An ISO 17025 accredited mobile laboratory for food safety testing for the agro and food sectors using next generation technologies – Proof of Concept and prototype design

FEASIBILITY REPORT

EXECUTIVE SUMMARY

The reported study was based on investigating the feasibility, potential impact, and economic viability of implementing a mobile ISO 17025 accredited food safety testing laboratory project in the SADC region along their food value chains, with an initial focus on 4 SADC countries namely South Africa, Namibia, Eswatini and Lesotho. Phase 1 of the project was funded through a Project Preparation Grant (PPG) awarded through the Standards and Trade Development Facility (STDF) which is based at the World Trade Organization (WTO).

The socioeconomic feasibility of the project was assessed. Stakeholder workshops and dialogues were hosted in Lesotho, Eswatini and Namibia to identify the need, or specific analysis requirements for mobile food safety testing in the SADC region. Strategic partnerships were established in hosting the workshops and consisted of co-host organizations, Lesotho Department of Agriculture (Lesotho), the Royal Science and Technology Park (Eswatini), and the Namibian Agronomic Board (Namibia). The need for an ISO 17025 accredited mobile laboratory for food safety testing in Lesotho, Eswatini and Namibia was established, in all the agricultural sectors that were in attendance. Commercial farming and food processor representatives in all three countries indicated that they are willing to pay for services offered by the mobile lab, granted that the services offered have a faster turnaround time than stationary food testing laboratories they are currently using, and the mobile services provide the same level of certification of their products. SMMEs and universities also highlighted the need for educating the public, small-scale famers, and small-scale food processors on the importance of food safety, possibly using the mobile laboratory for food safety awareness. Government institutions indicated they were open to negotiations of paying for services, provided they were in alignment with their mandates and the lab acted as support structure or extension of their existing food testing laboratories.

The market feasibility of the project was assessed, based on the stakeholder needs and challenges identified through engagement with the assessed countries. The project has competitive advantages and is commercially feasible. From a technical standpoint, the instruments required, and their specification based on food safety testing methods identified, the testing capacity and throughput was also established. Two mobile lab vehicle models were designed by the CSIR including a constructed 3D model. Based on the identified technologies and systems, the project should be technically feasible. The project organization and management requirements were also assessed based on the South African National Accreditation System (SANAS) and the Southern African Development Community Accreditation Services (SADCAS) accreditation requirements. The project organizational management structure outlining roles, responsibilities, and reporting relationships within the project were also defined. The project start-up capital requirements and financial feasibility of the project was assessed using three financial models and the findings reported on.

According to the analysis, the project would require a start-up capital investment of approximately 535 813 USD over a minimum period of one year. The project would be profitable if the start-up capital is acquired through an external funding grant and the mobile lab operates at its maximum capacity and testing throughput. If the project does not acquire an external funding grant, the project would not be financially feasible throughout its life cycle as the net present value is negative for both 5- and 10-year timelines.

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NOMENCLATURE

AOAC	Association of Official Agricultural Chemists
CAGR	Compound annual growth rate
CSIR	Council for Scientific and Industrial Research
FAO	Food and Agriculture Organization
GC-MS	Gas chromatography–mass spectrometry
HPLC	High-performance liquid chromatography
ISO	International Organization for Standardization
LC-MS/MS	Liquid chromatography–mass spectrometry/mass spectrometry
LIMS	Laboratory information management system
MS	Management Signatory
MRL	Maximum residue level
NR	Nominated Representative
NPV	Net present value of cash flow
PPG	Project Preparation Grant
QuEChERS	Quick, Easy, Cheap, Effective, Rugged and Safe
SADC	Southern African Development Community
SADCAS	Southern African Development Community Accreditation Services
SANAS	South African National Accreditation System
SDG	Sustainable Development Goal
SMME	Small, Micro, and Medium Enterprise
STDF	Standards and Trade Development Facility Trust Fund
SWOT	Strengths, weaknesses, opportunities, and threats
TEA	Techno-economic analysis
TS	Technical Signatory
TVC	Total viable count
USD	United Sates Dollar
WTO	World Trade Organization

1 INTRODUCTION AND BACKGROUND

1.1 Background

The Food and Agriculture Organization (FAO) has re-iterated that food safety is a shared responsibility.[1] The Covid-19 pandemic placed a spotlight on food security, food safety and on the importance of adapting food safety systems to respond to supply chain disruptions; and ensuring the continued access to safe food. Growing concerns among consumers on the safety of processed food due to the outbreak of Covid-19 caused an increase in the demand for the security and safety of food products, thus driving the food safety testing industry growth. However, this may not be the case in Southern African Development Community (SADC) countries where the priority is access to food, regardless of whether it's safe or not, particularly through informal markets and rural economies where food safety testing is not easily accessible. Analytical issues also vary across the different food supply systems in developing countries. Other factors that exacerbate African problems include constraints in resources and infrastructure, a lack of adequate regulatory and control systems for monitoring contamination, and limited availability of food due to war, famine, and other natural disasters.

As food trade expands throughout the world, food safety challenges in developed countries and developing countries have become a shared concern as different opportunities and threats from food safety risks emerge, and controls introduced to contain them.[2] Countries are being tempted to use food safety regulations as a means of protecting domestic industries from foreign competition. These features of food safety regulation - particularly in developed countries - have several implications for developing countries. The most important of these is the issue of access to growing markets for food exports, particularly high-value fresh commodities. Food security for all is a cornerstone of the United Nations 2030 Agenda, which recognizes that global sustainable development can only be achieved if hunger and all forms of malnutrition are eradicated.[3] Safe food also contributes to economic prosperity, boosting agriculture, market access, tourism, and sustainable development.

To address some of the challenges associated with food safety testing at ports of entry, and in remote areas, the Council for Scientific and Industrial Research proposed the use of an ISO 17025 accredited mobile laboratory for food safety testing for the agriculture and food sectors using next generation technologies. A Project Preparation Grant (PPG) was awarded through the Standards and Trade Development Facility (STDF) which is based at the World Trade Organization (WTO) for phase 1 of the project, which looked at conducting a feasibility study to assess the potential impact and economic viability of having a mobile ISO 17025 accredited food safety testing laboratory in SADC countries along their food value chains, with an initial focus on South Africa, Namibia, Eswatini and Lesotho.

1.2 Problem statement

Safety issues influence consumer perceptions and policies with respect to food production, processing, handling, and trade. However, with the quest by developing countries for a larger share of the global food trade and the desire to earn the necessary income for development, attention is now being paid to food safety issues. Food safety is an issue of growing importance due to several world-wide trends that contribute to increasing safety risks in food systems, such as the growing movement of people across borders; increased movement of agricultural and food products across borders; rapid urbanization; changes in food processing and handling practices; and the re-emergence/emergence of diseases, pathogens, toxins, and other issues. Emphasis is now being placed on the ability of all stakeholders in the food chain to be able to demonstrate adequate traceability of all food sources. Issues relating to food safety will therefore impact on agricultural production, agro-processing, food service industries, trade and commerce, public health, and overall economic development. The food industry also has a role to play in assuring food quality and safety through the application of quality assurance and risk-based food safety systems utilizing current scientific knowledge. The implementation of such controls throughout production, handling, processing, and marketing will lead to improved food quality and safety, increased competitiveness, and reduction in the cost of production and wastage, which can be addressed using a mobile food safety testing facility.

One area of concern is a lack of enforcement of stringent regulations that are in place such as the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act 54 of 1972) in South Africa. However, currently, laboratories for safety testing for both commercial and Small, Medium and Micro Enterprise (SMME) farmers for residue and pathogen testing are not easily accessible. This has led to increased expenses to courier samples to laboratories from pack houses, ports, central markets, airports, and borders, with the added risk of sample integrity being compromised. It is therefore important that the services delivered are relevant, cost effective and acceptable to import, export and local authorities.

In 2017, the International Labor Organization (ILO) and International Cooperative Alliance Africa (ICA Africa) jointly conducted a rapid assessment on cooperative competitiveness and potential for export and import in the selected SADC countries. Barriers to trade include quality, safety and service standards which are posing big issues for SADC based cooperatives to take advantage of the opportunities. International demand for agricultural products is high, however protocols and host country standards must be adhered to, and the SADC countries currently have low market share in growing international markets.[4] There is therefore a need for strengthening access to intra-Africa markets for local agricultural products. Laboratory accreditation should be attained to ensure analytical test results are internationally recognized. This is expected to strengthen global market access by providing assurance to global trading partners that the country's products meet technical standards for human safety and food quality.

However, African governments often lack the capacity and skills to provide support and regulatory services required throughout the value chain up to the where point food products are ready for export markets. Analytical issues vary across the different food supply systems in developing countries. From this perspective, three situations can be identified. Firstly, there is the export-oriented food value chain, then there is commercial food processing of products marketed in outlets ranging from first world style supermarkets to small scale sellers, and then there is the rural food supply in the form of subsistence farmers or small local markets. The value chain involving export of food commodities which must meet legislated requirements at their destination, mostly relies on private laboratories, preferably accredited to ISO standards. Given the cost of rejections at border controls, the data provided by these laboratories needs to be reliable and controlled by adequate quality assurance methods and to be generated from correct sampling plans. Frequently, these laboratories may not be in the country of origin of the food export due to a limited local market for such services.

1.3 Intent/Rational

Having access to accredited testing laboratories, that may also be considered for statutory testing for export markets, adds value to SMME and commercial farmer products, affording them the opportunity to sell products at a premium to larger markets. These mobile laboratories would also create job opportunities for technicians, food scientists and analytical chemists, providing on-the-ground support across the food value chain for surveillance and monitoring to alert public health facilities to anomalies in testing and potential foodborne disease outbreaks. Food safety testing mobile laboratories have been designed and exist in countries like India, Dubai, and Singapore,[5],[6],[7] and provide on-the-spot testing to minimize the risk of food-borne illnesses, with test results being made available in two days in contrast to the current turnaround time of five working days. There is a need to evaluate the need for cross border services from the identified countries (Lesotho, Eswatini and Namibia) using the mobile food safety testing laboratories as an extension of stationary laboratories and/ or set up of country specific fit for purpose mobile facilities.

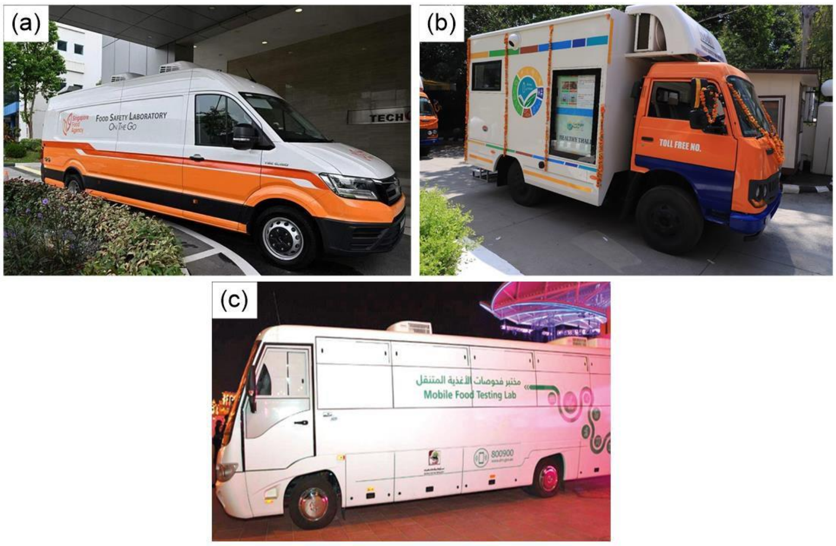

Figure 1.1: Mobile laboratories currently being used in for food safety testing in a) Singapore b) India and c) Dubai.

1.4 Significance

- The project will benefit the agriculture, agro-processing, and food sectors in the SADC region by addressing the need for testing facilities.
- The other benefit is that the project will result in improved safety and quality of agricultural produce and food ingredients. This is because onsite testing will be convenient, more cost effective, and generate results faster. Thus, decisions making will be faster, preventing delays which are normally costly in terms of product market acceptability and accepting or rejecting a consignment coming into or leaving the country.
- The project will also lead to job creation as sectors that were unable to validate the quality of their products because of limited access to accredited labs will now be able to, through on-site testing.

1.5 Approach

The project commenced on consultation with the STDF and then followed with gathering of data. Primary data was gathered through consultation with key stakeholders in the identified SADC countries (e.g. farmers, primary processors, SMMEs, government institutions) to get a better understand of the current state of the food safety testing industry in the region. Consultations included hosting stakeholder workshops, site visits, online meetings, and e-mail correspondence. Secondary data was gathered through internet searches and reviewing of various documents from the food testing industry. The results from the data gathering exercise were consolidated and analyzed in preparation for the feasibility report. The goal was to develop a proposal for phase 2 of the project, which is developing and constructing a customized mobile laboratory prototype. Part of the feasibility study included the production of a 3D printed model of a mobile laboratory (see Figure 5.4) to suit the needs of the specific countries. Having a printed model enabled potential users to understand the benefits and operation of the proposed mobile lab better than a digital model. The 3D model was also useful as a promotional piece as it can be very engaging. The model was designed through incorporating the basic requirements and common needs identified across the three countries.

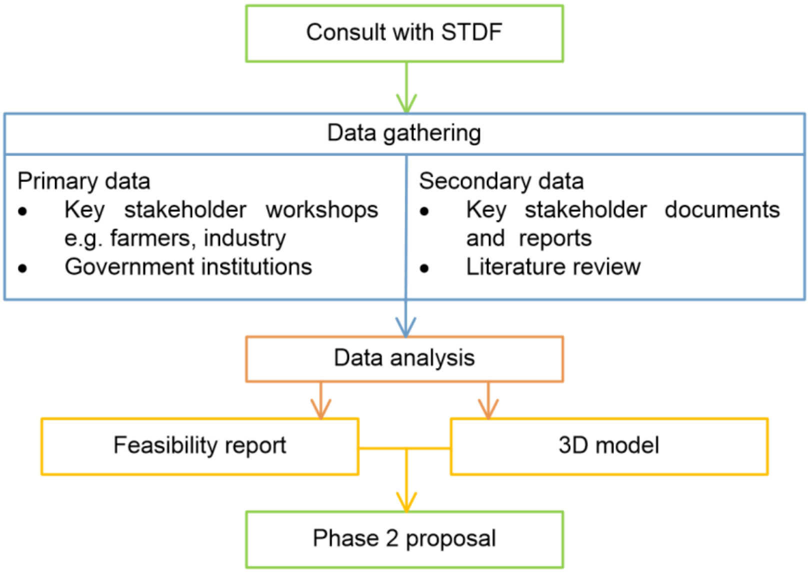

Figure 1.2: Methodology followed for in executing phase 1 of the project.

A project feasibility study is an assessment conducted during the planning phase of a project to determine whether the proposed project is viable, practical, and achievable. It involves evaluating various aspects of the project to understand its potential for success and to identify any potential obstacles or risks. A well-executed feasibility study provides stakeholders with valuable insights into the viability of a project and helps inform decision-making regarding its implementation. In this report, five project feasibility parameters were evaluated as illustrated in Figure 1.3 namely, socioeconomic, market, technical, organizational, and financial feasibility.

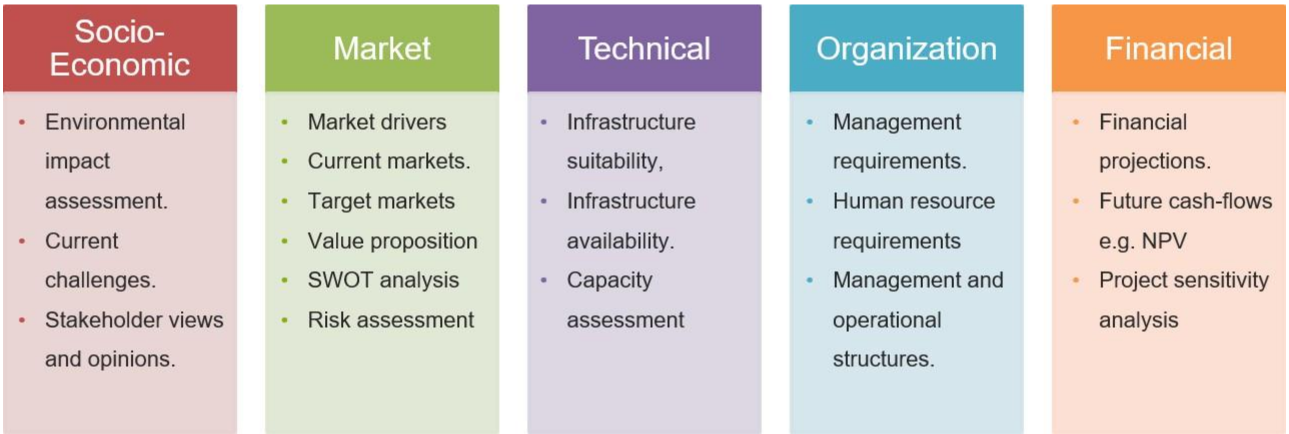

Figure 1.3: Project feasibility parameters evaluated in this feasibility study.

2 SOCIOECONOMIC FEASIBILITY

Socioeconomic feasibility refers to the assessment of whether a proposed project or initiative is viable and beneficial from both social and economic perspectives. This involves analyzing various factors such as the project's impact on society, including its potential to create jobs, improve living standards, enhance social welfare, and promote community development. Social responsibility has become one of the most important aspects of projects and business. Although the primary purpose for any business is to generate profit, the greater scope is its responsibility towards the development of the society and economy. A good business is not only measured based on its final profit but also on its contribution to improving the quality of life and the standard of living of people.

The Sustainable Development Goals (SDGs) are a set of 17 interconnected global goals adopted by the United Nations General Assembly in 2015 as part of the 2030 Agenda for Sustainable Development.[3] The SDGs emphasize the interconnectedness of various issues and the need for integrated approaches to development that address social, economic, and environmental dimensions simultaneously. Achieving the SDGs requires cooperation and collaboration among governments, civil society, the private sector, and other stakeholders at local, national, and global levels. The need to prioritize food safety is also highlighted in the FAO Strategic Framework 2022-2031.[1] Helping to achieve these goals is at the heart of the mobile laboratory project strategy. In ensuring that food is not only nutritious but also safe for consumption in countries with limited food safety testing resources, the project will contribute to the actualization of SDG 2 (End hunger). The project will be contributing to the realization of SDG 3 (Good health and well-being) by providing on-ground support for surveillance and monitoring of potential foodborne disease outbreaks and addressing food safety testing challenges at ports of entry and in remote areas. By providing accredited statutory testing of farmer, food processor and SMME products the project will be proving opportunities for commercial and export market infiltration, promoting trade and economic growth in the region towards the actualization of SDG 1 (No poverty) and SDG 8 (Decent work and economic growth). The project aims to strengthen regulatory, scientific, and technological capacities to ensure that food is safe and of the expected quality throughout the food chain in SADC countries, to move towards more sustainable patterns of food production and consumption in relation to SDC 12 (Responsible consumption and production). The success of the project will be achieved through collaborative efforts with the STDF, CSIR, SADC governments and other stakeholder engagements, in alignments with SDG 17 (Partnership for goals).

Figure 2.1: Food safety in relation to the UN Sustainable Development Goals – 2030.

Stakeholder workshops and dialogues were hosted in Lesotho, Eswatini and Namibia. Strategic partnerships were established in hosting the workshops and consisted of co-host organizations such as the Lesotho Department of Agriculture (Lesotho), the Royal Science and Technology Park (Eswatini), and the Namibian Agronomic Board (Namibia).

The main objectives of the workshops were as follows:

- To have dialogues in Lesotho, Eswatini and Namibia; with country specific agricultural and food industry sectors to identify needs or specific analysis requirements for food testing.
- To engage with farmers, processors, laboratories, policy makers, exporters and retailers identified in the three countries.

2.1 Lesotho stakeholder workshop

Lesotho, officially Kingdom of Lesotho, is in Southern Africa, landlocked, and wholly bordered by South Africa. It is a country, inside another country. Lesotho is situated in the Maluti Mountains and has some of the highest mountain peaks in Southern Africa. It covers an area of 30 000 km^2 and has a population of approximately 2 million people. Lesotho has a cool climate due to its elevation. The economy of Lesotho is based on agriculture, livestock, mining, and manufacturing. There is also dependence on remittance from migrant labor in the region, especially in South Africa. Most of the household practice in subsistence farming. Lesotho's primary food crops are maize, beans, wheat, sorghum, and peas. The currency is the Loti and is used interchangeably with the South African Rand.[8]

The project stakeholder workshop in Lesotho was held from the 21- 22 of February 2023, at the Victory Hall, Maseru, Lesotho. Workshop attendees included (see Figure 2.2) stakeholders from the Lesotho Department of Agricultural Research, Department of Crop, NUL-Environmental Health, Ministry of Agriculture and Food Security-Livestock, Ministry of Health, Ministry of Trade and Industry, Cooperatives and Marketing, Lesotho National Dairy Board, Lesotho Food Management Units, Maluti Fresh Produce Market, Likhothola & Likhetlane Fruits Farm and Lesotho Fishery Association, to name a few.

Figure 2.2: The Stakeholder Workshop/Dialogue on Mobile Labs for Food Testing in Lesotho was held from the 21- 22 of February 2023, at the Victory Hall, Maseru.

2.1.1 Challenges identified along the Lesotho food safety testing value chain.

The current challenges identified in the food testing value chains can be summarized as follows:

1. No food quality grading systems are in place for commercial purposes or exporting.
2. There is a great demand for capacity building. Limited expertise in food safety testing, due to shortage of trained experts and institutional training e.g., university, accredited laboratories.
3. There is inadequate and unregulated labelling of food products.
4. There are no accredited food laboratories, forcing reliance on South Africa.
5. There is no association/committee in place that brings together all food and agricultural sectors.
6. There is a need for a centralized regulatory/accreditation organization to instill food safety compliance of farmers, food processors and commercial retailers.

The specific challenges per sector are detailed as follows:

- **Water sector and fisheries**

1. Heavy metal leaching and waste process water dumping from industry is not being regulated and affects soil and water quality.
2. Poor fish feed quality led to a loss of 40 million Lesotho Lotis (LSL) in export to Japan.
3. Metal contamination from industry/mines affecting fish health and quality.
4. Poor oxygen quality in fisheries/water bodies sometimes leads to the suffocation of fish.
5. No traceability when there is disease outbreak due to water quality, and the Ministry of Health only intervenes when someone is reported ill.

- **Crops and vegetation sector**

1. The Department of Agricultural Research which is based in Maseru, has limited infrastructure and testing capacity. They are currently focused on testing of products coming into Lesotho. Even then, they are unable to test all products being imported due to limited manpower, product sampling and transportation.
2. Food and grains are imported from South Africa and neighboring counties and stored for extended periods of time without testing by the Food Management Unit (FMU) of Lesotho, where the consensus is that food from South Africa can simply be deemed as safe for consumption.
3. There is no QMS (quality management systems) in place for warehouses or storage of imported food items for public consumption e.g., maize. Mold and weevil contamination in storage warehouses has been reported to the government by the FMU.

4. Fumigators are sometimes used; however, the fumigation companies are appointed by the Department of Trade and Industry, they are not accredited or regulated, and they do not report or provide records of fumigation chemicals they use.
5. Farmers and primary processors are not adhering to the grain fortification requirement of grains supplied to school children through the Lesotho government school feeding program.

- **Livestock**

1. There currently aren't enough labs to cover food safety testing along the livestock and poultry value chain.
2. The are numerous incidents reported of hospitalization of civilians due to consumption of untested meat products.
3. There are no traceability systems in place along the livestock and poultry food safety testing value chain. Limited support from government for providing testing facilities.
4. Basic unaccredited testing is done by MAFS-Livestock and NUL.
5. Government provides more support of testing in crops and vegetation due to export and trade of these sector with neighboring countries.

- Farmers and Exporters

1. There is no grading system in place to establish the quality of their produce (e.g., apples, plums, peaches), which puts them at a disadvantage as the importing country (e.g., South Africa) decides the grade and subsequent price of their produce.
2. Those who can afford testing send the fruits and vegetables they produce to South Africa for safety/quality testing and certification, before export, leading to delayed results.
3. No accredited commercial laboratories are available for testing of fruit and vegetables in Lesotho, and the laboratories that can do the testing e.g., NUL- Environmental Health are in Maseru and not easily accessible to SMME exporting farmers.

2.1.2 Challenges identified in Lesotho policies and legislation

The following were identified as challenges in Lesotho Policies and Legislation on Food Safety:

1. Lesotho food safety responsibilities lie within multiple ministries/agencies.
2. Different government policies sometimes over-lap and clash.
3. Outdated legislation, fragmented and not always aligned with regional and international trends.
4. There is a need for an accredited food regulation institution and to improve the inspection systems.
5. Limited infrastructure capacity to perform inspection activities effectively.

6. Quality control and quality assurance of foods are very limited.
7. The institutional arrangements need to be updated.

2.2 Eswatini stakeholder workshop

Eswatini, officially known as Kingdom of Eswatini, was formerly known as Swaziland, but was renamed in 2018. Eswatini is a small landlocked country in southern Africa, and is bordered by Mozambique to its northeast, and South Africa to its north, west, south, and southeast. The population of Eswatini is estimated at 1.16 million people. The climate and topography in Eswatini are diverse ranging from cool and mountainous highveld to a hot and dry lowveld. The main local or African trading partner of Eswatini is South Africa, and to ensure economic stability, the Eswatini currency, Emalangeni is pegged against the South African Rand (1:1). The overseas trading partners are mainly United States and European Union. Eswatini main exports are sugar, wood pulp, cotton, beef, and soft drink concentrates. The main food crops in Eswatini include maize, legumes, tubers, sorghum, and horticultural crops. [9]

The project stakeholder workshop in Eswatini was held from the 28 to 29 March 2023, at the Happy Valley Conference Venue, Ezulwini, Eswatini. Workshop attendees included (see Figure 2.3) stakeholders from the Ministry of Health, Environmental Health Department, Royal Science and Technology Park, Swaziland National Nutritional Council, Eswatini Water and Agricultural Development, Food and Agricultural Organization (FAO), National Agricultural Marketing Board, National Maize Cooperation, Eswatini Farmers Association, Eswatini Sugar Association and SMME's Black Mamba, Women farmer, Eswatini kitchen, Bantwana Initiative, Matsapha Local Municipality to name a few.

Figure 2.3: The Stakeholder Workshop/Dialogue on Mobile Labs for Food Testing in Eswatini was held from the 28 - 29 of March 2023, at the Happy Valley Conference Venue, Ezulwini.

2.2.1 Challenges identified along the Eswatini food safety testing value chain.

The challenges discussed during the stakeholder workshop can be listed as follows:

1. There aren't sufficient food testing laboratories.
2. There are no reference testing facilities available.
3. There is no nutritional content testing being done in the country.
4. There is no shelf-life testing being done on locally manufactured food products.
5. There is inadequate and unregulated labelling of food products.
6. The country does not have accredited food chemistry testing laboratories in the country.
7. The is no accredited food microbiology testing laboratories in the country., except for a few parameters in water.
8. Food products from main commercial sectors (sugar milling, food canning plant) are being sent to South Africa for accredited testing and certification.
9. A forum or synergy is needed between various food and agriculture stakeholders (commercial food processors, retailers, government ministries, and SMMEs).

10. Continuous needs-based training is required.
11. Implementation and maintenance of the food safety quality management system is required.
12. There's limited operational budgets for exiting laboratories.
13. Eswatini Standards Authority (SWASA) standards are not aligned with international standards.
14. No high-tech laboratory equipment is available to provide testing at regional and international standards.
15. Food products are being imported into Eswatini from South Africa without any sampling for testing and traceability records. Only visual inspections are conducted.

2.2.2 Challenges in food monitoring for law enforcement purposes.

1. Outdated legislation that is fragmented and not always aligned with regional and international trends.
2. Inadequate number of accredited food laboratories.
3. Few independent food laboratories.
4. Limited testing scope.
5. Poor handling of samples by customers and retailers.
6. Products without batch numbers or traceability.

2.3 Namibia stakeholder workshop

Namibia, officially known as Republic of Namibia, is in Southern Africa and bordered in the west by the Atlantic Ocean, and shares land borders with Zambia and Angola to the north, Botswana to the east and South Africa to the south and east. The country occupies 825 615 km^2. The population of Namibia is estimated at 2.55 million people and is one of the most least densely populated countries of the world. The capital is Windhoek. The economy is based on agriculture, tourism, and mining industry. The major food crops of Namibia are maize, sorghum, and millet. Beef accounts for the largest livestock export. Namibia also produces horticultural produce, which include vegetable produce such as tomatoes, onions, carrots, and grapes, amongst others. There are mainly two types of farming systems in Namibia, commercial farming, and subsistence farming.[10]

The project stakeholder workshop in Namibia was held from the 29 - 30 of June 2023, at the Thuringerhof Hotel, Windhoek, Namibia. Workshop attendees included (see Figure 2.4) stakeholders from government institutions such as Namibian Agronomic Board, Ministry of Health and Social Services, Office of the Prime Minister, trade forums such as Namibia Trade Forum, private sector representatives such as, Namibian Association of Traders in Fresh Produce, National Association of Horticulture Producers, Agricultural bank of Namibia, SMME's such as, Daures Green

Village, Earthly Delights, and academic institutions such as the University of Namibia and Namibia University of Science to name a few.

Figure 2.4: The Stakeholder Workshop/Dialogue on Mobile Labs for Food Testing in Namibia was held from the 29 - 30 of June 2023, at the Thuringerhof Hotel, Windhoek.

2.3.1 Challenges identified along the Namibian food safety testing value chain.

The current challenges that were identified in the food safety testing value chain in Namibia can be listed as follows:

1. There is no food quality grading system in place for commercial purposes or exporting.
2. There is a great demand for capacity building. Limited expertise in food safety testing, due to shortage of trained experts and institutional training e.g., university, accredited laboratories.
3. Inadequate and unregulated labelling of food products.
4. Limited accredited laboratories.
5. No association/committee in place that brings together all food and agricultural sectors.
6. There is a need for a centralized regulatory/accreditation organization to instill compliance of farmers, food processors and commercial retailers.

The challenges per sector are detailed as follows:

- **Food Safety Testing Sector (mostly government):**

1. Lack of laboratory capabilities to offer testing services at the time they are required by the regulator, resulting in delays or partial implementation of regulations.
2. Limited collaboration between laboratories and regulators to broaden the testing scopes.
3. The technical capabilities of staff and instruments is limited.
4. Unable to extend accreditation scope due to costs.
5. Challenges with competent instrument service technician in the country, they are brought in from South Africa.
6. Unable to test across the country where the need is at its highest in farming and remote areas.
7. Unable to test at border posts, due to limited funding and capacity.
8. Accredited pesticide and mycotoxin testing is currently being outsourced in South Africa (e.g., PPECB, SAGL)

- **Private Sector/ Fresh Produce:**

1. A lot of farms are doing or going into primary processing (e.g., slicing and dicing), and require testing at their farm sites.
2. Farms in the north of Namibia are isolated and temperature control sampling (cold chain) is not established, resulting in a lot of spoilage/food losses due to lack of cold chain tracking/traceability.
3. Namibia has semi-desert terrain; farmers struggle with soil testing to routinely determine their soil quality and nutrient content.
4. Surface water is used for irrigation, issues arise with the contamination of this open surface water.
5. Farmers lack technical skills which are required for sampling and sample handling for test samples to be couriered to centralized food testing labs.
6. Farmers have a sense of fear of the unknown, resulting in corner cutting for them to reach food compliancy standards.
7. There is no of traceability along the farming value chain in Namibia, so it’s difficult to mandate accountability to farmers.
8. Farmers are worried about the cost of food testing, (which they are currently outsourcing in South Africa) especially with the rise in cost of agricultural supplies.

- **Traders Forums and Small, Medium and Micro Enterprises (SMME's):**

1. There is a lack of awareness on the need for food safety testing of products.
2. There is a lack of accessibility to food safety testing services.
3. SMME's feel that national food regulatory standards are constantly changing, and they don't have the capacity to keep up.
4. They lack the finances for safety testing of their products.
5. There is limited government support for the testing of their products, and government should actively invest.

2.3.2 Clients

Proposed testing and technologies needed from a mobile laboratory in Lesotho, Eswatini and Namibia are outlined in Tables 4.1, 4.2 and 4.3, respectively. Commercial farming and food processor representatives in all three countries indicated that they are willing to pay for services offered by the mobile lab, granted that the services offered have a faster turnaround time than stationary food testing laboratories they are currently using, and the mobile services provide the same level of certification of their products. SMMEs in all three countries indicated that they would be willing to pay for services offered by the mobile lab, however they would require some assistance or subsidy either from their government or the project funder. SMMEs and universities also highlighted the need for educating the public, small-scale famers, and small-scale food processors on the importance of food safety, possibly using the mobile laboratory for food safety awareness. Government institutions indicated they were open to negotiations of paying for services, provided they were in alignment with their mandates and the lab acted as support structure or extension of their existing food testing laboratories.

Table 2.1: Proposed testing and technologies needed from mobile laboratory in Lesotho.

Sector	Proposed testing
Crops, vegetables, and fruits	• Pesticide, herbicide testing e.g., maximum residue levels (MRLs) • Mycotoxin testing • Microbial testing • Scheduled soil and water testing of farming areas • Starch, sugar, fiber and moisture content testing or grains and fruits.
Livestock and Poultry	• Testing of meat: antibiotic residues, additives. • Testing of milk: microbial, composition, adulteration (water, additives), aflatoxin M1.

	• Testing of animal feed: nutritional composition, starch, fat, fiber, proteins, elements etc.
Water and Fisheries	• Heavy metals • Dissolved oxygen • Microbial • Pesticides • Minerals.

Table 2.2: Proposed testing and technologies needed from mobile laboratory in Eswatini.

Field	Proposed testing
Food Chemistry	• Plant origin • Moisture and total solids • Ash content • Crude fat analysis • Crude Protein analysis • Total CHO • Crude fiber • Minerals
Food Microbiology	• Plant and animal origin. • Total plate count • *Staphylococcus aureus* and coliforms • Salmonella spp • *Escherichia coli* • Veterinary drug residue – antibiotics
Post Harvesting	• Pesticide testing - MRL's • GMO Testing • Molecular testing • Feed composition testing. • Milk and milk products. • Mycotoxins

Table 2.3: Proposed testing and technologies needed from mobile laboratory in Namibia.

Field	Proposed testing
Pre-Harvesting	• Soil composition analysis testing. • Water testing e.g., microbial analysis. • Plant tissue analysis.
Food Microbiology	• Total plate count • Yeast and Mold • *Staphylococcus aureus* and coliforms • *Salmonella* • *Escherichia coli*
Post Harvesting	• Pesticide testing • Mycotoxin testing • Testing for Global G.A.P certification.

2.3.3 Government

Government departments/ministries and state-owned institutions in all three countries emphasized their interest in the mobile laboratory, the role it could play in mitigating food safety testing challenges in their countries and were open in their support of the project. Their interest was evident through the issuing of letters of interest, and the number of government delegates and institutions that were in attendance during the workshops. Critical issues such as how the STDF would facilitate the project, who would fund the project and maintain the services, who would own the mobile lab(s), which institution would incubate the project were also highlighted. Government institutions highlighted the need for STDF to engage with them in this regard.

3 REGULATORY EVALUATIONS

3.1 South Africa – Policy documents, food laws and national food control systems.

The main food safety regulatory laboratories in the country can be summarized as follows:

- South African Bureau of Standards (SABS): SABS was established as South Africa's national standardization body. SABS is a leading business services provider to organizations worldwide, offering a range of services for management system certification, product testing and certification, and standardization. This includes testing in Food & Beverages, including all aspects of their effects on man and his environment relating to activities in the following fields: chemical, microbiological, and physical tests on crops, grain, raw meat, milk beverages, water, processed foods, and bulk foods. [11]
- Perishable Products Export Control Board (PPECB): A national public entity for quality certification and cold chain management services for producers and exporters of perishable food products. Constituted and mandated in terms of the Perishable Products Export Control Act (PPEC Act), No 9, of 1983 to perform cold chain services. Also provides inspection and food safety services assigned by the Department of Agriculture, Forestry and Fisheries (DAFF) under the APS Act, No.119 of 1990.[12]
- The Southern African Grain Laboratory NPC (SAGL): A nonprofit laboratory created by the South African grain industry to act as reference laboratory for the grain and oilseed industry. They provide a range of laboratory services for grains and oilseed, as well as food, feed, and feedstuff. [13]
- The National Regulator for Compulsory Specifications (NRCS): An agency of the Department of Trade, Industry and Competition, established in accordance with the provision of National Regulator for Compulsory Specifications Act 5 of 2008. The NRCS's regulated food products and testing include frozen fish, canned fisheries, canned meat, and live abalone.[14]

South African legislation on food safety can be summarized as follows:

- Foodstuffs, Cosmetics and Disinfectants Act 39 of 2007.
- Meat Safety Act 40 of 2000.
- Agricultural Product Standards Act 119 of 1990 (amended 2020).
- National Regulator for Compulsory Specifications Act 5 of 2008.
- The Consumer Protect Act 68 of 2008
- Protection of Personal Information Act 4 of 2013.
- Occupational Health and Safety Act 85 of 1993.

3.2 Lesotho – Policy documents, food laws and national food control systems.

Lesotho legislation on food safety can be summarized as follows. [15]

- Agricultural Marketing Act, 1967.
- Public Health Order, 1970

The order provides some key food safety authorities, definitions, identification of responsibility, and provides authority for regulations. These regulations include:

- Milk Hygiene Regulations, 1999.
- Public Health Regulations,1973.
- Lesotho Iodization Regulation, 1999.
- Food Fortification Regulation, 2020.

There are several laws and regulations governing animal health, importing, and exporting of animals, as well as governing of veterinary services. These include:

- The Stock Disease Amendment Act No. 18, 1984.
- Importation of livestock and export of livestock and livestock products Amended Act No. 57, 1952.

Abattoir regulations of 1972

- Veterinary Surgeon Act No. 13, 1973
- Dangerous Medicine Act No. 21, 1973

3.3 Eswatini – Policy documents, food laws and national food control systems.

Eswatini legislation on food safety can be summarized as follows. [15]

Ministry	Title of Legislation	Implementing Agency
Health	Public Health Act, 1969 Public Health (Food Hygiene) Regulations, 1973 Public Health (Bakery) Regulations, 1974	Department of Environmental Health
	Salt Iodization Regulations, 1997 Bio-safety Act, 2012	Ezulwini Town Board Manzini City Council Matasapha City Council Mbabane City Council Malkerns City Council

Agriculture	Veterinary Public Health Act, 2013	Department of Veterinary & Livestock
	Dairy Control Act, 1968	Eswatini Dairy Board

3.4 Namibia – Policy documents, food laws and national food control systems.

Namibia legislation on food safety can be summarized as follows: [15]

- Trade Metrology Act No. 77 of 1973, Public Health Regulations,1973.
- Fertilizers, Farm Feed, and Agricultural Remedies and Stock Remedies Amendment Act, 1977
- The Public Services Act,1995
- Public Health Act 1919
- The Plant Pest Act, 1973
- Namibian Biosafety Act, 2006
- Animal Health Act, 2011
- The Meat Safety Act, 2000
- Prevention of Undesirable Residues in Meat Act, 1991
- The Medicinal and Related Substances Control Act, 2003

3.5 ISO/IEC 17025 accreditation bodies in the region

By using an accredited laboratory, the customer reduces the risk of using or producing a product that does not conform to the required specifications or industry standards. It also removes the need to have a product re-tested if it is exported, and finally it provides confidence to your clients that they know your product has been tested by an independent, competent, ISO 17025 compliant testing laboratory.

- **SANAS**

The South African National Accreditation System (SANAS) is recognized by the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act No. 19 of 2006) as the sole national accreditation body for providing an internationally recognized and effective accreditation and good laboratory practice (GLP) compliance monitoring system for the Republic of South Africa. SANAS is recognized as a signatory to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangements (MRAs), the International Accreditation Forum (IAF) Multilateral Arrangement (MLA), the African Accreditation Cooperation (AFRAC) MRA and the SADCA MRA for specific scopes. The internationally recognized network of competent laboratories, inspection bodies, certification bodies and Good Laboratory Practice (GLP) facilities, is facilitated through SANAS accreditation, to enable government, industry, the public and exporters to meet the growing demand for safe, high-quality goods and services. SANAS thus promotes accreditation as a means of facilitating international trade through the national, regional, and global acceptance of conformity assessment results.[16]

- **SADCAS**

The Southern African Development Community Accreditation Services (SADCAS) is a multi-economy accreditation body established in terms of Article 15 B of the Technical Barriers to Trade (TBT) Annex to the SADC Protocol on Trade with the primary purpose of ensuring that conformity assessment service providers (calibration/testing/medical laboratories, certification and inspection bodies) operating in those SADC Member States which do not have national accreditation bodies are subject to an oversight by an authoritative body. SADC countries Angola; Botswana; Democratic Republic of Congo (DRC); Lesotho; Madagascar; Malawi; Mozambique; Namibia; Seychelles; Eswatini; Tanzania; Zambia; and Zimbabwe do not have national accreditation bodies hence serviced by SADCAS. By assuring technical competence through accreditation, SADCAS plays a key role towards the achievement of SADC goals in trade facilitation and in the protection of health, safety, and the environment. SADCAS was registered in 2005 as a non-profit company limited by guarantee under the Botswana Companies Act, 2003 (Act No. 32 of 2004). SADCAS was approved by the SADC Council of Ministers in August 2007 as a Subsidiarity Institution of SADC.[17]

4 MARKET FEASIBILITY

4.1 Food safety drivers in the SADC region

The cost of unsafe food goes far beyond human suffering. Contaminated food hampers socioeconomic development, overloads healthcare systems and damages economies, trade, and tourism of a country. Economic opportunities of the international food market are lost to countries that are unable to meet international food safety standards. A joint statement by the FAO, WHO and WTO during the 2019 International Forum on Food Safety and Trade indicated that food safety issues cost developing countries more than 110 billion USD annually.[18] An increasingly globalized food supply means that risks from unsafe food can rapidly escalate from a local problem to an international emergency, exposing populations worldwide to food hazards.

Many developing countries in the SADC region import a significant share of the food supply for their population, with some – such as Lesotho and Eswatini – relying almost entirely on food imports to ensure food security.[19],[20],[21] Therefore, it is fundamental that countries invest in food safety. While many countries have sophisticated food-safety tools and systems, many do not. In the rapid evolution of science, technology, and communication today, as well as changes in agriculture, environment and consumer behaviors, authorities everywhere need to keep vigilant, share information and resources, and find ways to make sure all stakeholders contribute to effective outcomes. The drivers for food safety in the SADC region are listed in Table 4.1.

Table 4.1: Food safety drivers in the SADC region and their implications.

Driver	Implications
Environmental challenges	Environmental challenges such as climate change have led to a rise in food safety risks. Increasing global temperatures, droughts and flooding have had a detrimental effect on food security and value chain. These environmental threats have led to the emergence of new food pathogens, contaminants, and a rise in existing food contaminants e.g. mycotoxin.
Demographics changes	A trend of fast paced urbanization is affecting food systems within SADC countries. As more people migrate into urban areas this increases the demand for food in these areas, and with it comes the challenge of providing safe and nutritious food. Informal food sectors also develop and thrive in densely populated low-income urban areas and

	informal settlements, increasing the risks associated with food safety.
Increased consumer awareness	There is an increasing consumer awareness and demand for rapid and reliable food safety testing. Technological advances such as social media and e-commerce are changing the way that food is being perceived and purchased by consumers. Ease of access to information and media platform is regarding foodborne disease and outbreaks is changing consumers perceptions of food safety, food systems and government role in ensuring food safety.
Globalization of the food supply	Globalization of the food supply has led to the rapid and widespread international distribution of foods. Pathogens can be inadvertently introduced into new geographical areas. Travelers, refugees, and immigrants may be exposed to unfamiliar foodborne hazards in new environments. Globalization of the food supply also introduces challenges associated with food adulteration and traceability.
Stringent International food safety regulations	Food fraud and outbreaks of foodborne disease have led to the enforcement of more stringent international food safety regulations and an increased demand for food safety testing. As food imports grow, so does the interconnectedness of food safety regulatory systems. Similar systems enable reduced trade barriers and processing time, while major differences in systems can slow trade and increase the risk of food safety incidents.

4.2 Food Safety Testing Market in SADC countries

4.2.1 South Africa

The South Africa food safety testing market was valued at 69.6 million USD in 2022 and is expected to grow at a compound annual growth rate (CAGR) of 11 % from 2023 to 2032. Pathogens, chemicals, and genetically modified organisms (GMOs) are the three primary drivers in the food safety testing market, with microbiology testing accounting for 38.95 % of the market share in 2022.[22] The South Africa food safety testing market is divided into four regions. They are Gauteng, Western Cape, Mpumalanga, and the rest of South Africa. The Gauteng region dominates the market, and it is expected to retain its dominance.

From a growth perspective, Mpumalanga and Gauteng are the two potential markets, expected to witness growth by the year 2025. [23]

4.2.2 Swaziland

The current offering in food safety testing facilities in Eswatini can be summarized as follows: [15]

- Ministry of Agriculture – Malkerns Research Laboratory: Testing of food and products of plant origin.
- Manzini Municipal Laboratory: Basic microbial and chemistry testing.
- Mbabane Municipal Laboratory: Basic microbial and chemistry testing.
- Eswatini Water Services Corporation Laboratory: Few parameters in water.
- Eswatini Standards Authority (SWASA) - still setting up the laboratory.

4.2.3 Lesotho

The current offerings in food safety testing in Lesotho can be summarized as follows: [15]

- Testing of crops, vegetables, and fruits sector: The main testing is for maximum residue levels of pesticides (MRL's), which is done by the Department of Agricultural Research.
- In the Livestock and Poultry sector the Ministry of Agriculture and Food Security conducts the tests, and it consists mainly of basic testing on animal tissue e.g. antibiotic residues. Milk and egg testing is done by the National University of Lesotho (NUL) - Environmental Health Department.
- In the Water and Fisheries sector, the main tests are for heavy metals and microbial testing which is done by National university of Lesotho (NUL) - Environmental Health.

4.2.4 Namibia

The current offerings in food safety testing in Namibia can be summarized as follows: [15]

- Namibian Standards Institution: conducts testing in microbiological and chemical analyses on fish and fishery products, shellfish, dairy products, meat and meat products, environmental surveillance.
- Central Veterinary Laboratory: animal disease diagnostic, epidemiological testing of animal, meat and meat products, abattoir hygiene testing
- National Commission on Research, Science and Technology: GMO testing.

4.3 Target Market

When it comes to the services offered by food testing labs, there is a wide range of available customers. In essence, the mobile lab target market cannot be restricted to just one industry, but all industries that produce and manufacture food-based products. In view of that, the first-tier customers will be as follows:

- **Commercial market**

Grain, fruit, and vegetable farmer produce passes through many hands on its way to consumers. Some foods are sold closer to the point of production in village markets, whereas commercial produce moves through complex systems of harvesting, transportation, storage, and retail. As it moves through this system, grains, fruits, and vegetables are susceptible to contamination and spoilage, resulting in serious risks and negative impacts on health, nutrition, and economic development. Namibia has 6690 commercial farms according to the latest Nambian Agricultural Census.[24] The need for food safety testing for good agricultural practices (GAP) certification and exporting as well as the high cost associated with food safety testing and having to courier samples for accredited testing mostly to South Africa was highlighted by commercial farmer representatives (Namibian Association of Traders in Fresh Produce, National Association of Horticulture Producers) during the project workshop hosted in Namibia.[15] In Eswatini 40 % of the land is used commercially, mainly for farming of sugarcane and citrus.[25]

Commercial food processors convert agricultural produce into a wide range of consumer products. These products are susceptible to food safety risks and contamination during processing and transportation; therefore, they require testing before being sold in commercial retail outlets or exported. Commercial processors in Eswatini highlighted the challenges of accessibility to accredited food safety testing for retail markets and exporting of products such as sauces, jams, and canned products to highly regulated countries (e.g. South Africa).[15]

Storage facilities store food produce (e.g. grain silos) after harvesting. The mobile lab could assist in ensuring that the stored grains are not contaminated (e.g. mycotoxins, microbial contaminants) prior and during storage before they are transported to the end users. According to Farmers Weekly, there are about 283 bulk grain storage facilities in South Africa with a total commercial capacity of 15.7 million tons.[26] The Namibian National Strategic Food Reserves grain silos have a total storage capacity of 22900 metric tons.[27]

A mobile laboratory could provide easy access to affordable, accredited food safety testing, with a high reporting turnaround time to commercial farmers and processors in the SADC region.

- **Informal market**

The project will also be targeting small, micro, and medium enterprise (SMME) farmers and primary food processors, who require accreditation of their food products to infiltrate commercial retail and export markets. A mobile laboratory could also provide affordable testing to SMME farmers and primary processors in the SADC region.

- **Food regulatory institutions**

Government and regulatory institutions (e.g. departments of Health, Agriculture and Trade) that regulate the import and export of goods throughout the food value chain and at ports of entry will also be targeted. Countries such as Lesotho, Eswatini and Namibia rely mostly on food imports to ensure food security. According to the UN COMTRADE database, Lesotho, Eswatini and Namibia imported food and beverage products valued at 408.01, 304.92 and 784.22 million USD respectively from South Africa in 2022.[19],[20],[21] Moreover, statistics indicate that agriculture in Lesotho and Swaziland is predominantly based on subsistence farming without access to food testing services due to economic disparity, which leaves a majority of their populations exposed to risked associated with food safety.[28],[25] Mobile food testing laboratories could assist these governments in the prevention of foodborne disease outbreaks and in ensuring that food brought into the country is of good quality and safe for local consumers.

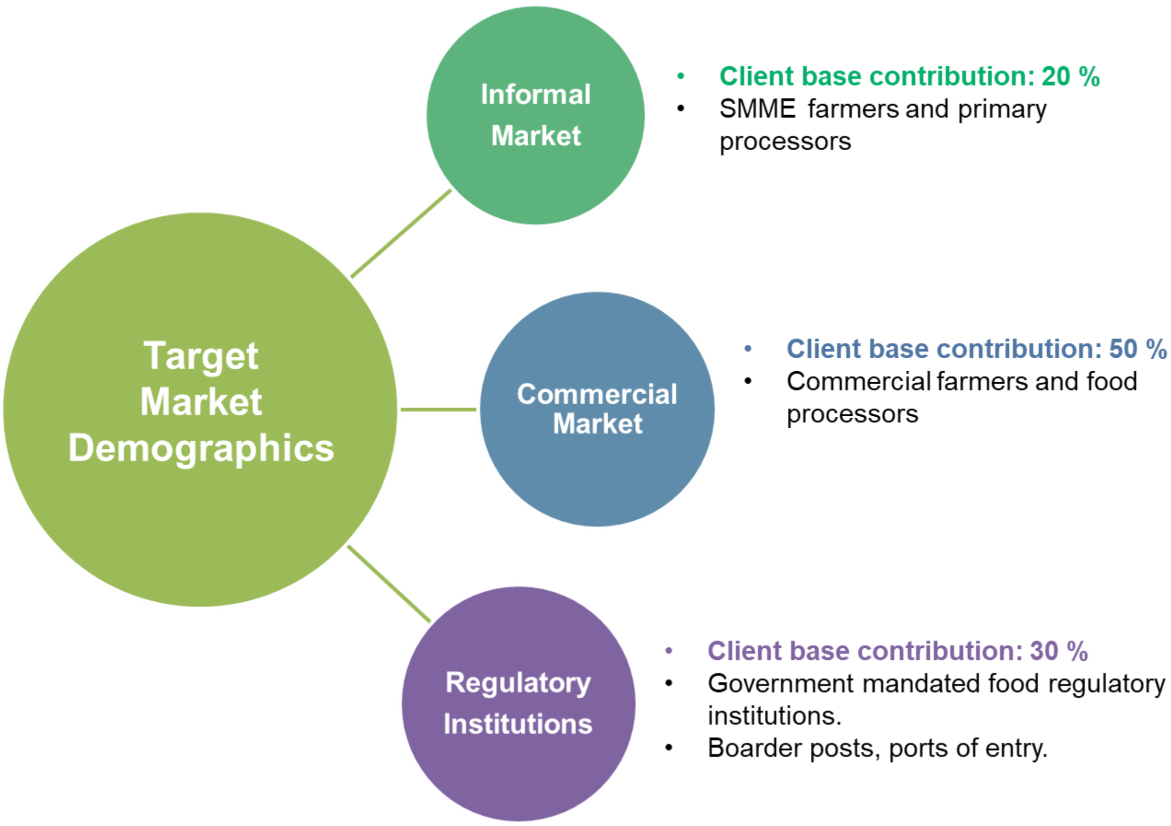

Figure 4.1 The target market demographics of the mobile lab project.

In addition to these primary target customers, there is also market potential in:

- School feeding schemes.
- Other markets such as informal food vendors.

Once the project has progressed along the development path, these additional customers and market regions can be investigated based on an understanding of their specific requirements and the customizability of the service to meet their needs. This mix of customers is beneficial as it helps maintain business whenever there are challenges within a particular market segment e.g. crop failures. By appealing to several market segments, the business can mitigate challenges and not become overly dependent on any single customer group.

4.4 Value Proposition

The value proposition is a mobile lab for food safety testing with the unique proposition of ISO17025 accreditation, a customized laboratory information management system (LIMS) and generation of results in real time at point of testing for mycotoxins, heavy metals, pesticides, and pathogens. With a mobile laboratory in place the cost of couriering samples will be eliminated as well as the cost of time delays in results, as they would be available on the same day as sample receipt. Sample integrity will not be compromised, and results will be both credible and reliable and generated in real time for access to clients.

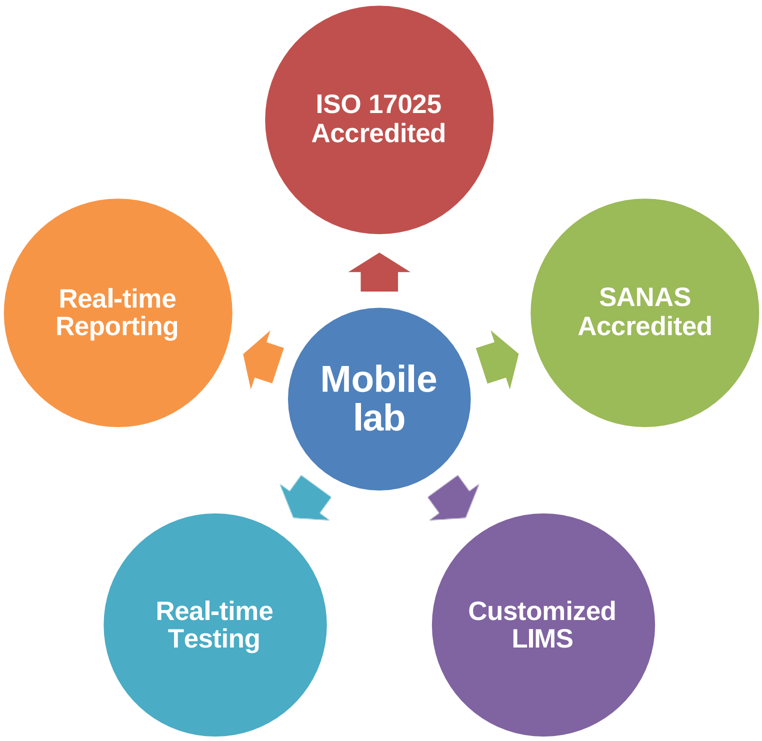

Figure 4.2: The target market demographics of the mobile lab project.

4.5 SWOT Analysis

It was established that there are existing food testing labs in Lesotho, Eswatini, Namibia and South Africa. Therefore, it is critical to follow due processes like conducting SWOT analysis to understand both the internal and external environment that could affect the project before it is established. The analysis will position the enterprise to maximize its strength, leverage on the opportunities that will be available to it, mitigate its risks and be equipped to confront its threats. A SWOT analysis of the mobile lab project was conducted, and the subsequent findings are illustrated in Figure 4.3. Table 4.2 gives a summary of the key risks associated with the project together with the likely impact and mitigations should they occur.

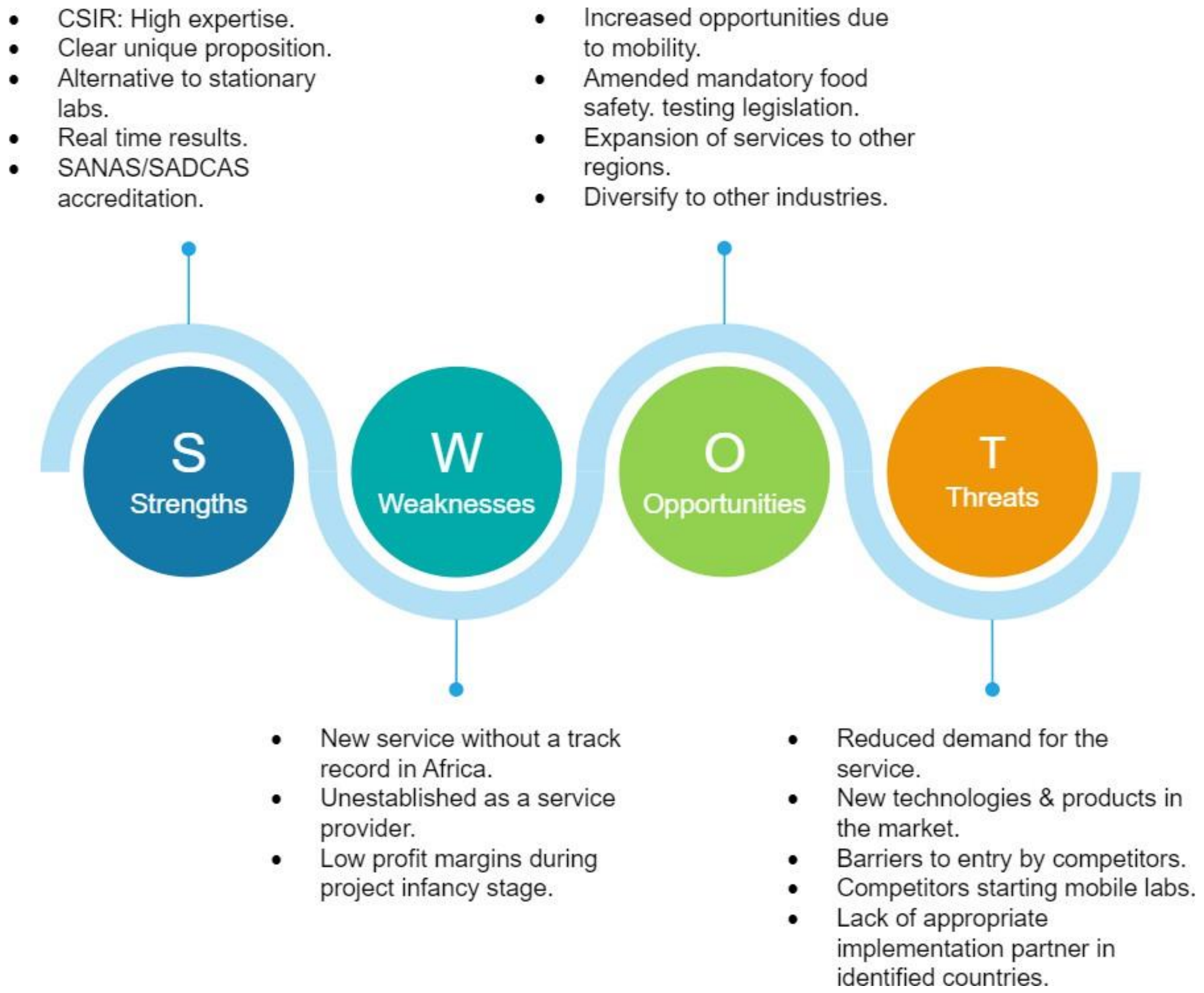

Figure 4.3: Mobile lab project SWOT analysis.

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Table 4.2: Risks and mitigation actions

Possible Risk	Impact	Likelihood	Overall Impact	Mitigation
High investment cost may discourage investors.	High	Medium	Medium	• Explore various funding models.
Low profit during project infancy stage.	High	High	High	• Establish possible service contracts with relevant stakeholders e.g. Government departments, commercial agricultural consortiums. • Ensure rigorous promotion of the project and services.
New service without a track record in Africa.	High	Medium	High	• Ensure mobile lab conforms to the same standards of accreditation as conventional stationary labs.
Unestablished as a service provider.	High	Medium	Medium	• Ensure rigorous promotion of the project and services. • Leverage on markets infiltration through project implementation partners.
Reduced demand for services.	High	High	High	• Establish possible service contracts with relevant stakeholders e.g. Government departments, commercial agricultural consortiums.
New technologies and products in the market.	Low	Medium	Medium	• Design mobile lab to easily adapt and incorporate new technologies and products in food safety testing.
Barrier to entry by competitors.	High	Low	Medium	• Clearly define the “mobile” brand and project novelty. • Emphasize and promote value proposition of mobile lab e.g. high efficiency than stationary labs through real-time testing and reporting.
Competitors starting mobile labs.	High	Low	Medium	• Provide high efficacy customer service and experience.
Lack of appropriate implementation partners in identified countries.	High	Low	Medium	• Project implementation partners were identified through letters of interest and project stakeholder workshops.

5 TECHNICAL FEASIBILITY

Mobile laboratories provide a variety of on-site services, traveling to places where outbreaks can occur and where monitoring is required. However, because these mobile food testing laboratories will be deployed to remote locations, the technical requirements of such an undertaking need to be thoroughly investigated. These mobile laboratories must be highly self-sufficient, regarding their logistics, testing capacity, and technical staff. When looking into selecting the type of mobile lab required for your operation, three characteristics need to be considered, namely mobility, average length of deployment and self-sufficiency (see Figure 5.1). Different types of laboratories have different degrees of mobility regarding transport and relocation, as well as anticipated levels of self-sufficiency and length of deployment.

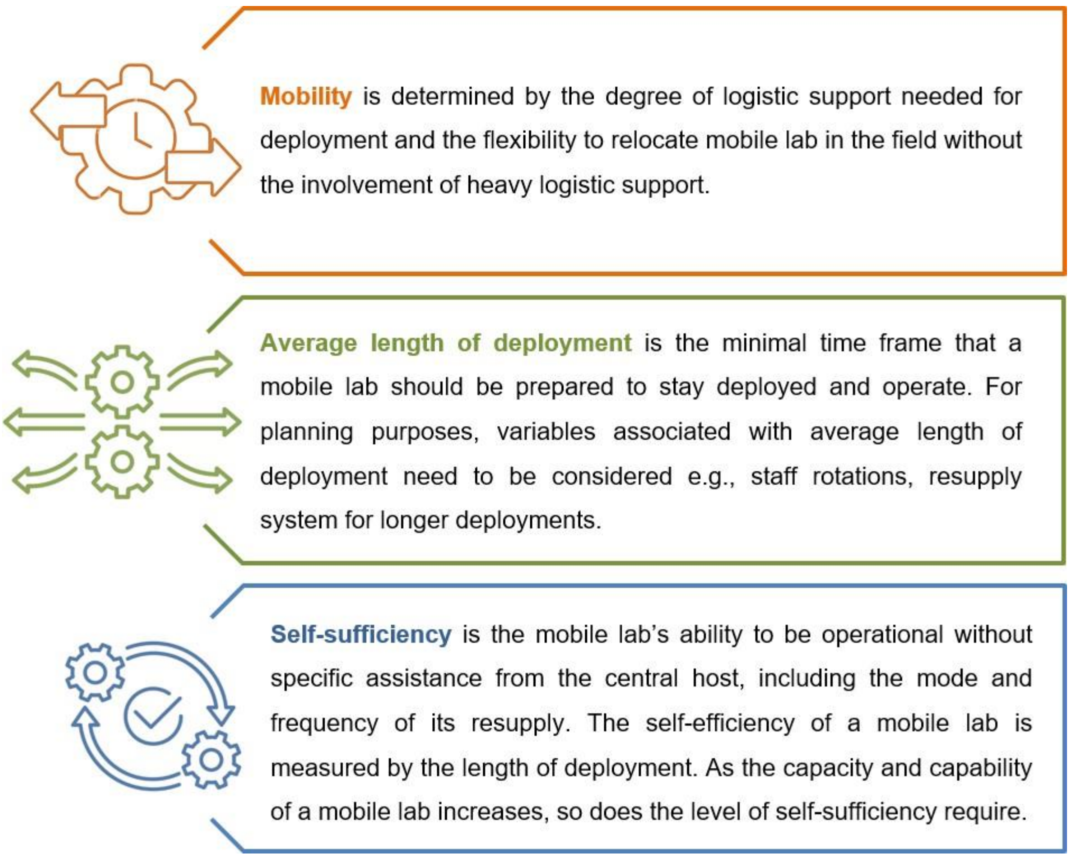


Figure 5.1: Mobile and logistics characteristics to be considered when selecting a mobile laboratory.

Various models of mobile laboratories have been developed and are widely used in the health, veterinary, and defense sectors. There are already examples of mobile food safety testing laboratories being used in countries such as Dubai, India, and Singapore.[5],[6], [7] In selecting the vehicle model for a mobile laboratory factor such as ease of mobility, space limitations, logistical and testing requirements must be considered. The proposed vehicle models for the food safety testing mobile lab are as follows:

5.1 Proposed vehicle models

Model 1: Medium to Advanced Testing

Figure 5.2: Examples of medium to advanced testing mobile lab.[29], [30]

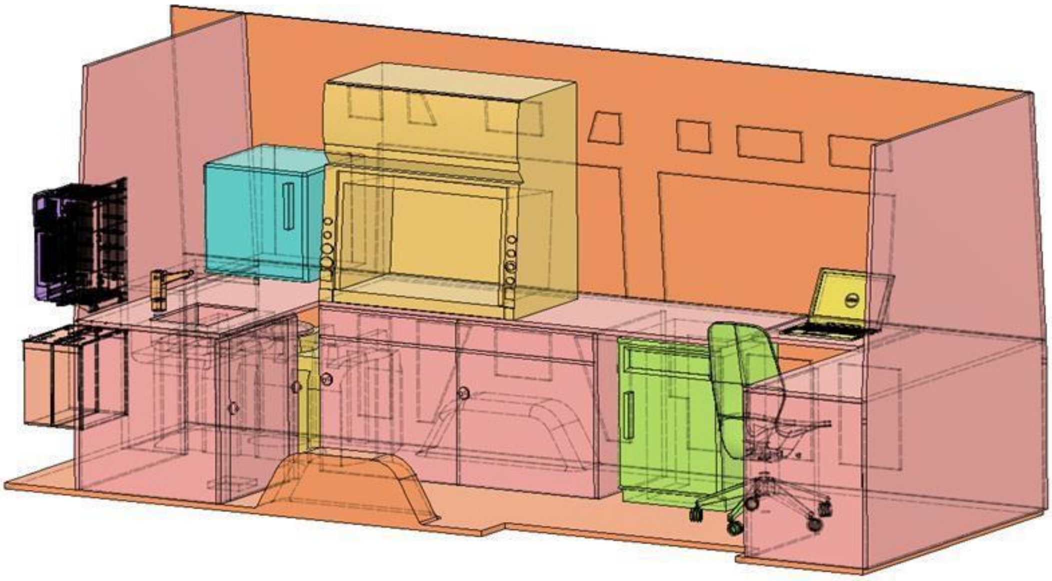


Figure 5.3: The layout of the Model 1 mobile laboratory floor plan showing elevations, as produced by CSIR Smart Places.

Features:

- A van or medium truck and canopy.
- Could be stationed in a specific location or move to different locations daily.
- Onsite sample collection, preparation, analysis, and disposal.

Pros:

- Ease of mobility in rugged and isolated terrain.
- Moderate fuel consumption/km.
- Can be easily stationed during and after operation.
- Ease of access to secured parking.
- Moderate to high testing capacity and throughput.
- Can conduct medium to advanced testing.

Cons:

- Limited workspace availability.
- Limited testing technology incorporation.
- Moderately self-sufficient.

Model 2: Advanced testing

Figure 5.4: CSIR 3D model of advanced testing mobile lab.

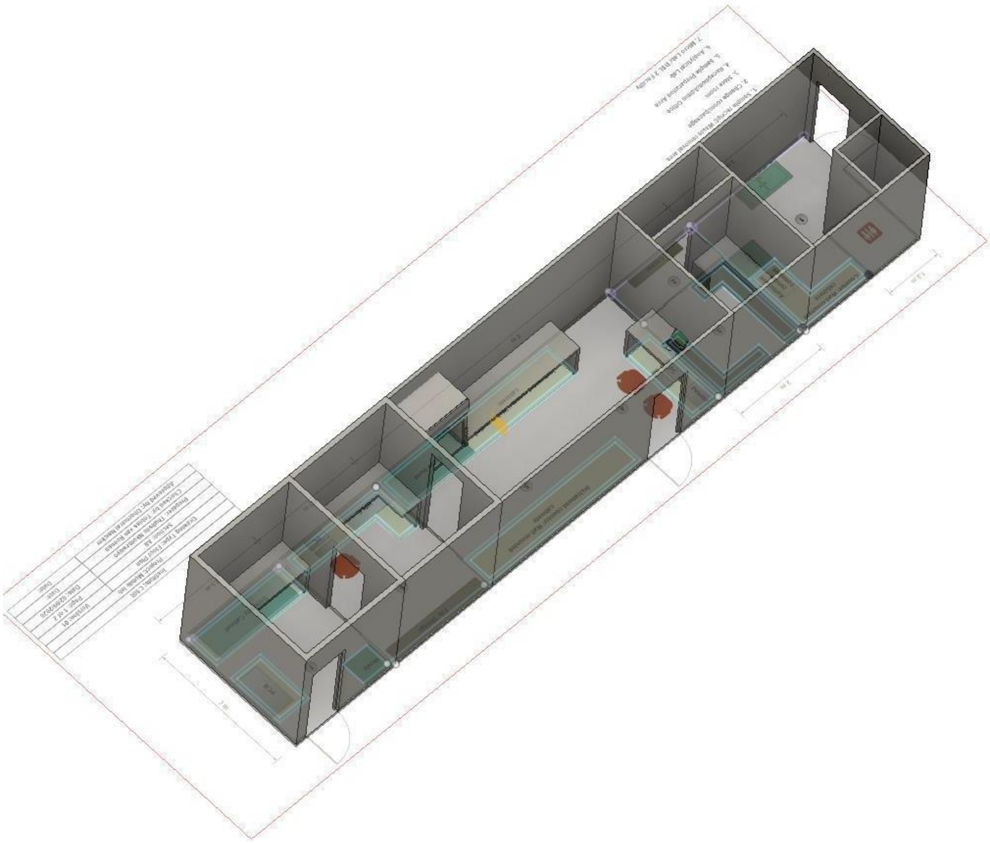


Figure 5.5: The layout of the Model 2 mobile laboratory floor plan showing elevations, as produced by CSIR Smart Places.

Features:

- 16-wheeler truck deployed specific to farming/production areas at specified periods and durations.
- Onsite sample collection, preparation, analysis, and disposal.

Pros:

- Highly self-sufficient.
- High testing capacity and throughput.
- Can conduct advanced testing.

Cons:

- Low mobility in rugged and isolated terrain.
- Limitations in secured parking.
- Requires specialized driver experience and permit.

5.2 Architectural finishes

5.2.1 Flooring

- Model 1

The subfloor will have a minimum of 18 mm plywood panel with level polyurethane resin screed, sealed and levelled. The flooring top layer will be finished with chemical resistant, 2.5mm, welded, vinyl flooring sheets. These will be fitted for all the floors of the laboratory. The flooring will be provided in a speckled blue finish and will include grey skirting at all wall and floor interfaces. The vinyl flooring will be bonded to the trailer subfloor with adhesive suitable for a semi flexible mobile structure, following the manufacturer's instructions. The wall-floor interface will be continuous with the floor covered 80mm up the wall and sealed to an impervious washable coving. The walls and ceiling will be paneled with 25 mm insulated Chromadek™ panels, with silicone sealed joints. The details of the sliding door need to be resolved during construction.

- Model 2

The flooring will be finished with chemical resistant, 2.5mm, welded, vinyl flooring sheets. These will be fitted for all the floors of the laboratory. The flooring will be provided in a speckled blue finish and will include grey skirting at all wall and floor interfaces. The vinyl floor screen will be bonded to the trailer subfloor with a screed and adhesive suitable for a semi flexible mobile structure, following the manufacturer's instructions. The wall-floor interface will be finished with a sealed impervious washable coving.

5.2.2 Internal walls, doors, and windows

- Model 2

Internal walls and swing doors will be constructed with a prefabricated insulated 75mm thick sandwich panel system that consists of 0.5 mm white Chromadek™ steel sheeting bonded to a self-extinguishing polystyrene core. The doors will be 0.9 m x 2 m, made of aluminum with insulated panels and will have stainless steel handles and lockable latches. Swing doors will be fitted into a sub-frame with 3 stainless steel hinges. All doors will be fitted with floor-mounted door stops and viewing panels. The external windows will be made of tempered glass with sliding frames, burglar bars and insect screens. They will be a size of 0.6 m x 0.9 m. Only the sample preparation area, and the toilet will have openable windows.

5.2.3 Furniture

The lab tops should be made of a material that is resistant to heat, chemicals, abrasion, and spills. The standard height for a lab bench is 91.5 cm, but this may be adjusted based on the needs of the lab. The lab tops should have a smooth, non-porous surface for easy cleaning and decontamination.

They should be designed to accommodate the necessary lab equipment and provide enough space for lab work. The edges of the lab tops should be rounded to prevent injuries. The depth of the bench should be at least 60 cm unless additional depth is required for specific equipment such as the biosafety cabinet. A fold-up section will be provided for a laptop and screen. The lab benches will include one integrated sink with waste going to a dilution trap and waste storage tank below. An elbow or hands-free tap shall be fitted above the sink with space for securable glassware drying and storage.

5.2.4 Technical systems

- Model 1

The peak power demands of the lab are estimated at 3.3kW with an average hourly demand of 350W. A technical compartment at the rear of the lab will be created to house the power, water, and gas systems. The power system will consist of an inverter, batteries, and PV panels. The design allows for a single phase 240V 3.6 kVA inverter, 5 kWh battery storage and 1 kWp roof mounted solar production. 3-phase electrical supply is not envisioned for the laboratory.

- Model 2

The synchronous power demands of the lab are relatively low. A dedicated room is required for the photovoltaic system's inverter and batteries. The design allows for a 240V 8 kVA inverter, 10.2 kilowatt hours of battery storage and 8 kWp roof mounted solar production. 3-phase electrical supply is not envisioned for the laboratory.

5.2.5 Water

The lab shall be fitted with 50L potable water tank and booster pump. The water reticulation will serve the hands-free tap and the Lab RO system if fitted. The 230V booster pump will be fitted with a pressure switch and shall deliver at least 12 L/min at 2.2Bar.

5.2.6 Gas

The equipment compartment shall be fitted with a medical grade 201-C CO_2 cylinder including standard valve and regulator. The CO_2 will be piped through the bulkhead in the lab with a gas tap installed in the bulkhead wall.

5.2.7 Power & Lighting

- Model 1

a. Photovoltaic (PV) System

The laboratory power will be served by a solar hybrid inverter with battery backup. Provision for selection between ground power, generator feed or vehicle engine charging shall be available.

b. Lighting

Luminaires will be surface mounted panels on the ceiling and strip LEDs under cupboards. The lighting system shall be designed to offer glare free 500 lux at lab bench working surfaces and 350 Lux at the PC terminal.

c. Power reticulation and supply

The full length of the outer wall in the lab shall be fitted with a power skirting at working height. and should be fitted with 7x switched socket outlets. The utility compartment shall be fitted with a double 230V switched socket outlet. The laboratory shall be fitted with a deployable earthing strap and spike.

- Model 2

a. PV System

The laboratory power will be served by a hybrid inverter with battery backup and provision for a ground-based grid tie when available.

b. Lighting

Luminaires will be surface mounted, and the lighting system shall be designed to offer 350 lux at working surfaces. Each room must have an independent lighting control.

c. Power reticulation and supply

The full length of the outer walls in the labs shall be fitted with power and data skirting at working height. Each room should be fitted with 3x switched socket outlets. Storerooms shall be fitted with double 230V socket outlets. The laboratory shall be fitted with a deployable earthing strap and spike.

5.2.8 Ventilation and Airconditioning

- Model 1

The laboratory and technical compartment will each be served with mechanical extraction ventilation. The technical compartment will be located at the end of the trailer so that heat rejection and fresh air inlet can be through separate walls. Each occupied room should be maintained at 25°C. using air conditioning Fresh air inlets shall be sufficiently separated from the vehicle exhaust.

- Model 2

a. Ventilation

All spaces excluding the toilet and storeroom will be served with mechanical ventilation. The equipment room will double as the inlet plenum for the ventilation system. The room will be located at the end of the trailer so that heat rejection and fresh air inlet can be through separate walls. Each occupied room should be maintained at 25°C. Humidity control is not required. The WC and equipment rooms shall have air extraction which will run continuously while the ventilation system is on. The equipment room's extraction shall run while the inverters are turned on.

b. Filtration

The laboratory will be fitted with a ceiling mounted H13 HEPA filtered recirculating air cleaner providing an equivalent of 10ACH to the space.

5.2.9 Fire prevention

- Model 1

The equipment room will be provided with a lithium-ion suitable fire extinguisher. The driver's side shall be fitted with a CO_2 fire extinguisher.

- Model 2

Fire safety regulations relevant to the country/district shall be adhered to. The laboratory rooms and stores shall include fire detection equipment linked to the alarm system. The equipment room will be provided with a lithium-ion suitable fire extinguisher. The admin and sample prep room shall be fitted with a CO2 fire extinguisher.

5.2.10 Security system

The laboratory should be equipped with an audible intruder alarm and silent panic button. Alarms shall be linked to a GSM network with notifications sent to delegated individuals. The interior and exterior should be fitted with access control and CCTV/web cameras to monitor lab access.

5.3 Technology requirements

Technology requirements of the mobile lab are based on the crucial food safety test methods identified during the Stakeholder Engagement Workshops held in Lesotho, Eswatini and Namibia. The proposed tests are summarized as follows:

- **Pesticide residue testing**

Pesticide residues present in high concentrations in fresh agricultural produce pose a significant threat to food safety. Therefore, it is critical to monitor pesticide residue levels in fruits, vegetables grains.[31] QuEChERS (Quick, Easy, Cheap, Effective, Rugged and Safe) is a method based on dispersive solid-phase extraction (d-SPE) widely used to extract multiple pesticides from food and liquid samples. The most widely used techniques for analyzing pesticides is gas chromatography–mass spectrometry (GC-MS).[32]

- **Mycotoxin testing**

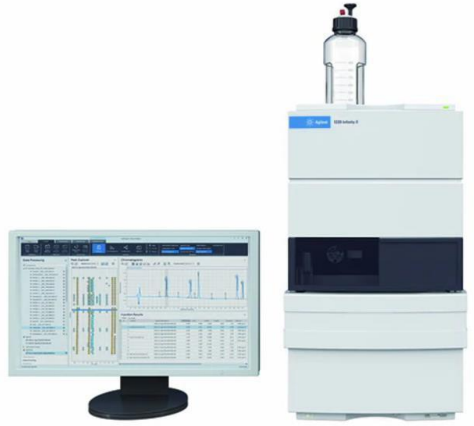
Mycotoxins are toxic metabolites or compounds that are produced by certain fungi which contaminate food products. In order to regulate the concentration of aflatoxins in products across the food value chain, highly accurate analysis methods are used to identify and quantify aflatoxins in food matrices have been developed. Liquid Chromatography with tandem mass spectrometry (LC-MS/MS) is the most effective and accredited method for measuring mycotoxins and polar pesticides and provide reduced matrix effect especially in complex sample matrices.[33] Foods tested would include grains, nuts, fruits, and vegetables, as well as animal feed.

- **Microbial testing**

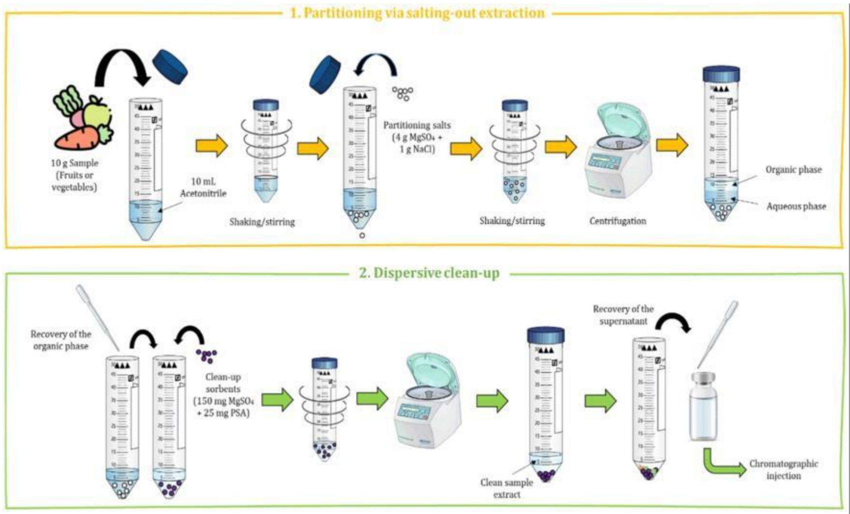
Microbial testing is used to ensure the quality, sterility, and safety of food samples. Total viable count (TVC) is a microbiological test used to estimate the total number of viable microorganisms present in a sample.[34] Escherichia coli (*E. coli*) is a bacterium that inhabits the intestine of humans and animals. Shiga toxin-producing *E. coli* can cause severe foodborne disease, transmitted to humans primarily through consumption of contaminated foods.[35] Salmonella enterica, is a major pathogen that is responsible for causing an estimated 93.8 million cases of gastroenteritis worldwide annually, leading to 59,100 deaths.[36] Total yeast and mold is a common microbiological test conducted to assess the microbial quality of various products, particularly in the food and beverage industry. This test determines the total count of viable yeast and mold present in a sample.[37]

As stated in ISO17025: 2017 clause 6.4 [38] "The laboratory shall have access to equipment (including, but not limited to, measuring instruments, software, measurement standards, reference materials, reference data, reagents, consumables or auxiliary apparatus) that is required for the correct performance of laboratory activities and that can influence the results." The identified food safety testing technologies that will be incorporated into the mobile lab are listed in Table 5.1, many of the available instruments listed, are standard in a typical food microbiology laboratory. Additional testing such as x-ray fluorescence (XRF) soil testing and near-infrared radiation (NIR) grain quality analysis could be phased into the mobile lab testing scope at a later stage and depending on need and availability of funding.

Table 5.1: Technical capacity of the current aflatoxin manufacturing facility and additional CAPEX requirements.

Analysis/Test	Method	Equipment/instrument	Features
Mycotoxin extraction	Romer Labs-MycoSpin™ 400 SPE column		• Only 5 minutes for whole clean-up. • One column for multi-mycotoxins and various commodities. • Fewer chemicals/material required. • Lower total cost in use. • No sample drying and reconstitution required.[39]
Mycotoxin Quantification	Agilent 1220 Infinity II LC HPLC		• Small-footprint HPLC. • Unique mobile upgrade allows installation of the 1220 Infinity II LC in a mobile lab. • UV detector. • Can be coupled to a fluorescence detector or mass spectrometer (MS) system (1260 Infinity II Fluorescence Detector or LC/MSD iQ).[40],[41]

Mycotoxin Quantification	Axcend Focus LC HPLC/UPLC		• Compact, lightweight, portable design. • Battery and electric powered. • Uses HPLC or UHPLC column. • 10 ml solvent/waste per week (180 times more green than traditional LC systems). • UV detector (235, 255, 275 nm). • Can be coupled to a MS system (Microsaic 4500 MiD®).[42]
	Microsaic 4500 MiD® Mass spectrometer		• No external vacuum pumps, and no external PC. • Mass range: 50-1400 m/z. • Reduced solvent, nitrogen, and power consumption.[43]
	Water ACQUITY UPLC I-Class / Xevo TQ-S LC-MS/MS		• Compact design in comparison to other LC-MS/MS systems. • High sensitivity, selectivity, and speed. [44] • LC-MS/MS is the most effective method for measuring mycotoxins and polar pesticides and provide reduced matrix effect especially in complex sample matrices.[32], [33]

Pesticide Extraction	QuEChERS		• QuEChERS (quick, easy, cheap, effective, rugged, and safe). • Widely used in the extraction of pesticides. Effective in isolating pesticides from complex matrices. Minimizes sample loss by limiting the number of steps. • Low operational cost. • Effective removal of matrix component interference leading to high target analytes recovery.[32] • AOAC Official Method 2007.01.
Pesticide Quantification	GC-MS		• Compact, lightweight (14.5 kg), portable design. • Operates under harsh conditions. • Battery and electric powered. • On-board helium cartridge. • User Interface Color touch screen with on-board operating menus. • Analyzes up to 12 samples per hour. • Mass range: 41-500 m/z.[45] • Able to identify and characterize high boiling point organochlorine pesticides in less than 10 minutes.[46]

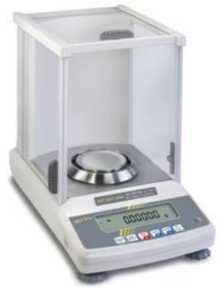
	3M™ Petrifilm® Rapid Yeast and Mold Count Plates.		• Rapid detection of Yeast and Mold. • Results available in as little as 48 hours in comparison to the traditional methods of 5 days. • Plates are sample-ready, eliminating all the costly and time-consuming steps of preparing media/agar dishes. • AOAC accredited method.[47]
Microbial enrichment	Hygiena MicroSnap® Total		• Rapid same-day test results for total viable count (TVC) bacteria, *E. coli*. • Test complete in < 8 hours. • Test consists of an Enrichment Device and a Detection Device containing a bioluminogenic (light-producing) substrate. • Flexible and easy-to-use format. • Can be used as a swab or with a sample diluent. • Lower total cost in use. • Tests are AOAC certified. [48]
	Hygiena MicroSnap® *E. coli*		
	Hygiena InSite® *Salmonella*		• A change in color after 24-48 hours of incubation is a presumptive positive for *Salmonella enterica*. • AOAC certified.[48]

Microbial Incubation			• The lab format incubator (30-70 wells) offers two separate blocks (A & B) each with separate temperature controls. • The small footprint version is ideal for labs with limited bench-top space and small test volumes (6-12 samples/wells).[49]
Microbial Quantification	Neogen® Petrifilm® Plate Reader Advanced		• Petrifilm plate reader. • Accurately enumerates plates in 6 seconds or less. • Achieves up to 94% reduced time in enumerating/colony counting. • AOAC accredited method.[47]
	Hygiena EnSURE® Touch		• Handheld device for verification and monitoring. Analyzes, quantifies, and reports data from MicroSnap® devices.[50] • Provides results in 10 seconds.

Sterilization	Prestige advance lab autoclave		• Compact, lightweight, benchtop. • FlexiRack and media tray load management system. • 16/22 liter chamber capacity options.
Material handling	Airfiltronix Mini-Ductless Fume Hood		• Ductless operation. • Compact and ideal for limited bench space. • Remove vapors and contaminates. • Quiet efficient operation powered by 530 cfm blower.

Sample/ consumable storage	Thermo ES Laboratory Refrigerator		• 151 L capacity. • Temperature range: +1°C to +10°C
Sample separation/ filtration	Bench-top centrifuge		• Digital speed control ≤ 5,000 rpm. • Safety lid-lock. • Unique air-flow design keeps samples cool. • 8 tube capacity, for tubes up to 15ml.
	Vacuum pump		• Ultimate vacuum: 12mbar. • Max pumping speed: 0.75m3/h. • Ideal for small scale filtration

Sample prep/mixing	Analogue Vortex Mixer		• Continuous or touch operating modes. • Speed range 0-2500 rpm. • Shaking Orbit 3mm (circular).
	PRO Scientific PRO250® Laboratory Homogenizer		• Compact handheld. • Speed range: 5000 to 30000 rpm. • Durable, processes. • samples for hours at a time. • Sensor prevents overheating and protects the motor unit.
	SP Bel-Art Micro-Mill-Grinder		• Grinding chamber assembly is removable to allow complete sample recovery and cleaning. High speed milling of small samples from 20 to 50ml. • Stainless steel blade that quickly pulverizes grains, seed, leaves, soil etc.

Sample weighing	Kern analytical balances	 	• Weighing capacity 5000 g, precision: ±3.0 g. • Weighing capacity 101 g, accuracy: 0.01 g, precision: ±0.15 g

5.4 Capacity and Throughput

The capability to perform single sample testing depends on the laboratory architecture, available instruments/equipment, biosafety requirements, and human resource capacity. Throughput is defined as the total output of the laboratory and number of samples processed by the laboratory during a given period. Physical manpower activity spent on each pesticide or mycotoxin test will be approximately 75 minutes, where results will be available for issuing after 75 minutes. Microbial testing will be conducted for a single sample and will include Total Viable Count (TVC), *E. coli*, *Salmonella* and Yeast and Mold. Physical manpower activity spent on each microbial test will be approximately 60 minutes. *E. coli* and TVC results will be available for issuing in 8 hours, while *Salmonella* and Yeast and Mold results will be available after 48 hours. Test result data will be captured and reported using a customized LIMS system. The estimated testing capacity for the mobile lab is shown in Table 5.2 and is based on the technology and methods shown in Table 5.1. The mobile lab will have an estimated throughput of 4 tests per target analyte(s).

Table 5.2: Estimated daily testing capacity and throughput of the mobile lab.

Test	Sample Prep (min)	Extraction or Incubation (min)	Analyte analysis (min)	Report Prep (min)	Test results (hrs)	HR activity/test (hrs)	Testing capacity per day*
Pesticides	20	20	10	25	1.25	1.25	4
Mycotoxins	20	10	20	25	1.25	1.25	4
Microbial	20	420-2820	10	30	8-48	1	4
Total tests							**12**

* Estimated capacity availability of test results, based on two laboratory operational staff and 8-hour workday including a 1-hour lunch break.

5.5 Information System and Database management

5.5.1 Laboratory information system

A LIMS (Laboratory Information Management System) is a software-based system used to manage laboratory operations, data, and workflows efficiently. ISO17025: 2017 states that laboratories should establish and maintain a quality management system that includes documented procedures for all aspects of laboratory operations. This includes procedures for data management, ensuring that data is handled consistently and accurately throughout its lifecycle.[38] LIMS systems play a critical role in laboratory operations by improving efficiency, data quality, regulatory compliance, and the collaboration of project stakeholders. The system will help the mobile lab manage its resources effectively, streamline workflows, and deliver accurate and reliable results to support decision-making and ensure the highest standards of quality and safety. Various types of LIMS systems are commercially available, including those designed specifically for laboratories specializing in food testing. Payments options for the systems also differ including once-off payment, annual payment, and per-user payment. The mobile lab will be fitted with a per-user annual payment LIMS system, with key features such as:

- Can be adapted for mobile applications.
- Can be both cloud-hosted and self-hosted, to make provision for internet/network reception fluctuations in the various countries.
- ISO 17025 complaint.
- Issuing of test result report and certificates.
- Data backup, security, and integrity.

5.5.2 Data management

Data integrity refers to the completeness, accuracy, and consistency of data throughout its lifecycle. It is important that the project and the mobile lab adhere to the data integrity requirements as outline in ISO 17025, as well as other recognized privacy regulation. In summary ISO 17025: 2017 requires the following:[38]

- Data Security: ISO 17025 requires laboratories to establish procedures for the secure storage, transmission, and retrieval of data to prevent unauthorized access, loss, or alteration. This includes implementing controls such as access restrictions, data encryption, and backup procedures to safeguard data integrity.
- Review and Approval: ISO 17025 requires laboratories to establish procedures for the review and approval of test results by authorized personnel. This ensures that data is reviewed for accuracy and completeness before being reported to clients or stakeholders.

Therefore, data generated through the mobile lab will be shared as follows:

- Project funder: Will be the owner of the data generated during the project duration.
- Host organization: Will be the custodians of the data, responsible for reporting the data generated though the mobile lab with the project funder.
- Mobile lab: Will be responsible for generating and transferring data.
- Mobile lab customers: Will be owner of data/ test results issued for samples they submitted for analysis.

6 ORGANIZATION AND MANAGEMENT REQUIREMENTS

In addition to available technology, to meet SANAS/SADCAS [51] and ISO 17025 [38] compliance a testing/analytical laboratory must have an efficient laboratory information management system (LIMS) that can be used to track samples, mitigate data handling and be able to report and store test/analysis results. The laboratory should have a quality management system (QMS) that meets accreditation requirements. There should be adequate control of environmental condition control to meet both instrument and testing requirements. Experienced employees with a history of working in similar microbiology laboratory facilities should be employed.[52]

6.1 Signatory Requirements

Accredited laboratories must ensure that all selected signatories of certificates / reports are approved by SANAS/SADCAS. Should the facility lack appropriately qualified and competent employees this could result in the laboratory failing to initially obtain or losing their existing accreditation.[53], [54] The following criteria is required for the approval of person(s) applying as Nominated Representative (NR), Management Signatory (MS) and Technical Signatory (TS).[53], [54]

6.1.1 Nominated Representative (NR) / Management Signatory

All accredited laboratories must formally appoint a NR who as the duly authorized representative of the lab will have the authority and responsibility for all matters relating to accreditation, compliance and maintaining all communication between the facility SANAS.

The NR should:

1. Have an in-depth knowledge and understanding of all requirements relating to accreditation / Compliance of the laboratory.
2. The NR must have a clear understanding of the SANAS/SADCAS Terms and Conditions of Accreditation/Compliance.
3. Know what accreditation/compliance is and have a positive attitude toward accreditation / compliance and its processes.
4. Irrespective of other duties and responsibilities, have a defined responsibility and authority to ensure that the laboratory facility, meets its obligations as specified in the terms and conditions of accreditation, complies with all the applicable accreditation requirements, and the management system principles are implemented and always followed to support their current scope of accreditation / compliance.
5. Have direct access to the highest level of management at which decisions are made on the laboratory's policies or resources.

6. Notify the relevant SANAS Accreditation Manager of significant changes relevant to the lab's accreditation / compliance status in writing at least four weeks prior to them taking effect.
7. Management Signatory (MS): Senior management responsible for running the certification scheme must have knowledge of certification at a level that is sufficient to allow the Management Signatory's signature to grant validity on the certificate. The signatory to a SANAS endorsed certificate must be approved by SANAS.
8. The NR must have a clear understanding of the Accreditation of Conformity Assessment, Calibration and Good Laboratory Practices Act,2006 (Act 19 of 2006).[55]

6.1.2 Technical Signatory (TS)

A TS is a person whose competency is declared by laboratory, and is confirmed by the SANAS, and whose signature grants validity on the laboratory certificates, reports and results issued under its accreditation. All technical signatories must be fulltime or formally employed (e.g. fixed-term contract) employees.

The TS should:

1. Accept responsibility for the contents (i.e. results and/or measurements) of the certificate/report which they authorized.
2. Have sufficient current knowledge of the method used, as well as the objectives of the test/analysis.
3. Be able to assess and interpret the data.
4. Be confident when authorizing results or measurements, that all the necessary checks had been completed as required by the management system to ensure the quality of the result.
5. Have an in-depth knowledge of all SANAS requirements relating to accreditation / compliance.
6. Be familiar with the management system implemented within the laboratory.

6.1.3 Contracted Technical Signatory (CTS)

The use of CTS is meant to be an interim arrangement to help an accredited organization which finds itself unexpectedly without a SANAS/SADCAS approved Technical Signatory in its own staff. In addition, the CTS must comply with all requirements as defined in 6.1.2 and the organization intending to use a CTS must ensure the following:

1. Inform SANAS/SADCAS of its intent to obtain approval for a CTS.
2. Have a formal agreement covering the arrangements, including confidentiality and conflict of interest between the accredited organization and the contracted person/ external body.
3. Take full responsibility for authorizations made by CTS on its behalf.

4. Ensure that the CTS meets all the requirements as defined in 6.1.2.
5. Have records of the proof of competence of the CTS permanently available at its premises.
6. Ensure that the CTS has sufficient presence within the accredited organization to be able to demonstrate satisfactory control of his/her function.

6.2 Human Requirements

According to SANAS, all employees working in the laboratory for accreditation purposes must be hired as CSIR permanent employees. Laboratory employees of accredited laboratories must have the appropriate qualifications, training and / or experience to competently perform the tasks they are accredited for. They must also be able to demonstrate their competence to the SANAS assessor for the scope being accredited.[53], [54] The minimum human resource requirements for the mobile lab in alignments with obtaining SANAS/SADCAS accreditation are listed in Table 6.1.

Core competencies required in all employees working in the laboratory will include:

- Communication
- Teamwork
- Customer orientation
- Continuous learning
- Results orientation
- Problem Solving.

Table 6.1: Mobile lab human resource capacity requirements for laboratory accreditation.

Job Title	Requirements	Key Responsibilities
Laboratory Manager **Gross Salary*:** **30 430 USD p.a.**	• MSc/PhD: Microbiology/Food Science/Food technology. • 10 years industry work experience within a relevant scientific field. • Experienced in laboratory quality management system (QMS) and facilitating compliance with SANAS/SADCAS/ISO 17025. • 3 years management experience.	• Will be the assigned Nominated Representative (NR) / Management Signatory (MS). • Maintain equipment calibration records and laboratory certifications in compliance with SANAS/SADCAS/ISO 17025. • Approve processes, procedures and maintain quality management system (QMS) documents in compliance with SANAS/SADCAS/ISO 17025. • Plan for and coordinate all major equipment maintenance activities. • Represents on behalf of the laboratory to the accreditation institutions.

		• Signing the test reports and calibration certificates on behalf of the laboratory. • Approving yearly plans and programs (e.g., training plan). • Maintains laboratory equipment performance by establishing quality standards. • Developing operations, quality, and troubleshooting procedures. • Maintains quality results by participating quality program. • Maintains laboratory information management system (LIMS). • Supervise, instruct, and provide training to laboratory staff. • Ensure staff are technically competent to perform their duties and train staff on new or updated procedures. • Perform test inspection for SANAS compliance and maintain employees training records. • Employee's training records. • Direct and monitor the laboratory quality management system objectives, procedures, and policies.
Food analytical scientist: **Gross Salary*:** **19 231 USD p.a.**	• BSc/MSc: Food Analytical Technology / Biotechnology. • Minimum of 5 years' work experience in a microbiology/biotechnology laboratory. • Excellent laboratory skills. • Knowledge on GLP • Excellent statistics knowledge • Laboratory technician experience.	• Act as Deputy Lab Manager. • To adhere to deadlines in carrying out analytical and microbial testing/of samples in accordance with ISO 17025. • Develop analysis techniques and/or procedures. • Provide input on ways to improve accredited methods and equipment performance. • Determine when tests/analysis will be conducted and their sequences. • Makes decisions of non- conforming test/analysis results. • Ensure that the instruments are calibrated, used, and verified accordingly.

	• Ability to conduct relevant analytical procedures in accordance with recognized methods. • Ability to remain motivated even when conducting repetitive microbiology procedures. • Strong analytical ability and ability to interpret results.	• Report instruments that require maintenance, repair, or calibration to the Lab Manager. • Monitoring technical performance in the laboratory to ensure efficient sample flow in the laboratory. • Interface with clients regarding test requirements and results. • Assist in preparing technical reports for use by clients. • Safety, Health, Environment, and Quality representative enforcing safety policies.
Microbiologist **Gross Salary*: 12 382 USD p.a.**	• BSc/MSc: Microbiology/Food Science • Minimum of 2 years' work experience in a microbiology/biotechnology laboratory • Excellent laboratory skills. • Knowledge on Good Laboratory Practice (GLP). • Basic statistics knowledge. • Ability to conduct relevant analytical procedures in accordance with recognized methods. • Ability to remain motivated even when conducting repetitive microbiology procedures.	• To adhere to deadlines in carrying out microbiological testing/analysis of samples in accordance with ISO 17025. • Knowledge of ISO 17025 standard. • Monitors inventories, equipment, and laboratory consumables. • Inventory control and ordering of microbiology test supplies. • Interface with clients regarding test requirements and results. • Assist in preparing technical reports for use by clients.

* Gross salary per annum (p.a.): Estimation based on average South African salary shown in Indeed.com.

6.3 Project management structure

One of the key issues raised during the stakeholder engagement workshops was how would the mobile lab or the project be managed. ISO17025: 2017 clause 5.5 [38] states that "A laboratory shall define the organization and management structure of the laboratory, its place in any parent organization, and the relationships between management, technical operations and support services". SANAS technical assessments for application towards ISO/IEC 17020 accreditation require that the laboratory must have an up-to-date organizational chart or documents that clearly indicates the functions and lines of authority of employees within the facility.[56] Laboratory organizational structuring enables:

- Facilitated management and operation.
- Effective delegation
- Optimized use of technical and human resources
- Laboratory operational flexibility
- Expansion of the laboratory scope

As outlined Figure 6.1 below, the proposed project management structure will operate as follows:

- **Project Funder:** The role of the project funder will be to ensure that the project is being conducted in accordance with the agreed scope and objectives. They will also monitor the project implementation outcomes. The project falling under the operational support (host) organization will report directly to funder.
- **Project Manager:** Will be directly responsible for managing the project, and employees working on the project. The project finance and human resource managers falling under the host organization, as well as the mobile laboratory manager will report directly to the project manager.
- **Laboratory Manager**: Will be the assigned Nominated Representative (NR) and Management Signatory (MS). He/she will be reporting directly to the Project Manager in the operational support organization. All employees working in the mobile lab will be reporting directly to the Laboratory Manager.
- **Analytical Technologist/ Scientist**: Will be the assigned Technical Signatories (TS) and SHEQ representatives, and Deputy Lab Manager reporting directly to the Laboratory Manager.
- **Microbiologists**: Will be the assigned Technical Signatories (TS) reporting directly to the Laboratory Manager.

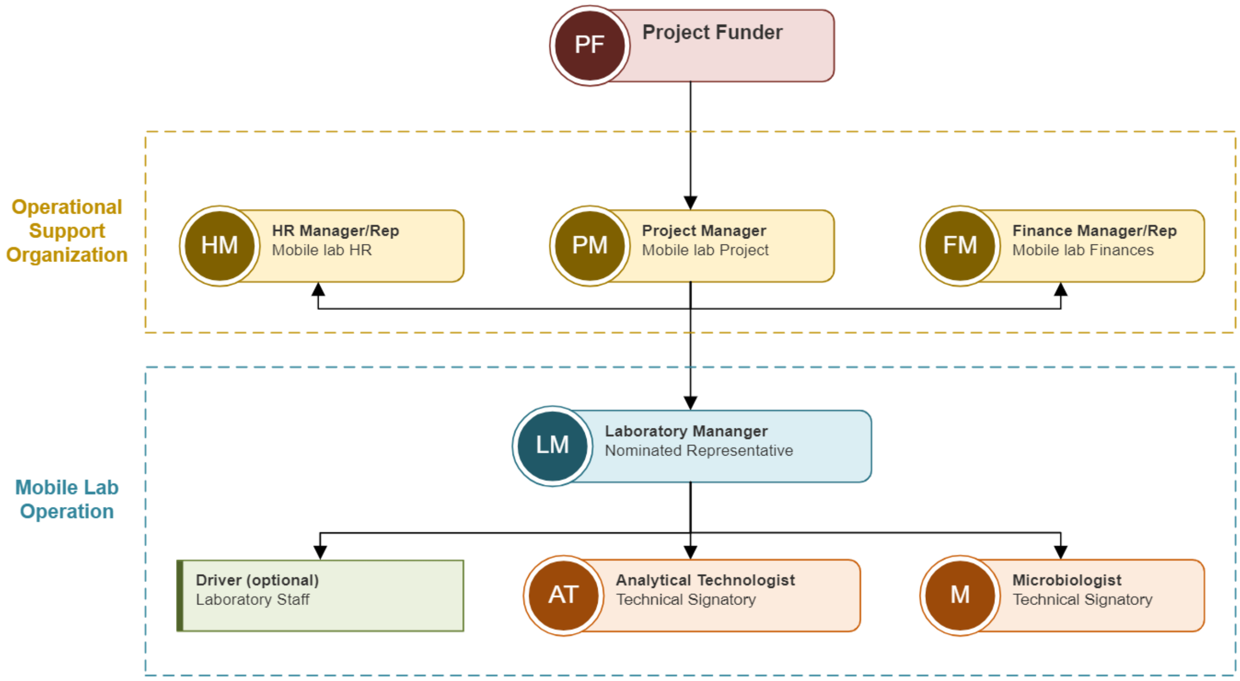


Figure 6.1: Proposed mobile lab project organizational structure.

6.4 Host (operational support) organization requirements.

The selected host organization should be committed to providing meaningful supervision and institutional support to the project. Ideally the organization should have notable experience in hosting technical projects, have highly experienced and proficient staff with an understanding of food safety analytical laboratory and technical project operations. They should be able to demonstrate that they are fiscally stable and have access to relevant resources. They should be unbiased and have no support for a particular organization, government, or person(s). The advantages of using a host organization for the mobile laboratory project are outlined below in Figure 6.2.

Figure 6.2: Advantages of using a host organization.

7 FINANCIAL FEASIBILITY

The methodology used in determining the financial feasibility of the project was based on three project scenario models over 10 years. The approach and data flow in all three financial models is shown in Figure 7.1. The USD to ZAR exchange rates used in the financial modeling and future cash flows are based on a forecasted annual percentage change of 4.12 % as shown in Appendix A.1, where the dollar to rand exchange rate in December 2023 was 1 USD = 18.96 ZAR. The capital requirements, costs, and pricing were used in the discounted cash flow analysis to determine the net present value (NPV) of the three project scenarios over a period of 10 years.

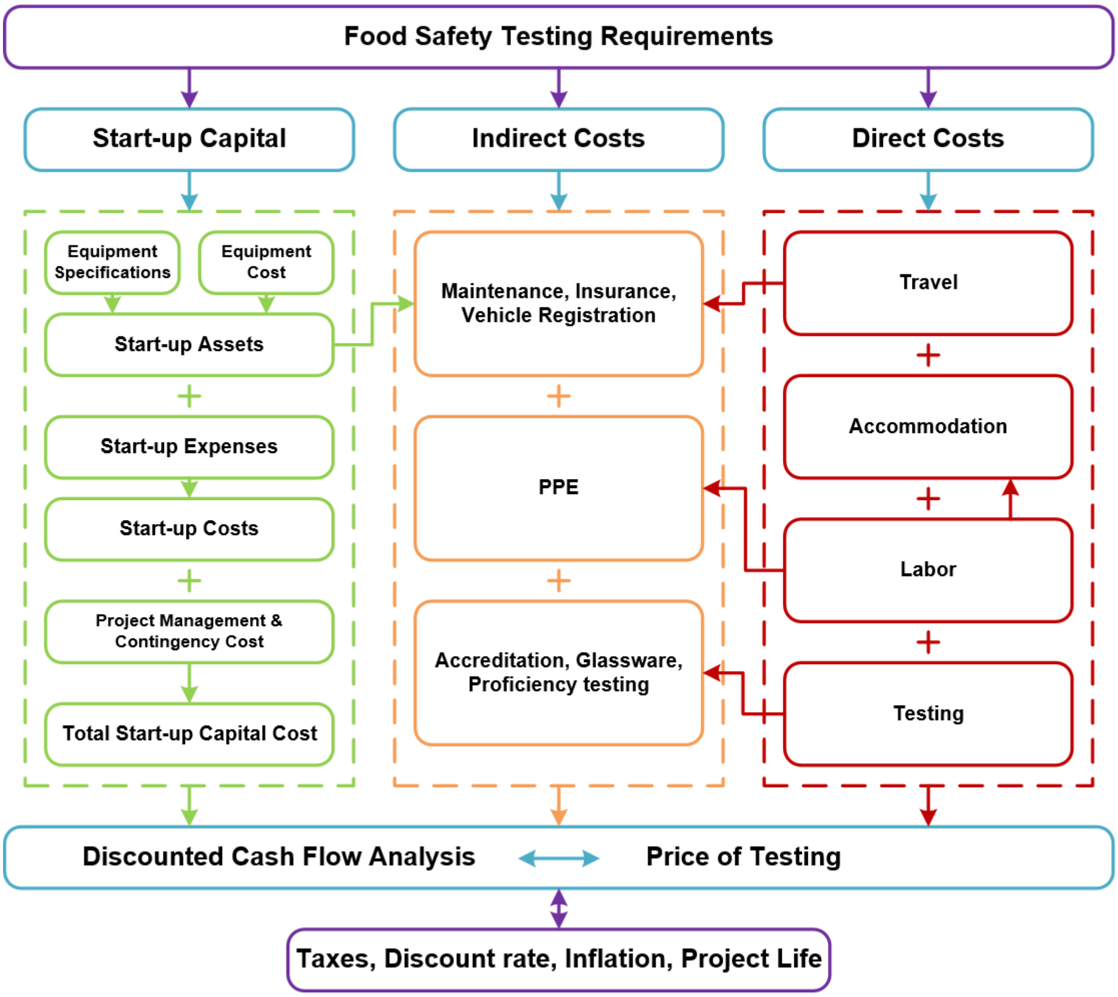


Figure 7.1: Approach used in the project financial feasibility analysis.

7.1 Start-up capital requirements

Start-up capital refers to the money needed to start a business and keep it running until it is established, i.e. it can turn a profit. The start-up capital costs were estimated at 535 813 USD, and their distribution is summarized in Table 7.1 and Figure 7.2. The start-up expenses, fixed assets, testing inventory, and labor requirements were based on the technical and organizational requirements identified in Section 5 and 6. The start-up asset costs include the Model 1 mobile lab vehicle and structural modifications (see Section 5.1), and the estimated cost of purchasing the equipment and instruments that will be required in the mobile lab as outlined in Table 5.1. The basis of the start-up expenses is that the mobile lab will need to be fully operational for at least a year to obtain SANAS/SADCAS accreditation, this year will be referred to as the "Establishment Year". A contingency cost was added to the start-up capital budget to account for any variations in price estimates. A project management cost during project establishment was also allocated in the requirements. Both project management and contingency were estimated at 10% of assets plus expenses. Detailed start-up capital costs are listed in Appendix A.2.

Table 7.1: The mobile lab start-up capital requirements during the establishment year, including assets and expenses.

Start-up Item	Cost (ZAR)	Cost (USD)
Instruments/equipment	3 577 083	188 665
Mobile lab + modification	1 431 850	75 520
Expenses	3 456 920	182 327
Contingency*	846 585	44 651
Project management*	846 585	44 651
Total Start-up Capital Requirements	**R 10 159 023**	**$ 535 813**

* Estimated at 10% of assets plus expenses.

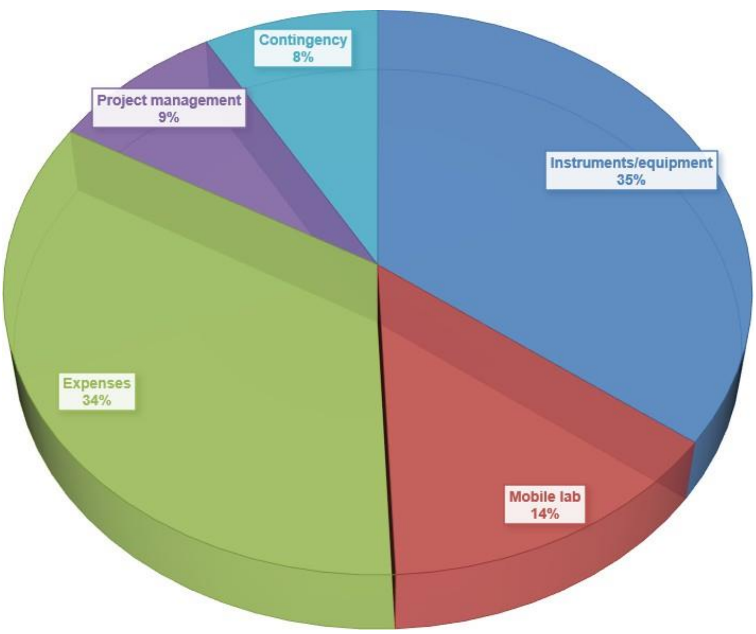


Figure 7.2: The distribution start-up capital requirements during the project establishment year.

7.1.1 Start-up Expenses

The start-up expenses that are directly related to the operation of the mobile lab include human resource, testing, traveling, operational staff accommodation and subsistence costs, and their distribution is shown in Figure 7.3. The human resource cost per annum amounts to 62 043 USD (see Table 7.2) and attribute to 40 % of the direct costs. Human resource cost only includes staff members directly related to the operation of the mobile lab and does not include operational support/host organization staff. The costs of testing per annum amount to 66 100 USD (see Table 7.3) and attribute to 42 % of the direct costs. The unit prices of the various testing materials were determined based on supplier prices. All chemical reagents were of the highest purity AR or HPLC grade and were used without further modification. Detailed costs per test are listed in Appendix A.3. Waste disposal charges were excluded, as the mobile lab is not expected to generate large volumes of waste. The estimated cost of travelling per annum for mobile lab models 1 and 2, in Lesotho, Namibia and Eswatini are listed in Table 7.4. An estimated traveling cost 6 049 USD was used in the start-up expenses based on mobile lab Model 1 operating in Namibia, which would contribute to 4 % of the direct costs. The staff accommodation and subsistence costs per annum amounted to 22 278 USD (see Table 7.5) and attribute to 14% of the direct costs and were based on average bed and breakfast accommodation in all four countries for two operational staff, deployed 4 days a week. The operational staff would from the country that the mobile lab is based in or take up residency in that country for certain periods of time and would be employed through the operational support/host organization. This would be to avoid traveling cost that would have to be funded directly through the company through a travel allowance or salaries. **Table 7.2:** Human resource costs directly related to the operation of the mobile lab.

Human resource	Annual Salary (ZAR)	Annual Salary (USD)
Mobile Lab Manager	576 946	30 430
Analytical Technologist	364 628	19 231
Microbiologist	234 764	12 382
Total HR Costs	**R 1 176 338**	**$ 62 043**

Table 7.3: Testing costs

Test	Cost/unit (ZAR)	Cost/unit (USD)	Cost/year* (ZAR)	Cost/year (USD)
Microbial	585	31	449 283	23 696
Pesticides	431	23	331 189	17 468
Total mycotoxins	616	32	472 776	24 935
Total Costs			**R 1 253 249**	**$ 66 100**

* Based on estimated testing capacity and throughput of each test (64 units /per month) over 12 operational months.

Table 7.4: Travel costs directly related to the operation of the mobile lab.

Starting point	Furthest Destination	Travel time (hrs)	Distance* (km)	Cost/year** (ZAR)		Cost/year (USD)	
				Model 1	Model 2	Model 1	Model 2
Lesotho (Maseru)	Quthing	3	350	40 303	161 213	2 126	8 503
Namibia (Windhoek)	Keetmanshoop	8	996	114 691	458 766	6 049	24 196
Eswatini (Manzini)	Lavumisa	2	278	32 012	128 049	1 688	6 754

* Distance from the starting point to the destination and back.

** Fuel price ZAR 23.99/L, 4 deployments per month, van (Model 1) and truck (Model 2) fuel consumption is 0.1L/km and0.4 L/km, respectively.

Table 7.5: Accommodation and subsistence costs directly related to the operation of the mobile lab.

Item	Cost pp/night (ZAR)	Cost/night (ZAR)	Cost/year* (ZAR)	Cost/year (USD)
Accommodation	800	1 600	307 200	16 203
Subsistence allowance	300	600	115 200	6 076
Total cost			**R 422 400**	**$ 22 278**

* 16 days per month, 4 nights per week.

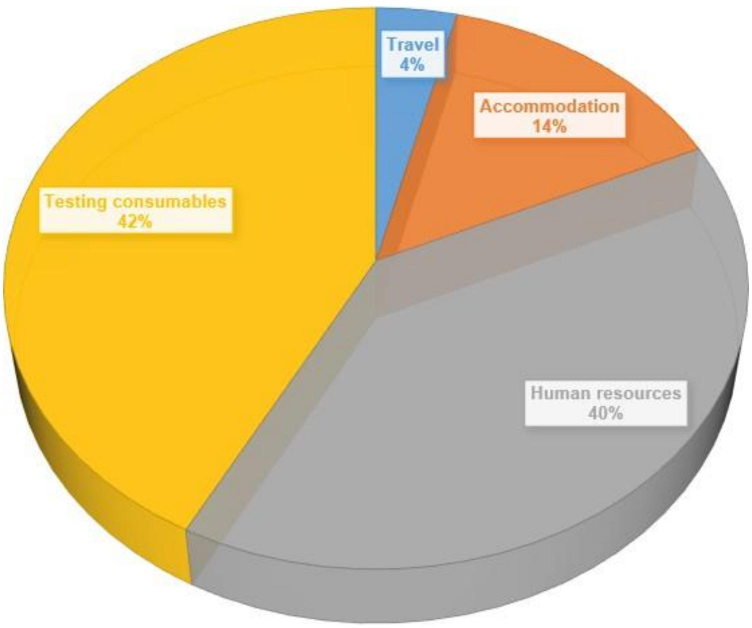


Figure 7.3: Direct cost distribution of the project establishment year.

The start-up expenses that are indirectly related to the operation of the mobile lab include SANAS/SADCAS accreditation, maintenance, insurance, PPE, glassware, and vehicle registration (see Table 6.6) and their distribution is shown in Figure 6.4. The annual accreditation fees amount to 5 059 USD,[57] and attribute to 38 % of the indirect costs. The estimated cost of inter-laboratory proficiency testing which is a SANAS/SADCAS requirement was estimated at 3 327 USD per annum,[58] and attribute to 25 % of the indirect costs. The annual maintenance cost was estimated at 2 642 USD and attributed 19 % of the indirect costs. Insurance was estimated at 1 899 USD per annum and attributed to 15 % of the indirect costs. The remaining indirect cost are PPE, glassware and vehicle registration attributed to 3% of the indirect costs.

Table 7.6: Summary of costs indirectly related to the operation of the mobile lab.

Item	Cost/year (ZAR)	Cost/year (USD)
SANAS/SADCAS Accreditation	95 921	5 059
Proficiency testing	63 080	3 327
Maintenance	50 089	2 642
Insurance	36 000	1 899
Glassware	5 000	264
PPE	3 000	158
Vehicle registration	540	28
Total Costs	**R 253 630**	**$ 13 377**

* Estimated at 1% of assets costs.

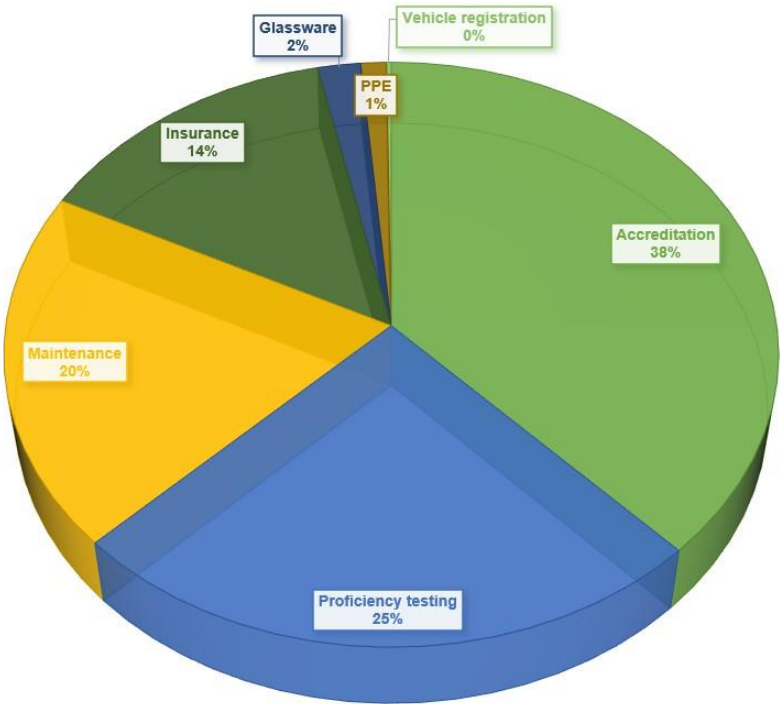


Figure 7.4: Indirect cost distribution of the project establishment year.

The once-start-up cost that will be incurred during the establishment year include the mobile laboratory LIMS system, initial staff training and accreditation initiation fees, are estimated at 12 480 USD (see Table 7.7).

Table 7.7: Summary of once-off start-up costs.

Item	Cost/year (ZAR)	Cost/year (USD)
LIMS system	110 916	5 850
Initial staff/operator training	75 000	3 956
Accreditation initiation fees	50 695	2 674
Total Once-off Costs	**R 236 611**	**$ 12 480**

7.2 Discounted Cash Flow Analysis

7.2.1 Financial Scenarios

Three financial scenarios were prepared with various qualifying criteria, which are summarized as follows:

Scenario 1 – "BASE CASE"

This scenario is to determine the cumulative profit potential over a 10-year period based providing all testing services (pesticide, mycotoxin and microbial) at current market related prices, operating at the estimated testing capacity/throughput outlined in Section 5.3. All laboratory operations are effectively and efficiently executed, with minimal challenges. The scenario basis is as follows:

- Based on securing a strong market share, with the mobile lab being well positioned with clients, and food safety regulatory institutions in each country.
- Highly skilled human resources, leading to high testing efficiency.
- Estimated testing throughput is achieved (64 each per month).
- All start-up expenses and assets are financed through funding.
- Highest profit potential.

Scenario 2 – "BREAK-EVEN"

This scenario is to determine the financial break-even or the annual income required to cover all costs and remain functional over a 10-year period, i.e. NPV remains at 0, with no profit. The scenario basis is as follows:

- Testing throughput is evenly reduced to break-even over 10 years.
- Determination of the minimum annual income required to cover all costs and remain functional over a 10-year period.

- Determine the minimum testing throughput that must be achieved to cover all direct and indirect costs and break even annually over a 10-year period.
- All start-up expenses and assets are financed through funding.

Scenario 3 – "NO FUNDING"

This scenario is to determine if the project would be profitable over a 10-year period without any establishment funding. The scenario basis is as follows:

- All costs remain the same as Scenario 1.
- Highly skilled human resources, leading to high testing efficiency.
- Estimated maximum testing throughput is achieved (64 each per month).
- All start-up expenses and assets are financed through a 10% fixed interest business loan.

7.2.2 Discounted Cash Flow Analysis Parameters

In the initial stages of a project, cash flows out of the company to pay for construction, equipment, and often engineering costs. When the initial project set-up is complete, and operations begin, the revenues from sale of a product or service begin to flow into the company. The difference between the revenue and expenditure at any period gives an indication of net cash flow during that period. The discounted cash flow is based on the best estimates of required investment, operating costs, sales volume, and sales price that can be made in the project. Expected or forecast project cash flows are often used in determining the techno-economic feasibility of a project.

The net present value (NPV) of a project is the sum of the present values of the future cash flows. Net present value is a more useful measure than return on investment (ROI) and net profit margin because it considers the change in value of money with time and considers annual changes in costs and revenues. The NPV of a project can be obtained using the following equation:[59]

$$NPV = \sum_{n=1}^{n=t} \frac{CF_n}{(1+i)^n} \quad (1)$$

Where, t is project time in years, CF is the cash follow in year n, and i is the interest rate.

The discounted cash flow analysis of the three project scenarios was based on the following assumptions:

- The baseline testing prices are at current market related prices.
- The annual tax rate is based on the South African corporate income tax rate which equivalent to 27%.

- The inflation rate was over-estimated at 6%, to counter any volatility.
- Tax and inflation rates remain kept constant over the project duration.
- The straight-line method was used in forecasting the annual depreciation in the projects fixed asset investment.
- Only one mobile lab is operational per annum, during the project life.

Table 7.8: Discounted cash flow analysis economic parameters starting from establishment year.

Scenario	1	2	3
Description	BASE-CASE	BREAK-EVEN	NO FUNDING
Mobile Lab Model	Model 1		
Travel distance (maximum)	996 km		
Project life	10 years		
Start-up funding (USD)	535 813	535 813	0
Fixed asset expense (USD)	264 184		
Start-up expenses (USD)	271 629		
Annual inflation	6%		
Discount rate	8%		
Income tax rate	27%		
Annual straight-line depreciation (USD)	26 418		
Pesticide price/test (USD)	21		
Mycotoxin price/test (USD)	90		
Microbial price/test (USD)	35		
Testing throughput (each test/month)	64	< 64	64
Operational rate (days/month)	16		

To identify which of the project factors or input variables has the most significant impact on the NPV of the three scenarios, a sensitivity analysis was conducted. In the NPV sensitivity analysis economic input variables were modified at ranges of a 100% increase and 100% decrease in the baseline values, using the following equations:[60]

$$\%\ change\ in\ NPV = \left(\frac{NPV_i - NPV_{baseline}}{NPV_{baseline}}\right) \times 100 \qquad (2)$$

and,

$$Sensitivity = \frac{\%\ change\ in\ NVP}{\%\ change\ in\ input\ variable} \qquad (3)$$

Where, NPV_i, is the NPV obtained when the input variable was changed by a certain percentage, while the remaining input variables were kept constant. $NPV_{baseline}$, is the baseline NPV obtained using the baseline input values.

7.3 Financial Appraisal Results

7.3.1 Financial projections

The projected cumulative income, expenses, and net profit in 5 and 10 years for the three financial scenarios are shown in Figure 7.5 and 7.6. The income statements of each scenario are shown in Appendix A.4. If the project secures establishment funding and secures testing sales at its estimated capacity without any volatility in project variables, an expected cumulative income of 1 130 384 USD and net profit of 74 482 USD will be made in 5 years. While an expected cumulative income of 2 354 008 USD and net profit of 155 920 USD will be made after 10 years. The projections for Scenario 2 indicate that, the mobile lab must secure monthly sales of 54 units of each test at minimum to break even annually with a net profit of 0 USD, where both the income and expenses will be 973 561 USD over 5 years and 2 025 714 USD over 10 years. If the project does not acquire establishment funding but is rather funded through a loan with 10 % fixed interest (Scenario 3), the project would run at a loss with net profits of – 30 062 USD and - 50 595 USD after 5 and 10 years, respectively.

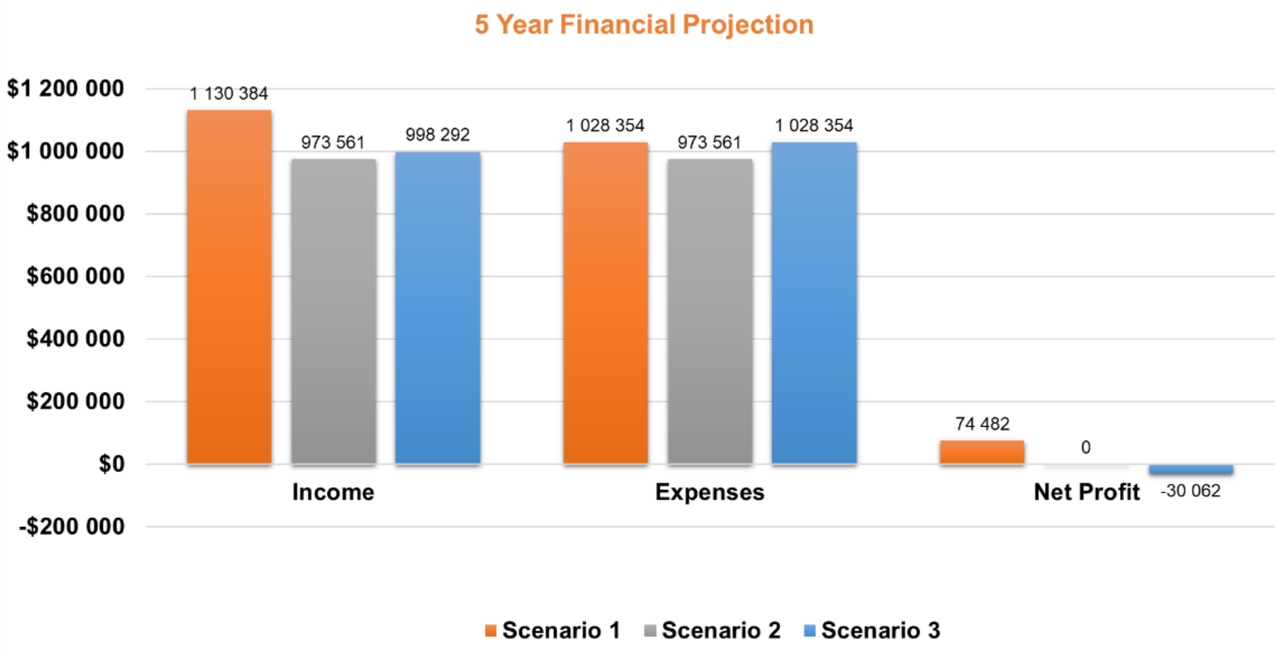


Figure 7.5: A comparison of the cumulative income, expenses and profit that can be obtained in the three project scenarios, after 5 years.

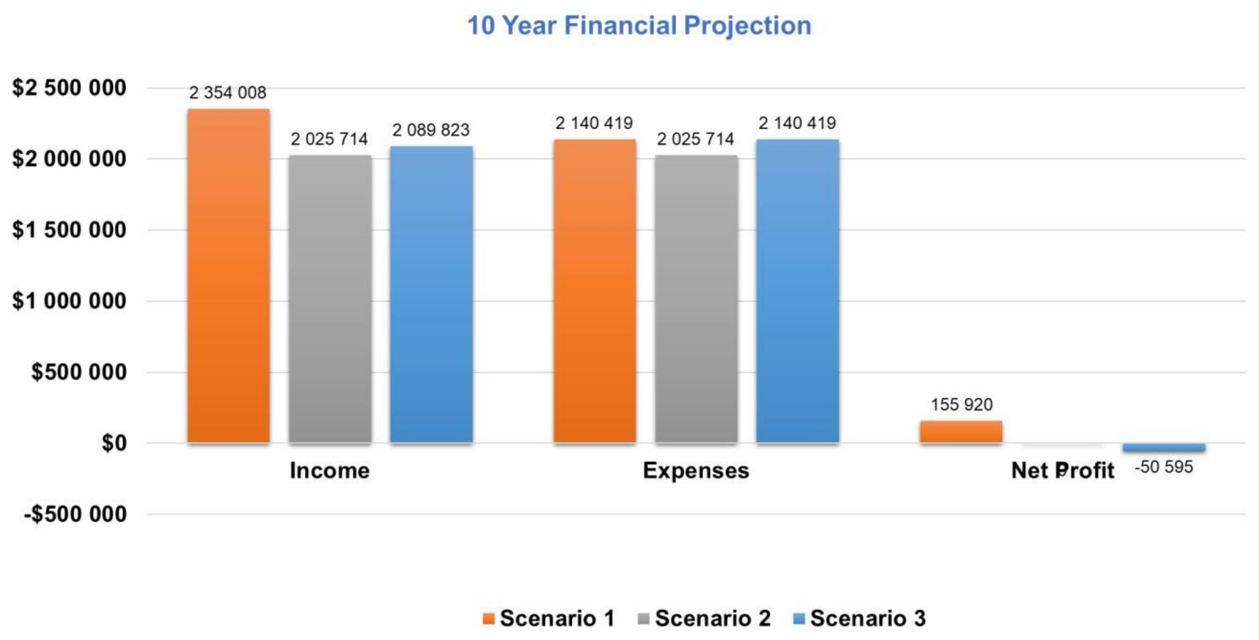


Figure 7.6: A comparison of the cumulative income, expenses and profit that can be obtained in the three project scenarios, 10 years.

A comparison of cumulative direct and indirect costs of Scenario 1 is shown in Figure 7.7. The cumulative cost of running the mobile lab would be, 1 028 354 USD over 5 years and 2 140 419 USD over 10 years. The projections suggest that the mobile lab direct costs will be approximately 12 times more than indirect costs throughout the project life cycle and that both the direct and indirect costs will more than double between 5 and 10 years.

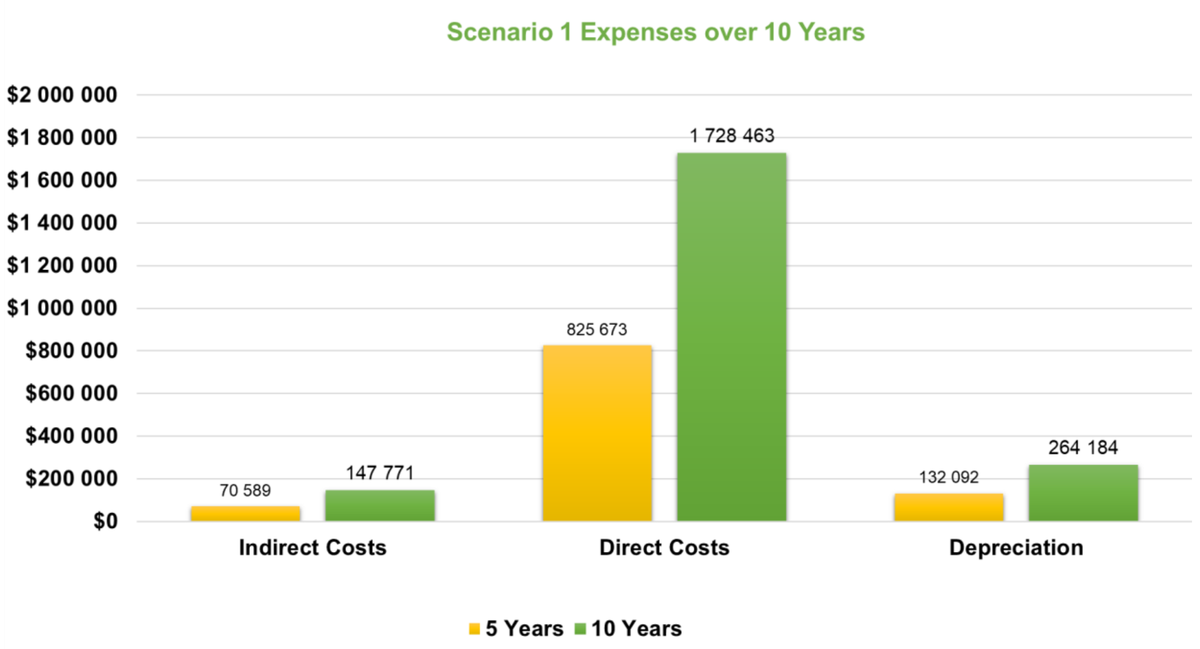


Figure 7.7: A comparison of the cumulative direct and indirect cost of Scenario 1, during the project life cycle.

7.3.2 Discounted Cash Flow Analysis

The results of discounted cash flow analysis of the three scenarios are shown in Figure 7.8, and the discounted cash-flow spreadsheets of each scenario are shown in Appendix A.5. The net present value (NPV) of future cash flows is positive in both 5 and 10 years in Scenario 1, which indicates that if the project secures establishment funding and secures testing sales at it estimated maximum capacity without any volatility in project variables, it would be a lucrative investment. If the project breaks even, NPV = 0 through the project life cycle. If the project does not acquire establishment funding (Scenario 3), the project would not be financially feasible throughout its life cycle, where NPV in both 5 and 10 years is negative.

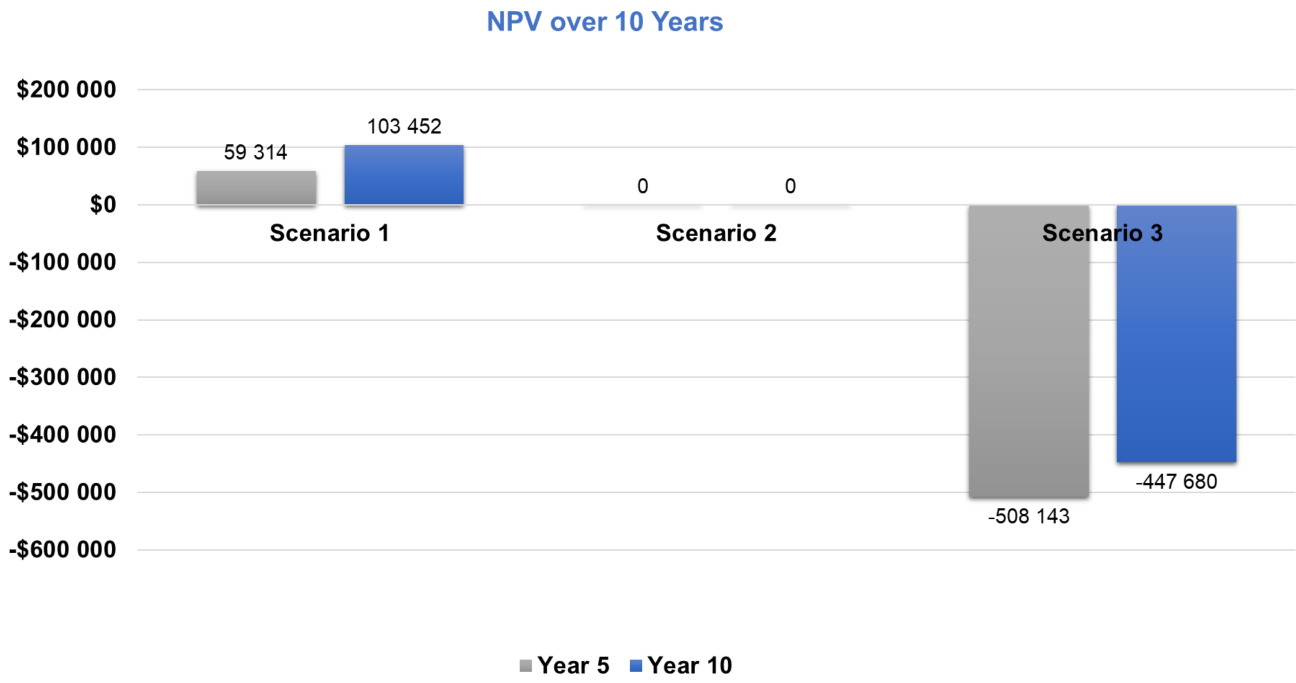


Figure 7.8: A comparison of estimated project net present values that can be obtained in the three project scenarios, after 5 and 10 years.

7.3.3 Sensitivity Analysis

The sensitivity analysis results for scenarios 1 and 3 are shown in are shown in Figures 7.9 and 7.10, while the sensitivity analysis data is shown in Appendix A.6. The analysis suggests that testing throughput, test pricing, project funding and human resource costs have the greatest impact on the project NPV. Whereas project variables such as indirect costs, tax rate, discount rate, loan interest rate and the inflation rate have minimal impact on the project NPV. The analysis of project funding sensitivity indicates that, if the project is funded through loan with 10 % fixed interest, either testing throughput or pricing would have to be increased for the project to be financially feasible. The throughput for each test per month would have to increase by a minimum of 67 % (i.e. 107 units of each test would have to be conducted per month) for the project to be profitable in 10 years with

NPV > 0, which would not be feasible in term of manpower and the laboratory capacity of model 1. However, increasing the pricing of each test by 44% would result in the project being profitable. If the loan was interest free increasing the pricing of each test by 38% would result in the project being profitable. The average turnaround time in SADC region for issuing of pesticide and mycotoxin results is usually 2-4 weeks and microbial results 1-4 weeks, therefore the value proposition of the mobile lab issuing pesticide and mycotoxin test results in 8 hours and microbial test results in 8- 48 hours could be used as justification to increase the pricing of by 38-44% of the current market price.

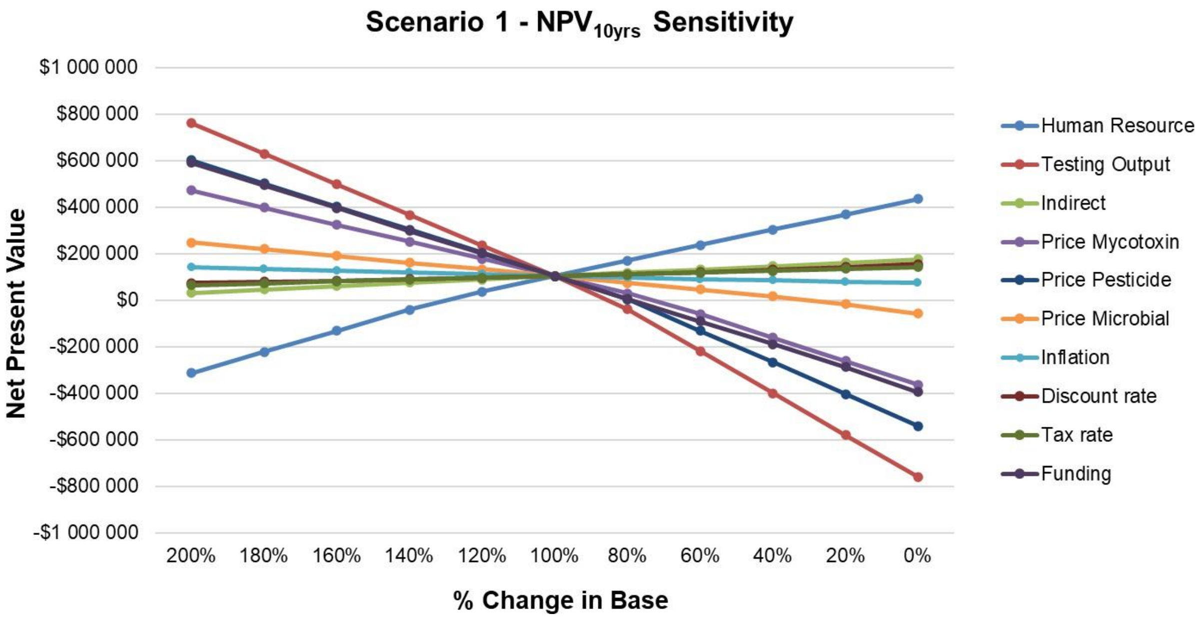


Figure 7.9: NPV sensitivity analysis of scenario 1, base-case after 10 years.

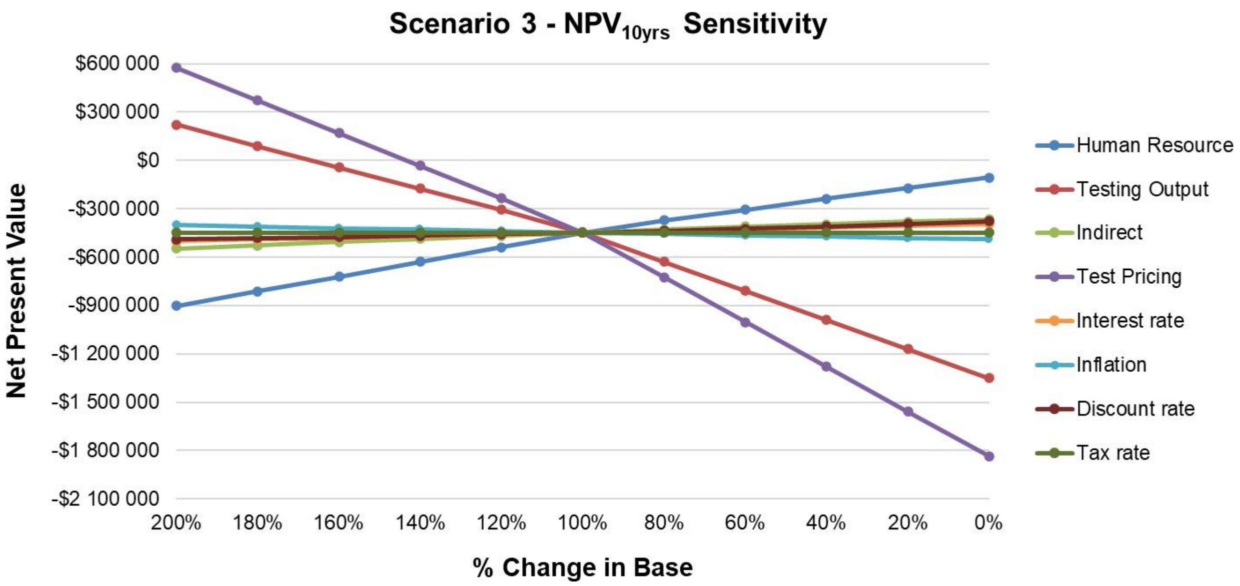


Figure 7.10: NPV sensitivity analysis of scenario 3, no project funding after 10 years.

8 CONCLUSION

The reported is based on a feasibility study that was conducted to assess the potential impact and economic viability of a mobile ISO 17025 accredited food safety testing laboratory in SADC countries along their food value chains, with an initial focus on South Africa, Namibia, Eswatini and Lesotho.

The socioeconomic feasibility of the project was assessed. Stakeholder workshops and dialogues were hosted Lesotho, Eswatini and Namibia to identify the need, or specific analysis requirements for mobile food safety testing in the SADC region. The need for an ISO 17025 accredited mobile laboratory for food safety testing in Lesotho, Eswatini and Namibia was established, in all the agricultural sectors that were in attendance. Challenges in their current food safety testing systems were identified and discussed, and the food safety testing they would require from the mobile laboratory service were identified. Policy documents, food laws, national food control systems and ISO 17025 accreditation bodies in each country were also identified.

The market feasibility of the project was assessed, based on the stakeholder needs and challenges identified through engagement with the assessed countries. The project has competitive advantages and is commercially feasible. Where the most pressing food safety challenges identified in the current market were microbial, mycotoxin and pesticide testing followed by product quality challenges related to soil and grain analysis/quality. Possible target consumers were also identified including, informal markets e.g. SMME farmers and primary processors, commercial markets e.g. commercial farmers and food manufacturers and food safety regulatory institutions e.g. government mandated food testing institutions, government enforced testing at border post and ports of entry. A project SWOT analysis was used to outline the project strength, weaknesses, opportunities and threats and a risk assessment was conducted to identify project risks and actions to mitigate them.

From a technical standpoint, the instruments required, and their specification based on food safety testing methods identified (microbial, mycotoxin, pesticide). The testing capacity and throughput was also established at four of each test method based on the available instruments and estimated manpower. The importance of data management and ownership in the project was also analyzed. Two mobile lab vehicle models were designed and considered, and their architectural requirements were outlined based on the required testing and testing throughput. Based on the identified technologies and systems, the project should be technically feasible.

The project organization and management requirements were also assessed based on SANAS/SADCAS accreditation requirements. The roles, responsibility and work-related experience of personnel who will be working directly in the mobile lab were outlined. The project organizational management structure outlining roles, responsibilities, and reporting relationships within the project were also defined.

The financial feasibility assessment and models were based on a Model 1 mobile laboratory, with two operational staff members, working on-site in the mobile lab for four days a week, conducting microbial, mycotoxin and pesticide testing of food samples. Three financial models were reported on, namely the base-case (scenario 1), annual break-even through the project life cycle (scenario 2) and no project establishment funding or the project is established through a loan (scenario 3). The key findings as follows:

- The project requires a start-up capital investment of approximately 535 813 USD over a minimum period of one year.
- Sponsorship or collaboration with various instruments suppliers should be considered as a means to reduced start-up capital costs.
- The project will be profitable if the start-up capital is acquired as establishment funding and the mobile lab operates at its maximum capacity and testing throughput, with and volatility in project variable. A cumulative project income of 1 130 384 USD and net profit of 74 482 USD would be made in 5 years. While a cumulative income of 2 354 008 USD and net profit of 155 920 USD would be made after 10 years.
- The cumulative cost of running the mobile lab including direct, indirect and depreciation costs would be, 1 028 354 USD over 5 years and 2 140 419 USD over 10 years.
- The mobile lab must secure monthly sales of 54 units of each test at minimum to break even annually with a net profit of 0 USD, where both the income and expenses will be 973 561 USD over 5 years and 2 025 714 USD over 10 years.
- The net present value (NPV) of future cash flows is positive for scenario one, and negative for scenario 3, which indicates that using base-case variable the project will not be feasible if it does not obtain establishment funding.
- Sensitivity analysis results suggested that variables such as testing throughput, test pricing, project funding and human resource costs have the greatest impact on the project NPV or profitability. If the project is funded through loan with 10 % fixed interest, the pricing of each test would have to be marked-up by 44% for the project to be profitable. If the loan was interest free increasing the pricing of each test by 38% would result in the project being profitable.
- The average turnaround time in SADC region for issuing of pesticide and mycotoxin results is usually 2-4 weeks and microbial results 1-4 weeks, therefore the value proposition of the mobile lab issuing pesticide and mycotoxin test results in 8 hours and microbial test results in 8- 48 hours could be used as justification to increase the pricing of by 38-44% of the current market price.

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APPENDIX A - FINANCIAL FEASIBILITY DATA

A.1. USD to ZAR forecasted annual percentage change

Year	December ZAR/USD rate	% change/ year
2013	10.2	
2014	11.09	8.73%
2015	14.46	
2016	14.07	-2.70%
2017	13.72	-2.49%
2018	13.73	0.07%
2019	14.65	6.70%
2020	15.44	5.39%
2021	15.87	2.78%
2022	17.13	7.94%
2023	18.96	10.68%
	Average change	**4.12%**
Year	**Jan-December ZAR/USD rate**	
2024*	R18.96	
2025	R19.74	
2026	R20.56	
2027	R21.40	
2028	R22.29	
2029	R23.21	
2030	R24.16	
2031	R25.16	
2032	R26.20	
2033	R27.28	
2034	R28.40	

A.2. Detailed start-up capital costs

	Proposed Supplier	Unit cost (ZAR)	No. Units	∑ Cost (ZAR)	∑ Cost (USD)
Start-up assets					
Mobile Lab					
Truck/van + service plan	VW	R957 850.00	1	R957 850.00	$50 519.51
Modifications + solar system	TBC	R474 000.00	1	R474 000.00	$25 000.00
Instruments/equipment					
Mobile HPLC	Agilent	R948 000.00	1	R948 000.00	$50 000.00
Torion T-9 Portable GC/MS	PerkinElmer	R1 858 080.00	1	R1 858 080.00	$98 000.00
3M™ Petrifilm® Plate Reader	Neogen	R211 024.80	1	R211 024.80	$11 130.00
Autoclave	Labotec	R139 000.00	1	R139 000.00	$7 331.22
Lab Fridge	Lasec	R19 435.00	1	R19 435.00	$1 025.05
Digital Dry Block Incubators	Hygiena LLC	R16 969.20	1	R16 969.20	$895.00
5L Laboratory Incubator	IVYX Scientific	R2 844.00	1	R2 844.00	$150.00
ANALOGUE VORTEX MIXER	Lasec	R5 375.95	1	R5 375.95	$283.54
Hygiena EnSURE™ Touch	Hygiena LLC	R26 839.15	1	R26 839.15	$1 415.57
Small ductless fumehood	Airfiltronix	R49 106.40	1	R49 106.40	$2 590.00
Aircon unit	Dometic	R23 859.40	1	R23 859.40	$1 258.41
Centrifuge - Benchtop (15 ml)	Benchmark Scientific	R8 645.76	1	R8 645.76	$456.00
PRO250® Homogenizer	Thomas Scientific	R63 042.00	1	R63 042.00	$3 325.00
SP Bel-Art Micro-Mill- Grinder	Thomas Scientific	R1 105.94	1	R1 105.94	$58.33
Grain spear	Sampling Systems	R3 839.40	2	R7 678.80	$405.00
Vacuum pump	Lasec	R38 170.73	2	R76 341.46	$4 026.45
Analytical balance	Merck	R26 867.69	2	R53 735.38	$2 834.14
Pipettes	Lasec	R11 000.00	6	R66 000.00	$3 481.01
Total Assets				**R5 008 933.23**	**$264 184.24**
Start-up expenses					
LIMS system	LabCollector - AgileBio	R110 916.00	1	R110 916.00	$5 850.00
Initial staff/operator Training	MiChem Dynamics	R75 000.00	1	R75 000.00	$3 955.70
Proficiency testing	SADCAS/SANAS Accredi	R63 079.92	1	R63 079.92	$3 327.00
Accreditation	SADCAS/SANAS	R95 920.80	1	R95 920.80	$5 059.11
Accreditation initiation fees	SADCAS/SANAS	R50 695.36	1	R50 695.36	$2 673.81
Human resources		R1 176 338.00	1	R1 176 338.00	$62 043.14
Testing consumables		R1 253 248.71	1	R1 253 248.71	$66 099.62
Travel		R114 691.39	1	R114 691.39	$6 049.12
Accommodation		R422 400.00	1	R422 400.00	$22 278.48
Maintenance		R50 089.33	1	R50 089.33	$2 641.84
PPE		R3 000.00	1	R3 000.00	$158.23
Vehicle registration		R540.00	1	R540.00	$28.48
Insurance		R36 000.00	1	R36 000.00	$1 898.73
Glassware		R5 000.00	1	R5 000.00	$263.71
Start-up Project Management				R846 585.27	$44 651.12
Contingency				R846 585.27	$44 651.12
Total Start-up Expenses				**R5 150 090.06**	**$271 629.22**
Total Start-up Cost				**R10 159 023**	**$535 813**

A.3. Detailed testing costs.

	Supplier	cost	Units	Cost/unit	Units/test	∑ Cost/test (ZAR)	∑ Cost/test (USD)
Microbial						**R585.00**	**$30.85**
MicroSnap E. coli	Hygiena LLC	R15 073.20	100	R150.73	1	R150.73	$7.95
MicroSnap Total Viable Count	Hygiena LLC	R9 385.20	100	R93.85	1	R93.85	$4.95
InSite® Salmonella	Hygiena LLC	R12 039.60	50	R240.79	1	R240.79	$12.70
3M™ Petrifilm® Rapid Yeast an	3M™	R2 112.47	50	R42.25	1	R42.25	$2.23
Maximum Recovery Diluent	Merck	R1 283.80	500	R2.57	3.42	R8.78	$0.46
Pipette tips	Lasec	R307.48	96	R3.20	8	R25.62	$1.35
Gloves	Lasec	R180.00	100	R1.80	2	R3.60	$0.19
Disposbale beaker	Merck	R1 937.46	100	R19.37	1	R19.37	$1.02
Pesticide						**R431.24**	**$22.74**
QuEChERS kit (maximum cost)	Agilent	R11 957.24	50	R239.14	1	R239.14	$12.61
Acetonitrile HPLC grade	Merck	R4 742.22	1000	R4.74	15	R71.13	$3.75
Water HPLC grade	Merck	R775.18	1000	R0.78	10	R7.75	$0.41
Disposable Helium cylinder	PerkinElmer	R46 452.00	6	R7 742.00	0.01	R77.42	$4.08
Pipette tips	Lasec	R307.48	96	R3.20	4	R12.81	$0.68
Gloves	Lasec	R180.00	100	R1.80	2	R3.60	$0.19
Disposbale beaker	Merck	R1 937.46	100	R19.37	1	R19.37	$1.02
Mycotoxins						**R615.59**	**$32.47**
MycoSpin™ 400	Romer Labs	R3 528.16	25	R141.13	1	R141.13	$7.44
Standard solution	NMISA					R291.92	$15.40
Acetonitrile HPLC grade	Merck	R1 352.40	1000	R1.35	56	R75.73	$3.99
Water HPLC grade	Merck	R775.18	1000	R0.78	56	R43.41	$2.29
Methanol HPLC	Merck	R1 352.40	1000	R1.35	6	R8.11	$0.43
Acetic acid HPLC grade	Merck	R4 502.12	500	R9.00	0.5	R4.50	$0.24
Vial/lid	Merck	R1 500.00	100	R15.00	1	R15.00	$0.79
Pipette tips	Lasec	R307.48	96	R3.20	4	R12.81	$0.68
Gloves	Lasec	R180.00	100	R1.80	2	R3.60	$0.19
Disposbale beaker	Merck	R1 937.46	100	R19.37	1	R19.37	$1.02
Aflatoxins (B1, B2, G1, G2)						**R354.41**	**$18.69**
MycoSpin™ 400	Romer Labs	R3 528.16	25	R141.13	1	R141.13	$7.44
Standard solution	NMISA	R1 537.00	200	R7.69	4	R30.74	$1.62
Acetonitrile HPLC grade	Merck	R1 352.40	1000	R1.35	56	R75.73	$3.99
Water HPLC grade	Merck	R775.18	1000	R0.78	56	R43.41	$2.29
Methanol HPLC	Merck	R1 352.40	1000	R1.35	6	R8.11	$0.43
Acetic acid HPLC grade	Merck	R4 502.12	500	R9.00	0.5	R4.50	$0.24
Vial/lid	Merck	R1 500.00	100	R15.00	1	R15.00	$0.79
Pipette tips	Lasec	R307.48	96	R3.20	4	R12.81	$0.68
Gloves	Lasec	R180.00	100	R1.80	2	R3.60	$0.19
Disposbale beaker	Merck	R1 937.46	100	R19.37	1	R19.37	$1.02
Fumonisins (B1 & B2)						**R429.67**	**$22.66**
MycoSpin™ 400	Romer Labs	R3 528.16	25	R141.13	1	R141.13	$7.44
Standard solution	NMISA	R2 650.00	50	R53.00	2	R106.00	$5.59
Acetonitrile HPLC grade	Merck	R1 352.40	1000	R1.35	56	R75.73	$3.99
Water HPLC grade	Merck	R775.18	1000	R0.78	56	R43.41	$2.29
Methanol HPLC	Merck	R1 352.40	1000	R1.35	6	R8.11	$0.43
Acetic acid HPLC grade	Merck	R4 502.12	500	R9.00	0.5	R4.50	$0.24
Vial/lid	Merck	R1 500.00	100	R15.00	1	R15.00	$0.79
Pipette tips	Lasec	R307.48	96	R3.20	4	R12.81	$0.68
Gloves	Lasec	R180.00	100	R1.80	2	R3.60	$0.19
Disposbale beaker	Merck	R1 937.46	100	R19.37	1	R19.37	$1.02
Fusarium toxins (Don & Zon)						**R408.47**	**$21.54**
MycoSpin™ 400	Romer Labs	R3 528.16	25	R141.13	1	R141.13	$7.44
Standard solution	NMISA	R2 120.00	50	R42.40	2	R84.80	$4.47
Acetonitrile HPLC grade	Merck	R1 352.40	1000	R1.35	56	R75.73	$3.99
Water HPLC grade	Merck	R775.18	1000	R0.78	56	R43.41	$2.29
Methanol HPLC	Merck	R1 352.40	1000	R1.35	6	R8.11	$0.43
Acetic acid HPLC grade	Merck	R4 502.12	500	R9.00	0.5	R4.50	$0.24
Vial/lid	Merck	R1 500.00	100	R15.00	1	R15.00	$0.79
Pipette tips	Lasec	R307.48	96	R3.20	4	R12.81	$0.68
Gloves	Lasec	R180.00	100	R1.80	2	R3.60	$0.19
Disposbale beaker	Merck	R1 937.46	100	R19.37	1	R19.37	$1.02
HPLC- Ochratoxin						**R394.05**	**$20.78**
MycoSpin™ 400	Romer Labs	R3 528.16	25	R141.13	1	R141.13	$7.44
Standard solution	NMISA	R3 519.00	50	R70.38	1	R70.38	$3.71
Acetonitrile HPLC grade	Merck	R1 352.40	1000	R1.35	56	R75.73	$3.99
Water HPLC grade	Merck	R775.18	1000	R0.78	56	R43.41	$2.29
Methanol HPLC	Merck	R1 352.40	1000	R1.35	6	R8.11	$0.43
Acetic acid HPLC grade	Merck	R4 502.12	500	R9.00	0.5	R4.50	$0.24
Vial/lid	Merck	R1 500.00	100	R15.00	1	R15.00	$0.79
Pipette tips	Lasec	R307.48	96	R3.20	4	R12.81	$0.68
Gloves	Lasec	R180.00	100	R1.80	2	R3.60	$0.19
Disposbale beaker	Merck	R1 937.46	100	R19.37	1	R19.37	$1.02

A.4. Income statement data

Scenario 1

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Income	**$ 219 010**	**$ 222 480**	**$ 226 013**	**$ 229 610**	**$ 233 271**	**$ 236 998**	**$ 240 792**	**$ 244 655**	**$ 248 588**	**$ 252 591**
Sales	$ 192 592	$ 196 062	$ 199 595	$ 203 191	$ 206 852	$ 210 580	$ 214 374	$ 218 237	$ 222 169	$ 226 172
Funding	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418
Expenditure	**$ 159 290**	**$ 162 160**	**$ 165 082**	**$ 168 056**	**$ 171 085**	**$ 174 167**	**$ 177 306**	**$ 180 500**	**$ 183 753**	**$ 187 064**
Direct Costs	$ 159 290	$ 162 160	$ 165 082	$ 168 056	$ 171 085	$ 174 167	$ 177 306	$ 180 500	$ 183 753	$ 187 064
Gross Profit	$ 59 720	$ 60 320	$ 60 931	$ 61 553	$ 62 186	$ 62 831	$ 63 487	$ 64 155	$ 64 835	$ 65 527
Indirect Costs	$ 13 618	$ 13 864	$ 14 113	$ 14 368	$ 14 627	$ 14 890	$ 15 158	$ 15 432	$ 15 710	$ 15 993
Operating profit	**$ 46 102**	**$ 46 457**	**$ 46 818**	**$ 47 185**	**$ 47 560**	**$ 47 941**	**$ 48 328**	**$ 48 723**	**$ 49 125**	**$ 49 534**
Depreciation	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418
Profit before tax	**$ 19 684**	**$ 20 038**	**$ 20 399**	**$ 20 767**	**$ 21 141**	**$ 21 522**	**$ 21 910**	**$ 22 305**	**$ 22 707**	**$ 23 116**
Tax	$ 5 315	$ 5 410	$ 5 508	$ 5 607	$ 5 708	$ 5 811	$ 5 916	$ 6 022	$ 6 131	$ 6 241
Net profit	**$ 14 369**	**$ 14 628**	**$ 14 892**	**$ 15 160**	**$ 15 433**	**$ 15 711**	**$ 15 994**	**$ 16 282**	**$ 16 576**	**$ 16 875**

Scenario 2

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Income	**$ 188 756**	**$ 191 681**	**$ 194 658**	**$ 197 690**	**$ 200 776**	**$ 203 918**	**$ 207 116**	**$ 210 372**	**$ 213 687**	**$ 217 061**
Sales	$ 162 337	$ 165 262	$ 168 240	$ 171 272	$ 174 358	$ 177 499	$ 180 698	$ 183 954	$ 187 268	$ 190 643
Funding	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418
Expenditure	**$ 148 719**	**$ 151 399**	**$ 154 127**	**$ 156 904**	**$ 159 731**	**$ 162 609**	**$ 165 539**	**$ 168 522**	**$ 171 559**	**$ 174 650**
Direct Costs	$ 148 719	$ 151 399	$ 154 127	$ 156 904	$ 159 731	$ 162 609	$ 165 539	$ 168 522	$ 171 559	$ 174 650
Gross Profit	**$ 40 037**	**$ 40 282**	**$ 40 532**	**$ 40 786**	**$ 41 045**	**$ 41 309**	**$ 41 577**	**$ 41 850**	**$ 42 128**	**$ 42 411**
Indirect Costs	$ 13 618	$ 13 864	$ 14 113	$ 14 368	$ 14 627	$ 14 890	$ 15 158	$ 15 432	$ 15 710	$ 15 993
Operating profit	**$ 26 418**	**$ 26 418**	**$ 26 418**	**$ 26 418**	**$ 26 418**	**$ 26 418**	**$ 26 418**	**$ 26 418**	**$ 26 418**	**$ 26 418**
Depreciation	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418
Profit before tax	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**
Tax	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Net profit	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**

Scenario 3

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Income	**$ 192 592**	**$ 196 062**	**$ 199 595**	**$ 203 191**	**$ 206 852**	**$ 210 580**	**$ 214 374**	**$ 218 237**	**$ 222 169**	**$ 226 172**
Sales	$ 192 592	$ 196 062	$ 199 595	$ 203 191	$ 206 852	$ 210 580	$ 214 374	$ 218 237	$ 222 169	$ 226 172
Funding	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Expenditure	**$ 159 290**	**$ 162 160**	**$ 165 082**	**$ 168 056**	**$ 171 085**	**$ 174 167**	**$ 177 306**	**$ 180 500**	**$ 183 753**	**$ 187 064**
Direct Costs	$ 159 290	$ 162 160	$ 165 082	$ 168 056	$ 171 085	$ 174 167	$ 177 306	$ 180 500	$ 183 753	$ 187 064
Gross Profit	**$ 33 302**	**$ 33 902**	**$ 34 513**	**$ 35 135**	**$ 35 768**	**$ 36 412**	**$ 37 068**	**$ 37 736**	**$ 38 416**	**$ 39 108**
Indirect Costs	$ 13 618	$ 13 864	$ 14 113	$ 14 368	$ 14 627	$ 14 890	$ 15 158	$ 15 432	$ 15 710	$ 15 993
Operating profit	**$ 19 684**	**$ 20 038**	**$ 20 399**	**$ 20 767**	**$ 21 141**	**$ 21 522**	**$ 21 910**	**$ 22 305**	**$ 22 707**	**$ 23 116**
Depreciation	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418	$ 26 418
Profit before tax	**($ 6 735)**	**($ 6 380)**	**($ 6 019)**	**($ 5 651)**	**($ 5 277)**	**($ 4 896)**	**($ 4 508)**	**($ 4 114)**	**($ 3 712)**	**($ 3 303)**
Tax	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Net profit	**($ 6 735)**	**($ 6 380)**	**($ 6 019)**	**($ 5 651)**	**($ 5 277)**	**($ 4 896)**	**($ 4 508)**	**($ 4 114)**	**($ 3 712)**	**($ 3 303)**

A.5. Discounted cash flow analysis data

Scenario 1

	Establishment	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Inflow of Cash	**$ 535 813**	**$ 192 592**	**$ 196 062**	**$ 199 595**	**$ 203 191**	**$ 206 852**	**$ 210 580**	**$ 214 374**	**$ 218 237**	**$ 222 169**	**$ 226 172**
Sales	$ 0	$ 192 592	$ 196 062	$ 199 595	$ 203 191	$ 206 852	$ 210 580	$ 214 374	$ 218 237	$ 222 169	$ 226 172
Funding	$ 535 813	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Outflow of cash	**$ 535 813**	**$ 178 223**	**$ 181 434**	**$ 184 703**	**$ 188 031**	**$ 191 419**	**$ 194 868**	**$ 198 380**	**$ 201 954**	**$ 205 593**	**$ 209 298**
Capital expenditure	$ 264 184	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Costs	$ 271 629	$ 172 908	$ 176 024	$ 179 195	$ 182 424	$ 185 711	$ 189 057	$ 192 464	$ 195 932	$ 199 462	$ 203 057
Tax	$ 0	$ 5 315	$ 5 410	$ 5 508	$ 5 607	$ 5 708	$ 5 811	$ 5 916	$ 6 022	$ 6 131	$ 6 241
Net cash flow	**$ 0**	**$ 14 369**	**$ 14 628**	**$ 14 892**	**$ 15 160**	**$ 15 433**	**$ 15 711**	**$ 15 994**	**$ 16 282**	**$ 16 576**	**$ 16 875**
Cumulative cash flow	**$ 0**	**$ 14 369**	**$ 28 997**	**$ 43 889**	**$ 59 049**	**$ 74 482**	**$ 90 193**	**$ 106 187**	**$ 122 470**	**$ 139 046**	**$ 155 920**

5 year outlook	
Discount rate	8.00%
IRR	#NUM!
NPV	**$ 59 314**

10 year outlook	
Discount rate	8.00%
IRR	#NUM!
NPV	**$ 103 452**

Scenario 2

	Establishment	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Inflow of Cash	**$ 535 813**	**$ 162 337**	**$ 165 262**	**$ 168 240**	**$ 171 272**	**$ 174 358**	**$ 177 499**	**$ 180 698**	**$ 183 954**	**$ 187 268**	**$ 190 643**
Sales	$ 0	$ 162 337	$ 165 262	$ 168 240	$ 171 272	$ 174 358	$ 177 499	$ 180 698	$ 183 954	$ 187 268	$ 190 643
Funding	$ 535 813	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Outflow of cash	**$ 535 813**	**$ 162 337**	**$ 165 262**	**$ 168 240**	**$ 171 272**	**$ 174 358**	**$ 177 499**	**$ 180 698**	**$ 183 954**	**$ 187 268**	**$ 190 643**
Capital expenditure	$ 264 184	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Costs	$ 271 629	$ 162 337	$ 165 262	$ 168 240	$ 171 272	$ 174 358	$ 177 499	$ 180 698	$ 183 954	$ 187 268	$ 190 643
Tax	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Net cash flow	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**
Cumulative cash flow	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**	**$ 0**

5 year outlook	
Discount rate	8.00%
IRR	#NUM!
NPV	**$ 0**

10 year outlook	
Discount rate	8.00%
IRR	#NUM!
NPV	**$ 0**

Scenario 3

	Establishment	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Inflow of Cash	**$ 0**	**$ 192 592**	**$ 196 062**	**$ 199 595**	**$ 203 191**	**$ 206 852**	**$ 210 580**	**$ 214 374**	**$ 218 237**	**$ 222 169**	**$ 226 172**
Sales	$ 0	$ 192 592	$ 196 062	$ 199 595	$ 203 191	$ 206 852	$ 210 580	$ 214 374	$ 218 237	$ 222 169	$ 226 172
Funding	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Outflow of cash	**$ 589 395**	**$ 172 908**	**$ 176 024**	**$ 179 195**	**$ 182 424**	**$ 185 711**	**$ 189 057**	**$ 192 464**	**$ 195 932**	**$ 199 462**	**$ 203 057**
Capital expenditure	$ 264 184	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Costs	$ 271 629	$ 172 908	$ 176 024	$ 179 195	$ 182 424	$ 185 711	$ 189 057	$ 192 464	$ 195 932	$ 199 462	$ 203 057
Loan Interest	$ 53 581										
Tax	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Net cash flow	**($ 589 395)**	**$ 19 684**	**$ 20 038**	**$ 20 399**	**$ 20 767**	**$ 21 141**	**$ 21 522**	**$ 21 910**	**$ 22 305**	**$ 22 707**	**$ 23 116**
Cumulative cash flow	**($ 589 395)**	**($ 569 711)**	**($ 549 673)**	**($ 529 273)**	**($ 508 506)**	**($ 487 365)**	**($ 465 843)**	**($ 443 933)**	**($ 421 628)**	**($ 398 922)**	**($ 375 806)**

5 year outlook	
Discount rate	8.00%
IRR	-39.348%
NPV	**($ 508 143)**

10 year outlook	
Discount rate	8.00%
IRR	-14.90%
NPV	**($ 447 680)**

A.6. Sensitivity analysis data

Scenario 1

Percent Change	100%
Variable Number	1

	Human Resource	Testing Output	Indirect	Price Mycotoxin	Price Pesticide	Price Microbial	Inflation	Discount rate	Tax rate	Funding
$ 103 452	1	2	3	4	5	6	7	8	9	10
200%	($ 313 021)	$ 762 000	$ 31 879	$ 471 887	$ 601 922	$ 248 756	$ 143 170	$ 73 777	$ 65 189	$ 591 403
180%	($ 222 074)	$ 630 290	$ 46 194	$ 398 200	$ 502 228	$ 219 695	$ 134 124	$ 78 542	$ 72 842	$ 493 813
160%	($ 131 126)	$ 498 581	$ 60 508	$ 324 513	$ 402 534	$ 190 635	$ 125 666	$ 83 815	$ 80 494	$ 396 223
140%	**($ 40 179)**	**$ 366 871**	**$ 74 823**	**$ 250 826**	**$ 302 840**	**$ 161 574**	**$ 117 759**	**$ 89 667**	**$ 88 147**	**$ 298 632**
120%	$ 37 061	$ 235 162	$ 89 138	$ 177 139	$ 203 146	$ 132 513	$ 110 365	$ 96 181	$ 95 800	$ 201 042
100%	**$ 103 452**	**$ 103 452**	**$ 103 452**	**$ 103 452**	**$ 103 452**	**$ 103 452**	**$ 103 452**	**$ 103 452**	**$ 103 452**	**$ 103 452**
80%	$ 169 844	($ 38 709)	$ 117 767	$ 29 765	$ 3 758	$ 74 391	$ 96 987	$ 111 594	$ 111 105	$ 5 862
60%	**$ 236 235**	**($ 219 133)**	**$ 132 081**	**($ 60 167)**	**($ 131 419)**	**$ 45 331**	**$ 90 941**	**$ 120 740**	**$ 118 757**	**($ 91 728)**
40%	$ 302 627	($ 399 557)	$ 146 396	($ 161 108)	($ 267 986)	$ 16 270	$ 85 285	$ 131 047	$ 126 410	($ 189 318)
20%	$ 369 018	($ 579 981)	$ 160 711	($ 262 049)	($ 404 553)	($ 17 522)	$ 79 994	$ 142 699	$ 134 063	($ 287 755)
0%	$ 435 410	($ 760 405)	$ 175 025	($ 362 990)	($ 541 121)	($ 57 331)	$ 75 042	$ 155 920	$ 141 715	($ 394 098)

Variable number	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Percentage applied	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Final percentage	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Scenario 3

Percent Change	100%
Variable Number	1

	Human Resource	Testing Output	Indirect	Test Pricing	Interest rate	Inflation	Discount rate	Tax rate
($ 447 680)	1	2	3	4	5	6	7	8
200%	($ 902 416)	$ 220 468	($ 545 725)	$ 574 129	($ 501 261)	($ 400 633)	($ 488 330)	($ 447 680)
180%	($ 811 468)	$ 88 758	($ 526 116)	$ 371 687	($ 490 545)	($ 410 305)	($ 481 803)	($ 447 680)
160%	($ 720 521)	($ 42 951)	($ 506 507)	$ 169 246	($ 479 828)	($ 419 615)	($ 474 580)	($ 447 680)
140%	($ 629 574)	($ 174 661)	($ 486 898)	($ 33 196)	($ 469 112)	($ 428 788)	($ 466 563)	($ 447 680)
120%	($ 538 627)	($ 306 370)	($ 467 289)	($ 235 638)	($ 458 396)	($ 438 209)	($ 457 640)	($ 447 680)
100%	($ 447 680)	($ 447 680)	($ 447 680)	($ 447 680)	($ 447 680)	($ 447 680)	($ 447 680)	($ 447 680)
80%	($ 371 688)	($ 628 104)	($ 428 070)	($ 724 997)	($ 436 963)	($ 456 536)	($ 436 526)	($ 447 680)
60%	($ 305 297)	($ 808 528)	($ 410 046)	($ 1 002 314)	($ 426 247)	($ 464 818)	($ 423 997)	($ 447 680)
40%	($ 238 905)	($ 988 952)	($ 395 136)	($ 1 279 632)	($ 415 531)	($ 472 566)	($ 409 879)	($ 447 680)
20%	($ 172 514)	($ 1 169 376)	($ 380 821)	($ 1 556 949)	($ 404 814)	($ 479 815)	($ 393 916)	($ 447 680)
0%	($ 106 122)	($ 1 349 800)	($ 366 507)	($ 1 834 267)	($ 394 098)	($ 486 598)	($ 375 806)	($ 447 680)

Variable number	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Percentage applied	100%	100%	100%	100%	100%	100%	100%	100%
Final percentage	100%	100%	100%	100%	100%	100%	100%	100%