightly more expensive than the Langstroth Hive. With the exception of frames, other fixtures are not interchangeable and have to be individually made. It also has a lower colonization rate compared to other hives in the market like the Langstroth.

### Opportunities

Growth in demand for African honey presents great opportunities for African beekeepers.

### Threats

The KTBH/TTBH and the Langstroth hives are better known than other hives, have commercial suppliers and manufacturers, have equipment that is compatible, and hence are more popular with the African beekeepers.

### Local availability of the technology/innovation and potential suppliers across Africa

The Horizontal Hive can easily be manufactured by local carpenters. The designs are freely available on the internet.

### Primary users of the technology/innovation

The primary beekeepers of Africa are the men.

### Climate-smart status of the technology/innovation

The Horizontal Hive supports indigenous African bee populations and thus supports the breeding and propagation of indigenous bees. The Horizontal Hive is placed on top of the ground. It therefore does not require specialized installation. This makes its installation very environmentally friendly because it does not destroy the environment.

### Environmentally friendly status of the technology/innovation

The Horizontal Hive can be locally manufactured using recycled materials thus preserving the environment.

### Suggestions for improvement of the technology/innovation

The Horizontal Hive is not well known in Africa. Its production potential needs to be determined and compared to that of the KTBH/TTBH and the Langstroth Hive in order to determine whether it should be disseminated.

### Strategies that can be adopted by national governments to promote the uptake of the Horizontal Hive

To promote this technology, national governments need to develop ways of increasing access for beekeepers to hives, especially to the newer designs.

# The Clay Pot Hive

## Primary use of the technology/innovation

Stingless bees (*Meliponini*) are a group of bees that are found in many tropical and sub-tropical regions. They belong to the family Apidae and are closely related to the common honey bees. These bees have small stingers that cannot sting and hence the name "stingless bees". They however defend themselves or their hives by biting. They prefer to nest in tree branches, hollow tree trunks and underground cavities. Therefore, they may not take to an over the ground hive. The Clay Pot Hive thus presents a perfect solution to keeping these bees and prevents them from going off to find more suitable nesting sites. With the focus on environmentally friendly and climate smart options, the Clay Hive is a great option. The Clay Pot Hive can be made from a specially designed clay pot or a recycled broken pot.



AU-IBAR

*Improvised clay pot*

## SWOT analysis of the technology/innovation

### Strengths

Africans have a culture of making clay pots. The clay soil that can be used to make these pots is readily available in in most environments in Africa. The clay pots are therefore cheap and can be made locally and at home. The Clay Pot Hive can also be made using recycled clay pots. The Clay Hive is durable and not easily vandalized. The stingless bees in the Clay Pot Hive can make different types of products in addition to honey.

### Weaknesses

The Clay Hive has been found to be vulnerable to the elements like rain water which seeps in through the openings or cracks. To maximize on honey production, the clay pot may need to be installed by a person with technical expertise.

### Opportunities

Africa is home to stingless bees. The stingless bees are few, and engaging in their beekeeping would ensure that their diversity is maintained while ensuring that the bees are being sustainably used. Communities who fear keeping bees out of concern of being stung can be engaged in keeping the stingless bees.

### Threats

Most beekeepers are more conversant with beekeeping activities that entail the use of modern hives such as the KTBH/TTBH, the Langstroth or traditional hive. The Clay Pot Hive is not commonly used, yet it is the most attractive to stingless bees.

## Local availability of the technology/innovation and potential suppliers across Africa

The Clay Pot Hive is locally available.

## Primary users of the technology/innovation

The primary users of the Clay Pot Hive are the men who make the traditional hives and venture into forests.

## Climate-smart status of the technology/innovation

The Clay Pot Hive promotes the sustainable use and breeding of stingless bees thus ensuring their conservation. Broken and recycled clay pots can be modified to make the hive, hence supporting the recycling of materials.

## Environmentally friendly status of the technology/innovation

The Clay Pot Hive is installed into the ground near bee foraging plants or in forests. It is made using clay soil that is found in the environment. It therefore has a low impact on the environment when being installed.

## Suggestions for improvement of the technology/innovation

Studies should be conducted using different types and sizes of clay pots to determine the best design that would yield a high quantity of honey.

## Strategies that can be adopted by national governments to promote the uptake of the Clay Pot Hive

Strengthening beekeeping extension services would ensure that some of the beekeepers take up the farming of stingless bees.

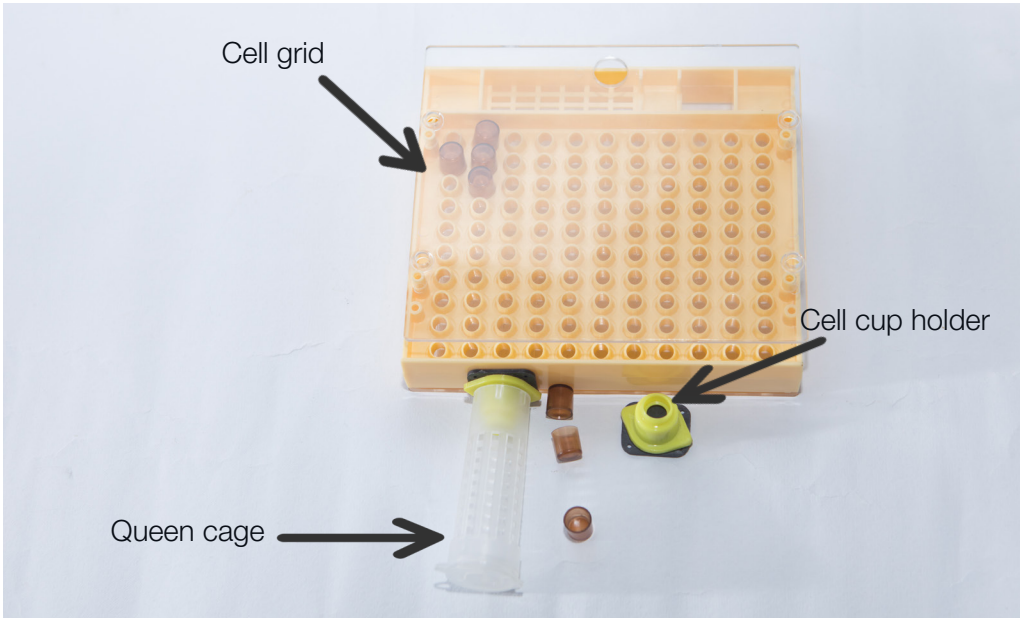
## Primary use of the technology/innovation

When a bee hive colony gets too big and crowded and competition for resources is at its highest, the worker bees begin to prepare for swarming. This is a process where the colony splits into two or three and flies out of the colony to begin nesting in a new location with the old queen. Swarming results in the loss of bees for a beekeeper. To prevent this,

# Queen rearing

## Primary use of the technology/innovation

A strong and actively laying queen is an essential component of a strong, vibrant and successful bee colony. A queen with good genetics including disease resistance traits, low aggression, good temperance, fast growth and strong pheromones, produces strong worker bees and strong pheromones that direct the activities within the colony, making them able to thrive in a diverse range of climatic and environmental ranges. Characteristics of a strong bee colony include less bee aggression, high productivity of honey and royal jelly, and strong ability to provide pollination services.




AU-IBAR

*Queen rearing kit*

## SWOT analysis of the technology/innovation

### Strengths

The rearing of queen bees can provide extra income to beekeepers in addition to selling honey and other bee products. It also ensures sustained honey and royal jelly production in colonies.

### Weaknesses

The numerous benefits of raising queens are hampered by the slow adoption of the practice. Queen raising requires specialized skills, accessories and training for beekeepers, which currently is limited to a few people on the continent. Queen rearing by inexperienced beekeepers poses the risk of raising queens with poor colony traits and poor genetics, which carries the additional risk of proliferating excessively aggressive bees.

### Opportunities

There is a high demand for queen bees with good colony traits including high productivity of honey and honey products and a determined genetic structure. Demand is also a growing for establishment of strong colonies. African bees have high genetic diversity which can be utilized for breeding programmes targeting the breeding of queens with good genetic structure.

### Threats

Queen rearing is a complicated process that requires technical skills that may not be easily available to beekeepers.

## Local availability of the technology/innovation and potential suppliers across Africa

Queen rearing technology would be available from APITRADE (Africa), Africa Apiculture Platform, TUNADO (Uganda), Golden Bees Ltd; ICIPE (Kenya), national agricultural departments, national agricultural research organizations, national governments, national agricultural research stations (NARS), universities, research institutions, NGOs and breeding stations.

## Primary users of the technology/innovation

African beekeepers are the main users of this technology.

## Climate-smart status of the technology/innovation

Queen rearing supports an increase in African bee populations, genetic diversity and numbers, thus ensuring food crops are adequately pollinated.

## Environmentally friendly status of the technology/innovation

Rearing of queens has little or no negative impact on the environment.

## Suggestions for improvement of the technology/innovation

Development of training programmes for beekeepers on queen rearing will ensure that only good queens are bred and propagated.

## Strategies that can be adopted by national governments to promote the uptake of queen rearing

National governments can promote this technology through strategies such as:

- Developing strong beekeeping extension services to ensure that beekeepers are informed of the potential benefits of queen raising
- Creating strong beekeeping associations to support extension services and create awareness on beekeeping as an income generating activity
- Creating partnerships for mitigation against the cost of setting up laboratories
- Establishing queen breeding programmes for the breeding of queens with good and strong genetic characteristics

# Instrumental insemination for bees

## Primary use of the technology/innovation

Instrumental insemination involves the artificial insemination of queen bees. To achieve the best results, queens are ideally inseminated with semen collected from drones specially collected and should be from superior breeds. Instrumental insemination has been found to be more successful compared to natural fertilization.




AU-IBAR

*Artificial insemination instruments*

## SWOT analysis of the technology/innovation

### Strengths

Instrumental insemination results in production of colonies with high genetic structure for high honey production. The resulting colonies have also been found to be robust and populous. The technology improves brood lines by ensuring the breeding of bees that contain good traits for producing honey and honey products. When queens are inseminated using this process they receive high quality and quantity enough to fill spermatheca which may not happen in natural mating. This guarantees fertilization, resulting in a higher success rate than from natural mating. Instrumental insemination overcomes the problem of not knowing whether natural mating was successful or not. When this method is used, breeders can select queens with the traits they desire and also select drones from drone mothers with complementary traits.

### Weaknesses

Instrumental insemination runs the risk of injuring or killing the bee. The process needs to be carried out in a highly specialized laboratory by highly specialized staff. The infrastructure and equipment required may be expensive and difficult to acquire since it has to be

imported from manufacturers who may not be located in Africa. The process also requires a high number of drones that may not be available, mainly because drones are seasonally produced and are not bred throughout the year. The use of instrumental insemination on bees needs buy-in from communities because they may not easily accept this technology. Owing to the expenses involved, the infrastructure and skill set required, this technology may not be easily found in Africa.

### Opportunities

Africa is endowed with a large genetic diversity and healthy bee populations from which genetic selections can be made.

### Threats

Instrumental insemination requires the services of highly technical staff. Proper screening of the queen and drone bees to be used is necessary to ensure that the process does not spread diseases. There is also a risk that semen collected can become contaminated before or during its use on queens.

## Local availability of the technology/innovation and potential suppliers across Africa

Instrumental insemination is locally available from ICIPE.

## Primary users of the technology/innovation

Instrumental insemination is mainly used by bee breeders and propagators like ICIPE.

## Climate-smart status of the technology/innovation

Instrumental insemination is climate smart because it promotes the breeding of honey bee populations, especially those that are linked with high production of honey and bee products.. This will ensure the preservation of the genetic diversity and conservation of the bee populations.

## Environmentally friendly status of the technology/innovation

Instrumental insemination occurs in a laboratory setting and therefore it has little or no impact on the environment.

## Suggestions for improvement of the technology/innovation

Uptake of this technology/innovation within Africa can be improved through creating awareness on the importance of improving the genetics of African bees.

## Strategies that can be adopted by national governments to promote the uptake of instrumental insemination

To promote this technology, governments should develop bee breeding programmes aimed at producing bee lines that are specialized in specific areas.

# Starter colony production

## Primary use of the technology/innovation

The purchase of a starter hive complete with established colonies, a queen, her brood and worker bees, provides an excellent starting point for new beekeepers, or for beekeepers who want to increase the number of hives. Specialization in the production of starter hives is an important factor for creation of sustainable bee production programmes for African nations.



melissokomianet.gr

*Starter hive*

## SWOT analysis of the technology/innovation

### Strengths

Starter bee colony production can provide established beekeepers with an additional source of income. It leads to the successful establishment of bee colonies harbouring bees with desired traits and guarantees the successful establishment of hives, which in turn guarantees high production of honey and bee products.

### Weaknesses

Starter colonies are difficult to transport because they are delicate and bees are very sensitive. Rough handling can cause the loss or death of bees. Weak starter colonies can result in the establishment of weak colonies which may not survive or will have low honey production.

### Opportunities

The high demand for honey and honey products has led to an increase in beekeeping activities in Africa, which has raised the demand for starter colonies.

### Threats

Risks of the starter colonies not adapting to the colony exist. Provision of starter colonies from established companies is key to preventing the spread of bee diseases, pathogens and pests.

### Local availability of the technology/innovation and potential suppliers across Africa

Starter colonies would be available from APITRADE (Africa), Africa Apiculture Platform, TUNADO (Uganda), Golden Bees Ltd; ICIPE (Kenya), national agricultural departments, national agricultural research organizations, national governments, national agricultural research stations (NARS), universities, research institutions, NGOs and breeding stations.

### Primary users of the technology/innovation

The primary producers of split colonies are establishments dealing with the commercial sale of hives and organizations engaged in training and capacity building initiatives including beekeepers.

### Climate-smart status of the technology/innovation

Development of strong starter colonies is key for the sustainable breeding of bees with good genetic qualities. This will ensure the sustainable production of honey and honey products while guaranteeing food security in Africa by ensuring that there are enough bee populations to carry out pollination services.

### Environmentally friendly status of the technology/innovation

Establishment of starter colonies has little or no impact on the environment.

### Suggestions for improvement of the technology/innovation

Combining the establishment of starter colonies with bee genetic research will ensure that bees with a high genetic diversity and high production traits are propagated and disseminated throughout the continent.

### Strategies that can be adopted by national governments to promote the uptake of starter bee colony production

Supporting communities to begin beekeeping activities as an income generating activity is important for Africa to meet its demand for African honey and bee products and also engage in its export. For this to happen, national governments need to:

- Strengthen their apiculture extension services
- Create awareness on beekeeping among communities in order to interest producers
- Create partnerships that can lessen the costs for beekeepers who want to begin starter colonies

# Queen bee separators/excluders

## Primary use of the technology/innovation

Queen bee separators or excluders are used to confine the queen to the brood chamber thus preventing her from laying eggs inside the super chamber where honey is stored.



AU-IBAR

*Queen bee excluder*

## SWOT analysis of the technology/innovation

### Strengths

The queen bee separator or excluder prevents the queen from laying eggs in the super chamber, ensuring that honey harvested is egg and larvae free, thus increasing its quality. Queen separators or excluders make it easy to quickly locate the queen and make hive inspection easy and fast. They are easy to install, cheap to acquire or make and have been found to control the spread of Varroa mites.

### Weaknesses

In nature, bees are not used to being separated from their queen, thus it may take some time for the drones to get used to it, and this may have a negative impact on honey and bee product production in the beginning. Perhaps one of the greatest weaknesses of the queen separator/excluder is the danger of drones getting stuck in it while moving from one side of the hive to the other. The drone's wings can also break as the drones pass through repeatedly. The risk also exists that the brood chamber may get saturated with honey.

### Opportunities

The potential increase in a hive's production of honey and bee products when an excluder/separator is used gives motivation for use of this technology. There are also opportunities for local fabricators, marketers and distributors to earn income from this technology.

### Threats

Many beekeepers do not see the benefit of using a queen bee separator/excluder and therefore they might not use it. Adequate studies have not been done to establish the difference in honey and bee product production when an excluder/separator is used and when it is not. This is a new technology and as with most new technologies it may take time to be adopted.

## Local availability of the technology/innovation and potential suppliers across Africa

Queen bee excluders/separators are easily available from hive manufacturers.

## Primary users of the technology/innovation

Commercial honey producers and experienced beekeepers are the primary users of this technology.

## Climate-smart status of the technology/innovation

The queen bee excluder/separator promotes increased honey production and the breeding of local African bee populations.

## Environmentally friendly status of the technology/innovation

Installation of queen bee excluders/separators in hives has no adverse effect on the environment.

## Suggestions for improvement of the technology/innovation

Queen bee separators/excluders are normally fabricated from metal sheets. A version made from wood or other natural products should be fabricated.

## Strategies that can be adopted by national governments to promote the uptake of queen bee excluders/separators

National governments can promote this technology through:

- Apiculture scientists determining whether there is value in the use of a queen bee excluder/separator or not
- Developing research and research networks and strengthening existing ones

# Bee gardens

## Primary use of the technology/innovation

The creation of bee gardens is a new initiative for people who want to be actively involved in the conservation of bees but have no interest in engaging in beekeeping activities or producing honey. Bee gardens provide bees with foraging sites that provide enough nectar and pollen, thus providing a constant source of food. All they require is that a gardener plants flowers that can provide bees with food and leaves some areas in the most natural form by not clearing weeds. This is a key support for bees to ride over adverse weather conditions. A bee garden also provides support to swarming bees that are looking for new nesting sites. Future food security is dependent on the survival of bee populations, and planting bee gardens in urban centres provides a mechanism through which people can support bee conservation.



winecountrytable.com

*Bee gardens*

## SWOT analysis of the technology/innovation

### Strengths

Bee gardens are easy to install, control and manage. They ensure that bees do not have to travel long distances in search of nectar, pollen and water. They support bee conservation programmes, boost national bee populations and assist in the maintenance of bee diversity by ensuring that bees do not die for lack of food. Bee gardens do not need additional resources and provide foraging bees with food resources without the additional commitment and investment made in bee hives or honey production.

### Weaknesses

The installation of bee gardens is best done in areas where the urban gardener will not clear all weeds and wild plants. This may not be an attractive thing for those who want to keep so-called manicured and well-tended lawns. Bees may have a preference for some types of flowers over others, and thus a bee garden enthusiast would need some technical input on the best flowers to grow.

### Opportunities

There is a growing movement of individuals interested in conservation of bees. Equally, numbers of local communities that would be interested in conserving bees are growing even though they are not beekeepers. Africa is endowed with healthy bee populations and a large diversity of flowering plants and foraging plants. African crop farmers are interested in conserving bees for pollination services.

### Threats

The use of pesticides and insecticides threaten bee health. Bees need a source of clean, fresh water, a resource which is becoming scarce in various regions of Africa. Bee gardens require sections of land that have naturally growing plants including weeds and untended land, which goes against standard agricultural practices.

## Local availability of the technology/innovation and potential suppliers across Africa

Bee gardens are easy to plant and with awareness creation and can be created in urban settings.

## Primary users of the technology/innovation

The primary users of this technology are gardening enthusiasts.

## Climate-smart status of the technology/innovation

Bee gardening supports the conservation and preservation of African bee populations. It supports the enhancement of food security through the conservation of pollinators for food crops.

## Environmentally friendly status of the technology/innovation

Bee gardens are natural and hence environmentally friendly. They do not require special skills to install and do not destroy the environment in any way.

## Suggestions for improvement of the technology/innovation

This technology may be improved by creating strategies for home owners, landscapes and others planting gardens to design gardens that are not only aesthetically attractive but also aid in the conservation of bees.

## Strategies that can be adopted by national governments to promote the uptake of bee gardens

National governments can promote this technology by creating awareness among gardening enthusiasts on the important role they can play in the conservation of African bees.

# Bee houses or bee hotels

## Primary use of the technology/innovation

The purpose of installing bee houses or bee "hotels" is to provide bees with a space where they can rest or brood while looking for a place to establish a nest. This technology is important and necessary for bees especially if they are too tired to fly back to their hive or if a bee has been caught up in bad weather. The primary goal is to preserve the genetic diversity of local bees through provision of a safe house. Bees targeted by the bee house/hotel are primarily the solitary and wild bees. Increasing climate change and environmental destruction pose a threat to bees found in the natural environment.



www.ealt.ca

*Wooden bee hotel*

## SWOT analysis of the technology/innovation

### Strengths

The bee house or hotel increases the population of bees and preserves their diversity. Bee houses/hotels are easy to design and can be constructed by local carpenters because they do not need a standard design. They are durable and easily colonized by bees.

### Weaknesses

The purpose of bee houses may not be easy to understand by beekeepers. They attract pests and bee diseases. This challenge can be overcome by separating the diseased cocoons from the healthy ones and destroying the diseased ones. Keeping the bee house/hotel away from the ground also decreases the incidences of fungi and other pathogens commonly found in hives.

### Opportunities

The increasing numbers of communities interested in participating in conservation of bees presents an opportunity for propagating the culture of installing bee houses/hotels in urban gardens.

### Threats

Naturally found bees may be of a more aggressive nature compared to more domesticated honey bees. Some communities are afraid of keeping bees. The practice of establishing bee houses may not be very well understood.

## Local availability of the technology/innovation and potential suppliers across Africa

The bee houses/hotels may not be in use in Africa.

## Primary users of the technology/innovation

Conservationists and environmentalists can take up bee house technology as one of their conservation practices.

## Climate-smart status of the technology/innovation

The practice of installing bee houses/hotels works to mitigate the effects of climate change where native, and naturally occurring and non-farmed bees, are protected from these adverse environmental changes.

## Environmentally friendly status of the technology/innovation

The bee houses/hotels are made using natural and recyclable materials such as wood and wood products. They are therefore very environmentally friendly. The installation of bee houses/hotels does not have any adverse effects on the environment but serve to conserve and preserve naturally occurring bees.

## Suggestions for improvement of the technology/innovation

Dissemination of information and education of people on the need to conserve not only farmed bees but also the native, wild and naturally occurring bees is an important component of the conservation of this naturally occurring genetic resource.

## Strategies that can be adopted by national governments to promote the uptake of bee houses/hotels

National governments can promote this technology through:

- Developing awareness programmes for communities, which should go a long way to increasing the uptake of this technology
- Developing and implementing policies and legislation guiding the safe use of agro- and domestic chemicals, which will safeguard this important and naturally occurring genetic resource

# 5.2. Technologies and Innovations targeting the Inputs and Services Components

# Pollination services

## Primary use of the technology/innovation

The provision of pollination services to farmers who need their crop to be pollinated is an innovation that has been necessitated by the reduction in the numbers of wild bees. Previously it was possible to plant crops and wait for them to be naturally pollinated by bees located in their environments. However, the decrease in numbers of bees caused by the farmers' use of agro-chemicals especially insecticides, and climate change, has compelled the farms looking for reputable apiaries with healthy bees, to provide this service. In this way, they guarantee the pollination of their crops and hence a successful harvest. Therefore, to assure a successful crop, farmers are increasingly seeking the services of apiaries to provide this service.



https://earthtimes.org

*Worker bee collecting pollen*

## SWOT analysis of the technology/innovation

### Strengths

The provision of pollination services provides farmers with healthy bees to carry out pollination and provides apiaries with additional incomes. During this time the beekeepers do not have to worry about the source of food for their bees. The beekeepers can take advantage of the time when the bees are located in one place to make a monofloral brand of honey. The provision of pollination services introduces bees into new environments, therefore assisting that environment through the introduction of bees.

### Weaknesses

Providing pollination service requires capital investment and this service may not pay well especially in the initial stages. The crop requiring pollination services may not be the most nutritious for bees and they may seek out other forages that are close by. Transportation of bees may result in their injury and death and at the end of the pollination services, does

not guarantee that the hives will return in good condition, or that the bees will be in good health. Bees could get exposure to chemicals and may die. Bees from the wild or from other hives – especially those provided by other pollinators – may be carrying diseases and pests thus exposing the healthy. Bee transportation calls for specialized infrastructure. The management of this business would require the beekeeper to hire personnel or to develop additional skills to manage it effectively. It can also be labour intensive.

### Opportunities

The growing agricultural sector means more opportunities for beekeepers to earn additional income from this business. Engaging in this service provides an opportunity for the agricultural sector to adopt environmentally friendly agricultural practices. There is a high awareness on the importance of preserving the environment. Provision of pollination services provides employment at the local/community level.

### Threats

The bees' foraging habit of departing in the morning carries the risk that they could be left behind. Such bees often die because of lack of a hive. Another risk comes from chemicals being used on the farms; these pesticides and insecticides could easily kill the bees. Likewise, other companies providing this service present a risk and again the beekeepers could lose their hives to these other competitors. The core business of a beekeeper may not be pollination services and this could interfere with the other services they are providing.

## Local availability of the technology/innovation and potential suppliers across Africa

Provision of pollination services is a key service and demand from large-scale farmers has necessitated its introduction into various markets.

## Primary users of the technology/innovation

The primary users of the pollination services are the large agricultural corporations requiring pollination services.

## Climate-smart status of the technology/innovation

Pollination service provision is a lucrative business that can transform the lives of beekeepers by providing them with additional sources of income.

## Environmentally friendly status of the technology/innovation

Provision of pollination services introduces bees into environments and ensures that food is sustainably produced. The increase in demand for pollination services will ensure that bees are conserved and bred for provision of the service.

## Suggestions for improvement of the technology/innovation

Attaching GPS locators can improve the security of the bee hives. Installing sensors in the hive can ensure that the beekeeper is able to monitor the health of the colony remotely. The data collected can be used to improve service provision.

## Strategies that can be adopted by national governments to promote the uptake of pollination services

National governments can promote this technology through several strategies including:

- Developing policies and legislation for the management of chemicals in agriculture and implementing policies that promote the use of bees as pollinators
- Advocacy and creating awareness among communities on the importance of conservation of biodiversity for the protection of indigenous African populations
- Developing programmes to reduce the effects of climate change
- Developing manufacturing standards for bee products
- Developing quality management standards for bee products
- Enhancing business capacity of bee keepers
- Developing strategies for private sector investment in bees

# Pollination brokers

## Primary use of the technology/innovation

Pollinator brokers are individuals who work with beekeepers and connect them to agricultural companies who need pollination services. Large agricultural companies require the services of millions of bees that may not be available in the wild, or within the proximity of the farm. These corporations may also not have the time, experience, expertise or interest in keeping bees to pollinate their crops. The number of bees required may be too high for one apiary to provide. So renting these services from several apiaries is the best option for these companies. Thus, pollinator brokers are individuals who coordinate the provision of pollination services by a number of apiaries. They ensure that the bees provided are healthy and sufficient to provide the services. Pollinator brokers are hired by these corporations to source healthy bees, negotiate the contracts and arrange transportation of the bees to and from the farms.

## SWOT analysis of the technology/innovation

### Strengths

Beekeepers, especially those with many hives and are members of beekeeper associations can become pollination brokers, thus earning from an additional source of income.

### Weaknesses

Provision of pollination brokerage services by a beekeeper is not the main business for the beekeeper. This business calls for proper planning and infrastructure.

### Opportunities

There are numerous opportunities for the youth of Africa to begin providing pollination brokerage services to large farms.

### Threats

Unacceptability and mistrust by the beekeepers are the key threats.

## Local availability of the technology/innovation and potential suppliers across Africa

The innovation is a new entrant to the apiculture value chain, thus is not easily available.

## Primary users of the technology/innovation

The primary users are all apiculture production systems.

## Climate-smart status of the technology/innovation

Provision of pollination services is a lucrative business that can transform the lives of beekeepers by providing them with additional sources of income.

### Environmentally friendly status of the technology/innovation

Provision of pollination brokerage services is an environmentally friendly practice that introduces bees into environments and ensures that food is sustainably produced. The increased demand for pollination services will ensure that bees are conserved and bred for provision of the service.

### Suggestions for improvement of the technology/innovation

Pollination services may be improved through developing apiculture co-operatives who will educate their members on the importance of pollination brokers.

### Strategies that can be adopted by national governments to promote the uptake of pollination services

National governments can promote this technology through several strategies including:

- Developing policies and legislation for the management of chemicals in agriculture that promote the use of bees as pollinators
- Advocacy and creating awareness among communities on the importance of conservation of biodiversity for the protection of indigenous African populations
- Developing programmes to reduce the effects of climate change
- Developing manufacturing standards for bee products
- Developing quality management standards for bee products
- Enhancing business capacity of bee keepers
- Developing strategies for private sector investment in bees

# Api-therapy

## Primary use of the technology/innovation

Api-therapy is an alternative form of therapy that uses products obtained directly from honeybees. These products include bee venom, honey, pollen, royal jelly, propolis and beeswax. Api-therapy is used to treat illnesses that are difficult to treat using conventional treatments. For example, it eases arthritis; heals injuries, wounds, pain, burns and tendonitis; treats asthma; and is used as a complementary treatment for neurological conditions including multiple sclerosis, arthritis and Parkinson's disease. Api-therapy uses a variety of bee products. Some api-therapies carry little or no risk, for example, addition of honey to ease a sore throat, but others carry a higher risk like the use of bee venom. Pollen can also be collected using a pollen trap.




AU IBAR




AU IBAR




Conrad Mudibo

Propolis capsules and tincture used for medication

## SWOT analysis of the technology/innovation

### Strengths

Api-therapy treatments are favoured because they use organically produced honey and are therefore safe for use on humans. They are cost effective, and result in an increase in the use of bee and bee products. They have been reported to have numerous effects that are advantageous in populations, including their anti-inflammatory, analgesic and bacterial properties. Treating these conditions is expensive and these products have the advantage of being cost effective.

### Weaknesses

The risk of Api-therapy inducing a severe allergic reaction makes these treatments not favorable for use by all populations. Frequent exposure to some products, for example, bee venom may result in resistance.

### Opportunities

There are immense opportunities for use of honey and bee products for pro-health through the promotion of natural treatment methods using honey and bee products. The side effects caused by conventional drugs have led to increased interest in these products. Some conditions do not respond to conventional treatments and have been reported to have good response to the use of bee and bee products. Api-therapy creates jobs at local/community level. Numerous opportunities exist for the development of new products including the making of candles.

### Threats

Alternative medical treatments carry the risk of severe allergic reaction in some individuals and this can lead to death.

## Local availability of the technology/innovation and potential suppliers across Africa

Api-therapy products are available from api-therapy practitioners.

## Primary users of the technology/innovation

The primary users are individuals interested in api-therapy as an alternative medicine.

## Climate-smart status of the technology/innovation

Api-therapy increases incomes of beekeepers, as it assists beekeepers to develop and produce specialized products.

## Environmentally friendly status of the technology/innovation

The practice of api-therapy does not have adverse effects on the environment, but rather, it promotes the conservation and preservation of bees.

### Suggestions for improvement of the technology/innovation

The mainstreaming of api-therapy into medical treatments can go a long way in promoting its safe use in the population.

### Strategies that can be adopted by national governments to promote the uptake of api-therapy

National governments can promote this technology through strategies such as:

- Creating awareness programmes among health providers on the benefits of api-therapy
- Creating awareness on the use of api-therapy products for prevention of diseases
- Building capacity of health care providers on the use of api-therapy
- Investing in the development of products that are safe
- Developing manufacturing standards for bee products

# Apicure®

## Primary use of the technology/innovation

Apicure® is a plant extract that has been found effective against the small hive beetle, *Aethina tumida* which is a pest found inside honey bee colonies. Apicure® is a relatively new compound produced by hydro-distillation of the Camphor basil, *Ocimum kilimandscharicum,* an Ocimum found in Eastern Africa, especially around Mt. Kilimanjaro and is preferred by foraging bees.

## SWOT analysis of the technology/innovation

### Strengths

Apicure® is a natural compound that is highly effective in the control of the small hive beetle. It is a natural compound that does not have adverse effects on bees and the honey and products they produce. It is safe for beekeepers to use and can be used continuously within the hive.

### Weaknesses

Being a new product, it may not be available for use throughout Africa and the region.

### Opportunities

The increasing numbers of hive pests including the small beetle mites presents an opportunity for the use of Apicure®. The growth in the organic market favours the use of natural products for disease and pest management. The production of Apicure® will provide employment opportunities especially when the product is available for export. The use of Apicure® results in an increase in honey and bee products, translating into higher incomes for beekeepers. The use of chemicals threatens the bee colonies and poses a danger to the beekeepers when they are administering them. Imported chemicals are also expensive and their use limits the production of organic honey.

### Threats

Organic compounds are often more expensive compared to chemical compounds, which might make beekeepers prefer the cheaper versions. The product is new and is still being commercially produced. It might be a while before it is available for free use by the beekeepers.

## Local availability of the technology/innovation and potential suppliers across Africa

The product may be available from the International Centre of Insect Physiology and Ecology (ICIPE).

## Primary users of the technology/innovation

Beekeepers, researchers and commercial honey producers are the primary users of Apicure®

### Climate-smart status of the technology/innovation

The product is a natural product for controlling pests that threaten the survival of bee populations. It therefore supports the breeding and propagation of bees.

### Environmentally friendly status of the technology/innovation

Apicure® is produced from Camphor basil, a foraging plant that the bees are very fond of. It does not have adverse effects on the environment and encourages the sustainable use of the Camphor basil.

### Suggestions for improvement of the technology/innovation

The effectivity of this product against other products should be investigated.

### Strategies that can be adopted by national governments to promote the uptake of Apicure®

National governments can promote this innovation by developing partnerships for the production, sale and marketing of the product.

# *Clausena anisata* as a bee lure

## Primary use of the technology/innovation

*Clausena anisata* is a plant that is primarily used to attract bees to new hives. The beekeepers rub the new hives with *Clausena anisata*, which is a small tree or shrub with strongly scented leaves and sweet-smelling flowers that grows up to 10 m tall. Rubbing the inside of a hive with a mixture of stems, leaves and flowers of this plant provides a strong-smelling concoction which attracts swarm bees to the presence of an empty hive.



www.commons.wikimedia.org

Clausena anisata *used to attract bees to new hives*

## SWOT analysis of the technology/innovation

### Strengths

*Clausena anisata* is affordable and easily available in many regions of Africa. *C. anisata* is a natural and safe method for attracting bees to hives. It aids in the successful establishment of bee colonies harbouring bees with desired traits.

### Weaknesses

*Clausena anisata* may not grow in all regions of Africa. There is no commercially developed product that beekeepers can purchase. Its efficacy may not be as high as that found in other commercial bee lures. *C. anisata* runs the risk of attracting all types of bees, including native or solitary bees that do not like colonizing hives. One has no control of the types of bees that will colonize the hive and the result is that they may be weak colonies. Also, the use of *C. anisata* may be labour intensive.

### Opportunities

There is a huge demand for starter colonies. *C. anisata* enables the domestication of wild native bees. In doing this, the beekeeper provides food resources, from a hive that shields the bees from the elements, thus protecting them from dying for one reason or another.

### Threats

Wild and native bees may be carrying diseases or pests which can pose a risk to the beekeeper's other hives. There are easier methods of acquiring starter colonies. Commercially available starter colonies from established centres have proven productive and hence would be better choices.

### Local availability of the technology/innovation and potential suppliers across Africa

*C. anisata* is locally available from indigenous forests. It however would need to be identified and harvested by a specialist.

### Primary users of the technology/innovation

The primary users of *C. anisata* are men, who are the primary beekeepers and are able to venture into the forests to collect the plant.

### Climate-smart status of the technology/innovation

The use of *C. anisata* as a bee lure promotes and supports the sustainable use of an indigenous plant thus ensuring its propagation and eventual commercialization.

### Environmentally friendly status of the technology/innovation

*C. anisata* is a natural resource found naturally growing in forests.

### Suggestions for improvement of the technology/innovation

*C. anisata* should be developed into a commercial product.

### Strategies that can be adopted by national governments to promote the uptake of *Clausena anisata* as a bee lure

National governments can promote this innovation through strategies such as:

- Developing strong beekeeping extension services, which would foster the sustainable use of this plant
- Developing research partnerships that would conduct further studies into its efficacy and dosage, and establish other uses for it
- Developing manufacturing standards for bee products

# *Cymbopogon citratus* (Lemon grass) as a bee lure

## Primary use of the technology/innovation

*Cymbopogon citratus* (Lemon grass) is a perennial grass in the family Poaceae that has long leaves and stems that emit a strong lemon fragrance. The scent emitted by this grass is said to be very similar to the pheromones that a queen bee produces. When used as a lure, it quickly attracts bee scouts and this leads to the rapid colonization of a new hive. Lemon grass also has mite repellent properties and can be used as a way of controlling Varroa and other mites.

The beekeepers make lemon grass by boiling its leaves in water for a few minutes. The heat is then switched off and the lemon grass brewed in hot water by allowing it to sit for a few minutes. The water is strained and mixed with two tablespoons of beeswax. The lure is then smeared over the inside wall of a hive and allowed to sit. Lemon grass has been reported to have medicinal properties including anti-microbial and anti-fungal properties, and is also a mite repellent.



www.commons.wikimedia.org

*Lemon grass used as a bee lure*

## SWOT analysis of the technology/innovation

### Strengths

*Cymbopogon citratus* is a naturally occurring grass that can easily be cultivated in most parts of Africa. It is easy to grow, is readily available in many regions of Africa and is very effective in attracting bees. It acts as a repellent against Varroa mites. It is reported to have anti-fungal anti-microbial and properties. The strengths supporting its use include the fact that it is a natural and safe method of attracting bees to hives. It therefore results in the successful establishment of bee colonies.

### Weaknesses

*Cymbopogon citratus'* efficacy may be less than commercially available bee lures.

### Opportunities

There is a huge demand for organically produced honey and the use of *C. citratus* supports the production of organic honey.

### Threats

The use of C. *citratus* carries the risk of a beekeeper attracting native, solitary bees that prefer natural hives rather than commercially produced hives. It may also attract bees with poor genetics and undesired traits like aggressive behaviour.

## Local availability of the technology/innovation and potential suppliers across Africa

C *citratus* is a naturally occurring grass found in many regions of Africa.

## Primary users of the technology/innovation

The primary users of *C. citratus* are men, who are the primary beekeepers in Africa and would be interested in capturing wild and native bees.

## Climate-smart status of the technology/innovation

*C. citratus* attracts bees found in the wild. This practice supports the conservation of indigenous African bee populations.

## Environmentally friendly status of the technology/innovation

*C. citratus* is a natural resource found naturally growing in forests.

## Suggestions for improvement of the technology/innovation

C. *citratus* should be developed into a commercial product.

## Strategies that can be adopted by national governments to promote the uptake of *Cymbopogon citratus* as a bee lure

National governments can promote this innovation through strategies such as:

- Developing strong beekeeping extension services that would foster the sustainable use of this plant
- Developing research partnerships that would conduct further studies into its efficacy and dosage, and establish other uses for it
- Developing manufacturing standards for bee products

# *Christiana africana* as a bee lure

## Primary use of the technology/innovation

*Christiana africana,* a tree that grows 6 to 12 m tall, is used as a bee lure to attract bees to new hives. Its leaves and bark are strong scented and bee keepers in some parts of Africa rub the plant concoction on the insides of new hives as a bee lure.



www.commons.wikimedia.org

Christiana africana *used as a bee lure to attract bees to new hives*

## SWOT analysis of the technology/ innovation

### Strengths

The use of *C. africana* as a bee lure is a safe and natural method of attracting bees to hives. It is easily available in many regions of Africa and is affordable. Its use results in the successful establishment of bee colonies harbouring bees with desired traits.

### Weaknesses

When a beekeeper uses *C. africana* as a bee lure he may not have control over the type of bees that colonize the hive. This also carries the risk that the colonies establishing in the hive are not strong. The preparation of *C. africana* may also be time consuming and labour intensive.

### Opportunities

*C. africana* provides an opportunity for the development of a safe herbal bee lure whose production would be compatible with the production of organic honey whose demand is high and growing steadily.

### Threats

*C. africana* may attract *b*ees that may not easily adapt to the colony. The naturally occurring bees that would be attracted to the hives may carry diseases, pests and pathogens.

### Local availability of the technology/innovation and potential suppliers across Africa

*C. africana* is found in many parts of Africa.

### Primary users of the technology/innovation

The primary users of *C. africana* are the primary beekeepers who are able to venture into the forests to collect the plant.

### Climate-smart status of the technology/innovation

*C. africana* attracts bees found in the wild, and hence supports the production of healthy bees thus supporting the conservation of healthy indigenous bee populations.

### Environmentally friendly status of the technology/innovation

*C. africana* is a natural African tree that has wide distribution. Its use as a bee lure will ensure its conservation.

### Suggestions for improvement of the technology/innovation

*C. africana* should be developed into a commercial product. Research should be undertaken to establish doses in order to create market confidence for it use.

### Strategies that can be adopted by national governments to promote the uptake of *Christiana africana* as a bee lure

National governments can promote this innovation through strategies such as::

- Developing strong beekeeping extension services that would foster the sustainable use of this plant
- Developing research partnerships that would conduct further studies into its efficacy, dosage and establish other uses
- Developing manufacturing standards for bee products

# *Ekebergia capensis* (Cape ash) as a hive antifungal and antimicrobial

## Primary use of the technology/innovation

*Ekebergia capensis (*Cape ash*)* is a large evergreen tree, growing up to 20 m tall. The bark, roots and leaves are used in traditional medicine for the treatment of various ailments in humans. Beekeepers in Ethiopia have used it as an antifungal and antimicrobial treatment for their hives.



www.commons.wikimedia.org

Ekebergia capensis *(Cape ash) used as an anitfungal and antimicrobial treatment*

## SWOT analysis of the technology/innovation

### Strengths

*Ekebergia capensis* is a naturally occurring tree found in most parts of Africa. It is easy to grow. Its use as an antifungal and antimicrobial treatment provides a cheap solution to fungal and bacterial infections in hives. Its use as a natural and non-chemical treatment also does not affect the quality of honey. *E. capensis* has been found to be very successful in the establishment of bee colonies harbouring bees with desired traits.

### Weaknesses

The use of *E. capensis* for antifungal and antimicrobial treatments has not been verified scientifically; therefore its dose has not been established.

### Opportunities

Africa has a long culture in the use of medicinal plants for treatment of humans. The use of *E. capensis* for the treatment of hive fungal and bacterial infestations offers an immense opportunity for the development of new organic products for the treatment of these infestations.

### Threats

*E. capensis* use faces competition from commercial products whose efficacy has been determined.

### Local availability of the technology/innovation and potential suppliers across Africa

*E. capensis* is a tree found in many parts of Africa.

### Primary users of the technology/innovation

The primary users of *E. capensis* are men, who are the primary beekeepers and venture into forests in search of the tree.

### Climate-smart status of the technology/innovation

*E. capensis* attracts bees found in the wild. This practice supports the conservation of indigenous African bee populations.

### Environmentally friendly status of the technology/innovation

*E. capensis* is a natural African tree with a wide distribution. Its use as a medicinal plant resource to treat fungal and bacterial hive infestations will ensure its conservation.

### Suggestions for improvement of the technology/innovation

*E. capensis* should be developed into a commercial product. Research should be undertaken to establish doses in order to create market confidence for it use.

### Strategies that can be adopted by national governments to promote the uptake of *E. capensis* as a hive antifungal and antimicrobial

National governments can promote this innovation through strategies such as:

- Developing strong beekeeping extension services that would foster the sustainable use of this plant
- Developing research partnerships that would conduct further studies into its efficacy and dosage, and establish other uses

# *Capsicum frutescens* (Chilli pepper) as a hive antifungal and antimicrobial

## Primary use of the technology/innovation

*Capsicum frutescens* is a wild chilli pepper with smooth, medium sized elliptical leaves, pungent fruits and slender branches that are 30-120 cm long. C. *frutescens* has been reported to have antifungal and antimicrobial activity.

The beekeepers prepare a concoction using the flowers, fruits and stems and rub it on the insides of hives. *C*. *frutescens* has two functions. The pungent odour produced acts to attract swarming bees to the new hives, while providing an anti-fungal and microbial function, thus protecting the hive from fungi and bacterial infestations.



www.commons.wikimedia.org

Capsicum frutescens *is a wild chilli pepper*

## SWOT analysis of the technology/innovation

### Strengths

The use of *C. frutescens* as an antifungal and antimicrobial remedy provides beekeepers with an organic treatment for their hives. The *C. frutescens* concoction can be made at home, hence reducing costs that would have gone into the purchase of commercial antifungal and bacterial treatments. Its use is compatible with the production of organic honey.

### Weaknesses

The use of *C. frutescens* for antifungal and antimicrobial treatments has not been verified scientifically, therefore its dose has not been established. There is no established protocol for its use and the search for the tree and its preparation may be time consuming.

### Opportunities

*C. frutescens* as an antimicrobial and antibacterial remedy would provide huge opportunities for the development of an organic compound. The demand for organically produced honey is huge and is growing at a steady rate.

### Threats

*C. frutescens* use faces competition from commercial products and from its use in human medicine.

## Local availability of the technology/innovation and potential suppliers across Africa

*C. frutescens* is a tree found in many parts of Africa.

## Primary users of the technology/innovation

The primary users of the *C. frutescens* are men, who are the primary beekeepers and venture into forests in search for the tree.

## Climate-smart status of the technology/innovation

*C. frutescens* attracts bees found in the wild and hence supports the production of healthy bees, thus supporting the conservation and of healthy indigenous bee populations.

## Environmentally friendly status of the technology/innovation

*C. frutescens* is a natural African tree with a wide distribution. Its use as a medicinal plant resource to treat fungal and bacterial hive infestations will ensure its conservation.

## Suggestions for improvement of the technology/innovation

*C. frutescens* should be developed into a commercial product. Research should be undertaken to establish doses in order to create market confidence for it use.

## Strategies that can be adopted by national governments to promote the uptake of *Capsicum frutescens* as a hive antifungal and antimicrobial

National governments can promote this innovation through strategies such as:

- Developing strong beekeeping extension services that would foster the sustainable use of this plant
- Developing research partnerships that would conduct further studies into its efficacy and dosage, and establish other uses
- Developing manufacturing standards for bee products

# *Thymus vulgaris* (Thyme) as a natural treatment for Varroa mites

## Primary use of the technology/innovation

*Thymus vulgaris* commonly known as Thyme is a herb with a rich spicy smell and contains a volatile oil that contains monoterpenes and tannins. Beekeepers use it as a natural treatment against Varroa mites. It has been reported to have antimicrobial properties and is commonly used in human medicine as an anti-microbial.

The beekeepers crush the leaves and stem in a little vegetable oil and then spread this on the insides of the hive. They also leave a few drops of pure thyme oil in a container that is placed in the middle of the hive. During a hot day the oil vaporizes and spreads throughout the hive killing the Varroa and other mites.



AU-IBAR

Thymus vulgaris, *commonly known as Thyme, a herb used by beekeepers as a natural treatment against Varroa mites*

## SWOT analysis of the technology/innovation

### Strengths

*Thymus vulgaris* is simple to prepare, has been found to be effective, is a natural, non-chemical treatment and so does not affect the quality of honey. It is compatible with the production of organic honey and has been found not to interfere with the production of high quality honey. It is widely used around the world as a treatment against Varroa mites.

### Weaknesses

The use of *T. vulgaris* though widespread and popular, does not have an established protocol. Its efficacy might therefore vary from beekeeper to beekeeper thus affecting its effectivity.

### Opportunities

*Thymus vulgaris* is widely used in aromatherapy and is a popular herbal treatment. Therefore, its use as an alternative treatment against Varroa mites can be easily accepted.

### Threats

There is a huge demand for use of *T. vulgaris* in the organic oil and human alternative medicine fields.

## Local availability of the technology/innovation and potential suppliers across Africa

*T. vulgaris* is a herb found in many parts of Africa and is cultivated for commercial purposes.

## Primary users of the technology/innovation

The primary users of *T. vulgaris* are the primary beekeepers.

## Climate-smart status of the technology/innovation

*T. vulgaris* is a herb that is cultivated for commercial purposes. Its use in the apiculture sector is compatible with the conservation and preservation of plant resources.

## Environmentally friendly status of the technology/innovation

*T. vulgaris* is a commonly cultivated herb. Its use as a medicinal plant resource to treat fungal and bacterial hive infestations will ensure its conservation.

## Suggestions for improvement of the technology/innovation

*T. vulgaris* should be developed into a commercial product. Research should be undertaken to establish doses in order to create market confidence for it use.

## Strategies that can be adopted by national governments to promote the uptake of *Thymus vulgaris* treatment for mites

National governments can promote this innovation through strategies such as:

- Developing strong beekeeping extension services that would foster the sustainable use of this plant
- Developing research partnerships that would conduct further studies into its efficacy, dosage and establish other uses for it
- Developing manufacturing standards for bee products

# 5.3 Technologies and Innovations targeting the Processing and Value Addition Components

# Royal Jelly production

## Primary use of the technology/innovation

Royal Jelly is a product secreted by the hypopharyngeal gland of young worker bees to feed young larvae and the adult queen. The larvae and queen are fed with an overabundance of royal jelly and they are unable to consume all of it. It is this extra jelly that is harvested for commercial purposes. The production of Royal Jelly entails the use of queens that have been carefully selected and found to produce high quality Royal Jelly. Beekeepers purchase these queens from bee breeders who have bred queens for the trait of high Royal Jelly production. This process also requires careful selection of ideal combs made by young worker bees. Often, older bees are shaken off and younger, newly emerged worker bees are introduced.




AU-IBAR

*Royal Jelly processed in tablet form*

## SWOT analysis of the technology/innovation

### Strengths

The process results in the production of higher quantities of Royal Jelly. The process is not complicated.

### Weaknesses

Royal Jelly production necessitates the purchase of queens after every generation owing to the loss of hybrid vigour. It also requires a populous colony with surplus nurse bees. A successful programme requires queens that have been bred for this purpose. It has been

found that queens that have not been selected for this trait produce about 15 percent less Royal Jelly than is possible. This jelly may also not be of a high quality, as is demanded for by the market. The Royal Jelly production process requires technical expertise to handle the queens. The purchase of queens and installation of infrastructure may be an expensive venture for small holder producers. Being a new technology in Africa, there is limited skilled capacity. There are few African queen breeders and breeding programmes.

### Opportunities

This is a high value product in high demand and provides beekeepers with the potential to make profits of up to 200 percent. There are opportunities for its use in the growing api-health, api-therapy and medical therapy sector. Beekeepers who have many hives and are already established in honey production can potentially specialize in Royal Jelly production thus creating employment opportunities for the youth of Africa.

### Threats

Royal Jelly production is anchored on a bee breeding programme which may not be fully established in Africa and there may be little interest in development of, and investment in, this technology in Africa. Demand for this product may be too high to meet. The cost of the infrastructure may be high. Demand for apiculture products that are easier to produce is high so beekeeper may find it easier to invest in these others so as to have quick profits. There is a risk of the queen bee dying if not handled well. Though the demand for Royal Jelly in the developed world is high, there may not be a well-developed market in Africa. Royal Jelly may also be very expensive and out of reach for many Africans.

## Local availability of the technology/innovation and potential suppliers across Africa

Genetically improved and breed queens may not be easily available in Africa.

## Primary users of the technology/innovation

The potential users of this technology are investors interested in investing in high value products.

## Climate-smart status of the technology/innovation

Royal Jelly is a very high value product, giving producers profits of up to 200 percent. It therefore can change the living conditions of Africans who choose to invest in it.

## Environmentally friendly status of the technology/innovation

Establishment of queen bee breeding programmes ensures the conservation of indigenous bees. Investment in the production of Royal Jelly has little impact on the environment.

## Suggestions for improvement of the technology/innovation

Royal Jelly production can be improved by developing breeding programmes targeting the genetic improvement of bees, using African bees.

## Strategies that can be adopted by national governments to promote the uptake of Royal Jelly production

National governments can promote the uptake of this technology through several strategies including:

- Developing breeding programmes targeting African bees
- Developing partnerships to encourage the entry of producers and investors in this area
- Advocacy and awareness creation campaigns to ensure steady market demand for bee venom
- Developing partnerships that promote api-therapy and api-health
- Developing capacity enhancement programmes to transfer knowledge and skills to producers
- Developing manufacturing standards for bee products
- Lobbying for the fast registration to get the product into the market fast and efficiently

# The centrifugal honey extractor

## Primary use of the technology/ innovation

Traditional methods of extracting honey involve manually crushing the honey combs to extract honey. These manual methods of honey extraction result in lower quality and quantities of honey. The centrifugal honey extractor is a mechanical device that is used to extract honey using centrifugal force.



AU-IBAR

*Centrifugal honey extractor*

## SWOT analysis of the technology/innovation

### Strengths

The centrifugal honey extractor produces high quality honey and is highly durable. It is simple to use and can be used by individuals and cottage industries as well as in larger automated processing industries. It results in the hygienic extraction of honey and bee products. It has high honey extraction efficiency and does not cause the destruction of combs, which can then be returned to hives, thus resulting in higher production from one hive.

### Weaknesses

Commercial versions of the centrifugal honey extractor are expensive and may not be affordable for individual or small and medium enterprise users. The design of many centrifugal honey extractors limits their use in a broad range of extractors. Unfortunately, the centrifugal honey extractors only extract honey from the Langstroth, KTBH and TTBH hives.

### Opportunities

Increase in honey production in Africa presents huge opportunities for the use of the centrifugal honey extractor. Many commercial honey producers use the Langstroth, KTBH and TTBH hives, hence creating a demand for honey extractors that are compatible. This demand creates employment opportunities for local fabricators and the youth who are the main employees in this manufacturing industry.

### Threats

The use of other types of hives other than the Langstroth, KTBH and TTBH could affect the demand for the centrifugal extractors and the accompanying accessories. In the informal fabricating sector, the local fabrications are often not manufactured using stainless steel and this could compromise honey quality.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology/innovation is locally available and can be locally manufactured.

## Primary users of the technology/innovation

The primary users of this technology are the African beekeepers.

## Climate-smart status of the technology/innovation

The centrifugal honey extractor is climate smart because it results in a rise in agricultural productivity, reduces wastage of honey, and increases incomes of the beekeepers.

## Environmentally friendly status of the technology/innovation

The centrifugal honey extractor extracts honey from honey combs without destroying them. The bees therefore do not use a lot of energy to make new honey combs, making this form of extraction to be very environmentally friendly.

## Suggestions for improvement of the technology/innovation

The centrifugal honey extractor is only used in the extraction of honey and cannot be used in the extraction of other products.

## Strategies that can be adopted by national governments to promote the uptake of the centrifugal honey extractor

National governments can promote this technology through strategies such as:

- Developing incentives to promote local fabrication of high quality steel extractors to meet local demand
- Creating partnerships with financiers and individuals to mitigate the production costs for beekeepers

# The honey press

## Primary use of the technology/innovation

The honey press is a method of honey extraction from honey combs. A beekeeper removes frames of honey from the hives and places them inside a metal mesh basket. The lid of the honey press is then closed. When the lever is depressed, the honey is forced out of the combs and drips into the inside of the honey press; it is then removed by opening up a valve located at the bottom.



www.alibaba.com

*Honey press machine*

## SWOT analysis of the technology/innovation

### Strengths

The stainless-steel version of the honey press is very durable and produces high quality honey. It is easily adaptable to manual extraction setting or to an automated setting to extract larger quantities of honey. It is compatible with extraction of honey from traditional or modern hives, because what the honey press process uses are the honey combs.

### Weaknesses

To remove honey from the honeycombs that are on frames, one has to detach them from both sides of the frames. This process destroys the honeycombs and hence the bees have to make new ones. The process takes time and slows down production. Most honey press machines have an inner basket into which the honeycombs are placed before being crushed. However, sometimes crushed honeycombs end up passing through it and into the honey, thus decreasing the quality of the honey. This honey can be strained but it is a messy and tedious process.

### Opportunities

Eighty to ninety percent of the hives found in Africa are the KTBH/TTBH and local traditional hives, which depend on the honey press for processing. More demand for African honey will provide opportunities for local fabricators to become engaged in the manufacture of this press, presenting numerous business and employment opportunities.

### Threats

The current negative perception concerning the quality of honey from traditional hives could affect demand for the honey press machines. There is also a concern about the locally produced honey press machines which are often not fabricated using stainless steel and could thus compromise the honey quality.

## Local availability of the technology/innovation and potential suppliers across Africa

The honey press machines are locally available and can be locally manufactured. It can also be purchased as an accessory from APITRADE (Africa); Africa Apiculture Platform; TUNADO (Uganda); Golden Bees Ltd; and ICIPE (Kenya).

## Primary users of the technology/innovation

The primary bee keepers and honey producers of Africa are men, who are the predominant beekeepers and honey producers in Africa.

## Climate-smart status of the technology/innovation

The honey press is compatible with many types of hives. It improves the livelihoods of the beekeepers who keep traditional hives by providing an income from fabricating the honey press or engaging in beekeeping activities.

## Environmentally friendly status of the technology/innovation

The honey press is eco-friendly in its installation and use.

## Suggestions for improvement of the technology/innovation

The honey press can be modified so that it does not destroy honeycombs while extracting honey. Easy to use, manual honeycombs would be an improvement of this design.

## Strategies that can be adopted by national governments to promote the uptake of the honey press

National governments can promote this technology through strategies such as:

- Developing incentives to promote local fabrication of high quality steel extractors to meet local demand
- Creating partnerships with financiers and individuals to mitigate the costs for beekeepers who want to begin fabricating, selling or marketing this product

# The solar beeswax extractor

## Primary use of the technology/innovation

Beeswax is the foundation of hives. Worker bees, as soon as they are produced, begin to secrete liquid wax from special wax-producing glands located on the undersides of their abdomens. The worker bee moves this wax from her body and into her mouth and chews it until it becomes pliable. She then molds it into hexagonal cells that eventually become the hive's honeycomb.

Beeswax is a highly valuable product that is used in the medical and beauty industries. It has also been used to make candles for thousands of years.



AU-IBAR

*Solar beeswax extraction*

## SWOT analysis of the technology/innovation

### Strengths

The solar beeswax extractor can be fabricated at home. The fabrication process is easy, making the product affordable, easy to use and it is eco-friendly. The extraction process is completely natural and hence it is compatible with the organic production of beeswax.

### Weaknesses

Commercial beeswax machines exist in the market, making them more popular. The solar beeswax extractor extracts small quantities at a time, which may be a problem for larger amounts of beeswax. Manufacturers are all located outside Africa, making access to the product challenging.

### Opportunities

Boosting beekeeping in Africa presents the opportunity to produces beeswax, which is not being produced at high levels. The demand for beeswax in Africa is high, while international demand is even higher.

### Threats

This is a new product whose efficacy may not be as high as the commercially available products. As a new product the amount of beeswax it produces may vary.

## Local availability of the technology/innovation and potential suppliers across Africa

The solar beeswax extractor is not locally available.

## Primary users of the technology/innovation

The potential users of the solar beeswax extractor are beekeepers.

## Climate-smart status of the technology/innovation

The solar beeswax extractor uses solar energy, a green energy hence making it an ideal climate-smart device. It also does not produce any emissions or gases that can be detrimental to the environment. It has the potential to improve the livelihoods of beekeepers by increasing their incomes.

## Environmentally friendly status of the technology/innovation

The solar beeswax extractor does not have any impact on the environment when it is being installed.

## Suggestions for improvement of the technology/innovation

The integration of the solar beeswax extractor with sensors and digital scales would make it possible to collect real time data.

## Strategies that can be adopted by national governments to promote the uptake of the solar beeswax extractor

National governments can promote the uptake of this technology through strategies such as:

- Supporting developers to patent and register the solar beeswax extractor to enable its full-scale manufacture. The government ministries of industrialization should lobby to get the product into the market.
- Developing partnerships that would lead to the full development of the solar beeswax extractor, including government and private sector
- Initiatives that promote, advocate and create awareness and run campaigns to ensure steady market demand for organic beeswax

# The bee venom (apitoxin) extractor

### Primary use of the technology/innovation

Bee venom, apitoxin, the poison that is released by a bee when it stings, is a highly valuable product that has found application in the medical fields in the treatment of diseases that have not responded to conventional medical treatments such as osteoarthritis, Parkinson's disease, multiple sclerosis, nerve pain and other conditions. The effectivity of bee venom as a medicine remains controversial especially on account of the adverse allergic effects it induces in some patients. The bee venom business is highly profitable and beekeepers can increase their profits by about 200 percent. This is enhanced by the fact that making the bee venom extraction equipment is not complicated. All bee venom extraction equipment are based on electrical devices mounted on a bee collection frame. Electrical impulses pass through these, making the bee sting the frame and release the bee venom which is collected into a cup.



AU-IBAR

*Bee venom extractor*

## SWOT analysis of the technology/innovation

### Strengths

The bee venom equipment, which can be locally made, is simple to make and install, making it an affordable option. The method used is simple and easy to comprehend. The use of electrodes does not kill the bees, hence making the method easy to use. Perhaps the best benefit to using this method is that it is a natural extraction method that is compatible with the organic production of bee products.

### Weaknesses

The use of this method reduces wax and honey production by 15 percent. This therefore requires that the beekeeper specializes in one sector at the expense of the other. Bee venom extraction, though simple, requires specialized personnel to both handle the bees and set up the equipment. Despite this, many beekeepers may find the process labour intensive and time consuming. The infrastructure set-up may be expensive for small holder producers who consider this line an expensive venture. This being a new production line for African beekeepers, there are not enough people with the production skills required. This method needs the use of electricity, which may not be available in many parts of Africa.

### Opportunities

Bee venom is a highly valued product from which beekeepers can make up to 200 percent in profits. The demand for its use in api-health, api-therapy and medical therapy in the world is growing at a tremendous rate. There is therefore a vast untapped opportunity for African beekeepers. There also are opportunities to set up local fabricators, marketers and distributors.

### Threats

Bee venom has been found to produce severe allergic reactions that can sometimes cause death in some patients. This has resulted in a negative perception and resistance by medical personnel to use it for the treatment of various ailments. The demand for the product may be too high for Africa, so fabricators, in their rush may compromise the quality of the product. There is a risk of bees dying if they are not handled well. Quality controls and registration of the apitoxin in various markets may be an expensive and time-consuming exercise. Another risk is that there is little interest in Africa in producing bee venom.

## Local availability of the technology/innovation and potential suppliers across Africa

The bee venom extractor is not locally available and would need to be locally fabricated.

## Primary users of the technology/innovation

The potential users of the bee venom extractor are beekeepers.

## Climate-smart status of the technology/innovation

The bee venom extractor supports the rise in incomes of beekeepers thus improving their livelihoods. The extraction process is a sustainable method of extracting bee venom.

### Environmentally friendly status of the technology/innovation

The bee venom extractor does not have any impact on the environment when it is being installed.

### Suggestions for improvement of the technology/innovation

The technology may be improved by developing prototypes of the bee venom extractor for Africa.

### Strategies that can be adopted by national governments to promote the uptake of the above technology/innovation

National governments can promote this technology through several strategies including:

- Developing partnerships to encourage the entry of producers and investors in this area
- Advocacy and awareness creation campaigns to ensure steady market demand for bee venom
- Developing partnerships that promote api-therapy and api-health
- Developing capacity enhancement programmes for transferring knowledge and skills to producers
- Lobbying for fast registration to get the product into the market fast and efficiently

# Infused honey

## Primary use of the technology/innovation

The production of honey through the infusion method results in flavoured honey without the challenge of making the bees feed on one type of flower. Infusing honey with medicinal herbs and plants provides the additional medicinal benefit of that specific herb or flower. The infusion method involves two techniques: a heat method, where the honey is gently heated with a herb or medicinal plant; or a cold method, where the honey is mixed with the herb or medicinal plant and left to sit for a period.




AU-IBAR

*Infused honey with various herbs*

## SWOT analysis of the technology/innovation

### Strengths

The infusion method is simple, easy to perform and is affordable. It does not require specialized personnel or equipment and can be carried out by any beekeeper. It is a great source of providing the beekeeper with additional sources of income.

### Weaknesses

Perhaps the greatest weakness of this method is that infused honey may not have a long shelf life compared to pure honey. The beekeeper runs the risk of mixing batches of honey with different flavours if care is not taken to clear the infusion containers of previous batches. The infusion process can introduce fungi and bacteria into the honey and hence needs to be undertaken under sterile conditions. The herbs and plants used in the infusion process may carry water which can cause the honey to spoil and get contaminated.

### Opportunities

With increasing urbanization, there is a corresponding increase in specialized food products, infused honey being one of them. Africa is endowed with a large diversity of medicinal plants that can be used to make specialized products. Infused honey is considered to be an organic honey, for which there is a great demand.

### Threats

The acceptance of this product needs a good marketing strategy which may not be in place. The infusion process requires a small investment in equipment and processes that will result in the hygienic production of the product. Beekeepers may not be interested in.

## Local availability of the technology/innovation and potential suppliers across Africa

Infusion of honey can easily be done in Africa.

## Primary users of the technology/innovation

Beekeepers are the potential makers of infused honey.

## Climate-smart status of the technology/innovation

The production of infused honey presents beekeepers with an alternative source of income, thus securing their livelihoods. It also would increase the production of honey, thus ensuring the health of the general population.

## Environmentally friendly status of the technology/innovation

The production of infused honey does not require any specialized installations and hence it is a very environmentally friendly process.

## Suggestions for improvement of the technology/innovation

Researchers and producers should develop recipes for production of infused honey and disseminate these to encourage more producers to enter this field.

## Strategies that can be adopted by national governments to promote the uptake of infused honey production

National governments can promote the uptake of this technology through several strategies including:

- Advocacy and awareness creation campaigns to educate beekeepers on the production of infused honey as an income generating project
- Developing partnerships with medicinal herbalists and pharmacologists that will assist in the development of specialized types of infused honey that can be integrated into alternative medicine programmes
- Developing capacity enhancement programmes for transferring knowledge and skills to producers
- Lobbying for the fast registration of infused honey products

# Pollen traps

## Primary use of the technology/innovation

This innovation targets collection of pollen from bees. Bees are known to also collect pollen from flowers in addition to nectar. The pollen is consumed by bees as a source of protein. Indeed, pollen is the only source of protein for young bees being raised. The worker bees collect pollen by wetting the dry pollen using juices from their mouths and then sticking the pollen to the stiff hairs on the hind legs. While the worker bees deliberately collect pollen, a larger amount of pollen sticks on the bee's body while the bee is foraging for nectar and pollen. This excess pollen is what pollen traps collect.

Pollen traps are wire mesh grids placed at the entrance of hives to collect the pollen attached to the body of the bee while it is entering the hive. The mesh is made using metal wire mesh with a grid of about 5-mesh per inch. It is used with a covered pellet collection container that prevents a bee from entering to harvest the collected pollen.

The trade and marketing of bee pollen worldwide is growing at a tremendous rate. In many markets, bee pollen is sold as a supplement. Bee pollen has been reported to be rich in nutrients including amino acids, vitamins, lipids and over 250 other active products. In some countries like Germany, bee pollen has been recognized as a medicine and is a widely used product in api-therapy and api-medicine.




*Pollen trap*

## SWOT analysis of the technology/innovation

### Strengths

The technique used in the collection of pollen is a simple one, only involving the installation of a wire mesh. The wire mesh is cost effective and it results in the harvesting of large quantities of pollen. Collecting bee pollen from the bees as they are entering the hive does not interfere with the production of honey or other products.

### Weaknesses

The collection of pollen from the bees as they enter the hive stresses them especially when they do not have enough pollen in the hive, resulting in their focusing on the collection of more pollen at the expense of producing honey. This has the negative result of reducing the amount of honey being produced in a hive. The wire mesh for pollen production has to be made in a specific way or else it can crush, kill or maim the bees. The pollen collected during wet and humid months may have high moisture content and therefore may not be of high value. Pollen collection is therefore best done during the dry months. This would require the removal of the wire meshes during the months when the pollen will not be collected. Microbiological standards for pollen do not exist in many African countries.

### Opportunities

Pollen is a high value product whose consumption as a supplement and use in the ap-itherapy and api-medicine sectors is growing worldwide. Pollen production is highly profitable and African beekeepers therefore have the opportunity to diversify into the production of this high value product. This will have the added advantage of increasing employment opportunities.

### Threats

Adverse allergic reactions have been reported in some patients. This has led to negative perceptions on the use of this product. Demand for this product may be too high to meet. African beekeepers may not be interested in diversifying into this product, especially in view of the high demand for honey production, which may be easier. Bee pollen collection carries the risk of collecting pollen from diseased hives, thus carrying the risk of propagating some diseases. Pollen may be too expensive to purchase and not affordable for many. The interest in developing this technology in many countries may not be there.

## Local availability of the technology/innovation and potential suppliers across Africa

The bee pollen mesh collector can be easily made in Africa.

## Primary users of the technology/innovation

The potential users of the bee pollen collector are beekeepers interested in investing in high value production of pollen.

### Climate-smart status of the technology/innovation

Collection of bee pollen supports beekeepers, especially in producing a high value product. This will increase their incomes making them earn and make a profitable living.

### Environmentally friendly status of the technology/innovation

The bee pollen collector does not have any impact on the environment. This technology does not require any specialized installation and does not need a power source.

### Suggestions for improvement of the technology/innovation

The technology may be improved through the following measures being taken by African countries:

- Development of standard measurements for the manufacture of the pollen collector to ensure that it will not injure or harm the bee in any way
- Development of microbiological standards for pollen

### Strategies that can be adopted by national governments to promote the uptake of pollen traps

National governments can promote this innovation through several strategies including:

- Developing partnerships to encourage the entry of producers and investors into this area
- Capacity building for beekeepers for the production of bee pollen
- Developing local and international markets for bee pollen
- Developing microbiological standards for the safe consumption of pollen
- Developing partnerships that promote api-therapy and api-health
- Developing capacity enhancement programmes for transferring knowledge and skills to producers
- Lobbying for fast registration to get the product into the market fast and efficiently

# Propolis traps

## Primary use of the technology/innovation

Propolis is a product that is obtained from the hives. It is usually located on frames, covers or openings of hives. Propolis is a high value product that is in high demand owing to its antiseptic, anti-inflammatory, antioxidant, antibacterial, antimycotic, antifungal, antiulcer, anticancer and immunomodulatory properties.

Bees, while foraging, also collect plant resins using their hind legs and carry them into hives. They then mix the resin with saliva to produce propolis. Bees use it to seal cracks or holes that bring in drafts that can reduce internal temperatures, thus minimizing the effects of bad weather. Propolis also prevents predators from entering hives. Propolis has also been found to promote colony health because of its antifungal, antiviral and antibacterial properties.

To encourage bees to make propolis, the beekeeper removes all or part of the back wall and replaces this with a propolis collecting frame. This frame is a grid made from plastic with spaces. The bees then fill these spaces with propolis as a way of maintaining the internal climate.



Ihor Hvozdetskyi/shutterstock

*Propolis traps*

## SWOT analysis of the technology/innovation

### Strengths

Propolis is easy to collect, especially when a propolis collection frame is installed. When small quantities of propolis are being collected, it is not necessary to install the frame. The propolis collection method does not require many inputs.

### Weaknesses

The disadvantage of installing propolis frames in hives is that it makes the bee focus on propolis production hence negatively impacting honey production. Replacing the back-hive wall with a propolis frame may have adverse effects on the internal climate of the hive, especially if there are adverse external temperatures. Harvesting larger quantities of propolis requires infrastructure investment.

### Opportunities

Propolis is a highly valued product on the international market and has potential to increase the incomes of African beekeepers in a very significant manner. There are therefore tremendous opportunities for beekeepers to specialize in propolis production. This would create numerous employment opportunities for Africans.

### Threats

The demand for propolis may be too high to meet. Africans may also not be able to purchase it owing to its high cost. There is also very high demand for other bee products that are easier to produce and may be easily marketed. There therefore may be little interest in investing in the production of propolis.

## Local availability of the technology/innovation and potential across Africa

Propolis is produced in Africa though not in very significant quantities.

## Primary users of the technology/innovation

African beekeepers interested in increasing their incomes would be the primary users of this technology.

## Climate-smart status of the technology/innovation

Investments in the production of propolis would result in the beekeepers getting very high returns for their product, hence ensuring that they have a guaranteed source of income.

## Environmentally friendly status of the technology/innovation

The production of propolis does not require any installation and hence it is environmentally friendly. Beekeeping encourages the conservation of bee diversity.

## Suggestions for improvement of the technology/innovation

The technology may be improved by developing locally available propolis frames that do not use plastic as the main material.

## Strategies that can be adopted by national governments to promote the uptake of propolis traps

National governments can promote this technology through strategies such as:

- Advocacy and awareness creation campaigns among beekeepers to encourage more to specialize in propolis production
- Developing partnerships to encourage the entry of producers and investors to the production of propolis

# Remote hive monitoring systems (bee hive sensors)

## Primary use of the technology/innovation

Installation of bee hive monitoring systems in hives provides for real-time monitoring of bee health and collection of real-time hive data. Most sensors collect data such as brood temperature, humidity, hive weight (which is a great indication of honey production) and bee counts (to inform on the colony population). Sensors allow beekeepers to monitor colony health and behaviour, which was not possible previously. This data when shared with global colony health networks provides valuable information not only to advice on individual beekeeper's colonies but also on country, regional and global bee colony health.



www.media.wired.com

*Remote hive monitoring systems*

## SWOT analysis of the technology/innovation

### Strengths

Bee hive monitoring systems monitor the health of bee hives and provide an easy, efficient and reliable method to collect data. They allow for the rapid detection of problems within the hive, for example, if a hive has no bees, or if there are Varroa mites. Because the monitoring system has a GPS locator, the hive's location is known and if it is moved or stolen this will immediately be detected. The bee hive monitoring systems collect real-time data for analysis.

### Weaknesses

The infrastructure for the bee hive monitoring system may be expensive especially where annual licenses for software are required. The system once installed may incur continuous maintenance costs. It also requires the services of a specialist to monitor the hives remotely.

The system runs the risk of being stolen. Beekeepers may not see the need for its use and thus it may not be easily accepted. The monitoring system needs a smart device or mobile phone to monitor the hives with, which may not be suitable for all users.

### Opportunities

The growing apiculture industry presents opportunities for investment. Large-scale producers may want to increase efficiencies and make more products, and they would be able to easily do this with the use of the bee hive monitoring system. Increased theft of hives presents opportunities for beekeepers to purchase this technology/innovation.

### Threats

There are risks that the bee hive monitoring systems may not be easily adopted in view of the costs and because the beekeepers may not see a need for them. The mainstream extension service providers may see the system as a threat.

## Local availability of the technology/innovation and potential suppliers across Africa

The bee hive monitoring system is not locally available.

## Primary users of the technology/innovation

This bee hive monitoring system targets commercial honey and bee producers because they would have the money to invest in it.

## Climate-smart status of the technology/innovation

Bee hive monitoring systems promote bee and colony health thus supporting the management of bee populations.

## Environmentally friendly status of the technology/innovation

The installation of bee hive monitoring systems has little or no impact on the environment.

## Suggestions for improvement of the technology/innovation

Uptake of this technology/innovation within Africa can be improved through:

- Developing partnerships with local software
- Re-negotiating proprietorship with patent owners to make it possible for local companies to purchase it

## Strategies that can be adopted by national governments to promote the uptake of the bee hive monitoring system

National governments can promote this technology/innovation through:

- Ensuring legal frameworks exist
- Creating awareness at consumer level so as to trigger a demand for products that can be tracked and traced

# 5.4 Technologies targeting the Trade and Markets Components

# Honey bulking and collection centres

## Primary use of the technology/innovation

Beekeepers use this innovation to access larger markets that require larger quantities of honey or bee products than they are able to supply. Farmers in bulking centres are also able to access inputs at wholesale prices.

## SWOT analysis of the technology/innovation

### Strengths

Creation of honey bulking and collection centres has various strengths including that the management is able to negotiate better prices for their products. Honey bulking results in larger quantities of honey, thus enabling the centres to negotiate better prices for beekeepers compared to when they sell their product individually. Strong honey bulking and collection centres are able to access large markets, including export markets.

### Weaknesses

Honey bulking and collection centres may not have formal infrastructure and may lack storage facilities. Small collection centres may not be able to avoid the services of middlemen. Beekeepers at the collection centres may not have current market information thus their products may be sold at a lower price. Collection centres attract small producers and after bulking they may still not be able to meet required volumes. Collection centres may not have control of the quality of honey. A beekeeper on delivering his product to a collection centre loses his brand. The overreliance of beekeepers on bulking agents means that they lose market information.

### Opportunities

Honey bulking and collection centres are an important component of the apiculture value chain. Therefore, there are opportunities for formalizing bulking agents and providing them with funding from government and private sector.

### Threats

Honey bulking and collection centres rely on honey being delivered to them and they have no way of controlling the quality and quantity of the honey delivered. Bulking products from a variety of sources compromises the quality. The quantities may at times be too low for the collection centres to run a sustainable business; this, together with unstable and unreliable market prices threatens their survival. Beekeepers may be stuck with products that they cannot sell or dispose of if the prices offered at collection centres are too low. The risk also arises that payments may be delayed or may be released in instalments that may not be favorable to small-holder beekeepers. The lack of trust between beekeeper and bulking agent threatens the business, especially if there are reports of lack of integrity among the management of the collection centre.

### Local availability of the technology/innovation and potential suppliers across Africa

Honey bulking and collection centres can be easily constituted at community level.

### Primary users of the technology/innovation

Honey bulking and collection centres are able to target small-holder beekeepers and youth.

### Climate-smart status of the technology/innovation

Honey bulking and collection centres when managed properly, can have immense impact on communities by increasing their incomes.

### Environmentally friendly status of the technology/innovation

Formation of honey bulking and collection centres is environmentally friendly. They can also drive investments in the apiculture value chain, leading to the sustainable use of the African bee populations.

### Suggestions for improvement of the technology/innovation

Honey bulking and collection centres could be more effective if their role in the apiculture value chain is recognized.

### Strategies that can be adopted by national governments to promote the uptake of honey bulking and collection centres

National governments can promote this innovation through strategies such as:

- Developing policies and legislation that recognize and formalize the role played by collection and bulking centres in the apiculture value chain
- Building the capacity of the managers and staff at collection centres to enable them run profitable enterprises

# Live bee colony markets

## Primary use of the technology/innovation

Live bee colony markets are markets catering especially to the trade and marketing of live bees. This is an innovative concept that allows for new beekeepers to start hives for existing ones to boost the number of bees in their colonies. These live bee colony markets are especially found in Ethiopia and form a part of the beekeeping customs.

## SWOT analysis of the technology/innovation

### Strengths

The bee colony markets sell bees at an affordable rate, are easy to set up, and result in the successful establishment of bee colonies, which reduces the time that bees take to colonize hives.

### Weaknesses

The assemblage of a large number of bee starter colony sellers in one location carries health and safety risks, especially since these markets are busy and are located in populated areas. Live colony markets carry the risk of loss of bees because the bees can easily fly away while at the market or when being transported from one location to another. The risk of people being stung by bees at markets and during their transportation is another weakness. Furthermore, the buyers can get incomplete colonies, for example, one that does not have a queen, resulting in the establishment of weak colonies. They also have no control on the quality of bees being purchased. The production of starter colonies can be labour intensive.

### Opportunities

There is a high demand for honey and bee products, therefore creating a huge opportunity for beekeepers. Demand is also a growing for organically produced honey. Growth in bee keeping across the continent will have the added advantage of increasing pollination services, consequently resulting in a rise in crop production. There is a great demand for starter colonies and bee products.

### Threats

The bees may not easily adapt to the new hive when they are introduced. There are communities that are afraid of keeping bees. The threat exists of spreading brood diseases, pests and pathogens.

## Local availability of the technology/innovation and potential across Africa

The live bee colony markets are found in certain regions of Africa, for example, Ethiopia.

### Primary users of the technology/innovation

Men, who are the primary beekeepers and are able to venture into the forests to collect native and wild bees, are the primary users of this innovation.

### Climate-smart status of the technology/innovation

The live bee colony markets are climate smart and offer communities with a sustainable method of earning a living.

### Environmentally friendly status of the technology/innovation

The establishment of live bee colony markets has little impact on the environment. Introducing native bee colonies into new regions leads to increased genetic diversity of bee populations. The capture and breeding of bee populations is compatible with conservation measures for bees. Propagating bees provides communities with food, hence supporting sustainable use of bees.

### Suggestions for improvement of the technology/innovation

This innovation could be improved by developing national marketing strategies for bee starter colonies.

### Strategies that can be adopted by national governments to promote the uptake of live bee colony markets

National governments can promote this innovation through several strategies including:

- Developing strong beekeeping extension services
- Developing awareness programmes for communities in order to interest producers
- Creating partnerships that can mitigate costs of setting up colony establishment enterprises
- Developing local capacity for bee and colony management
- Determining the best geographic locations to rear bees
- Developing early warning systems to detect bush fires that destroy hives
- Developing breeding programmes for bees that are resistant to diseases, pests and parasites
- Establishing bee disease detection and treatment programmes
- Developing capacity enhancement programmes for bee keepers
- Conducting trainings for extension officers in bee pest management
- Promoting apiculture in low fire-hazard risk areas

# Api-tourism (bee tourism)

## Primary use of the technology/innovation

Api-tourism is a form of tourism that promotes beekeeping as a traditional and commercial practice. It is a new innovation that serves to promote bee and bee products, and raise awareness on the risks faced by the pollinators, while showcasing a variety of wildlife and unique scenery within countries. Activities of api-tourism include visits to apiaries and museums where a beekeeper is offered an opportunity to observe a beekeeper's work, including how honey is made, processed and marketed, and other bee products such as beeswax.




AU-IBAR

*Promoting beekeeping*

## SWOT analysis of the technology/innovation

### Strengths

Api-tourism boosts tourism and draws vital foreign exchange into countries, thus boosting incomes for locals and beekeepers. It is a highly specialized type of tourism with direct benefits to the community and acts as free advertising for the apiculture value chain. Api-tourism naturally leads to the protection of habitats and results in community practices that promote the protection of bees, including the banning of chemicals that kill bees. It spurs the development of industries around honey, for example, spas that use honey treatments. Tourists are made aware of the key role that bees play as pollinators.

### Weaknesses

Api-tourism requires that the beekeepers develop infrastructure that would attract tourists, including nature trails, shops and resting areas, which requires significant investment. Api-tourism can be labour intensive and needs a national strategy with policies and legislation to promote it.

### Opportunities

This is a new and emerging area which has not been developed for Africa. New and unique tourism programmes, for example agri-tourism, where agricultural benefits of keeping bees are explained, are emerging. There is a great awareness on the importance of preserving the environment and there are great opportunities for use of honey and bee products for pro-health through promotion of natural treatment methods using honey and bee products. Api-tourism creates jobs at local/community level.

### Threats

Api-tourism faces competition from mainstream tourism sectors and requires a marketing strategy. The tourism market is seasonal and beekeepers who rely only on it can become bankrupt.

## Local availability of the technology/innovation and potential suppliers across Africa

Api-tourism can be made available in Africa through the development of specially designed programmes.

## Primary users of the technology/innovation

Api-tourism can be adopted by established beekeepers.

## Climate-smart status of the technology/innovation

Api-tourism promotes the use of bees as pollinators, and the decrease in the use of agro-chemicals. It has the potential to bring in foreign exchange and to positively impact the livelihoods of beekeepers

## Environmentally friendly status of the technology/innovation

Api-tourism promotes beekeeping while ensuring the conservation of bees, indigenous forests and habitats that are bee foraging areas.

## Suggestions for improvement of the technology/innovation

Suggestions for improvement of this technology include the development of national api-tourism strategies.

## Strategies that can be adopted by national governments to promote the uptake of api-tourism

National governments can promote this innovation through several strategies including:

- Developing api-tourism through direct support from governments and organizations responsible for beekeeping. This therefore requires the development of policies and legislation that would provide the framework for the establishment of api-culture.
- Developing awareness programmes for communities to invest in api-tourism
- Identifying regions that would be ideal for api-culture and promote them
- Creating partnerships that can mitigate costs of infrastructure and set-up costs
- Developing local capacity for bee and colony management
- Determining the best geographic locations to use to market bees
- Developing breeding programmes for bees that are resistant to diseases, pests and parasites
- Developing capacity enhancement programmes for bee keepers
- Conducting trainings for extension officers in bee pest management
- Promoting apiculture in low fire-hazard risk areas

# Honey festivals

## Primary use of the technology/innovation

Honey festivals are cultural events organized by beekeeping communities to market honey and honey products.




AU-IBAR

*Honey festival exihibition*

## SWOT analysis of the technology/innovation

### Strengths

Honey festivals focus on marketing all the components of the apiculture value chain. With a minimum entrance fee, they are able to attract large numbers of people thus making them excellent marketing events for bees, honey and other bee products. The festivals are excellent ways of enhancing beekeepers' skills through knowledge sharing during the event. They also provide important information to non-beekeepers especially on the role played by bees in ensuring food security. They offer the beekeeping experience to non-beekeepers by promoting it as a hobby, thus winning over new beekeepers. Honey festivals offer the public an opportunity to taste honey and experience other bee products. Participants also learn how to make products be they food or cosmetic products using honey. The festivals are opportunities for attracting tourists into regions and growing the export apiculture trade.

### Weaknesses

Honey festivals need support from the Town Council and governments for them to be successful. The events can be expensive and therefore need corporate sponsorships for success. Events that do not attract adequate funding run the risk of not being successful. Honey festivals require intense planning to ensure public awareness is raised. Vendors and participants may find the event expensive especially if they need to transport bees and bee products from their farms. When the event is very large the participants may not be able to visit all the stands and when the event is too small it may not attract enough public or bee keepers as participants. Sometimes the focus of the event may not only be on apiculture, hence apiculture marketing may be lost.

### Opportunities

Honey festivals offer the opportunity for creating broad partnerships for them to be successful. Honey festivals are a great marketing opportunity for beekeeping as a commercial enterprise.

### Threats

Transportation of honey bees to the festival runs the risk of bees dying. To mitigate costs, festivals may need to incorporate non-apiculture activities thus losing the focus on the apiculture value chain. The management of the festival may also have other preferences or priorities other than apiculture.

## Local availability of the technology/innovation and potential suppliers across Africa

Honey festivals can easily be constituted at the city, town or community levels.

## Climate-smart status of the technology/innovation

Honey festivals provide an opportunity for beekeepers to diversity their incomes and specialize in other aspects of the apiculture value chain that they had not engaged in before.

## Environmentally friendly status of the technology/innovation

Honey festivals have to be planned in an environmentally friendly fashion so that their installation is not detrimental to the environment. This is includes using recyclable or biodegradable materials when setting up and ensuring that there is a waste collection and recycling strategy in place before the event begins.

## Suggestions for improvement of the technology/innovation

The innovation can be improved through networking with the tourism sector to incorporate honey tours into existing programmes.

## Strategies that can be adopted by national governments to promote the uptake of honey festivals

National governments can promote this innovation by developing strategies to network with industries that would support honey festivals.

# 6



# Digital Innovations and Technologies transforming the Livestock Value Chain in Africa

# Mobile-based last-mile logistic platforms

## Primary use of the technology/innovation

This technology allows for the delivery of services to remote communities. These services may include feed, vaccines, and day- to-day products needed at the local farm level. Examples of this technology include:

**Cowtribe** (https://www.cowtribe.com/)

This mobile application has two main products:

- **Zhulia**: This is a product that supports small agrovet owners and allows them to manage their inventory, sales and orders.
- **Vaccine delivery:** this seeks to support small-scale farmers including women to access vaccines for their livestock. Doing this will transform the vaccine value chain with direct and positive impacts on livestock.




Cowtribe

*Last mile mobile platform*

## SWOT analysis of the technology/innovation

### Strengths

The use of the last mile platform is cheap, and it can be scaled up easily. It provides a rapid mechanism for purchase and sale of goods by delivering direct services between users and sellers where no middle men are involved. It ensures that any customer issues are dealt with directly and rapidly. It offers customers lower prices compared to conventional solutions.

### Weaknesses

The high initial costs of infrastructure development limit the easy penetration of the market with this technology. The falling costs of mobile phones are reducing the costs of this technology. The mobile penetration in the last mile communities may prove challenging. There would be a great need for capacity building of supply chain suppliers. The success of this technology is dependent on existing supply chain infrastructure which may not be in place.

### Opportunities

The rapid development of infrastructure in the last mile communities is opening up regions of Africa that were completely closed off.

### Threats

There are several threats, including the unreliable supply chain infrastructure and the existence of too many copycat competitors. The last mile users may not be knowledgeable on the use of the technology and may need capacity building. The public sector support to provision of this service may be low or non-existent. The demand in the rural, last mile community may be rudimentary or non-existent. The technology set-up is expensive. There may be other supply chains that have more buy-in from the communities. While the infrastructure in rural communities may be getting upgraded and developed, there may be areas where it may be poorly developed.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology is locally available.

## Primary users of the technology/innovation

The primary users of the technology are the veterinary service providers.

## Climate-smart status of the technology/innovation

The last-mile logistic platform is climate smart because it supports the health status of livestock communities in rural areas, thus increasing pastoralists' ability to withstand the adverse climatic effects.

## Environmentally friendly status of the technology/innovation

The last-mile logistic platform has no impact on the environment.

## Suggestions for improvement of the technology/innovation

This technology can be improved by ensuring integration with mobile and other digital platforms.

The uptake of this technology/innovation within Africa can be improved through:

- Developing partnerships with local software manufacturers
- Re-negotiating proprietorship with patent owners to make it possible for local companies to purchase it

### Strategies that can be adopted by national governments to promote the uptake of the last-mile logistic platform

National governments can promote this technology through several strategies including:

- Developing strategic partnerships with telecommunication companies
- Developing partnerships with industry and other stakeholders that will assist in the development, financing, dissemination and use of the technology
- Implementing policies that integrate the last mile service
- Building capacity of rural communities to build trust and confidence
- Providing affordable insurance against the product and content
- Developing strategies that ensure that more farmers, especially those in remote areas receive veterinary services
- Improving adoption of technology among rural communities
- Investing in developing and improving infrastructure in the rural areas

# Digital disease reporting technologies

### Primary use of the technology/innovation

Early disease diagnosis and early warning systems reduce the spread of diseases and allows for early interventions that prevent their spread and high livestock death.

There are several examples of such digital technologies that are in use in Africa, for example, Animal Resources Information System (ARIS).

Enhanced surveillance for livestock diseases serves as an early warning system that can detect disease in animals before spillover to humans (https://doi.org/10.1371/journal.pntd.0006353).

### SWOT analysis of the technology/ innovation

#### Strengths

The digital reporting of diseases provides a rapid mechanism for the detection of disease outbreak. It provides a real time monitoring and evaluation of disease as activies are going on.

#### Weaknesses

The high internet interconnectivity costs may limit the technologies' full utilization in Africa.

#### Opportunities

Digital disease reporting will ensure rapid disease reporting and reduce current costs in reporting.

#### Threats

This technology relies on fast internet connectivity which may be a challenge in remote regions of Africa.

### Local availability of the technology/innovation and potential suppliers across Africa

The technology is locally available.

### Primary users of the technology/innovation

The primary users of the technology are the veterinary service providers.

### Climate-smart status of the technology/innovation

This technology is climate smart because it supports the health status of livestock communities especially in rural areas.

### Environmentally friendly status of the technology/innovation

This technology has no impact on the environment.

## Suggestions for improvement of the technology/innovation

This technology can be improved by ensuring integration with mobile and other digital platforms.

The uptake of this technology/innovation within Africa can be improved through:

- Developing partnerships with local software
- Re-negotiating proprietorship with patent owners to make it possible for local companies to purchase it

## Strategies that can be adopted by national governments to promote the uptake of digital disease-reporting technologies

National governments can promote this technology through several strategies including:

- Investing in developing and improving infrastructure in the rural areas
- Developing strategic partnerships with telecommunication companies
- Developing partnership with industry and other stakeholders that will assist in the development, financing, dissemination and use of the technology
- Implementing policies that integrate the Last Mile service
- Developing strategies that ensure that more farmers, especially those in remote areas receive veterinary services

# Digital and mobile platforms

With more than 650 mobile phone subscribers in Africa, the transformative potential of the mobile phone in the livestock sector cannot be underestimated.

### Primary use of the technology/innovation

These are digital mobile phone tools that farmers use to access information and advice on a wide range of farming and livestock production issues.

There are several examples of such digital technologies that are in use in Africa, for example:

I. **iCow** (https://icow.co.ke/) is the first mobile application that has a calendar which enables farmers to keep track of their herds' gestation so that they do not miss a breeding opportunity. Other features available include:

- A farmer library that allows a farmer to access a wide range of information
- Smart tools to help a farmer determine his soil type and the best type of seeds to use
- Mashauri (advice), a service that sends production information to farmers

II. **Jaguza (https://jaguzafarm.com/)**

This is a mobile phone application that assists farmers in the proper management of their herds. It uses artificial intelligence (AI) to solve challenges farmers faces including disease diagnosis, providing market, farming methods, livestock monitoring, social security and reporting.

III. **Cowtribe (https://www.cowtribe.com)** is a mobile application with two features, Zhulia and a vaccine delivery system. Zhulia is an ERP system customized to support rural agrovets to manage their stock. The other Cowtribe application enables the seamless delivery of vaccines to rural communities in Ghana.




iCow

*Digital mobile phone tools used in accessing information and advice on farming and livestock production*

## SWOT analysis of the technology/innovation

### Strengths

The mobile phone applications allow farmers to access market information, thus enabling them to make decisions on whether they need to travel to the market to sell their livestock or not.

### Weaknesses

The high initial costs of infrastructure development limit the easy penetration of the market with this technology. The falling costs of mobile phones are consequently reducing the costs of this technology. The mobile penetration in the last mile communities may prove challenging. There would be a great need for capacity building of supply chain suppliers. The success of this technology is dependent on existing supply chain infrastructure which may not be in place.

### Opportunities

The rapid development of infrastructure in the last mile communities is opening up regions of Africa that were completely closed off.

### Threats

There are several threats, including the unreliable supply chain infrastructure, and the existences of too many copycat competitors. The last mile users may not be knowledgeable on the use of the technology and may need capacity building. The public sector support to provision of this service may be low or non-existent. The demand in the rural, last mile community may be rudimentary or non-existent. The technology set up is expensive. There may be other supply chains that are in existence that have more buy-in from the communities. While the infrastructure in rural communities may be getting upgraded and developed, there may be areas where it may be poorly developed.

## Local availability of the technology/innovation and potential suppliers across Africa

The technology is locally available.

## Primary users of the technology/innovation

The primary users of the technology are the veterinary service providers, agrovet owners and last mile communities.

## Climate-smart status of the technology/innovation

The last-mile logistic platform is climate smart because it supports the health status of livestock communities in rural areas, thus increasing pastoralists' ability to withstand the adverse climatic effects

## Environmentally friendly status of the technology/innovation

The last-mile logistic platform has no impact on the environment.

## Suggestions for improvement of the technology/innovation

This technology can be improved by:

- Ensuring integration with mobile and other digital platforms
- Developing partnerships with local software
- Re-negotiating proprietorship with patent owners to make it possible for local companies to purchase it

## Strategies that can be adopted by national governments to promote the uptake of digital mobile phone tools

The technology can be improved through several strategies including:

- Developing strategic partnerships with telecommunication companies
- Developing partnership with industry and other stakeholders that will assist in the development, financing, dissemination and use of the technology
- Implementing policies that integrate last mile service
- Capacity building of rural communities to build trust and confidence
- Providing affordable insurance against the product and content
- Developing strategies that ensure that more farmers, especially those in remote areas are receiving veterinary services
- Improving adoption of technology among rural communities
- Investing in developing and improving infrastructure in the rural area

# 7 Appendix

## List of Contributors


**Abdifatah Omar Esack**
Ministry of Livestock for Jubaland State Somalia
Kismayo, Somalia

**Abdou Sani Boukari**
Agropast-consult
Niamey, Niger

**Abdul Rahman Sesay**
Njala University
Freetown, Sierra Leone

**Abdulmojeed Yakubu**
Nasarawa State University, Keffi
Lafia, Nigeria

**Adam Kade Malam Gadjimi**
Ministère de L'Agriculture et de L'Elevage
Niamey, Niger

**Adoungotchodo Libérale Mahinléo**
AYL-FAIN
Bénin; Abomey-Calavi

**Alenayehu H.Mariam**
Veterinarian and Programme Development and Quality Assurance Head
Brooke, Ethiopia

**Anondraka Michel**
Direction Générale de l'Elevage
Antananarivo, Madagascar

**Ayagirwe Basengere Rodrigue**
Université Evangélique en Afrique
Republique Democratique du Congo/ Bukavu

**Baba Adongo**
Executive Director
Footprints Bridge International
Accra, Ghana

**Ben Ameur Hatem Abdeljawed**
Ministère de L'Agriculture de la Pêche et des Ressources Hydrauliques
Cite Olympique, Tunisie/Tunis

**Beth A. Miller**
International Goat Association
Little Rock, AR USA

**Biryomumaisho Dickson**
The Uganda National Apiculture Development Organisation (TUNADO)
Kampala, Uganda

**Biuma Ilunga Rosalie**
Fédération des Paysans Producteurs Agricoles de Kinshasa
Confédération Nationale des Producteurs Agricoles du Congo RD Congo, Kinshasa

**Bogoria Tsetse Traps**
Kenya

**Bosco Okello**
Apitrade Africa
Uganda

**Butoyi Melchior**
Centre National d'Insémination Artificielle et d'Amélioration Génétique
Bujumbura, Burundi

**Caren's Poultry Farm**
Eldoret, Kenya

**Cecilia Rague-Kaisha**
Underwriting Africa Limited
Nairobi, Kenya

**Charity Kruger**
Executive Director
Center for Environment Agricultural Research and Advocacy
Gaborone, Botswana

**Charles Lagu**
Executive Director
National Animal Genetic Resources Centre and Data Bank
Kampala, Uganda

**Christian Keambou Tiambo**
Centre for Tropical Livestock Genetics and Health (Cameroon – Buea)
International Livestock Research Institute (Nairobi, Kenya)

**Christian Nawej Kabongo**
Forest Fruits Ltd
Lusaka, Zambia

**Cleopas Gathara Wahome**
Dorper Sheep Breeders Society of Kenya
Naivasha, Kenya

**Cleopas Okore**
Ministry of Agriculture, Livestock, Fisheries and Cooperatives
Nairobi, Kenya

**Dacko Okologna Shelly Anne Marie**
AYL-Fain (ONG femme forêt et développement)
Bangui, République Centrafricaine

**Dairy Training Institute**
Naivasha, Kenya

**Daisy Nheta - Manungo**
Women Embracing Change in Agriculture - Namibia
Rundu, Namibia

**Damiao Nguluve**
Institute of Agricultural Research
Matola, Mozambique

**David Kihurani**
University of Nairobi
Nairobi, Kenya

**Deidré A Januarie**
Chief Agricultural Scientific Officer
Directorate of Agricultural Research & Development
Ministry of Agriculture, Water & Land Reform
Windhoek, Namibia

**Dennis Jacoyange**
Board Member
Kakamega Dairy Cooperative Society
Nairobi, Kenya

**Derradji HAREK**
Institut National de la recherche Agronomique D'Algerie (INRAA)
Algiers, Algeria

**DGAK**
Nyeri, Kenya

**Diakité Aminata**
FENAJER
Bamako, Mali

**Diallo Aboubacry**
ASDEN
Podor Saint Louis, Nguendar, Sénégal

**Diallo Boubacar**
Consultant/ Chercheur
Conakry, Guinée

**Donald Rugira Kugonza**
Makerere University
Uganda

**DVS – Kabete**
Kenya

**Eddington Gororo**
Chinhoyi University of Technology
Chinhoyi, Zimbabwe

**Edward Nengomasha**
Animal Production Expert
AU-IBAR

**Egerton University**
Njoro, Eldoret, Kenya

**Ellison Musimuko**
Principal Livestock Production Officer
Ministry of Fisheries and Livestock &
PhD Student at The University of Zambia
Lusaka, Zambia

**Erastus Kyalo**
Technical Lead Kenya Livestock Market Systems
ACDI VOCA
Nairobi, Kenya

**Evelyn Khamala**
LocateIT Ltd
Nairobi, Kenya

**Faith Nyamakwere**
Stellenbosch University
Cape Town, South Africa

**Faith Owuor**
Farm Africa
Nairobi, Kenya

**Fiona Fliintan**
International Livestock Research Institute & International Fund for Agricultural Development
Rome, Italy

**Felicien Shumbusho**
Rwanda Agriculture & Animal Resources Development Board
Rwanda

**Gerald Terence Monthy**
Senior Agriculture Scientist
Seychelles Agricultural Agency
Government of Seychelles
Seychelles Island, Indian Ocean

**Gibbeh Bah Gambia**
Beekeeping
Banjul, Gambia

**Gireshsingh Mungla**
University of Mauritius
Mauritius

**Godson Aryee Zagbede**
Council for Scientific and Industrial Research, Animal Research Institute
Accra, Ghana

**Hadera Gebru**
Freelance Consultant
Livestock Development and Natural Resource Management
Addis Ababa, Ethiopia

**Haifa El-Hentati**
Banque Nationale de Gènes de Tunisie
Tunisie

**Halima Abubakar Saeed**
Confederation of Traditional Stockbreeders Organizations (CORET)
Kaduna, Nigeria

**Hassan Ally Mruttu**
National Coordinator for Management of Animal Genetic Resources
Ministry of Livestock & Fisheries
Dodoma,Tanzania

**Helen Mbabazi**
AgriBusiness Development Advisor
AVSI Foundation
Kampala, Uganda

**Hifadhi Cooperative**
Ndabibi, Kenya

**ICIPE – Kasarani**
Nairobi, Kenya

**Innocent Nkangala**
Deputy Director Livestock Development
Dept. of Animal Health and Livestock Development
Malawi

**Jacqueline Gowe**
Zimbabwe Apiculture Platform
Zimbabwe

**Jean Baptiste Hategekimana**
African Youth in Livestock,
Fisheries & Aquaculture Incubation
Network
Kigali, Rwanda

**Jonas Kizima**
Tanzania Livestock Research Institute
Dodoma, Tanzania

**KAGRC – Kabete**
Kenya

**Kahsay Negash Ghebreegziabher**
Ministry of Agriculture
Asmara, Eritrea

**KALRO – Bachuma**
Kwale County, Kenya

**KALRO – Kiboko**
Makueni, Kenya

**KALRO - Muguga**
Kenya

**Keitometsi Ncube**
Head of Sales
Morui Ranching
Bulawayo, Zimbabwe

**Kemboi's Farm - Kuinet**
Eldoret, Kenya

**Kennedy Wanyonyi Barasa**
State Department for Livestock
Directorate of Livestock Production
National Livestock Recording Centre
Naivasha, Kenya

**Kennedy Dzama**
Professor
University of Stellenbosch
Stellenbosch, Cape Town, South Africa

**Khaled Fantazi**
Institut National de la recherche
Agronomique D'Algerie (INRAA)
Algiers, Algeria

**Kouakou Konan Ernest**
Direction de L'Aquaculture et des pêches
Abidjan, Côte D'Ivoire

**Kourouma Fassou**
Groupement des Éleveurs de Guinée
Dixinn, Conakry
République de Guinée

**Kourouma Fassou**
AYL-FAIN Guinée
Conakry, République de Guinée

**Kuku Chick**
Eldoret, Kenya

**Lenana Bee Keeping Institute**
Kenya

**Lestina Nhlema**
Managing Director
Northern Honey Processors
Mzuzu, Malawi

**Lower Eastern Dairy Cooperative Alliance (LEDCA)**
Kenya

**Machakos Agricultural Training Centre**
Kenya

**Maili Saba**
Nakuru, Kenya

**Maria da Glória Taela**
Agraria Research Institute of Mozambique
Maputo, Mozambique

**Mary Sitina Yapete Arionje**
National Ministry of Livestock and
Fisheries
Juba City, Republic of South Sudan

**Mathira West RLRC**
Karatina, Kenya

**Mavis Nduchwa**
CEO, Kalahari Honey
Gaborone, Botswana

**Mboumba Sylvere**
Université des Sciences et Techniques de Masuku
Franceville, Gabon

**Mogotio Poultry Keepers**
Baringo, Kenya

**Ministry of Agriculture and Livestock**
Development - Naivasha farm
Naivasha, Kenya

**Mr. & Mrs. Edward Mugambi**
Njoro, Kenya

**Mr. Kihangi's Farm**
Kenya

**MRET Farm – Machakos**
Kenya

**Mugurin Pastures Growers**
Baringo, Kenya

**Mweemba Halyoka**
Livestock Production & Extension Officer
Ministry of Fisheries & Livestock
Livingstone, Zambia

**Naglaa AL Ahmady Ghazala**
Bee Research Department Plant Protection Research Institute
Agriculture Research Centre
Cairo, Egypt

**Nakuru Girls High School**
Nakuru, Kenya

**Nakuru West Poultry,**
Nakuru, Kenya

**Nalini Aubeeluck**
Artifice Ltd.
Mauritius

**Namuswa Chona**
District Marketing Development Officer
Ministry of Agriculture
Livingstone, Zambia

**Negash Bekena**
General Manager for Ethiopian Apiculture Board
AU-IBAR
Apiculture Subsector Development Section
Ethiopia, Addis Ababa

**Nereus Poultry Ltd.**
Mwala, Kenya

**N'FEIDE Toï**
Ministère de l'Agriculture de la Production Animale et Halieutique (MAPAH)
Institut Togolais de Recherche Agronomique (ITRA)
Lomé, Agbodrafo, Togo

**Nkhensani Valoyi**
Network of African Youth for Development
Africa Agribusiness incubators Network-SA, UpRoot Afrika
Pretoria, South Africa

**Nyeri Town Milk Dispenser**
Kenya

**Obvious Mapiye**
PhD Candidate
Stellenbosch University
Cape Town, South Africa

**ONDO-AZI Alain Serges**
Pôle Régional de Recherche Appliquée au développement des Systèmes Agricoles d'Afrique Centrale (PRASAC)
N'Djamena, TCHAD

**Olpejeta Conservancy**
Nanyuki, Kenya

**Oluwole Abiola**
Business Operations Manager
my-Cedars Agric Services Ventures
Abeokuta, Nigeria

**Patricia Mayuni**
Ministry of Agriculture & Food Security
Lilongwe, Malawi

**Paul Atsu**
Digital Innovation, Communication & Youth Development Programme Lead
Footprints Bridge International (F-BRIDGE) and African Youth in Livestock, Fisheries & Aquaculture Incubation Network (AYL-FAIN)
Ghana

**Paul Egesa Egang'a**
Kenya Animal Genetic Resources Centre
Nairobi, Kenya

**Peter Lincoln Kariuki**
Farm Manager
Gachagua Enterprises
Embu, Kenya

**Philip Justib**
Ministry of Livestock & Fisheries
South Sudan

**Pipeline**
Nakuru, Kenya

**Ratiarainandrasana Virginie Gorette**
RENAFEP MADA
African Women Fish Processors & Trade Network, Madagascar (AWFISHNET MADA)
Madagascar

**Reithabetse Makoa**
Mapoteng Dairy
Lesotho

**Richard Osei-Amponsah**
Senior Lecturer
Animal Breeding & Genetics
University of Ghana
Accra, Ghana

**Robyn Alders**
Senior Consulting Fellow
Centre for Universal Health
Chatham House & Kyeema Foundation
Brisbane, Australia

**Roland PARTU Varkpeh**
Ministry of Agriculture
Monrovia, Liberia

**Rukaiyah Lawal Gwamna /Ag MD**
Milcopal, Coret
Kaduna, Nigeria

**Rupsha R Banerjee**
Scientist, Institutions and Innovation
International Livestock Research Institute
Nairobi, Kenya

**Samir Alsheikh**
Desert Research Centre
Cairo, Egypt

**Sibonginkosi Bachobeli**
Ministry of Agriculture
Francistown, Botswana

**Solomon Abegaz Kebede**
Ethiopian Institute of Agricultural Research
Ethiopia

**Sonia Bedhiaf-Romdhani, Prof and**
Continental President of AWARFA-N
INRA-Tunisia
Tunisia, Tunis

**Sospeter Onchoke Nyamwaro**
Agricultural Economist
Kenya Agricultural & Livestock Research Organization
Kenya

**Tebug Thomas Tumasang**
Tugi Livestock Farmers Organization
Mbengwi Cameroon
Dschang, Cameroon

**Tesfalem Aseged Ayele**
Assistant Researcher
Ethiopian Biodiversity Institute
Addis Ababa, Ethiopia

**Thandi Nhlengethwam**
Executive Director
The AIDS Information and Support Centre
Manzini, Eswatiini

**The Beehive**
Nairobi, Kenya

**The Hive Kenya Limited, Mombasa Road**
Nairobi, Kenya

**Thiam Fatoumata**
AFAO Mali
Bamako, Mali

**Timothy Gondwe**
Lilongwe University of
Agriculture & Natural Resources
Malawi

**Utlwanang Moreri**
Ministry of Agricultural
Development & Food Security
Agricultural Research Officer
Gaborone, Botswana

**Victoria Norgbey**
National President
AWARFA-N
Accra, Ghana

**Willen's Dairy Farm**
Eldoret, Kenya

**Yonas Hayle Hagos**
Ministry of Agriculture
Asmara, Eritrea

**Younga Ouedraogo Alix Gladys R W**
REJEPE
Ouagadougou, Burkina Faso

**Willington Bessong Ojong**
Caeperfarming cooperative
Cameroon

AFRICAN UNION
INTERAFRICAN BUREAU
FOR ANIMAL RESOURCES

EUROPEAN UNION



African Union
Inter-African Bureau
for Animal Resources
(AU-IBAR)
Kenindia Business Park
Museum Hill, Westlands Road
P.O. Box 30786
00100, Nairobi, KENYA

Telephone: +254 (20) 3674 000 / 201
Fax: +254 (20) 3674 341 / 342
Email: ibar.office@au-ibar.org

www.au.ibar.org

9 789966 077448