DRAFT FINAL REPORT:

DEMAND AND SUPPLY ANALYSIS OF HIGHER EDUCATION SKILLS IN THE SADC AGRO-PROCESSING, MINERAL PROCESSING AND PHARMACEUTICAL VALUE CHAINS – RECOMMENDATIONS ON COURSES, PROGRAMMES, CO-ORDINATION AND GOVERNANCE STRUCTURES

12 OCTOBER 2020

SOUTHERN AFRICAN REGIONAL UNIVERSITIES ASSOCIATION

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LIST OF ABBREVIATIONS

Abbreviation	Description
AGRA	Alliance for a Green Revolution for Africa
AM	(Remote) Additive Manufacturing
AMDC	African Minerals Development Centre
API	Active Pharmaceutical Ingredients
ARV	Anti-Retroviral Treatment
ASM	Artisanal and small-scale mining
ATM	African Traditional Medicine
CAD	Computer-Aided Design
CHIETA	Chemical Industries Education Training Authority
CSIR	Council of Scientific and Industrial Research
DMR	Department of Mineral Resources
FAO	Food and Agriculture Organisation
FET	Further Education Training
FP&M	Fibre Processing and Manufacturing
GET	General Education Training
GMO	Genetically Modified Organism
GMP	Good Manufacturing Practice
GMP	Good Manufacturing Practices
HEI	Higher Education Institutions
ICT	Information and Communications Technology
ILO	International Labour Organisation
IT	Information Technology
IV	Intravenous
KSP	Kilimanjaro School of Pharmacy
MERSETA	Manufacturing, Engineering and Related Services SETA
MQA	Mining Qualifications Authority
NMRA	National Medicines Regulatory Authority
NQF	National Qualifications Framework (South Africa)
PGM	Platinum Group Metals
R&D	Research and Development
SADC	South African Development Community
SAGMA	Southern African Generics Medicine Association
SAIIA	South African Institute of International Affairs
SAMMRI	South African Minerals to Metals Research Institute
SAQA	South African Qualifications Authority
SETA	Sector Education and Training Authority
SHEQ	Safety Health, Environmental and Quality
TUT	Tshwane University of Technology
TVET	Technical and Vocational Education and Training
UHAS	Muhimbili University of Health and Allied Sciences
VC	Value Chain
WEF	World Economic Forum
WHO	World Health Organisation

EXECUTIVE SUMMARY

The main goal of the Southern African Development Community (SADC) integration agenda in human resource development is to increase the availability of educated and highly skilled human capital to promote the investment efficiency and competitiveness of the region in the global economy, as well as improving the quality of lives of the region's population.

The SADC Industrialization Strategy 2015-2063 was developed as an inclusive long-term modernization and economic transformation framework to enable the raising of living standards, intensifying of structural change and the engendering of a rapid catch up of the SADC countries with the industrialisation output of developed countries.

From an implementation perspective, the strategy requires that the emphasis needs to shift to some of the microeconomic elements underpinning future growth, with a particular emphasis on moving up regional and global value chains supported by regionally coordinated procurement; targeted domestic and foreign investment; technology transfer; skills development; and the development of a friendly investment and regulatory environment.

The action plan of the strategy therefore includes skills and capacity development investments especially in education, innovation, institution-building and physical assets to create strong knowledge economies in SADC countries, and raise productivity and competitiveness.

The SADC Protocol on Co-operation in Education and Training, 1997, emphasises the required collaboration of member states in respect of Higher Education and Training, and highlights the roles and functions of proposed Centres of Excellence and Specialisation. It is specified that the criteria for the selection of such Centres should be in terms of an equal opportunity to bid by the relevant Universities in the region as issued by the SADC, and appointed by the relevant Sub-sector on Education and Training Technical Committee.

Against this background, the SADC Ministers responsible for Education and Training, and Science, Technology and Innovation in 2018 endorsed the concept of a network of partner institutions and universities to be designated as Centres of Excellence and Centres of Specialisation, with the overarching purpose to address the skills development goals of the Southern African Development Community (SADC) Industrialisation Strategy.

In 2019 the SADC Ministers directed the SADC Secretariat to conduct a comprehensive skills audit, and a costed and time bound roadmap for the operationalisation of a proposed governance structure to give effect to the resolutions and skills development goals.

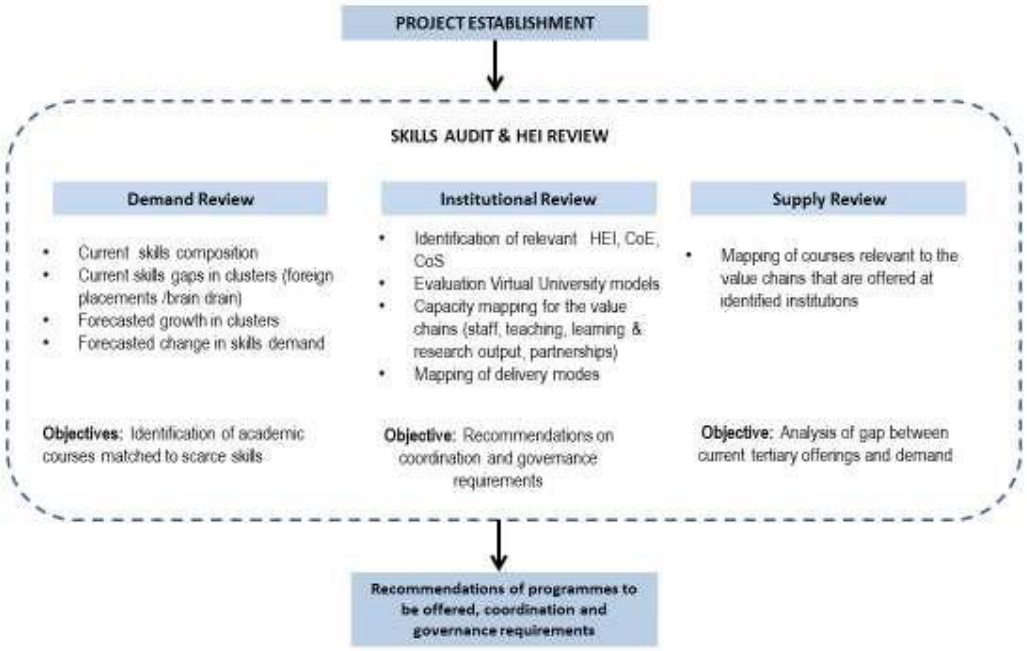
The SADC Secretariat has therefore commissioned this study by the Southern African Regional Universities Association (SARUA) to conduct a comprehensive skills audit in the agro-processing, mineral beneficiation and pharmaceutical value chains, and to provide

recommendations for the operationalisation of instruments to facilitate the skills development requirements of these value chains.

This regional skills supply and demand study focuses on the identified priority value chains to:

i. Identify the skills demand to inform the programmes to be offered in line with the agreed value chains.
ii. Map the relevant existing academic programmes and qualifications being offered in the region.
iii. Determine the skills development programmes required to address gaps, and which institutions should be designated as Centres of Excellence and Centres of Specialisation, and the type of operational and governance structures to be established.

The overall methodology can be illustrated as follows:



In accordance with the Terms of Reference issued for the study, and as outlined in the Inception Report as agreed to by the SADC, the study consist of six key phases as follows:

Phase 1: Inception

Phase 2: Information and data collection for the identification of skills required for the development of the value chains for agro-processing, mineral beneficiation and in pharmaceuticals

Phase 3: Data Analysis and Preparation of a Draft Skills Demand Assessment and Analysis Report, including recommendations on courses and programmes for value addition in agreed value chains

Phase 4: Regional Consensus Building of Draft Skills Assessment Report

Phase 5: First round supply assessment and mapping of accredited tertiary institutions and Centres of Excellence and Specialisation

Phase 6: Validation and finalisation of Skills Audit Report and Recommendations on Coordination and Governance structures for proposed skills development instruments

The Phase 1 to 3 work was followed by Phase 4 and 5 of the project, which has included engagement with relevant stakeholders on the findings of the skills demand audit, and a first round mapping of accredited tertiary institutions, skills supply and Centres of Excellence and Specialisation, and which has culminated in this Final Report which integrates the work done through the relevant project phases.

In terms of the structure of this report, Section 1 provides an introduction, including a discussion of the methodology used, key assumptions and the definitions of key concepts used in the text.

An outline is provided of the:

- Key economic realities driving skills demand in different value chains;
- Current skills demand (high and medium skills), skills shortages and trends applied to forecast future skills demand;
- Regional and national policies (i.e. desired outcomes) for value chains, and the identification of skills that will be needed to realise these outcomes;
- Updated sub-sector employment data for all SADC countries, applying aggregated databases of the SADC Secretariat, the International Labour Organisation (ILO) and official employment figures from central statistical offices of countries where such data is available. (South Africa, Namibia, Botswana, Lesotho, Zambia and Tanzania).

The skills composition of value chains was based on the skill levels of different core sub-sectors within each cluster, and in applying the ratios provided in the South African Sector Education and Training Authorities (SETAs) through their respective sector skills plans.

Forecasted output, employment and skills trends were based on growth rates derived from a literature review of cluster trends in the SADC, as well as globally.

The desktop data and literature analysis were supplemented by first round interviews with regional industry experts in each value chain, and which was extended to other key and relevant stakeholders, including private companies operating across the regional value chains in the SADC during Phase 4.

The skills demand forecast was based on fairly conservative assumptions as indicated in the table below:

Key variables		Agro-processing	Mineral Processing	Pharmaceuticals
Forecasted output growth (2018-2030)	Assumption	Forecasted growth for agro-processing sector in Africa; population and urban growth	Forecasted growth for different minerals sectors in Africa	Forecasted growth in SADC public expenditure
	Value	2.7% p.a.	1.2% p.a.	0.8% p.a.
Forecasted employment growth (2018-2030)	Assumption	Employment elasticity of SA manufacturing sector 2000-2018 was 0.8, i.e. for 1% output growth employment increased with 0.8%		
	Value	2.2% p.a.	1.0% p.a.	0.6% p.a.
Shifts in the skill structure (2018 -2030)	Assumption	Based on shifts in SA food processing sector	Based on shifts in SA chemical sector	Based on shifts in SA chemical sector
	Value	High skills from 11% to 15% of workforce; medium skills from 52% to 51%	High skills from 16% to 17% of workforce; medium skills from 62% to 63%	High skills from 25% to 29% of workforce; medium skills stayed the same

Importantly, and in the context of this report, the role of a proposed SADC University of Transformation (SUT) is approached within the specific parameters of the coordination of the supply of education and training opportunities within the three value chains. This report does not make general proposals on the SUT, as this is the subject of another SADC-commissioned project, in terms of which Eswatini is developing a proposal on the administrative hub for the SUT, including proposals on its organisational design and academic role.

Section 2 provides an overview of the study background and the future world of work based on recent economic and technology trends for developing countries, and as background for identifying emerging skills demand trends in general.

The major drivers of change shaping the workforce of the future are new technological breakthroughs, demographic shifts, shifts in global economic power as well as resource scarcity, climate change and more recently, and emerging at the time of conducting this analysis, a global pandemic.

Sections 3 to 5 discuss the three value chains in more detail by providing a general overview of the value chains and value chain skills demand and supply trends within the SADC, and provides an analysis of:

- Forecasted demand for high and medium skills in the formal economy;
- Current scarce skills in the formal sector – full qualifications;
- Emerging skills;
- Skills demand for policy development;
- SADC priority sub-sectors;
- Required skills to facilitate development of the SADC value chain;
- Identified courses and programmes.

An overview of the supply side responses as obtained through surveying of HEI and other skills development stakeholders is provided in the respective value chain supply side analysis sections.

Section 6 provides a high-level overview of the main economic and employment characteristics of each of the value chains in relation to skills development requirements within each of the SADC countries.

Section 7 provides the findings of the skills demand audit.

Generally, the skills audit has provided an indication that the skills demand in each value chain consists of the following categories:

i. Existing degrees and diplomas based on the organic growth of the formal core sectors of the different value chains. The forecasted demand is highest for the agro-processing sector; followed by mineral processing (skills per annum) and pharmaceuticals. The highest demand is forecasted for honours degrees and higher, while some 10-13% could be on diploma-level;
ii. Upgraded trade certificates to occupational certificates at TVET level to up-skill medium skilled workers currently employed in the agro-processing and mineral processing VCs;
iii. Short courses and programmes to build skills that respond to technological changes and other change drivers relevant to the sector to up-skill the current workforce in each value chain. This could involve some 50% of the current workforce within each value chain as well as new workers in points 1 and 2 above;
iv. Short courses and programmes or post graduate degrees linked to the actualisation of regional policy objectives related to each value chain.

Based on the underlying value systems as outlined in the different possible world of work scenarios forecasted in Section 2, *supra*, the policy direction or most possible skills demand trends anticipated in the value chains will largely determine what type of skills programme would become more relevant in terms of value add, as outlined in the following Table:

Underlying value system	Policy direction/ anticipated future trend	Type of skills demand that is more relevant
Regionally fragmented; focus on internal more inclusive, socially responsible production structures (focus on the value of being human with in close-knitted society)	Productivity increases: product security; import replacement – inward looking but with strong regional value chain participation potential	Medium-small firms, informal, technical and soft research – focus on appropriate- scaled technologies and ownership structures and emerging technologies with humanistic focus
Regionally fragmented, innovative and individualistic (focus on being part of global trends, development of youth, creativity and innovation)	Increased local competitiveness, niche products within regional global value chains – inward looking but with strong regional value chain participation potential	Small, medium firms, technical research - strong focus on emerging 4th industrial revolution technologies
Globally/regionally integrated with strong collective local/regional focus – focus on being human in a global society	Responsible and efficient value chains that maximises social and environmental benefits, using niche regional value chains to position SADC in global value chains – outward looking (regional and global)	Large firms, pharma (small) – technical and soft research with focus on emerging technologies with a social and environmental focus
Globally/regionally integrated with focus on the loyalty to large corporates and brands	Productivity increases, improve SADC as attractive investment for global corporate sector - outward looking (regional and global)	Large firms, technical skills with focus on emerging skills

Section 8 provides the findings of the skills supply audit. An assessment is provided of the:

- Regional outlook for collaboration and network building
- Existing Teaching and Learning programmes
- Obstacles for greater regional collaboration
- Engagements with value chain industry representatives
- Regional gaps in terms of value chain education demand
- Options for regional delivery models to address industrialisation skills demand

Section 9 provides the recommendations.

Overall, the baseline study has identified several areas where additional and further interaction with HEIs and other tertiary skills development stakeholders is required. It also is necessary to agree on the detail of an appropriate value adding regional skills development response, and specifically the optimal programme delivery models to be considered. Therefore, it has been recommended that, during an initial phase, the SADC establishes a “network of universities” model for each value chain to, enable the required participation and input to a proposed delivery model and programme content.

The supply analysis has identified gaps in skill supply in respect of skills demand factors, and consideration is therefore required by the proposed network regarding:

i. Programmes that are offered by SADC universities, and where the existing capacity is sufficient to address SADC's needs. As these universities will continue to enrol students in such programmes, their relevance, content and interest in respect of a SADC role is to further be assessed.
ii. Existing programmes, but with a need for additional capacity: An assessment of a SADC role in providing capacity development, e.g. by making additional enrolments possible through e-learning. (E.g. using a shared revenue model with the university that is the academic owner of the programme).
iii. New programmes that could be developed through the SADC network of universities in each value chain - where no or inadequate existing programmes exist. Such approach may also include a range of capacity development initiatives related to inter alia teaching and learning, curriculum development and accreditation and quality assurance.

In order to make progress in expanding the baseline established in this report, to agree on the content and implementation of a SADC skills development initiative and the establishment of a proposed SADC Network of Universities, the following next steps are proposed:

i. Issue the required Calls for Expression of Interest to HEIs and other stakeholders to participate in the establishment of a “network of universities” model proposed above, as well as to apply to be accredited as Centres of Excellence or Specialisation in accordance with the criteria for the selection of such Centres specified in the SADC Protocol, namely in terms of an equal opportunity to bid by

the relevant Universities in the region as issued by the SADC, and appointed by the relevant Sub-sector on Education and Training Technical Committee.

ii. Further engage the necessary SADC, industry and university structures in the different member states to validate the demand and supply findings and further develop a model of regional skills demand – supply engagement and delivery as recommended.

iii. Initiate a follow-up research process with national-level representatives to gather information on additional higher education institutions, as well as industry representatives.

iv. Conduct a needs analysis amongst interested institutions on the types of support that each value chain network would require, as the basis for the development of a concept paper on the necessary governance and operational framework to support each value chain network.

Note: Impact of the COVID-19 Pandemic

It is important to note this report cannot take the impact of the COVID-19 pandemic on the supply and demand of skills in the three value chains into account in a sufficiently substantiated manner. The full economic impact of the pandemic on employment trends, and on supply side activities within each value chain necessarily is as yet uncertain. Thus, the assessment of the need for skills development must remain open to developing economic trends related to the impact of the pandemic.

DEMAND AND SUPPLY ANALYSIS OF HIGHER EDUCATION SKILLS IN THE SADC AGRO-PROCESSING, MINERAL PROCESSING AND PHARMACEUTICAL VALUE CHAINS

1 INTRODUCTION

1.1 PROJECT SCOPE AND STRUCTURE

This Final Report follows on the Phase 1 Inception Report of the project brief issued by the SADC to conduct a comprehensive skills audit and provide a roadmap for the operationalisation and planning for a proposed virtual SADC University of Transformation, as well as the Phase 2 and 3 Report which analysed the skills demand for the development of the value chains of agro-processing, mineral beneficiation and pharmaceuticals in the Southern African Development Community (SADC).

The Phase 1 to 3 work was followed by Phase 4 and 5 of the project, which included the development of broad based regional consensus on the findings of the skills demand audit, and provides recommendations on courses and programmes for value addition in agreed value chains based on a first round mapping of accredited tertiary institutions and Centres of Excellence and Specialisation, which has culminated in this Final Report which integrates the work done through all project phases.

In terms of the structure of the report, Section 1 introduces the report including a discussion of the methodology used, key assumptions and the definitions of key concepts used in the text. Section 2 provides an overview of recent economic and technology trends for developing countries in relation to various possible scenarios for the world of work as background for identifying emerging skills trends in general.

Sections 3 to 5 discusses the three value chains in more detail by providing a general overview of the value chains and value chain demand trends within the SADC, and includes identified programmes and courses, of a formal and non-formal nature, as well as the supply of skills development responses. Section 6 provides a high-level overview of the main economic and employment characteristics of each of the value chains in relation to the skills development demand of the value chains within each SADC country.

In Section 7 the overall findings of the skills demand audit, an indication of the skills development requirements and proposed courses and programmes is provided.

Section 8 provides the findings of the skills supply survey conducted.

Section 9 provides the recommendations on a mechanism to agree on proposed courses and programmes for value addition in the value chains, and the coordination and governance structures for delivery model options.

1.2 METHODOLOGY AND SOURCES

The high-level analysis of the skills demand in the report firstly focusses on the economic realities driving skills demand in the different value chains (taking into account the uncertainties relating to the impact of the COVID-19 pandemic). To this end the current skills demand (high and medium skills) of the different value chains within the formal economy was analysed, including current skills shortages as well as trends to forecast future skills demand. In addition to the current and emerging economic realities facing the value chains, the study also focusses on policies (i.e. desired outcomes) for the value chains and attempts to identify the skills that might be needed to realise these outcomes.

The skills composition of the different clusters was based on the skill levels of the different core sectors within each cluster, and in applying the ratios provided by the South African Sector Education and Training Authorities (SETAs) through their respective sector skills plans.

Forecasted output, employment and skills trends were based on growth rates derived from a literature review of cluster trends in the SADC, as well as globally. Section 9 contains a list of sources referenced for the report.

For the Skills demand report, the desktop data and literature analysis above was supplemented by interviews with regional experts in each value chain (see Section 9 for persons interviewed).

An on-line consultation on the draft Skills demand assessment and recommendations on courses and programmes report was held on 30 June 2020 with representatives of SADC universities and other post- secondary institutions, as well as selected industry representatives from the identified SADC value chains.

For the skills supply analysis a structured survey was conducted with a database of accredited SADC higher education institutions, other post-secondary institutions and selected government and industry representatives. The identification of the institutions that were invited to participate in the survey was based on the following overlapping criteria:

- Institutions that have official national accreditation;
- Institutions that have featured as the top ranked universities in existing Africa-focused databases;
- Institutions that offer programmes in one or more of the three value chains, based on knowledge from existing databases (such as the IAU handbook);
- Institutions identified through other SARUA-led research in regional higher education programmes.

The purpose of the survey was to gather initial views on the demand for skills within the identified value chains, and to gather input for the first phase mapping of the relevant existing and/or planned academic programmes and qualifications being offered in the region. The survey was available for one month in July-August 2020, and invitations and

reminders where sent out via the online survey portal, and directly from the Executive Director of SARUA's office.

1.3 CONSTRAINTS OF THE DEMAND AND SUPPLY ASSESSMENT REPORT

The major constraints of this study were:

- Updated employment data for all the SADC countries is not readily available, especially at sub-sector level. The high-level analysis of this report relied on the aggregated databases of the SADC Secretariat and the International Labour Organisation (ILO), as well as official employment figures from the central statistical offices of countries, where available. Official employment data was available for Botswana, Lesotho, Namibia, South Africa, Tanzania and Zambia. Data gaps were to some extent addressed through web-searches and academic papers related to the value chain clusters.
- A total of 74 responses from representatives in 12 SADC countries was received in response to the supply side survey. Whilst this is encouraging and provides a strong baseline, it does not yet provide a full regional picture of the supply of academic programmes and will need to be further followed-up in subsequent phases.

Given the timing of the research in April – August 2020, there were some limitations to the research brought about by the COVID-19 pandemic. The major impact was availability and response times of individuals who were working from home, distanced from colleagues and dependent on good connectivity and IT support. These impacts were mitigated by providing for ample time for responses and survey completion

1.4 KEY ASSUMPTIONS FOR THE SKILLS DEMAND FORECAST

The skills demand forecast was based on fairly conservative assumptions as indicated in Table 1 below. All the data sources used in the report are listed in Section 9 below.

Table 1: Key Forecast Assumptions

Key variables		Agro-processing	Mineral Processing	Pharmaceuticals
Forecasted output growth (2018-2030)	Assumption	Forecasted growth for agro-processing sector in Africa; population and urban growth	Forecasted growth for different minerals sectors in Africa	Forecasted growth in SADC public expenditure

	Value	2.7% p.a.	1.2% p.a.	0.8% p.a.
Forecasted employment growth (2018-2030)	Assumption	Employment elasticity of SA manufacturing sector 2000-2018 was 0.8, i.e. for 1% output growth employment increased with 0.8%		
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	Value	High skills from 11% to 15% of workforce; medium skills from 52% to 51%	High skills from 16% to 17% of workforce; medium skills from 62% to 63%	High skills from 25% to 29% of workforce; medium skills stayed the same

1.5 KEY ASSUMPTIONS FOR THE SKILLS SUPPLY ASSESSMENT

The SADC Industrialization Strategy 2015-63 identifies three “binding constraints” that are hampering accelerated industrialisation:

i. Inadequate and poor-quality infrastructure;
ii. A severe deficit of the skills needed for industrial development;
iii. Insufficient finance.

The skills defined as in deficit are those essential to progression up the technology ladder and as also confirmed in the demand analysis below.

While the demand side assumptions are based on sectoral growth projections, the skills supply assessment assumes some broad regional awareness of the resulting market employment trends and regional skills demand. The assumptions below were also tested in the supply survey, to determine whether the “frontloading of industrialization… promoted through the adoption of a strategy of developmental regionalism” as the Industrialization Strategy formulates it, has any foothold in the region.

Assumptions in the assessment of the skills supply to support regional industrialisation are:

- Some recognition of the skills demand requirements for the achievement of the SADC Industrialisation Strategy objectives exists among national skills development and education institutions.

- There is an acceptance of the principles underpinning the SADC Protocol on Education and Training among education institutions, in particular as these relate to collaboration and the prevention of duplication.
- The relevance of the role of accredited SADC higher education institutions and other post-secondary institutions in value chain development is accepted.

These assumptions build on what the SADC Industrialization Strategy emphasises as the integrated and complementary roles of member states and the private sector. From a supply side point-of-view, the Strategy advocates targeted development of programmes on a member state level. The text box below reflects the Strategy's approach to addressing the binding constraint of a skills deficit:

Skills Development

Increased spending on formal academic education is a necessary but not a sufficient condition for industrialization.

Education is pivotal and should be re-purposed to bridge the technology gap between the SADC region and its international competitors. A knowledge-based economy will require a high level of science, technology, engineering and mathematics (STEM) training.

To support industrialization, education systems would indeed need to be restructured and re-purposed with focus on technical and vocational skills of all kinds, especially those appropriate for a modern, knowledge economy.

All SADC Member States devote a substantial part of public spending to formal education. Despite this, all the countries have serious skills deficits, implying that education priorities need to be revisited with more resources made available for vocational training of all kinds, and especially those required in medium- and high-technology industries and occupations.

1. Education systems should be re-shaped to ensure that young people are trained – and re-trained – to meet the demands of modern business and public administration with specific focus on mathematics, science and technology disciplines, and innovation.
2. Tertiary education should be required to produce quality graduates in STEM disciplines.
3. Regional centres of excellence and specialization should be identified and strengthened, and new ones established where appropriate.
4. Universities and other tertiary educational institutions should be encouraged to create close links with the business and industrial communities and the latter should be consulted on the curriculum design.
5. Employers should be incentivized with tax breaks or outright subsidies to step up their in-house training programmes and support research and development.

> 6. Member States should facilitate the movement of factors of production – capital and skills - within the SADC region. To this effect, there is particular need for undertaking a skills audit at regional level and establishing mutually agreed accreditation frameworks as important elements of critical resource availability and enhancing productivity.
>
> (SADC, 2015)

1.6 SUPPLY SIDE SURVEY OF THE HIGHER EDUCATION SECTOR

As a follow-up phase to the demand side analysis included in this report, a supply side survey was distributed electronically to the SARUA database of accredited public and private higher education institutions in the region. The purpose was twofold:

1. To begin to determine the current scope and reach of formal sector supply of programmes which can support industrialisation in the region;
2. To assess the nature of the gap between skills demand and skills supply, in order to inform further follow-up research.

The survey was also an opportunity to receive first-hand information on how institutions view the supply side challenges for meeting industrialisation demand, and also to identify potential future programmes which could address the demand identified.

As indicated below, a total of 74 responses were received from 51 institutions across 12 SADC countries. These responses provide an initial view on how the higher education sector views its role in contributing to industrialisation and what some of the key requirements would be going forward, and the findings are integrated into Sections 3 to 5 below.

No responses were received from Comoros, Democratic Republic of Congo (DRC), Madagascar and Seychelles.

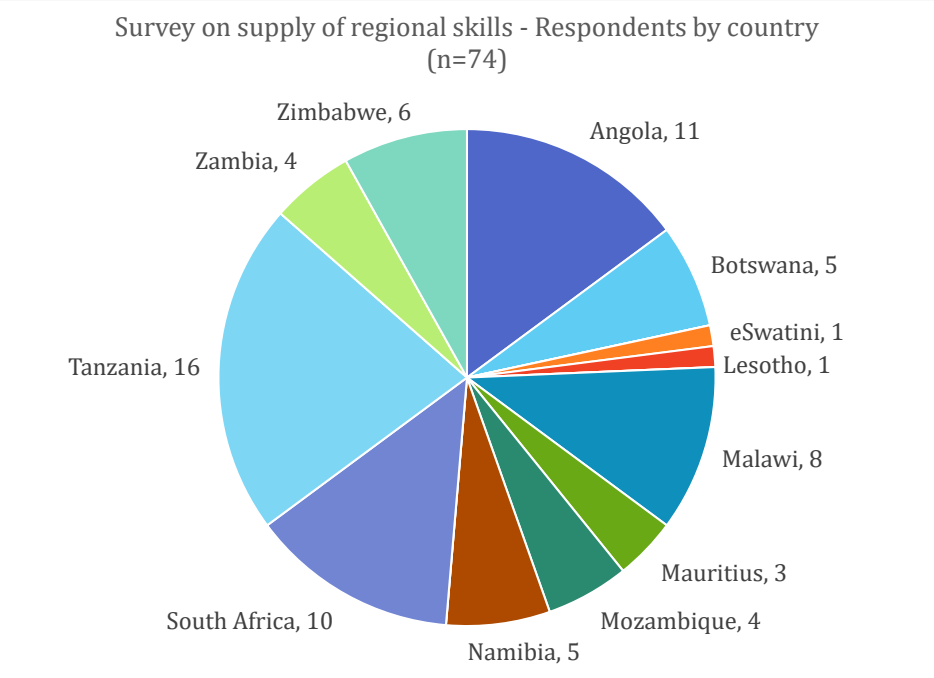


Figure 1: Survey of supply side formal academic offerings: respondents by country

1.6.1 INSTITUTIONAL STRATEGY ALIGNMENT

An important insight gained from this initial engagement is that among the sample of higher education stakeholders canvassed, the SADC Industrialisation Strategy is not yet as visible as other regional policy instruments, e.g. the SADC Protocol on Education and Training, and the African Union's Vision 2063. While the responses show some familiarity in the higher education sector with its broad intent, there is not as yet extensive engagement. While this does not necessarily imply a lack of engagement between industry and higher education on an institutional or national level, it will be necessary in going forward to evaluate the value and relevance of adequate alignment with regional industrialisation strategies for individual institutions.

> *The University of Zimbabwe Strategic Plan 2019-2025 sets out to guide the University community and partners on a transformative pathway to the delivery of goods and services towards industrialization and modernization of Zimbabwe.*
>
> Prof Florence Mtambanengwe Executive Director: Research & Innovation, University of Zimbabwe

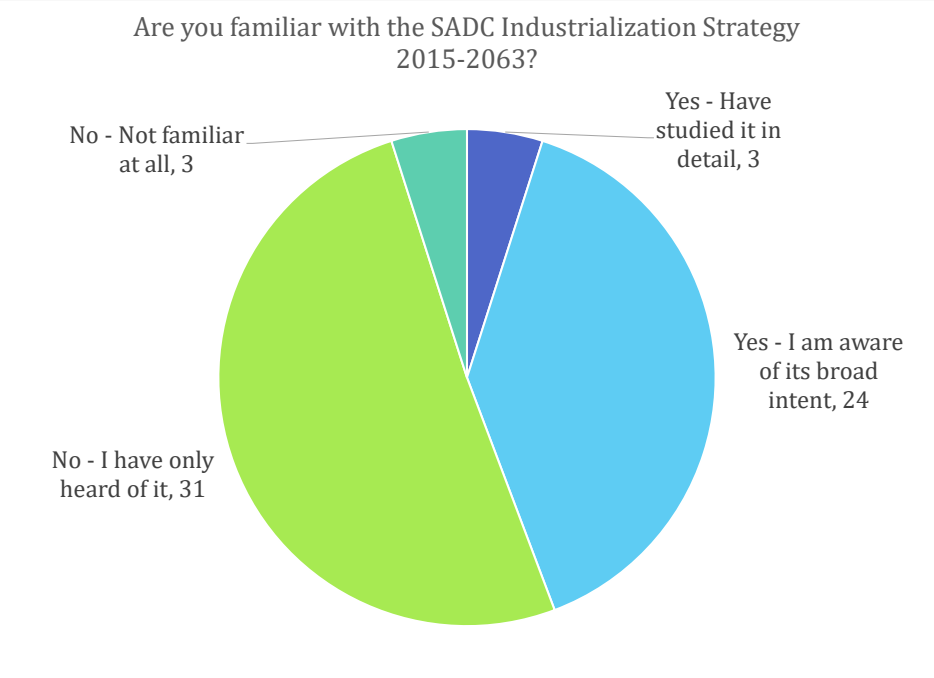


Figure 2:Higher education familiarity with the SADC Industrialization Strategy

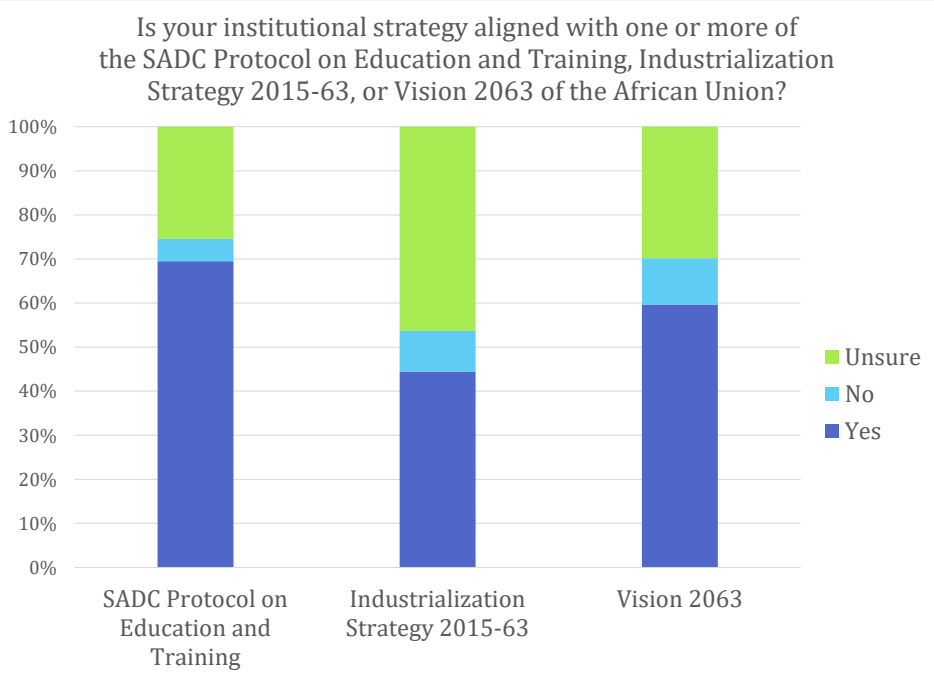


Figure 3: Institutional strategy alignment with regional strategies

Against the background of these responses, it should be noted that the Industrialisation Strategy, in outlining three integrated pathways for the region, acknowledges the distance

between institutions and the region's macro view and emphasises that implementation needs to happen at national level:

> "It is recognized that most of the pragmatic policy measures will be implemented at national not regional, level. Within SADC development context, and based on recent experiences regionally and globally, the Industrial Strategy identifies three clear-cut priorities for accelerated industrialization:
>
> 1. Agriculture-led growth including agricultural value chains;
> 2. Natural resource-led growth including minerals beneficiation and processing, also linking into value chains, both regional and global, and
> 3. Enhanced participation in domestic, regional and global value chains."
>
> SADC, 2015

What is therefore relevant to this study and as further discussed under recommendations in the final section of the report, is the need for a supply side operating model to address the regional picture and end goal, while primarily implementing skills programmes on a national level with national institutional partners.

1.6.2 AVAILABILITY OF EDUCATION AND TRAINING OPPORTUNITIES

In evaluating the extent to which higher education institutions are responding to the demand for degrees, diplomas and short courses, a draft demand analysis report was shared with all survey respondents, to understand the context of the demand and the analysis done. A general question asked whether institutions are responding to the value chains.

The results as presented in Sections 3-5 of the report show that the agro-processing value chain has more existing programmes in place at the sampled institutions than the other two value chains, as identified by respondents. This points to an existing historical regional offering of agriculture-focused programmes, more so than with mineral beneficiation and pharmaceuticals. The reasons for these need to be tested, and could include the regional importance of agriculture, the high degree of specialisation required to recruit staff in mineral beneficiation and pharmaceuticals, and the high capital cost associated with the latter two.

Across all three value chains the majority of skills development contributions are through formal teaching and learning offerings. This is not surprising given the profile of the institutions, and prevalence of private institutions. Short courses seem to be the least on offer from the initial sample.

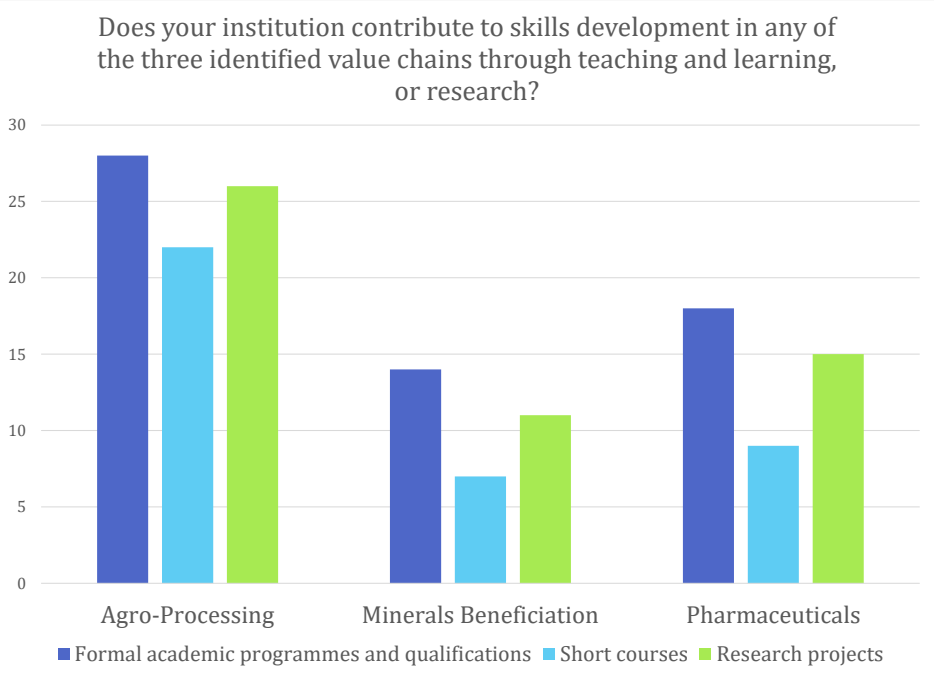


Figure 4: Comparison of skills development focus across three value chains

1.7 APPROACH TO THE PROPOSED SADC UNIVERSITY OF TRANSFORMATION CONCEPT

The SADC Protocol on Co-operation in Education and Training, 1997, emphasises the required collaboration of member states in respect of Higher Education and Training, and highlights the roles and functions of proposed Centres of Excellence and Specialisation. It is specified that the criteria for the selection of such Centres should be in terms of an equal opportunity to bid by the relevant Universities in the region as issued by the SADC, and appointed by the relevant Sub-sector on Education and Training Technical Committee.

Against this background, the SADC Ministers responsible for Education and Training, and Science, Technology and Innovation have endorsed the concept of a network of partner institutions and universities to be designated as Centres of Excellence and Centres of Specialisation, and requested that the SADC Secretariat commission a study to conduct a comprehensive skills audit, and develop a costed and time bound roadmap for the operationalisation of a SADC University of Transformation (SUT).

In the context of this report, the role of such proposed SADC University is approached within the specific parameters of the coordination of the supply of education and training opportunities within the three value chains. This report does not make general proposals on the SUT, as this is the subject of another SADC-commissioned project, in terms of which Eswatini is developing a proposal on the administrative hub for the SUT, including proposals on its organisational design and academic role. Given this important qualification, the approach of this report to addressing the skills development

requirements in the identified value chains, emphasises that the establishment of a SUT should be approached in phases. An initial phase should focus on the establishment of a network of partner organisations to coordinate skills provision within each value chain. In line with the collaboration theme of the Protocol, the SADC should determine the appropriate governance and coordination structure for the work of the value chain networks. In other words, it is proposed that in its initial phase the SUT essentially should be a virtual SADC Network of Universities structure which plays a coordination role amongst participating institutions. More specifically, this report recommends that for each value chain, there should be a network of universities that oversees and coordinates education and training provision.

As such the SUT concept is therefore qualified on the basis that the optimal form and content for the delivery of any agreed to instruments for skills development on a regional basis will evolve over time, and that a roadmap for such delivery will consist of several elements.

On such basis this report therefore examines several options for operationalisation, including the delivery of programmes to be distinguished as:

i. Programmes that are offered by SADC universities, and where the existing capacity is sufficient to address SADC's needs. As these universities will continue to enrol students in such programmes, their relevance and content in respect of a SUT role is to be assessed. For example, in this case, the SADC Network of Universities primary role may be to provide administrative and logistical services to support participating institutions.
ii. Existing programmes, but with a need for additional capacity: An assessment of the role of a network of universities in providing capacity development, e.g. by making additional enrolments possible through e-learning. (E.g. using a shared revenue model with the university that is the academic owner of the programme).
iii. New programmes that could be developed through the SADC network for each value chain- where no or inadequate existing programmes exist. Such an approach may also include a range of capacity development initiatives related to inter alia teaching and learning, curriculum development and accreditation and quality assurance.

1.8 KEY CONCEPTS

Several key concepts are applied and referenced in this study and are defined as follows:

Value chain: Within the context of the report, a value chain includes suppliers (input), core manufacturing sectors/industries, support industries (e.g. packaging, funders, advice centres etc.) as well as final distributors of the product. For purposes of the skills demand analysis however, the main focus of this study will be on core industries within the value

chain. That said, a number of core industries of the minerals processing could be considered support or side activities to the agro-processing value chain (e.g. canning, fertilisers and machinery) while some core activities of value chains could also be inputs for other core sectors within the same value chain (e.g. packaging within agro-processing or energy products within mining). Apart from the core manufacturing activities, the focus will also be on Research and Development (R&D) activities since the latter are very much linked to university activities and skills. R&D also plays an increasingly important role in the competitiveness of local and regional manufacturing capabilities.

Agro-processing value chain: Consists of raw agricultural inputs, processing of these agricultural products (half-processed for further processing or goods for final consumption), support activities (e.g. packaging, transport, research) as well as retail and wholesale of these products in the local, regional or international markets. Our focus will be on the core manufacturing sub-sectors and research within the agro-processing value chain with the main categories being food processing and beverages, textiles and leather, paper and wood.

Minerals processing value chain: Consists of raw minerals (mining activities) as inputs being processed or beneficiated to a more finished product with a higher sales value. Mineral processing involves a range of processes from large, capital-intensive industries such as smelting to smaller labour-intensive processes, such as craft jewellery, dimension stone, fertiliser and ceramic pottery. The minerals processing phase is assumed to begin just after stage 1 (extraction and minor modifications such as raw diamonds and copper concentrates). Stage 2 would include low level downstream processing such as metals and matte; stage 3 alloys and stage 4 the final mineral product ready to be used as input into the final consumer product (e.g. cut diamonds for jewellery manufacturing or stainless steel used in pots and pans). Stage 5 involves the final consumer good with processed minerals as input, e.g. a piece of jewellery or a steel cabinet). The cluster also includes support activities (e.g. energy, transport) as well as distribution of these products in the local, regional or international markets. This report focus will be on the core manufacturing sub-sectors and research within the minerals processing value chain the main categories including processing of energy minerals, ferrous metals, base metals, fertilisers, cement, diamonds, platinum, soda ash, mining machinery.

Pharmaceuticals value chain: Excludes blood services and medical devices (although regarded as part of the larger health technology sector) but includes medical drugs, vaccines, diagnostic tests and some laboratory equipment closely related to the industry including IV fluids, syringes, surgical equipment, lab reagents and materials, methylated spirit – although the harder tools like surgical equipment could overlap with medical devices. The full pharmaceutical value chain includes research, product development, pre-clinical toxicology, clinical trials, full scale manufacturing and distribution. Universities, science councils (e.g. the CSIR, Medical Research Council) play a large role from the research phase through to clinical trials. The report focus will be on the core manufacturing

sub-sectors and research within the pharmaceutical value chain, the main categories being Anti-Retroviral Treatments (ART), Anti-TB treatments, Anti-malarial treatments, the treated bed net value chain, condoms, health commodities (syringes, IV fluids, surgical equipment, lab reagents and materials, methylated spirit) and other drugs not listed above (e.g. herbal medicines/ general generics etc.).

Formal employment: The large part of the skills demand analysis is on formal as opposed to informal employment. The reasoning behind this focus is that it is more likely the formal sector of the economy (consisting of businesses registered for tax purposes) that would employ higher level and higher cost skilled workers that received training at tertiary institutions.

Low/ Unskilled Labour refers to workers who possess no particular skills and have low levels of formal education (between Grade 4 and Grade 9 in the South African schooling system). This type of work usually involves simple duties that don't require judgment. In some cases, unskilled labour requires physical strength and exertion, i.e. elementary professions with General Education training (GET), i.e. on the National Qualifications Framework (NQF) level 1 of the South African Qualification Authority (SAQA).

Medium/ Semi-Skilled Labour does not require advanced training or specialized skills, but it does require more skills than an unskilled labour job. Professions in this category include technicians, service and sales workers, skilled artisans and trades people (with trade certificate) and plant operators. People who perform semi-skilled labour usually have a qualification in the Further Education and Training (FET) band or NQF levels 2, 3 and 4 according to SAQA, such as a high school diploma (between grade 10 and Grade 12 in the South African schooling system), or occupational qualifications offered by Technical and Vocational Education and Training (TVET) institutions and spanning various levels on the NQF, but mainly up to level 5.

High /Skilled Labour refers to workers who have specialized training or skills. These workers are capable of exercising judgment and have knowledge of the particular trade or industry in which they work. The skill category involves managers and professionals with Higher Education Training (HET), i.e. Grade 12 (NQF 4) plus an occupational certificate/diploma (NQF 5); a B degree /higher diploma (NQF 6); Honours degree/post graduate certificate (NQF 7) or a Masters or Doctorate Degree (NQF 8). People who perform skilled labour will most likely have a college or university diploma or degree. The lower tertiary qualifications (NQF 5 occupational certificate or diploma) are usually supplied by TVET institutions as well as technical universities. The higher tertiary qualifications (NQF 6-8) are usually supplied by technical or academic universities.

Short Courses are defined as non-formal courses or learning programmes (where more than one course is offered) over a short duration (less than 6 months) which do not result in a formal qualification, but can be recognised as contributing to one, subject to national and institutional provisions on the recognition of prior learning.

2 STUDY BACKGROUND: THE FUTURE WORLD OF WORK

The major drivers of change shaping the workforce of the future are new technological breakthroughs, demographic shifts, shifts in global economic power as well as resource scarcity and climate change.

A study conducted by PriceWaterhouseCoopers (2018) lists potential future workplace scenarios based on the current opposing forces of collectivism versus individualism on the one hand, and fragmentation versus integration on the other hand. On the basis of these opposing forces the study visualises four types of future worlds of work, namely:

- A fragmented and collective-orientated (yellow) world where humans come first and being human is valued, and where funding will go towards ethical brands with the focus on artisans and smaller collective production units;
- A fragmented and individualistic (red) world in which organisations and individuals race to give consumers what they want, digital platforms dominate and the influence of those with winning ideas, specialists and niche profit-makers flourish;
- An integrated and collective-orientated (green) world where social and environmental responsibility drives the corporate agenda, with concerns around climate change, sustainability, and demographic changes dominating the agenda;
- A integrated and individualistic (blue) workplace where big conglomerates continue to grow bigger and more concentrated, where individual preferences and mass consumption trumps beliefs about social responsibility.

These above-mentioned categories have been applied to the value chain skills demand analysis findings to illustrate the expected skills development demand scenarios at Section 7, Table 28: Expected skills development demand scenarios, *infra*.

The future work of world will possibly contain elements of all these different scenarios. Irrespective of the scenario, emerging technologies are likely to play a large role. The latest technological developments are linked to the so-called fourth industrial revolution with a larger integration between different manufacturing sub- sectors and fields of specialisation. Technologies of the fourth industrial revolution are linked to the following developments (Levin and Cunningham, 2018; Banga, 2017; WEF, 2019):

- Increased digitalisation: Digital infrastructure plays an increasingly new role in all sectors of the economy. The building blocks of digital infrastructure are Information and Communications (ICT), infrastructure (internet access, connectivity and affordability), ICT education, digital skills (building mass market, internet software and applications), cloud computing, data intelligence (big data) and digital products (e-commerce products, electronically transmitted products and remote additive manufacturing products (AM) that can be produced through 3D printing). The digital economy already involves 43% of the US workforce, 20% in the UK and 18% in France and Germany;

- Increased automation: With progress made in machine learning algorithms and artificial intelligence (AI), manufacturing technology is rapidly advancing in the development towards self-learning robots with increased stationary robots, non-humanoid land robots and fully automated aerial drones already in use;
- The use of advanced materials: Advanced materials and nanomaterials are increasingly being developed e.g. materials with shape memory, thermoelectric efficiency;
- Advances in renewable energies and energy capture and storage: Renewable energies are advancing at a rapid pace through research in wireless energy transfer, new computing technologies and breakthroughs in battery and fuel cell efficiency;
- Advances in biotechnologies and neuro-technology: Forefront pharmaceutical research has achieved breakthroughs in smart drugs, neuroimaging and bio-electronic interfaces, gene sequencing and customised therapeutics;
- The rapid development in space technologies for functional applications: Developments such as small satellites (CubeSats) are facilitating the development of more cost-effective technologies in fire prevention applications, environmental monitoring, monitoring the movement of fishing vessels etc.

These technologies are expected to facilitate a shift from mass manufacturing to mass customisation, characterised by increased efficiency, flexibility and cost effectiveness. Manufacturing could become more self- organising due to a new class of factory workers; value chains will be seamlessly connected due to increases in connectivity based on sensor technology, mobile devices, big data and image and speech recognition. Digitisation also has the potential to facilitate increased production by smaller units, geographically distributed across countries. It is likely to increase monopolistic power in the market. Countries with higher digital skills and lower cost of internet and higher connectivity will be preferred production destinations (Levin and Cunningham, 2018). According to research by the World Economic Forum (2019) skills availability and labour costs could increasingly become the driving force behind production location choice instead of other traditional factors such as labour laws, economics of scale/agglomeration and proximity to raw materials.

Researchers list the following emerging manufacturing skills related to the so-called fourth industrial revolution (Deloitte, 2018; WEF, 2017; WEF, 2019: Banga, 2017, Devex, 2020):

- Lower demand for physical and manual skills and basic cognitive skills;
- Demand for higher cognitive skills will grow, driven by the need for greater creativity and complex information processing;
- Increase in the number of professionals such as sales and marketing, customer care services, engineers, managers, and executives; data analysts and scientists, software and applications developers, e- commerce and social media specialists, training and development specialists, innovation managers, development

specialists with skills in areas such as impact measurement and evaluation, social fund raising and resource mobilisation, e-learning and knowledge management;

- New fields that could emerge include AI and machine learning specialists, big data specialists, information security analysts, user experience and human-machine interaction designers, robotics engineers and blockchain specialists;
- The need for technological skills, both advanced and basic IT and digital skills. Employees will need to have at least a baseline understanding of computer technology and may also need to understand how to use it to design and manufacture products. These include computer-aided design (CAD) software like AutoCAD often used by engineers. The ICT intensity of jobs in South Africa increased by 26% and in Kenya by 19% over the last decade;
- In agro-processing digitalisation plays an increasingly important role across the value chain: Researchers are working to combine sensors, robotics and AI to create a fleet of mobile robots to improve pant breeding and crop-management practices. Drones are already used for harvest inspections. Mobile applications are used to improve market information and integrate supply networks. E-commerce already plays a role in the distribution and sourcing of agricultural products;
- In mineral production lower resource intensities and the increased use of recycled minerals as part of the growth in the circular economy could diminish the demand for raw materials. 3D printing is expected to play an important role in the processing of minerals.

Up-skilling and lifelong learning are the hot topics in emerging labour market trends today. A study by the WEF (2019) forecasted that about half of the workforce will require significant up-skilling or re-skilling within the next decade, with training requirements varying from six months (35%) to more than a year (10%). In Africa between 40% and 52% of all work activities are susceptible to automation, but the impact is expected to be moderated by relatively low labour costs (WEF, 2017). Companies will be looking for formal as well as on-the- job resources to train and educate their employees to prepare them to operate technologies. Another way in which manufacturers will be closing the gap is by tapping into up-and-coming talent by partnering with vocational schools, high school and middle schools, and offering internship and apprenticeship programmes (Deloitte 2018).

Within the SADC internet connectivity is still at low levels with only Swaziland, Angola, South Africa, Botswana and Lesotho recording internet penetration levels between 20% and 40%. Internet penetration is below 10% in countries like Malawi, Mozambique, Tanzania and the DRC. South Africa, the most technologically advanced of the SADC countries in terms of connectivity, is assessed by the WEF as in the nascent quadrant – i.e. anticipated to experience challenges in participating in the new fourth industrial revolution. The reasoning behind the concern includes the declining manufacturing sector, the shortage of engineers, scientists and digital skills, the high level of market

concentration that is blocking liberalisation and challenges in terms of leadership and coordination on a governmental level. Perhaps one of the more important constraints listed relates to the high level of economic and social exclusion that the country faces, with the associated risk that technological change could worsen the economic divide rather than bridge it (Levin and Cunningham, 2018).

Not all scientists agree with the concept of a fourth industrial revolution. Some regard it as propaganda by techno-optimists and question whether the speed of technological change has actually accelerated. Other scientists hope that humanity will be the larger focus area of the fourth industrial revolution so that developing countries can harness technological revolutions to improve quality of life, reduce inequality and mitigate the negative impact on natural resources and the environment (Levin and Cunningham, 2018).

While it may be premature to predict exactly how the world will respond to the current COVID-19 pandemic, some possible impacts could include:

- The pandemic could result in an increased policy focus on smaller geographic areas. In regional SADC terms this could imply a more inward (national) focus or increased reliance on the immediate SADC region for regional co-operation as opposed to global networks;
- In food processing there could be a shift towards more resilient 'shorter' value chains from local product to local/regional markets instead of reliance on global value chains;
- With rural communities perceived to be more resilient in times of pandemics, there could be a renewed interest in rural as opposed to urban development in the region;
- The pandemic could have highlighted the merits of technologies that facilitate non-physical access to deep rural communities (e.g. drone and mobile technologies);
- In terms of access to essential pharmaceuticals, the pandemic might have highlighted the risk for individual countries to become too dependent on suppliers from outside the national boundaries. This could imply less interest in the development of regional pharmaceutical supply networks, as opposed to developing national self-sufficiency in the production of essential medicines;
- Development aid for developing countries could come under pressure due to the negative economic impact of the pandemic on the developed world. This could reduce donor funding for SADC research projects and other development programmes.
- HEI and other tertiary skills development institutions will re-examine their delivery models.

3 THE AGRO-PROCESSING VALUE CHAIN

3.1 FORMAL SECTOR DEMAND – FIRMS AND TECHNICAL RESEARCH INSTITUTIONS

3.1.1 BACKGROUND

Agro-processing is one of the largest manufacturing sub-sectors in the SADC, employing about 1million people in the formal core sectors, i.e. almost 40% of formal manufacturing employment. In terms of total employment, the contribution of the SADC agro-processing sector is however relatively small, employing only 4% of the formal workforce in the SADC. This is especially low compared to the estimated 12% contribution of formal agricultural employment to total formal employment in SADC. South Africa dominates employment in the agro–processing sector and employed more than 45% of the formal workforce in the value chain.

Outside South Africa, the agro-processing value chain is relatively limited in the SADC. There is limited supply of agricultural products from large commercials, and the agricultural sector is largely dominated by low productivity smallholder farming. Large commercial farming activities are mainly concentrated in South Africa with some commercial activities in Zambia, Namibia, Botswana and Mozambique. The soil is in general acidic and needs fertilisers and lime to increase production capacity. Most of the inputs for commercial farming (e.g. animal health products, packaging, seed, fertiliser, crop production, equipment and machinery) are imported from South Africa since there is limited manufacturing capacity within the SADC countries. South Africa hosts local production capacity for agricultural inputs (e.g. Omnia, Sasol) but also hosts multinationals that distribute imported goods throughout SADC. International suppliers also distribute inputs through other SADC countries. Most SADC countries experience high post-production losses. Lack of grain storage capacity and contamination needs to be managed in the SADC (Imani, 2019).

As indicated in Table 3 below, the food processing value chain dominates employment in the SADC agro-processing value chain employing close to 70% of people employed by agro-processing activities.

Commercial agro-processing capacity in the SADC is concentrated in the hands of a few large food-processing firms mainly located in South Africa, e.g. Tongaat Hulett, Pioneer foods, Tigerbrands etc. There are also larger companies present across other SADC countries e.g. Namibia Mills, Lesotho mills, Grande Moagens de Angola, Agrival (Madagascar), National foods (Zimbabwe) many of them wholly or partially owned by South African multinationals. In terms of smallholder farmers, there is some supply availability and agents (small unqualified informal traders) aggregate and collect goods from small holders with little value added through processing. These products are mainly sold in informal markets.

Currently small vendors and shops and local markets do however play a large role in the distribution of goods to consumers. Large scale commercial trading of value-added agricultural products is mainly located in South Africa, Zimbabwe, Namibia and Botswana but is gradually moving northwards. Larger commercial retailing is anticipated to increase with increased urbanisation in the SADC. Regionally retail organisations would source locally from Eastern Africa (Kenya) with limited sourcing from SADC countries due to quality and quantity issues. The presence of South African supermarket chains in most SADC countries increases the possibility for large central offset of processed goods.

The textile sub-sector is the second largest sector, employing 17% of the formal agro-processing workforce in SADC. Thousands of farmers are involved in cotton-growing across SADC: in Mozambique alone, there are about160 000 cotton producers mainly smallholder farmers. Processing is limited to cotton lint with little local processing into yarn, fabrics or garments. The industry is characterised by low levels of output and poor quality with ginneries using low level technologies. The industry furthermore faces challenges from cheap imports of final clothing products from Asia. There is however potential to improve the regional value chain through processing productivity increases (Imani, 2019).

The wood and paper industry is the smallest sub-sector in the agro-processing value chain, employing around 13% of formal SADC workers in the agro-processing industry. Large scale commercial activities are mainly concentrated in South Africa with large firms such as SAPPI playing a large role in global supply chains with some local sourcing within the SADC. The paper and wood industry faces challenges in terms of its negative environmental image as well as high recycling rates that have resulted in a slow-down in global growth. There is however still scope for paper-related packaging materials replacing plastics.

The agro-processing value chains in SADC are still mainly dominant national sub-sectors and not regional (intra trade) value chains. Intra-regional exports only contributed 10-20% to the total exports of Sub-Saharan Africa, i.e. much lower than experienced in other regions such as Asia, Europe and Americas (Imani, 2019). There is however potential for increased regional linkages. Unfortunately, information related to input and output relationships across different value chains are sketchy in the SADC. There are some anecdotal examples of agro- processing value chains across the SADC region. These include:

The South Africa cotton producing industry outsourcing the spinning of cotton lint to spinning operations in Mauritius and Zimbabwe;

- Imports of macadamia nuts by South Africa from Mozambique
- Lesotho exporting hides to South Africa (Bloemfontein) to be processed into leather for the auto manufacturing industry in South Africa

- South African supermarkets establishing outlets in the SADC region – Shoprite, Woolworths, Pick and Pay and Spar beginning to source some local products from the SADC countries where they operate, e.g. maize meal from CIM, a large maize milling operation south of Maputo and yogurt and fruit juice from Madagascar
- Agricultural equipment is locally manufactured in South Africa and to some extent in Zambia. South Africa manufactures and distributes imported goods across the SADC while Zambia distributes locally and in Angola. South Africa is involved in the whole value chain including design, manufacturing and distribution (Chigumira, 2019).

In Southern Africa, R&D investment is low by international standards, i.e. less than 1% of regional output. With the exception of South Africa, international funding organisations are the main source of R&D in SADC. More than 70% of R&D activities across SADC are performed by government laboratories, public R&D institutions and universities. Industry R&D in general is relatively low, with weak R&D capabilities and industry-research institutional collaborations. Other constraints include low government expenditure on R&D, weak institutional infrastructure for coordinating and facilitating research commercialisation and skills shortages (Fessehaie et. al, 2016).

The formal agro-processing value chain in SADC is supported by numerous research institutions across the region. The Food, Agriculture and Natural Resources Directorate (FANR) of the SADC oversees the strengthening of the R&D capacity in agriculture and the agro-processing sectors in the region. The focus is on primary agricultural research to improve the productivity of the agriculture sector across the SADC to strengthen food security. This forms part of the agenda of the SADC Multi Country Agricultural Productivity Programme (MAPP). Agricultural R&D in the region in general experiences staffing constraints, operational losses, deterioration of infrastructure and limited inter-regional collaboration. The dissemination of research knowledge to small farmers is another challenge (SADC, 2008).

Apart from various university faculties, there are about 33 public research institutions across the SADC that focus on agriculture or agro-processing related research. The largest of these institutions are located in South Africa, namely the Agricultural Research Council (ARC) (that also conducts research on behalf of some 33 community organisations) and the CSIR (Advanced Food and Agriculture Division). Some institutions focus on smaller scale technologies for rural businesses (e.g. the Centre for Agricultural Mechanisation and Rural Technology in Tanzania and the Rural Industries Innovation Centre (RIIC) in Malawi). There are a few examples of regional research networks, as for example the case with the Botswana National Food Technology Research Centre (NARFTC) that collaborates with both institutions within Botswana (i.e. University of Botswana and the Botswana College of Agriculture) as well as the CSIR in South Africa and the Southern Africa Root Crop Research Network (SARRNET). In South Africa a few

larger national firms have their own research facilities (e.g. the Sappi Shaw Research Centre).

3.1.2 FORECASTED DEMAND FOR HIGH AND MEDIUM SKILLS IN THE FORMAL ECONOMY

Table 2 identifies the following four sources of skills demand resulting from organic growth within core agro- industries in SADC over the next 10 years applicable to large and smaller firms operating in the formal economy:

- Firstly, there could be some up-skilling requirements for the estimated 116 500 high skilled workers current employed by these sub-sectors. As was indicated some 50% of the workforce (including high skilled workers) could require some up-skilling or re-skilling within the next decade with training requirements varying from six months (35%) to more than a year (10%);
- With anticipated shifts towards high skilled jobs as opposed to medium skilled jobs some 3 400 medium skilled workers in SADC agro-processing sectors might need to up-skill annually in order to avoid retrenchment. The reskilling would most likely be on Technical and Vocational Education and Training (TVT) level and involve artisans obtaining occupational certificates (NQF 5) in addition to their trade certificates (NQF 4). It might also be required to combine the up-skilling with some of the emerging skills that will be discussed in more detail below;
- The demand for higher skills of new entrants to the labour market could be in the region of 10 000 a year. These higher skills would mainly be supplied by technical and academic universities in the SADC region. In the manufacturing sector typically 13% of the higher education skills are higher technical skills (NQF 5) and would be supplied by TVET institutions as well as technical universities (MERSETA, 2017);
- The additional demand for medium skills in the SADC agro-processing industry (excluding up-skilling of the current medium skilled labour force) could increase by some 19 000 per year over the next 10 years. This demand is typically catered for by TVET institutions.

Table 2: Current Formal and Projected Skills Needs Employment in SADC Agro-Processing Core Sectors, 2018-2030

AGRO-PROCESSING SUB-SECTORS	South Africa	REST OF SADC	TOTAL SADC	% share	Total high skilled labour	Labour force up-skill medium-high	Annual increase in high skills	Annual increase in medium skills
	CURRENT (TOTAL)					FORECAST (INCREMENT PER ANNUM)		
Unit	No.	No.	No.	%	No.	No. p. a.	No. p. a.	No. p. a.
Year	2018	2018	2018	2018	2018	2018-2030	2018-2030	2018-2030
Basic processing of meat, fish and fruit and veggies, legumes	59,029	79,301	138,030	13.8%	15,183	138	719	1,214
Vegetable and animal fats	21,542	15,275	36,517	3.6%	4,017	37	190	321
Dairy products	26,956	31,043	57,698	5.7%	6,347	58	337	637
Animal feeds	12,279	14,950	27,079	2.7%	2,979	27	141	238
Bakery and sugar confectionary	45,798	24,576	70,374	7.0%	7,741	70	411	777
Sugar	16,451	25,260	38,711	3.9%	4,258	39	226	427
Grain mill products	23,594	61,951	82,544	8.2%	9,080	83	482	911
Other food products	48,829	7,000	54,329	5.4%	5,976	54	283	478
Wine and related	26,435	-	26,435	2.6%	2,908	26	155	292
Beer and related	29,079	35,993	65,072	6.5%	7,158	65	380	718

AGRO-PROCESSING SUB-SECTORS	South Africa	REST OF SADC	TOTAL SADC	% share	Total high skilled labour	Labour force up-skill medium-high	Annual increase in high skills	Annual increase in medium skills
	CURRENT (TOTAL)					FORECAST (INCREMENT PER ANNUM)		
Unit Year	No. 2018	No. 2018	No. 2018	% 2018	No. 2018	No. p. a. 2018-2030	No. p. a. 2018-2030	No. p. a. 2018-2030
Soft drinks	26,854	31,218	58,072	5.8%	6,388	58	303	511
Tobacco	15,620	26,493	42,113	4.2%	4,632	42	219	370
Total food and beverages	**352,465**	**353,860**	**696,974**	**69.4%**	**76,667**	**697**	**3,852**	**6,910**
Preparation of textiles and fibres	10,700	55,478	66,177	6.6%	8,603	199	447	1,204
Rope and cordage etc.	1,259	48,813	50,072	5.0%	6,509	150	338	911
Manufacture of textiles	11,454	13,813	25,266	2.5%	3,285	76	171	460
Hides and leather	9,398	18,813	28,211	2.8%	3,667	85	126	304
Total textiles and leather	**32,811**	**138,515**	**169,726**	**16.9%**	**22,064**	**509**	**1,146**	**3,089**
Sawmilling and planing of wood	10,112	30,545	40,657	4.1%	5,285	123	1	123
Manufacture of wood products for further processing	6,734	27,745	34,479	3.4%	4,482	104	1	104
Manufacture of wood products	4,554	3,495	8,049	0.8%	1,046	24	0	24

AGRO-PROCESSING SUB-SECTORS	South Africa	REST OF SADC	TOTAL SADC	% share	Total high skilled labour	Labour force up-skill medium-high	Annual increase in high skills	Annual increase in medium skills
	CURRENT (TOTAL)					FORECAST (INCREMENT PER ANNUM)		
Unit Year	No. 2018	No. 2018	No. 2018	% 2018	No. 2018	No. p. a. 2018-2030	No. p. a. 2018-2030	No. p. a. 2018-2030
Paper pulp and products manufacturing	49,024	4,750	53,774	5.4%	6,991	215	183	389
Total wood and paper	**70,424**	**66,535**	**136,959**	**13.6%**	**17,805**	**411**	**8**	**411**
Total agro-processing	**455,700**	**584,900**	**1,003,659**	**100.0%**	**116,536**	**3,442**	**10,120**	**19,345**

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); official data for selected SADC countries, SETA skills information, sector forecasts for individual sectors, South Africa's manufacturing sector output -employment elasticity

3.1.3 CURRENT SCARCE SKILLS IN THE FORMAL SECTOR – FULL QUALIFICATIONS

In terms of skills, farming in SADC would require all the typical agricultural skills, namely agronomy, soil specialists, agricultural production and supply chain management. The relevant South African SETAs identified typical skills shortages currently recorded in the South African agricultural and agro-processing industries as illustrated in Table 3 below:

Table 3: Scarce Skills in the Agricultural and Agro-Processing Sectors of South Africa, 2018

Degree (NQF 6 and above)	Higher diploma; occupational certificates (NQF 5)
Electrical engineer	Printing machinist
Mechanical engineer	Multimedia design
Agricultural Engineer	Patternmaker
Remote sensing specialist	Production/ops supervisor

Degree (NQF 6 and above)	Higher diploma; occupational certificates (NQF 5)
Renewable energy specialist	Industrial machinery mechanist (Millwright)
GIS specialists	Wood machinist
Veterinarian	Perishable produce export technology
Plant breeders	Meat inspection
Plant pathologists	National certificate: fruit packing and grading
Soil scientists	National certificate: horticulture
Animal scientists	FET: Pest control
Plant scientists	FET: Seed analysis
Seed research	FET: Seed marketing
Business skills	FET: Seed processing and packaging control
Marketing skills (global market trends)	National certificate: plant production
Financial management (including foreign exchange)	National certificate: grain milling
Legal and regulatory compliance	National certificate - agriculture equipment maintenance and repair
Agricultural economics	National diploma: grain handling management
Strategic/long term planning (business management)	FET: manufacturing technical maintenance
Supply and distribution managers (freight forwarding, customs clearance procurement, supply chain management)	National certificate: Abattoir slaughtering processes
Logistics management	National certificate: poultry vaccination
Aqua culture	Irrigation technicians, irrigation engineering
Control /process engineering	Produce inspector and quality control
Operations /project management	Agricultural product processing engineering technologist
Sustainable farming, adaptation and alternative energy	Engineering technologists
Agricultural research	Natural resources engineering technologist
Legal skills	Agricultural machinery mechanic

Degree (NQF 6 and above)	Higher diploma; occupational certificates (NQF 5)
Soil specialists	Farming technology/mechanisation management
Agronomy	Hydro and irrigation specialists
IT specialists and software developers	Health and safety
Food and beverages scientist (very high) – chemicals	

Source: AGRISETA, 2016; Food and Beverage SETA, 2018 and the FP&M SETA, 2018

As indicated in Annexure A below, typical positions that are trending in SADC correspond to the list above. The typical computer skills required include Microsoft Office, Adobe illustrator and CorelDraw graphics (textiles); CMSS software systems and SAP.

3.1.4 EMERGING SKILLS

Change drivers in the demand for skills in the agro-processing sector include global competitiveness, climate change, drought and food security, the green economy (energy-efficiency, eat local, natural food, sustainable sourcing, ethical sourcing, waste reduction), demand for increased shelf life, as well as technology changes (AGRISETA,2016 and WEF, 2019). Based on these drivers, some emerging skills could include:

- The pressure for higher productivity in raw food production due to concerns for food security amidst growing populations in SADC will increase the demand for multidisciplinary skills such as food and beverage scientists and microbiologists;
- Technical skills in processing (electrical, mechanical, renewable, water saving, organic, integrated/closed production systems, production design to optimise local skills, warehousing, marketing and distribution) will increase in importance;
- Innovations in packaging materials (personalised packaging; alternatives to plastic packaging) will increase the demand for R&D in materials (material sciences, polymer sciences);
- Risk mitigation and planning skills could become more important among managers;
- Hygiene and food safety in food production will increasingly become priority issues. Quality control and food safety specialists are expected to play a more important role in further production chains;
- Skills related to the green economy are expected to gain in importance (sustainable energy; climate change specialists and environmental research skills). For instance, in the paper industry the global vision is to maximise recycled content; source fibre responsibly, (avoid natural forests and virgin wood); develop energy efficient mill technology and clean production techniques (chemicals during production – chlorine free production techniques);

- Environmental pressure and water scarcities could increase the need for waste-water specialists;
- Advanced marketing skills would be required to enter new emerging markets in Africa, e.g. e-commerce and social media skills;
- Skills in logistical planning for regional exports could become more important;
- Automation and robotics are anticipated to be rapidly adopted in many sub-sectors of the food and beverage manufacturing sector. For example, drone and remote sensing technology could become increasingly important for the inspection of crops. This will require highly skilled employees and training of current staff to operate new or upgraded machines;
- An increased role is foreseen for Virtual Reality (VR) in skills training. This will increase the demand for VR consultants, systems analysts, software developers, trainers/lecturers and facilitators.

3.2 SKILLS DEMAND FOR POLICY DEVELOPMENT

3.2.1 SADC PRIORITY SUB-SECTORS

As indicated in Table 2 below, the Action Plan for the SADC Industrialization Strategy and Roadmap (SADC, 2017), identified eleven priority agricultural value chains for the development of the agro-processing industry in the SADC. In a follow up study commissioned by the SADC secretariat in 2019, the agro-processing value chains were studied in more depth by Imani Development (2019). The study finally excluded some of the value chains originally identified (sugar, cassava, dairy, wildlife products and forestry products) and included four product value chains (VCs) that were not in the 2017 report namely some textile products (fibre (cotton) processing and sisal rope), sugar, tea and biomass production from indigenous invasive species and wattle for coal timber and electricity.

The selection of the VCs in the Imani study was based on a number of criteria including the extent of value added, number of countries involved, economic impact , import replacement, export potential, utilisation of previously unused assets, sensitivity to climate extremes, potential cost of investment (as measure for potential accessibility to rural communities) as well as potential return on investment. The selected VCs all have a strong potential to develop deep rural areas within the SADC and largely focus on smallholder farming and production and in many cases on collective ownership. In all cases strong public investment and policy measures would be required to actualise the potential of these value chains. The underlying value system behind the choice of these VCs is to increase local processing capacity and food security within each SADC country through smaller, decentralised production units geographically spread across the SADC with the objective to serve the growing local populations within each country. Limited attention is given to cross-regional specialization, or the integration of value chains across different SADC countries.

The processing of grains (rice and wheat) was identified as the VCs with the highest potential to develop due to high levels of imports outside the SADC and due to the shifting consumption patterns of the urban population. The processing of maize as traditional crop was identified as the VC with the second highest potential. The two leading oilseeds that were identified are soybean and sunflower for human and animal consumption. Soybean production has increased in recent years and most SADC countries can produce the crop. The production of fibre-cotton as major crop declined across the SADC in recent years. Processed cotton products are imported as regional markets are flooded by subsidised manufactured products from Asia. Yet there is some basic fibre processing capacity in some SADC countries that has the potential to develop.

The study also identified two new VC opportunities in agro-processing that could have a high growth potential namely the harvesting of wood for biomass, as well as geese and ducks as new poultry value chains. Red meat is also considered a high potential VC that could develop stronger regional as well as global VCs. Botswana, Namibia and South Africa are already main exporters and opportunities already exist for beef exports to the Middle and Far East.

Table 4: SADC Priority Sub-Sectors, Agro-Processing Industry

Sub-sectors	Selected by SADC Industrialization strategy (2017)	Selected by Imani study (2019)	Countries identified for the VC
Maize and wheat processing	Yes	Yes	Angola, DRC, Lesotho, Namibia, Tanzania
Rice processing	Yes	Yes	Swaziland, Madagascar, Namibia, South Africa, Zimbabwe
Soya beans, black eyed beans, peanuts	Yes	Yes, soya beans, other beans -dries, packaging, peanut butter, snacks	DRC, Swaziland, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania, Zimbabwe
Oil seeds	Yes	Yes, sunflower and avocado oil, oilcakes-cattle feed	Malawi, Namibia, Tanzania, Zambia

Sub-sectors	Selected by SADC Industrialization strategy (2017)	Selected by Imani study (2019)	Countries identified for the VC
Fish products	Yes	Yes, freshwater tilapia	Angola, Comoros, DRC, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania
Sugar	Yes	No	Botswana, DRC, Swaziland, Malawi, Mauritius, Mozambique, South Africa, Tanzania, Zambia, Zimbabwe
Meat products (poultry and beef)	Yes	Yes, red meat and ducks for meat and feathers	Botswana, DRC, Swaziland, Madagascar, Namibia, South Africa, Tanzania, Zambia
Cassava	Yes	No	Angola, DRC, Madagascar, Malawi, Mozambique, South Africa, Tanzania, Zambia, Zimbabwe
Dairy	Yes	No	Botswana, DRC, Swaziland, Madagascar, Malawi, Namibia, South Africa, Tanzania, Zambia, Zimbabwe
Horticulture (fruits, vegetables and flowers)	Yes	Yes, guavas, peaches, tomatoes, onions, macadamia nuts	Comoros, DRC, Swaziland, Malawi, Namibia, South Africa, Tanzania, Zambia, Zimbabwe
Wildlife (game meat and hide processing)	Yes	No	Botswana, DRC, Namibia, South Africa, Zambia
Forestry and non-forest timber (medicines, cosmetics, essential oils)	Yes	No	Angola, DRC, Swaziland, Malawi, Mauritius, Mozambique, South Africa, Tanzania, Zambia, Zimbabwe
Fibres- cotton and cotton ginning	No	Yes, ginning	-

Sub-sectors	Selected by SADC Industrialization strategy (2017)	Selected by Imani study (2019)	Countries identified for the VC
Sisal to rope	No	Yes	-
Other non-sugar plantation crop (tea, coffee)	No	Yes	-
Indigenous invasive species (sickle bush, black and yellow thorn) and wattle for biomass - coal, timber and electricity	No	Yes	-

Source: SADC (2017) and Imani (2019)

3.2.2 REQUIRED SKILLS TO FACILITATE DEVELOPMENT OF THE SADC VALUE CHAIN

While the skills discussed in the section above are likely to emerge from the organic growth of the SADC agro- processing sector over the next decade, the direction of growth of the sector could depend to some extent on the SADC policies towards the development of the value chain that, in turn, would require certain skills.

Close to 58% of employment in the SADC is created by the small businesses in the informal sector. In more than half of the SADC countries (Angola, Comoros, DRC, Madagascar, Malawi, Mozambique, Tanzania, Zambia, Zimbabwe) informal sector activities contribute more than 70% towards total employment opportunities. Apart from the formal skills analysed above, there is also large scope for skills development to facilitate development of the agro-processing value chain to enhance the livelihoods of smallholder farmers and informal businesses operating in the value chain. These skills are used by development organisations in the NGO sector (international and local), higher education research institutes and public sector agencies and governments and departments. Some players in SADC currently include the Alliance for a Green Revolution for Africa (AGRA), The African Centre for Economic Transformation and the Food and Agriculture Organisation (FAO).

In addition, the key objectives of the SADC Protocol on Industry are to foster globally competitive regional value chains through SMMEs development, quality control and regulatory compliance, innovation and R&D, promotion of interregional trade in all processing stages, environmental protection; green technologies as well as occupational health and safety.

The Imani study (2019) highlights some particular challenges and recommendations related to the SADC agro- processing value chain that could shed some light on some policy-related skills requirements for the development of the value chain:

- Increasing the supply of raw agricultural materials within the SADC through increased production. The focus should be on the increased distribution and availability of fertiliser and calcific and dolomitic lime;
- Improving market information systems further. The SADC has played a leading role in establishing the Agricultural Information Management System (AIMS) that provides early warning of disasters, assesses vulnerabilities, monitors weather patterns and provides integrated databases for food security planning. There is an additional need to distribute more market information on prices and markets to empower farmers and processors to aggregate smallholder produce and identify market opportunities. For example, digital software (mobile) could add much value in distributing information on price and aggregating volumes from small holders for processing facilities. This could also increase the availability of products for the processing industry;
- South Africa could contribute to increased production of raw materials that it requires for further processing from other SADC countries (e.g. macadamia nuts from Mozambique) by assisting with the development of cultivars and providing improved seed or plant material, e.g. strong rootstocks with disease resistance;
- A large emphasis is placed on improving the processing capacity of staple products (maize, wheat and rice) within the SADC to improve food security and replace imports. The study recommends increasing small local milling and processing capacity (e.g. rice, flour, breakfast cereals, bread etc.) through envisaged small food factories across the rural SADC. Skilled management would be required to handle the technical aspects related to hygiene, safety, packaging, branding and marketing and distribution through rural shops;
- Basic technological assistance (e.g. dough mixers, wood fired ovens, dough freezing equipment) is needed to assist small cooperatives in undertaking dough production and baking activities. Opportunities exist for numerous small new entrepreneurs;
- Increased rice production in the SADC would make a large contribution to import substitution. South Africa has production capabilities, but does not produce raw rice due to water scarcity. Through novel technologies current low productivity areas (Zambia, Mozambique, Malawi, Madagascar) could increase regional production. The focus should also be on improving the capability of small producers to undertake direct branding and marketing for rice producers;
- Local processors in the SADC will need assistance in terms of food safety and product standards to gain access to the regional supermarkets' distribution chain;
- Packaging and canning costs are a constraint for many SADC processors. Systems need to be created where cans and bottles and other containers can be made

available at reasonable costs. Therefore, it is recommended that the canning and packaging capacity to support the local processing of fruit and vegetables be increased, since transport costs of empty cans can be high. Canning and packaging factories close to orchards also reduce post- harvest losses;

- The producers of coffee beans and tea leaves seldom share in high end value. The further processing from high quality green coffee beans has been recommended, packaged and branded with registered rights to the marketing of the coffee according to the 'estate of origin';
- In terms of red meat production, high growth potential exists for the export of natural beef from grass feedlots from South Africa, Zambia, Namibia and Botswana. Small farmers could potentially participate by rounding up young cattle to be sold to the larger feedlots. For the industry to thrive, attention should be given to good quality breeding material, making animal health products more affordable, upgrading technology and establishing abattoirs and ultra-hygienic meat processing plants. International standards need to be observed, e.g. traceability plays a large role in regional and global value chains. The local production of feedstock needs to increase since cattle feed is bulky and costly to export over large distances;
- Skills are needed to explore the increased production of tilapia for export to Europe;
- Regional strategies and coordination need to be in place to exploit the opportunity for large scale regional harvesting of indigenous invasive plants for biomass to create electricity, produce livestock feed, methanol fuel, timber panels and high-quality charcoal;
- Need to harmonise packaging and labelling standards (e.g. GMO labelling).

3.3 IDENTIFIED COURSES AND PROGRAMMES

The demand for the following main courses or academic programmes has been identified above:

Existing degrees and diplomas based on the organic growth of the formal core sectors of the agro-processing value chain. According to Table 2 above there could annually be an additional demand for some 10,000 high skilled workers in the SADC agro-processing sectors. The distribution of the qualification levels would typically be as indicated in Table 5 below with a large percentage falling in the post graduate categories, at least to Honours level or 4 years of full-time study after senior certificate.

Table 5: Typical distribution of qualification levels in the manufacturing sector

Level of higher degree qualification	% of the skilled manufacturing labour force
Occupational certificate or diploma	13%

B degree/higher diploma	11%
Honours degree/post graduate certificate	49%
Master /doctorate degree	26%
Total	**100%**

Source: Food and Beverage SETA, 2018 and the FP&M SETA, 2018

The degrees and diplomas that would most likely be in the higher demand area are illustrated in Table 3 above.

Upgrading current trade certificates to occupational certificates at TVET level to up-skill some 3,400 medium skilled workers per annum (currently employed) to higher skilled positions. The certificates in Table 3 above would most likely be the courses most in demand.

The demand for short courses and programmes to build skills that respond to technological changes and other change drivers relevant to the sector. In this regard the up-skilling of some 50% of the current 116 500 people employed in high skilled positions across the SADC could be relevant. Apart from the current workforce being up-skilled through these programmes, the short courses and programmes could also form part of the standard degree and diploma programmes identified in points 1 and 2 above, rolled out to the growing workforce. Topics of the short courses could include:

- Resource (energy, water) saving production techniques including waste-water treatment
- Organic produce and certification
- Integrated/closed production systems
- Innovations in packaging materials for agro-processing
- Climate risk management
- Hygiene and food safety
- Sustainable sourcing of inputs
- Marketing skills for new emerging markets in Africa, e.g. e-commerce and social media skills
- Skills in logistical planning for regional exports
- Automation and robotics (e.g. remote sensing technology)
- Virtual Reality (VR) in skills training

Short courses linked to the development impact of value chains could include the following topics:

- Skills in Development studies or Agricultural economists with specific regional focus areas such as improving the sourcing of raw supply to agro-processing chains within

the SADC by addressing constraints such as market structures and the high local prices of primary commodities (e.g. sugar); removing or planning around logistical constraints, nationalistic agendas, regional policies;

- Applied supply chain management within the SADC with specific focus on small holder product aggregation, regional input, logistics etc. for example using digital technologies;
- Applied entrepreneurial skills for agro-processing within the SADC (supply risk management, climate risk management, political risks, regional sourcing, appropriate technologies etc.)
- Applied social entrepreneurial skills (mobilising public funds to mitigate constraints, unlock regional opportunities across the regional value chain, facilitate cooperation between development agents, markets operators, institutions)
- The governance of collective production structures.

3.4 SUPPLY SIDE RESPONSES

In evaluating the extent to which higher education institutions are responding to the demand for degrees, diplomas and short courses, respondents were referred to the emerging agro-processing learning themes as identified in the demand analysis of this report, and asked to indicate in which of these learning themes there are already programmes or short courses offered.

The top five **most prominent** learning themes are:

1. Climate risk management;
2. Hygiene and food safety;
3. Resource saving production techniques;
4. Marketing skills for new emerging markets in Africa;
5. Applied social entrepreneurial skills.

The five **least prominent** learning themes are:

1. Virtual Reality (VR) or Augmented Reality (AR) in skills training;
2. The governance of collective production structures;
3. Innovations in packaging materials for agro-processing;
4. Skills in logistical planning for regional exports;
5. Organic produce and certification.

The full list is provided in Figure 5 below. This analysis removes duplication of institutional responses, therefore only counting one response per institution.

This could point to the prevalence of more traditional disciplines still being reflected in academic programmes, but it should also be considered that the learning themes that do not feature strongly could also be associated with either short courses or postgraduate specialisation.

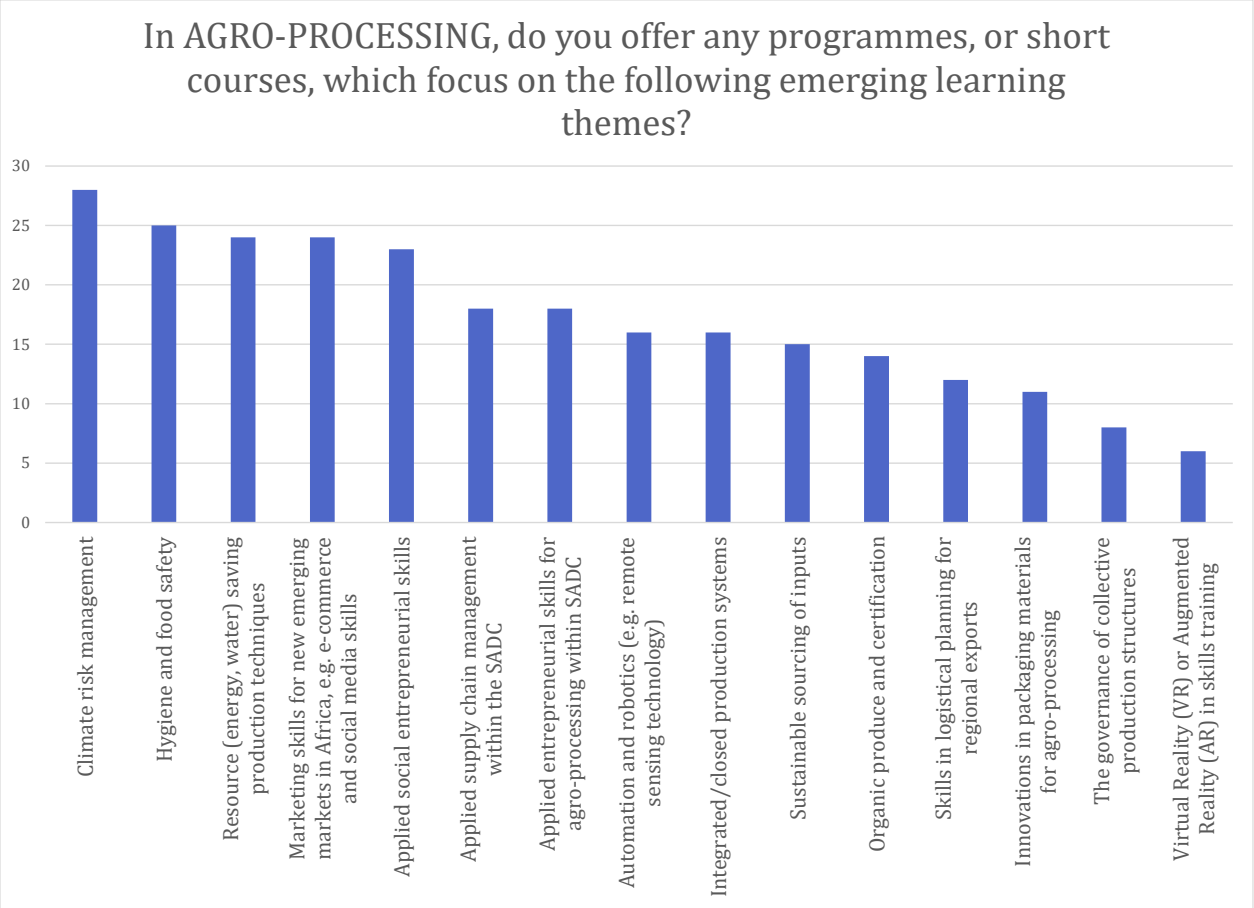


Figure 5: Prevalence of emerging learning themes in agro-processing programmes

When the positive responses are mapped against countries and institutions, even considering that the sample is not fully representative, there seems to be a general regional spread of programmes which claim to address emerging learning themes. This is shown in the table below:

	Climate risk management	Hygiene and food safety	Resource (energy, water) saving production	Marketing skills for new emerging markets in	Applied social entrepreneurial skills	Applied supply chain management within the	Applied entrepreneurial skills for agro-processing	Automation and robotics (e.g. remote sensing	Integrated/closed production systems	Sustainable sourcing of inputs	Organic produce and certification	Skills in logistical planning for regional	Innovations in packaging materials for agro-	The governance of collective production	Virtual Reality (VR) or Augmented Reality (AR)
Angola	**X**	**X**	**X**	**X**	**X**			**X**	**X**		**X**		**X**	**X**	**X**
Higher Polytechnic Institute of Malanje		X													
Óscar Ribas University					X										X
Universidade Agostinho Neto															
Universidade José Eduardo dos Santos	X	X	X	X	X			X	X		X		X	X	
Botswana	**X**	**X**		**X**	**X**	**X**	**X**			**X**		**X**		**X**	
BA ISAGO University	X	X										X			
Botho University															
Botswana Open University															
University of Botswana					X	X				X				X	
eSwatini															
Eswatini Medical Christian University															
Lesotho															
Lesotho College of Education															

	Climate risk management	Hygiene and food safety	Resource (energy, water) saving production	Marketing skills for new emerging markets in	Applied social entrepreneurial skills	Applied supply chain management within the	Applied entrepreneurial skills for agro-processing	Automation and robotics (e.g. remote sensing	Integrated/closed production systems	Sustainable sourcing of inputs	Organic produce and certification	Skills in logistical planning for regional	Innovations in packaging materials for agro-	The governance of collective production	Virtual Reality (VR) or Augmented Reality (AR)
Malawi	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**	**X**		
Mzuzu University	X	X	X		X						X				
National Council for Higher Education															
Unicaf University				X		X									
University of Malawi	X	X	X	X	X	X	X	X	X		X	X	X		
Mauritius	**X**	**X**	**X**		**X**	**X**	**X**	**X**	**X**			**X**			
Open University of Mauritius															
University of Mascareignes			X		X			X	X						
University of Mauritius	X	X	X			X	X		X			X			
Mozambique	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**
Instituto Superior de Contabilidade e Auditoria de Moçambique															
Instituto Superior Politécnico de Manica (ISPM)	X	X	X	X	X	X	X		X	X	X	X	X		

	Climate risk management	Hygiene and food safety	Resource (energy, water) saving production	Marketing skills for new emerging markets in	Applied social entrepreneurial skills	Applied supply chain management within the	Applied entrepreneurial skills for agro-processing	Automation and robotics (e.g. remote sensing	Integrated/closed production systems	Sustainable sourcing of inputs	Organic produce and certification	Skills in logistical planning for regional	Innovations in packaging materials for agro-	The governance of collective production	Virtual Reality (VR) or Augmented Reality (AR)
Universidade Lurio	X		X					X							X
Namibia	**X**	**X**		**X**										**X**	**X**
The International University of Management	X			X										X	X
University of Namibia		X													
South Africa	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
North-West University							X			X					
Sol Plaatje University					X			X							
Stellenbosch University		X	X	X	X	X	X	X		X	X	X			
University of the Free State	X	X		X	X	X	X		X	X			X		
Walter Sisulu University															
Tanzania	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Blue Pharma College of Health															
Dar Es Salaam Institute of Technology			X												
Kaole Wazazi College of Agriculture	X	X	X	X	X	X	X		X	X	X	X	X		

	Climate risk management	Hygiene and food safety	Resource (energy, water) saving production	Marketing skills for new emerging markets in	Applied social entrepreneurial skills	Applied supply chain management within the	Applied entrepreneurial skills for agro-processing	Automation and robotics (e.g. remote sensing	Integrated/closed production systems	Sustainable sourcing of inputs	Organic produce and certification	Skills in logistical planning for regional	Innovations in packaging materials for agro-	The governance of collective production	Virtual Reality (VR) or Augmented Reality (AR)
Kilimanjaro Agricultural Training Centre	X	X	X	X			X				X				
Nelson Mandela African Institution of Science and Technology	X	X	X	X	X	X	X	X	X	X	X		X	X	
St. Joseph University in Tanzania			X					X			X				
St. Maximilliancolbe Health College															
Zambia	**X**	**X**	**X**	**X**						**X**					
Chalimbana University	X	X	X	X						X					
Copperbelt University	X		X												
Zambian Open University															
Zimbabwe	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**					
Bindura University of Science Education	X			X		X	X			X					
Catholic University of Zimbabwe	X			X	X										
Midlands State University	X														

	Climate risk management	Hygiene and food safety	Resource (energy, water) saving production	Marketing skills for new emerging markets in	Applied social entrepreneurial skills	Applied supply chain management within the	Applied entrepreneurial skills for agro-processing	Automation and robotics (e.g. remote sensing	Integrated/closed production systems	Sustainable sourcing of inputs	Organic produce and certification	Skills in logistical planning for regional	Innovations in packaging materials for agro-	The governance of collective production	Virtual Reality (VR) or Augmented Reality (AR)
National University of Science and Technology															
University of Zimbabwe	X	X	X	X	X			X	X						

4 THE MINERAL PROCESSING VALUE CHAIN

4.1 FORMAL SECTOR DEMAND –FIRMS AND TECHNICAL RESEARCH INSTITUTIONS

4.1.1 BACKGROUND

In terms of employment, the SADC mineral processing value chain is substantially smaller than the agro- processing value chain, employing an estimated 320 000 formal workers in 2018, more than 80% being employed in the South African mineral processing sector. This represents about 1.3% of formal SADC employment compared to the close to 6% contribution of mining employment to SADC formal employment.

As discussed above, mineral processing involves different stages of value addition to unprocessed mining products. Primary mining includes ore extraction and ore concentration, while mineral processing commences with further processing of ore and concentrates following different stages of smelting, refining, semi- manufacturing (ready to be included in final consumer goods) and the manufacturing of final consumer articles using mineral products as inputs. The secondary and tertiary phases of metal processing (smelting, refining and semi-manufacturing) are usually characterised by low labour intensity, high capital requirements and high energy intensities (Tom, 2015).

South Africa dominates the mineral production value chain in the SADC using at least 5 metals in more advanced mineral beneficiation stages (aluminium, ferrochrome alloys, using ferrochrome and nickel alloys in the production of stainless steel and steel production). In addition, South Africa also manufactures finished products from steel and iron, copper, gold, diamonds and the Platinum Group Metals (PGM). In the rest of the SADC, the beneficiation of metals is predominantly still at relatively low (secondary) value adding stages with the exception of some secondary, tertiary and final processing stages in Mozambique (aluminium); Zimbabwe (copper finished products; chromium to stainless steel; fabricated gold products); Zambia (manufactured copper goods) and cut diamonds (South Africa, Mauritius, Namibia, South Africa and Tanzania) (Tom, 2015).

The SADC's mineral processing value chain faces challenges in terms of general energy intensity, the high costs of capital equipment, the relatively small size of the regional market and the distance to markets (DMR, 2011). Regardless of these efforts, beneficiation is yet to successfully extend in scope and capacity within the mining sector.

The three dominant sub-sectors are the processing of non-ferrous metals (PMG metals, gold, copper, aluminium, cobalt etc.) (35% of employment) followed by steel and iron products (23%) and processing of energy minerals (coal, gas, uranium etc.) (16%). As is the case in the agro-processing industry, the highly concentrated market structures in the provision of raw and semi-processed mining materials in some cases makes further downstream processing of minerals unprofitable (e.g. ArcelorMittal's steel products and SASOL's plastic products). Increased local competition in the early stages of processing could provide an answer. In South Africa for example the IDC assisted China's Hebei Iron and steel group to build a new steel plant in South Africa (SAIIA, 2014).

The steel industries use manganese, chromium, nickel, and vanadium as alloys with iron. Beneficiation of these commodities is limited in the SADC steel industry (concentrated in SA) but did well in the export boom when the Chinese construction sector expanded rapidly. Since the Chinese also expanded their smelting capacity, there is excess capacity of smelters worldwide. In South Africa the ferrochrome smelting industry is currently rationalising with many local chrome producers once again exporting raw minerals directly to China rather than domestic smelters. Copper beneficiation in Zambia followed the same backward trend in terms of copper beneficiation in recent years. The South African PGM processing sector (auto-catalysts and pre-cursor materials) has significant R&D but potentially lacks the commercialisation of activities. The PGM market could also come under pressure if the increase in electrical motors reduces the demand for autocatalytic converters (Fessehaie and Rustomjee, 2018).

South Africa is also a dominant regional processor of energy minerals. It has the second largest refining capacity in Africa after Egypt. Two homegrown companies (SASOL and PetroSA) play a large role in the SADC petro-chemicals value chain. Final products of the South African petro-chemical processing industries include petrol, kerosene (paraffin), diesel, propane, liquid oxygen and nitrogen, distillates, eco-fuels, process oils and alcohols. SASOL also pioneered the breakthrough processing of coal to liquid technologies and dominates the local market in the provision of chemical feedstock for plastics and fertilisers. This sub-sector is therefore also linked to the agro- processing industry in the SADC (DMR, 2011).

Two smaller sub-sectors that also play a role as inputs in the agricultural sector include the production of cement and lime products as well as machinery and equipment (agriculture and mining). While South Africa dominates in these sub-sectors as well there is some domestic capacity across SADC, e.g. cement in Mozambique and machinery and equipment in Zambia (Chigumira, 2019).

Some of the smaller mineral processing sub-sectors provide some opportunities for more labour intensive and or smaller operations in the SADC:

- Salt is an important input in the chemical sector, food processing, agriculture and water treatment sectors. Salt refinement is usually done closer to the final market, and with an undeveloped chemical sector in the SADC the use of salt in the smaller food processing market is more likely (McGregor, Emvula and Brown, 2017);
- In terms of further diamond and precious stones processing into jewellery, significant investment is needed for further beneficiation. Some constraint to the SADC jewellery sector includes the general lack of capital, skills and the relatively high unskilled labour costs compared to India or China. However, there are hubs in the SADC (Mauritius) where the jewellery sector is tuning into the global growth of the sector with increased demand from India and China;
- Dimension stone (marble, granite etc.) is becoming more popular for use in the construction industry. The processing needs electrical equipment and is highly automated with low labour force requirements. The final finishes are usually done at local sites to reduce damage or breakage transport costs. Only basic cutting is required in export markets (McGregor, Emvula and Brown, 2017);

- Graphite is used in the steelmaking process, and in the production of batteries, break-linings, lubricants and pencils. The demand for high purity graphite is increasing for new technology applications such as lithium and batteries (Ibid);
- There is a growing demand for silica sand in glass making (solar panels), metal casting, chemical production etc. Processing involves washing, screening and extracting impurities. Due to its low selling costs, high transport costs and natural abundance, plants are usually situated closer to the end users with access to large markets and cheap electricity to make them competitive (Ibid).

There are a number of examples of regional value chains within the SADC mineral processing sector (SAIIA, 2014):

- Namibia and South Africa import copper concentrates from Zambia. South Africa dominates the local value chain in terms of copper semi-manufactures (e.g. wire cables and pipes)
- There is some evidence of a regional aluminium value chain albeit at a low level of development. Mozambique has aluminium processing capacity (Mozal) but provides no further downstream processing of aluminium due to lack of a technological base and skills. In Mozambique, aluminium processing remained a classic enclave with little forward and backward linkages. Botswana exports aluminium boats to Zambia but has no capacity to produce aluminium, which it imports at considerable costs from SA (SAIIA, 2014)
- SADC imports large volumes of mining machinery and equipment from South Africa. In Botswana for example 73% of machinery and equipment is imported from South Africa; while the comparative figures are 37% in Zambia and 57% in Zimbabwe. South Africa's largest export markets of mining capital equipment in the SADC are Zambia, followed by the DRC, Mozambique and Zimbabwe. Products include conveyor systems, pumps and valves, off-road special vehicles and mineral processing equipment. Aftermarket care is a key component of SA's high presence in the market. International suppliers also have agents and sales offices in South Africa, usually supported by local engineering firms that also do aftermarket services (Fessehaie and Rustomjee, 2018)

South Africa has the highest R&D research capabilities in SADC and operates at the global frontier for mining related technologies. Mintek, as well as the South African Minerals to Metals Research Institute (SAMMRI) play leading roles in research related to mineral beneficiation in the country. SAMMRI is the leading research collaboration between South African universities and industry. While a significant number of researchers at SAMMRI originate from the SADC, there is no regional cooperation programme in place. The Wits Centre for Mechanised Mining Systems was set up by mining houses for graduate training in mechanisation. The centre also has various students from the SADC (Fessehaie et. al, 2016). Tanzania, Angola and the DRC also have dedicated mining research institutions. In Angola and the DRC research mainly focuses on primary mining activities.

4.1.2 FORECASTED DEMAND FOR HIGH AND MEDIUM SKILLS IN THE FORMAL ECONOMY

Table 6 identifies the following three sources of skills demand resulting from organic growth within core mineral processing sectors in the SADC over the next 10 years:

- Firstly, there could be some up-skilling requirements for the estimated 52 000 high skilled and potentially 100 medium skilled workers currently employed by the mineral processing core industries in the SADC. As was indicated some 50% of the workforce (including high skilled workers) could require some up-skilling or re-skilling within the next decade with training requirements varying from six months (35%) to more than a year (10%);
- The demand for higher skills of new entrants to the labour market could be in the region of 655 a year. These higher skills would mainly be supplied by technical and academic universities in the SADC region. In the manufacturing sector typically 13% of the higher education skills are higher technical skills (NQF 5) and would be supplied by TVET institutions as well as technical universities (MERSETA, 2017);
- The additional demand for medium skills in the SADC mineral processing industry (excluding up- skilling of the current medium skilled labour force) could be in the region of some 2,000 per year over the next 10 years. This demand is typically catered for by TVET institutions.

Table 6: Current Formal Employment and Projected Skills Needs in SADC Mineral - Processing Core Sectors, 2018-2030

MINERALS - PROCESSING SUB-SECTORS	South Africa	REST OF SADC	TOTAL SADC	% share	Total high skilled labour	Labour force up-skill medium-high	Annual increase in high skills	Annual increase in medium skills
	CURRENT (TOTAL)					FORECAST (INCREMENT PER ANNUM)		
Category	No. 2018	No. 2018	No. 2018	% 2018	No. 2018	No. p. a. 2018-2030	No. p. a. 2018-2030	No. p. a. 2018-2030
Manufacture of coke oven products, processing of hydrocarbons, other petroleum products and processing of nuclear fuel	39,750	10,800	50,550	15.6 %	15,165	101	300	257

MINERALS - PROCESSING SUB-SECTORS	South Africa	REST OF SADC	TOTAL SADC	% share	Total high skilled labour	Labour force up-skill medium-high	Annual increase in high skills	Annual increase in medium skills
	CURRENT (TOTAL)					FORECAST (INCREMENT PER ANNUM)		
Category	No. 2018	No. 2018	No. 2018	% 2018	No. 2018	No. p. a. 2018-2030	No. p. a. 2018-2030	No. p. a. 2018-2030
Manufacture of fertilizers and nitrogen compounds	4,348	300	4,648	1.4%	511	-	5	23
Manufacture of cement, lime and plaster	17,324	8,000	25,324	7.8%	2,786	-	27	126
Cutting, shaping and finishing of stone (including diamond cutting and polishing)	1,716	5,800	7,516	2.3%	827	-	8	38
Manufacture of other non-metallic mineral products n.e.c. (including jewellery)	2,899	3,200	6,099	1.9%	671	-	6	30
Manufacture and casting of basic iron and steel, structural steel products and containers	65,500	7,900	73,400	22.7%	10,276	-	99	472
Manufacture and casting of other metals (precious and other)	87,000	24,500	111,500	35.0%	15,610	-	150	717
Manufacture of structural metal products and containers	15,500	-	15,500	4.8%	2,170	-	21	100

MINERALS - PROCESSING SUB-SECTORS	South Africa	REST OF SADC	TOTAL SADC	% share	Total high skilled labour	Labour force up-skill medium-high	Annual increase in high skills	Annual increase in medium skills
	CURRENT (TOTAL)					FORECAST (INCREMENT PER ANNUM)		
Category	No. 2018	No. 2018	No. 2018	% 2018	No. 2018	No. p. a. 2018-2030	No. p. a. 2018-2030	No. p. a. 2018-2030
Manufacture of structural non-refractory clay and ceramic products	4,995	-	4,995	1.5%	699	-	7	32
Manufacture of machinery for mining, quarrying and construction	22,505	2,000	24,505	6.9%	3,431	-	33	158
TOTAL MINERAL PROCESSING	**261,536**	**62,500**	**324,036**	**100.0%**	**52,145**	**101**	**655**	**1,953**

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); official data for selected SADC countries, SETA skills information, sector forecasts for individual sectors, South Africa's manufacturing sector output -employment elasticity

4.1.3 CURRENT SCARCE SKILLS IN THE FORMAL SECTOR – FULL QUALIFICATIONS

The relevant South African SETA identified typical skills shortages currently recorded in the South African mining and mineral processing industries as illustrated in Table 7 below:

Table 7: Scarce Skills in the Mining and Minerals Processing Sectors of South Africa, 2017

Degree (NQF 6 and above) - new skills	Higher diploma; occupational certificates (NQF 5)- new skills	Up-skilling of existing labour force required
Automation and control engineer (industrial engineer)	Agricultural technician	High skills
Bioengineers	Millwright (electro-mechanic)	Mine surveyor
Business/technical training manager	Air conditioning equipment Mechanic	Electronic engineer

Degree (NQF 6 and above) - new skills	Higher diploma; occupational certificates (NQF 5)- new skills	Up-skilling of existing labour force required
Chemical engineer	Auto electrician	Finance manager
Chemist	Battery bay and lamp attendant and repairer	Geophysicists
Electrical design engineer	Blast furnace operator	Industrial production manager
Electrical engineer (chemicals)	Boiler maker	Process engineer /industrial engineer
Electronic engineering technologist	Boiler maker	Project manager
Energy efficiency consultant	Chemical waste controller	Quality systems coordinator
Engineering manager (chemicals)	Chemical engineering technician	SHEQ manager (radiation protection, risks and safety)
Financial analyst	Crane and hoist operator	Medium skills
Geologist	Diamond and gemstone setter	Boiler maker
Health and safety manager	Diamond cutter	Crane and hoist operator
Industrial engineer	Diesel fitter	Design and manufacturing draughtsperson
IT security manager	Diesel mechanic	Diamond and gemstone setter
Logistics manager	Dragline operator	Diamond cutter
Maintenance and management engineer	Earthmoving equipment mechanic	Diesel mechanic
Market research analyst	Electrical fitter	Electrical engineering technician
Materials scientists	Electrical mechanic	Environmental officer
Mechanical engineer	Electrician (engineering)	Final diamond processing controller
Mechanical engineer (mines)	Electronic engineering technician	Front end loader operator
Mechatronics engineer	Metallurgical or materials technician	Mine equipment planner
Metallurgical engineer	Metal polisher	Millwright (electro-mechanic)
Metallurgists	Manufacturing plant manager	Metallurgical or materials technician
Mineral economist	Environmental officer	Hydraulic mechanical fitter
Mining engineer	Fitter and turner	Hydrographic surveyor

Degree (NQF 6 and above) - new skills	Higher diploma; occupational certificates (NQF 5)- new skills	Up-skilling of existing labour force required
Operational risk manager	Fitter machinist	Instrument mechanic
Petroleum engineer	Fitter welder	Instrument mechanic process control systems
Petrologist	Front end loader operator	Jewellery die stamper
Physical science technician	Instrument mechanic	Jewellery industrial designer
Plant engineer (mechanical engineer)	Instrument mechanic process control systems	Jewellery wax carver
Process engineer /industrial engineer	Jewellery evaluator	Load -haul dump operator
Production /operations manager	Jewellery industrial designer	Loader operator
R& D manager	Jewellery model maker	Machine operator (stone cutting and processing)
Regulatory affairs officer	Jewellery setter (diamonds and gemstone)	Maintenance manager l
Rock engineer	Jewellery wax carver	Manufacturing foreman
Sales rep (industrial products)	Load -haul dump operator	Mechanical engineer technician
Software developer	Maintenance fitter	Mechanical instrument technician
Supply chain manager	Maintenance planner	Metal processing plant operator
	Mineral beneficiation process controller	Mobile mining equipment operator
	Plant manager	Ore process engineer (metallurgical engineer)
	Productions operations supervisor	Plant manager
	Sheet metal worker	Production plant supervisor
	Toolmaker	Safety engineering technologists (industrial engineering technologists)
	Winding engine driver (humans and materials)	Sales representative industrial products
		SHEQ practitioner
		Technical sales consultant
		Winding engine driver (humans and materials)

Source: MQA (2014) and CHIETA (2017)

As indicated in Annexure B below, typical positions that are trending in the SADC correspond to the list above. Typical specialised computer skills required include computer-aided design (CAD) programmes.

4.1.4 EMERGING SKILLS

Some of the trends in the industry that would act as change drivers for skills demand include (Maennling and Toledano, 2019):

- Increased pressure for resource efficiency globally and the efficient use of minerals and energy gave rise to the concept of the circular economy, namely the adoption and implementation of various strategies aimed at efficient use of resources and the reduction of waste and re-purposing of waste. In the case of mineral resources, it means continually re-using, re-cycling and re-purposing scrap. For example, Novelis re-purposes scrap aluminium for Jaguar Landrover as their sole aluminium supplier;
- Demand for most minerals is projected to be high in order to achieve the energy transition to decarbonize energy systems. Given that low-emission energy and transportation systems are more mineral-intensive than their fossil fuel-based counterparts, the transition provides a great opportunity for the mining sector. At the same time, the mining sector will have to reduce its own emissions. Mining companies that power their operations with renewable energy, operate electric or hydrogen-powered truck fleets and integrate recycling in their value chains will be best placed to sell low-carbon premium minerals;
- Mining extraction will continuously shift to areas not previously seen as economically viable that would place pressure on technological breakthroughs in automation and digitalization to achieve more targeted and efficient mining, e.g. in-situ leaching (a mining process used to recover minerals such as copper and uranium through boreholes drilled into a deposit), block caving (an underground mining method that uses gravity to exploit ore bodies located at depth) or bio mining (a technique for extracting metals from ores and other solid materials typically using prokaryotes or fungi);
- Novel financing and production models will become more common. With increased financial risk after the Chinese commodity boom slowed down, alternative financing solutions were developed such as royalty and metal stream agreements that reduce the burden on mining companies' balance sheets. To spread the risk of new capital-intensive projects, these financing solutions are likely to continue to grow;
- Increased cooperation with other specialist fields and industries is foreseen in the research field related to the development of new materials. For example, "Origami robots" are state-of-the-art soft, flexible robots that could find use in drug delivery in human bodies, search and rescue missions in disaster environments, and humanoid robotic arms. Because these robots need to be flexible, they are often made from soft materials such as paper, plastic, and rubber. Combining metals such as platinum with burned paper (ash), the new material has enhanced capabilities while maintaining the foldability and lightweight features of traditional paper and plastic.

As highlighted in the paragraph above, emerging skills in the mining and minerals processing industries could revolve around new production techniques to maximise the recycling of metals; reduce the resource (water and energy) impact of mining processes as well as improved efficiency in marginal mining areas through novel technologies incorporating the fields of IT and biotechnology. Other skills include the development of innovative financing models and deal structuring as well as expertise in novel materials involving mining products.

Apart from these skills, the WEF (2019) also predicts that the fourth industrial revolution increases demand for skills in mining and metals sectors related to sales and marketing, new technology, data management and analysts, process automation specialists, big data specialists, AI and machine learning specialists, systems engineers, materials specialists, supply chain and logistics specialists.

4.2 SKILLS DEMAND FOR POLICY DEVELOPMENT

4.2.1 SADC PRIORITY SUB-SECTORS

The table below summarises the mineral processing value chains and related countries highlighted in the SADC industrial action programme.

Table 8: SADC Priority Sub-Sectors, Minerals Processing

Mineral sub-sector	Countries identified for the VC
Energy minerals	Angola (oil), Botswana (coal), DRC (oil, gas, uranium), Swaziland (coal), Madagascar (coal), Malawi (uranium, gas and coal); Mozambique (gas and coal), SA (coal), Tanzania (gas and coal), Zimbabwe (coal)
Ferrous metals (iron and steel etc.)	Angola, DRC, Swaziland, Mozambique, Namibia, South Africa, Tanzania, Zambia and Zimbabwe
Base metals (copper, aluminium, nickel, cobalt)	DRC, Madagascar, Mozambique, Namibia, South Africa, Tanzania, Zambia and Zimbabwe
Fertilizer	DRC, Malawi, Mozambique, Namibia, South Africa, Tanzania, Zambia and Zimbabwe
Diamonds	Angola, Botswana, DRC, Lesotho, Namibia, South Africa, Tanzania, Zimbabwe
Platinum	DRC, SA and Zimbabwe
Cement	DRC, Malawi, Mozambique, Namibia South Africa, Tanzania, Zambia, Mozambique
Soda ash	Botswana, South Africa, Tanzania, Zambia
Mining machinery	SA, Zambia
Small scale mining	DRC, Tanzania, Malawi

Source: SADC (2017)

4.2.2 REQUIRED SKILLS TO FACILITATE DEVELOPMENT OF THE SADC VALUE CHAIN

While the skills discussed in the section above are likely to emerge from the organic growth of the SADC minerals beneficiation sector over the next decade, the direction of growth of the sector would depend to a large extent on the SADC policies towards the development of the value chain that, in turn, would require certain skills. These skills could be used by development organisations in the NGO sector (international and local), higher education research institutes and public sector agencies and governments and departments. Some players in the SADC currently include the African Minerals Development Centre and Resource Watch.

The focus areas of the SADC Regional Mining Vision (RMV) is the promotion of forward and backward linkages as well as side stream linkages into power, technology development, STEM skills development, R&D etc. Inter-regional linkages across the value chain are also considered an important part of the development of the regional mining value chain, since it could create economies of scale for mining supply inputs as well as intermediate outputs for further processing. Last mentioned is an important consideration in the mining and mineral processing sectors due to the high capital costs involved. The main objective of the regional mining and mineral processing sector would be to support the growth and development in the rest of the regional economy (manufacturing, agriculture, infrastructure etc.).

One particular constraint that was identified in the downstream processing of mining products across most SADC countries involved the monopolistic/oligopoly pricing of metals and intermediate feedstock for downstream value addition due to the lack of domestic competition that, in turn, are due to the lack of scale economics and constrained domestic markets. Constraints for downstream mineral processing as well as upstream or backward linkages included inadequate STEM skills and low levels of R&D (AMDC, 2018).

The key regional mineral feedstock value chains and recommendations related to the value chains that were identified by the 2017 study commissioned by the SADC include (AMDC, 2018):

- **Iron and steel:** The objective for this regional value chain is to increase the regional supply of steel beyond South Africa and Zimbabwe to reduce the price of steel as basic input into construction. The value chain report proposes facilitating the development of scrap-based mini mills in all SADC countries. The focus should be on the adaptation of optimal technology for the smaller cast iron units using locally available energy sources (e.g. coal, gas).
- **Regional polymer (plastics) value chain:** The study proposes the development of two additional regional hubs apart from the current SASOL/Secunda hub in order to develop a more competitive plastic industry in the SADC. Feedstock could come from the Revuma basin (Mozambique and Tanzania) in the north east and the oil and gas resources in the north-west (DRC and Angola). The idea is to establish three competitive regional polymer, petrochemicals and fertiliser complexes in the SADC that would lower input prices and promote further downstream processing.

- **Regional base metal value chain (mainly aluminium and copper):** the study conceptualises two new world scale aluminium plants and rolling mills based on energy from natural gas and hydropower HP to produce cost competitive feedstock to downstream projects in construction and manufacturing sectors across the SADC. The north east (Rovuma basin) and north-west (DRC/Angola) regional hubs are once again proposed.
- **The regional energy minerals value chain:** The study proposed research into the regional roll-out of gas-based grid power from the gas fields in Temane and the Rovuma basin. It also proposes increasing the liquid oil refinery capacity within the SADC.
- **Regional cement value chain (limestone, coal, gas, gypsum):** Due to low value to mass it is recommended that cement manufacturing capacity should be localised, close to all consuming areas as vital feedstock for the construction industry. Since current production methods need some economies of scale there is a risk of over-pricing in the cement industry due to the logistics catchment.
- **Fertiliser value chain:** In order to support agricultural development in the region, the study proposed regional fertiliser nodes/supply blending plants across the region that could address the specific soil requirements of different areas. The DRC, South Africa (Secunda/Phalaborwa) and the Rovuma basin are suggested as possible nodes.
- **Artisanal and small-scale mining (ASM):** Between 10 and 15 million people across the SADC are in the informal (illegal) mining sector. With formalisation, the sector could play a vital role as 'potential nursery' for the development of indigenous medium and large-scale mining in the SADC. Capacity is needed in terms of titles, access to finance, environmental and safety compliance, processing facilities and fair marketing. The sector also provides a gap for digital networking and the development of regional ASM Innovation and Technology hubs (Rasmiths) in areas with large numbers of artisanal miners (e.g. DRC, Tanzania, Malawi).

4.3 IDENTIFIED COURSES AND PROGRAMMES

The demand for the following main courses or academic programmes has been identified above:

Existing degrees and diplomas based on the organic growth of the formal core sectors of the mineral- processing value chain. According to Table 6 above there could annually be an additional demand for some 655 high-skilled workers in the SADC mineral-processing sectors. The degrees and diplomas that would most likely be in higher demand area are illustrated in Table 7 (columns 1 and 2) above.

Diplomas or degrees to up-skill some 110 medium-skilled workers per annum (currently employed) to higher-skilled positions. The certificates in Table 7 (column 3 above) would most likely be the courses most in demand.

Short courses, and new degrees and diplomas that respond to technological changes and other change drivers relevant to the sector. In this regard the up-skilling of some 50% of the current 52,000 people employed in high- skilled positions across the SADC could be

relevant. Apart from the current workforce being up-skilled through these courses and programmes, the short courses and programmes could also form part of the standard degree and diploma programmes identified in points 1 and 2 above rolled out to the growing workforce. Diploma courses could include auto-electricians for the envisaged mechanisation of modern mines

Emerging degree courses could include auto-electrical-, mechatronic- and bioengineers

Topics of the short courses could include:

- Short courses in resource efficient production technologies and the re-purposing of waste
- Financial models and deal structuring in emerging markets
- The use of minerals in new technological applications (materials specialists).

Short courses linked to the objectives for the development of the regional mineral processing value chain in the SADC could include the following topics:

- Skills in Development studies or Mineral Economics with specific regional focus areas such as improving the sourcing of raw minerals within the SADC by addressing constraints such as market structures and the high local prices of primary commodities (e.g. steel or aluminium); removing or planning around logistical constraints, nationalistic agendas, regional policies;
- Applied entrepreneurial skills for small mining production applied to conditions in the SADC (environmental risks, supply risk management, climate risk management, political risks, regional sourcing, appropriate technologies, financing etc.);
- Technical skills geared towards unlocking the regional mineral processing VC:
  - Technological innovations to improve the economies of scale of smaller production units in steel manufacturing (steel mills); cement manufacturing, ASM
  - Required regional skills needed for regional hubs in chemicals/polymers, fertiliser, aluminium in Tanzania, Mozambique, DRC and Angola.

4.4 SUPPLY SIDE RESPONSES

As indicated in Section 1.5, there is a smaller offering of degree programmes and short courses available under the mineral beneficiation value chain.

The three **most prominent** learning themes are:

1. Financial analysis and deal structuring in emerging markets;
2. The use of minerals in new technological applications (materials specialists);
3. Skills to facilitate technological innovations to improve the economies of scale of smaller production units in mining.

The three **least prominent** learning themes are:

1. Skills in Development Studies or Mineral Economics with specific regional focus areas such as improving the sourcing of raw minerals within SADC;
2. Skills for regional hubs in chemicals/polymers, fertiliser, aluminium;
3. Auto-electricians for the envisaged mechanisation of modern mines.

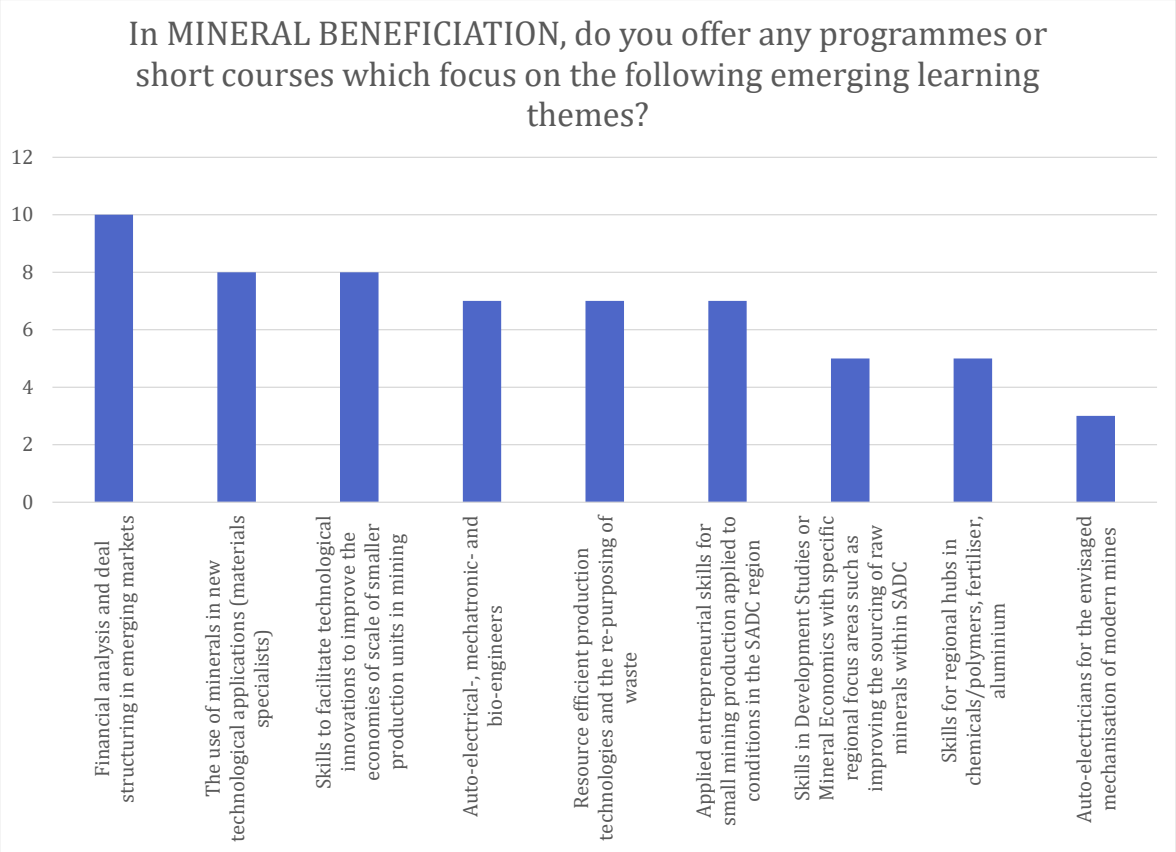


Figure 6: Prevalence of emerging learning themes for mineral beneficiation

When viewed according to country and institution, the initial sample shows that the introduction of emerging learning themes around mineral beneficiation is driven at an institutional level. In Zambia, this is Copperbelt University, in South Africa, large universities like Stellenbosch University and North-West University were identified and in Malawi the University of Malawi was identified as playing a prominent role.

	Financial analysis and deal structuring in emerging markets	The use of minerals in new technological applications (materials	Skills to facilitate technological innovations to improve	Auto-electrical-, mechatronic- and bio-engineers	Resource efficient production technologies and the	Applied entrepreneurial skills for small mining production applied to	Skills in Development Studies or Mineral Economics with	Skills for regional hubs in chemicals/polymers, fertiliser, aluminium	Auto-electricians for the envisaged mechanisation of
Angola	**X**					**X**			
Higher Polytechnic Institute of Malanje									
Óscar Ribas University	X					X			
Universidade Agostinho Neto									
Universidade José Eduardo dos Santos									
Botswana	**X**	**X**				**X**			
BA ISAGO University									
Botho University		X							
Botswana Open University									
University of Botswana									
eSwatini									
Eswatini Medical Christian University									
Lesotho									
Lesotho College of Education									
Malawi	**X**	**X**	**X**	**X**	**X**		**X**	**X**	
Mzuzu University									

	Financial analysis and deal structuring in emerging markets	The use of minerals in new technological applications (materials	Skills to facilitate technological innovations to improve	Auto-electrical-, mechatronic- and bio-engineers	Resource efficient production technologies and the	Applied entrepreneurial skills for small mining production applied to	Skills in Development Studies or Mineral Economics with	Skills for regional hubs in chemicals/polymers, fertiliser, aluminium	Auto-electricians for the envisaged mechanisation of
Unicaf University	X								
University of Malawi	X	X	X	X	X		X	X	
Mauritius	**X**				**X**			**X**	
Open University of Mauritius									
University of Mascareignes	X								
University of Mauritius					X			X	
Mozambique	**X**		**X**	**X**	**X**				
Instituto Superior de Contabilidade e Auditoria de Moçambique									
Instituto Superior Politécnico de Manica (ISPM)									
Universidade Lurio	X		X	X	X				
Namibia	**X**		**X**			**X**			
The International University of Management	X		X			X			
University of Namibia									
South Africa	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
North-West University		X	X		X	X			

	Financial analysis and deal structuring in emerging markets	The use of minerals in new technological applications (materials	Skills to facilitate technological innovations to improve	Auto-electrical-, mechatronic- and bio-engineers	Resource efficient production technologies and the	Applied entrepreneurial skills for small mining production applied to	Skills in Development Studies or Mineral Economics with	Skills for regional hubs in chemicals/polymers, fertiliser, aluminium	Auto-electricians for the envisaged mechanisation of
Sol Plaatje University									
Stellenbosch University		X	X	X	X	X	X	X	
University of the Free State	X					X	X		
Walter Sisulu University									
Tanzania		**X**	**X**	**X**				**X**	**X**
Blue Pharma College of Health									
Dar Es Salaam Institute of Technology			X						
Kaole Wazazi College of Agriculture									
Kilimanjaro Agricultural Training Centre									
Nelson Mandela African Institution of Science and Technology		X		X				X	
St. Joseph University in Tanzania			X	X					X
St. Maximilliancolbe Health College									
Zambia	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Chalimbana University									

	Financial analysis and deal structuring in emerging markets	The use of minerals in new technological applications (materials	Skills to facilitate technological innovations to improve	Auto-electrical-, mechatronic- and bio-engineers	Resource efficient production technologies and the	Applied entrepreneurial skills for small mining production applied to	Skills in Development Studies or Mineral Economics with	Skills for regional hubs in chemicals/polymers, fertiliser, aluminium	Auto-electricians for the envisaged mechanisation of
Copperbelt University	X	X	X	X	X	X	X	X	X
Zambian Open University									
Zimbabwe	**X**	**X**		**X**	**X**		**X**		**X**
Bindura University of Science Education							X		
Catholic University of Zimbabwe	X								
Midlands State University		X							
National University of Science and Technology									
University of Zimbabwe		X		X	X				X

5 THE PHARMACEUTICAL VALUE CHAIN

5.1 FORMAL SECTOR DEMAND –FIRMS AND TECHNICAL RESEARCH INSTITUTIONS

5.1.1 BACKGROUND

Local pharmaceutical manufacturing capacity is limited in the SADC. Only 15% of generic ARVs are produced in the SADC and 24% of other drugs. Pharmaceuticals products are mainly imported from India, the UK and Europe. The supply of pharmaceuticals is dominated by multinationals with local distribution and warehouses mainly located in South Africa (Mothibe, 2018).

As indicated in Table 9 below, there is some local pharmaceutical production in the SADC employing an estimated 23 000 people in 2018, more than half of them employed in South Africa. With the patent rights of many blockbuster patents expiring during the past decade, the manufacturing of generic medicines increased, not only in China and India but also in some SADC countries. The local generic pharmaceutical (over the counter

/OTC medicines) sub-sector employs the majority of workers in the SADC. Many of these workers are employed by multinational manufacturing companies with local production capacity (e.g. Johnson and Johnson, Adcock Ingram etc.). These large multinationals conduct R&D in their countries of origin outside the SADC.

Local production of treated bed nets is the second largest employer in the value chain and is dominated by one family-owned company in Tanzania. The company had made some investment in R&D but most of the research related to the value chain is sponsored by the World Health Organisation (WHO).

Global pharmaceutical research is largely driven by market demand and as a result, medicines for some diseases that dominate in lower income countries (HIV/AIDS, TB and Malaria) are neglected because there is no viable market for them, due to the relative low public health expenditure in regions like the SADC. Donor funding (e.g. WHO, Bill Gates foundation) plays a large role in the funding of the procurement of these medicines on behalf of national governments.

Multinationals from India (CIPLA, Hetero Mylan etc.) are the main suppliers of Anti-Retroviral drugs purchased through open tenders in SADC countries. Only six companies in the SADC manufacture ARVs, which altogether covers only 15 % of the SADC generic ARV market. Only two local companies (Aspen in South Africa and Varichem in Zimbabwe) prequalify in terms of WHO regulations.

Active Pharmaceutical Ingredients (APIs) for ARVs are still imported from India, although South Africa has been planning an ARV API manufacturing facility since 2012. A state-owned company Ketlaphela Pharmaceutical SOC Ltd has been established to increase

local manufacturing and to decrease the reliance and risks associated with high level of imports. Around 70 to 80 percent of the cost of ARVs resides in the so-called API (active pharmaceutical ingredient), the part of the medicine responsible for the therapeutic effect (Mothibe, 2018).

South Africa biotech companies (e.g. Kapa Biological systems, H3D) currently research and manufacture TB treatments. None of the APIs for TB are manufactured in the SADC. Two companies in the SADC produce APIs for anti-Malaria drugs, namely Bionexx in Madagscar producing artemisine (API) using inputs from smallholder farmers and Pharmakina in the DRC producing quinine from quinine tree bark.

A couple of companies in South Africa and one company in Namibia manufacture condoms, although there is still a large supply gap in the SADC market. The South African government has recently been promoting the local condom industry in South Africa due to its high labour intensity and potential for black economic empowerment. The production of condoms, anti-malarials and bed-net value chains are labour intensive with a large portion of unskilled workers.

The SADC pharmaceutical value chain faces a number of challenges (Endeva, 2014):

- There is a general lack of API capacity in the region (with the exception of some capacity in South Africa);
- Nearly all reagents, intermediaries, specialised solvents and equipment (glass lined vessels, valves instruments) have to be imported at high costs;
- The market size in the region is relatively low which explains the inability of the region to attract large multinationals to produce intermediaries such as API locally;
- There exists a public perception of poor quality in local medicines and medical equipment;
- There is limited regional trade in locally produced pharmaceuticals. National governments have local procurement guidelines in place but no preference for procurement from other SADC countries;
- There is a lack of established mechanisms for procurement quality assurance in the region;
- There is a lack of consumption data and inadequate estimation of needs and forecasting of medicine requirements;
- Weak regulatory systems are one of the contributing factors to many unregistered products on the market, and also the mushrooming of unlicensed wholesalers and retailers with instances of counterfeit medicines being sold on street markets in some countries;
- There is inappropriate use of medicines in all SADC countries, with more than half of all medicines in the region prescribed, dispensed or sold inappropriately, and half of all patients fail to take them as prescribed.

On a positive note, the Harmonised Regulation System for medicine in the SADC facilitated the registration of new medicines across the region since it reduced medicine approval time for applicants with one assessment covering a number of countries (Mothibe, 2019).

The pharmaceutical value chain in SADC is also characterised by low levels of R&D since large multinationals conduct research outside the SADC. The exception is smaller biotechnology firms (e.g. Kapa systems in the Western Cape) that undertake research in HIV, TB, malaria and other exotic diseases with high prevalence rates in Africa. Research is mainly funded by international donors.

Some prominent R&D pharmaceutical institutions in SADC include:

- The University of Cape Town (UCT) Drug Discovery and Development Centre, H3D - focus on Africa diseases research and development (R&D) of new malaria medicines, as well as new tuberculosis and antimicrobial resistance treatments, and training of a new generation of African scientists with key modern pharmaceutical skills required to discover modern medicines
- The University of the Western Cape research on TB drug resistance
- ARV research conducted by a Johannesburg-based research group from the University of the Witwatersrand on ARV resistance and side effects (Moorhouse and Venter, 2019)
- Various research organisations in South Africa form a platform for the research of African Traditional Medicine (ATM) including the Centre for Scientific and Industrial Research (CSIR), Agricultural Research Council (ARC), the Medicines Research Council (MRC), Department of Agriculture (DoA) as well as Department of Science and Technology (DST). Within its Indigenous Knowledge Systems unit, the University of the Free State is involved in research in medicinal plants used for the treatment of malaria, HIV, cancer and diabetes (Motibe and Sibanda, 2018)
- Apart from the South Africa research institutions above, there are also some medical research clusters in Tanzania (the Kilimanjaro School of Pharmacy (KSP), Muhimbili University Medical College of Medical Science, the Ifakara Health Research and Development Centre) and in Madagascar (Malagasy Institute of Applied Research, National centre for applied pharmaceutical research, Pasteur Institute of Madagascar) that focus on AIDS, malaria and ATM.

5.1.2 FORECASTED DEMAND FOR HIGH AND MEDIUM SKILLS IN THE FORMAL ECONOMY

Table 9 identifies the following three sources of skills demand resulting from organic growth within core local pharmaceutical production in SADC over the next 10 years:

- Firstly, there could be some up-skilling requirements for the estimated 5 800 high skilled workers currently employed by the pharmaceutical core industries in SADC.

As was indicated some 50% of the workforce (including high skilled workers) could require some up-skilling or re-skilling within the next decade with training requirements varying from six months (35%) to more than a year (10%);

- The demand for higher skills of new entrants to the labour market could be in the region of 130 a year. These higher skills would mainly be supplied by academic universities in the SADC region;
- The additional demand for medium skills in the SADC pharmaceutical industry (excluding up-skilling of the current medium skilled labour force) could be in the region of some 70 per year over the next 10 years. This demand is typically catered for by TVET institutions.

Table 9: Current Formal Employment and Projected Skills Needs in SADC Pharmaceuticals Core Sectors, 2018-2030

PHARMACEUTICAL SUB-SECTOR	South Africa	REST OF SADC	TOTAL SADC	% share	Total high skilled labour	Labour force up-skill medium-high	Annual increase in high skills	Annual increase in medium skills
	CURRENT (TOTAL)					FORECAST (INCREMENT PER ANNUM)		
	No.	No.	No.	%	No.	No. p. a.	No. p. a.	No. p. a.
Category	2018	2018	2018	2018	2018	2018 - 2030	2018-2030	2018-2030
Anti Retrovirals (ARV)	2,000	1,190	3,190	13.7%	957	-	22	11
Anti TB drugs	700	60	760	3.3%	228	-	5	3
Anti–Malarials	300	1,250	1,550	6.7%	310	-	7	3
Treated bed net value chain	-	3,400	3,400	14.6%	442	-	10	8
Condoms	600	30	630	2.7%	32	-	1	1
Basic health commodities (syringes, IV fluids, surgical equipment, lab reagents and	400	740	1,140	4.9%	114	-	3	2

materials, methylated spirit)								
Generic OTC (migraine etc)	8,000	4,550	12,550	54.0%	3,765	-	86	44
TOTAL PHARMACEUTICALS	**12,000**	**11,220**	**23,220**	**100.0 %**	**5,848**	**-**	**133**	**71**

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); official data for selected SADC countries, SETA skills information, sector forecasts for individual sectors, South Africa's manufacturing sector output -employment elasticity.

5.1.3 CURRENT SCARCE SKILLS IN THE FORMAL SECTOR – FULL QUALIFICATIONS

The pharmaceutical value chain is skills intensive and the majority of skills are scarce skills and higher skills. The relevant South African SETA identified typical skills shortages currently recorded in the South African pharmaceutical industries as illustrated in Table 10 below:

Table 10: Scarce Skills in the Pharmaceutical Industry of South Africa, 2017

Degree (NQF 6 and above)	Higher diploma; occupational certificates (NQF 5)
Epidemiologist (study of disease trends)	Chemical waste controller
Research scientist	Pharmaceutical technician
Micro-biologist	Regulatory affairs officer
Biochemist	
Biotechnologist	
Clinical/animal trial scientist	
Regulatory affairs scientist	
Sales representative	
Market research analyst	
Software developer	
Chemist	
Microbiologist	
Health and safety manager	
R& D manager	
Production /operations manager	
Process and project engineers (GMP Standards)	

Chemistry Process Engineering (GMP standards)	
Process Quality Control	
Chemical Engineer	
Industrial pharmacist	
Retail pharmacists	
Operational risk manager	
Educational scientist	
Drug safety researcher	
Patent attorney:	
Marketing advisor	
Health economist/ Statistician	

Source: CHIETA (2017)

Details of particular skills shortages in the SADC pharmaceutical value chain include the following (Te Water Naude, 2013 and SAGMA, 2014):

- Despite the general brain drain of pharmaceutical personnel in the SADC region, there is a general shortage of skilled industrial pharmacists. Internships for local industrial pharmacists are needed;
- The demise of the Pharmaceutical Production technology course that offered pharmaceutical technicians training within a production environment left a large gap for South African local pharmaceutical manufacturers. This course was previously administered by the Pharmaceutical Manufacturers Association (PMA);
- Training is required in Applied Goods Manufacturing Practise for Pharmaceuticals including for example the introduction to pharmaceutical quality assurance systems preparing for inspection, introduction to international patent law, environmental control and monitoring etc;
- Training is also needed in pharmaceutical validation and regulatory compliance including lab control systems; analytical methods for compliance, dossier compilation for National Medicines Regulatory Authorities (NMRAs), bio-availability and bio-equivalence testing;
- Pharmaceutical technology training is required in water sampling and testing, drug product stability and shelf life;
- Training in pharmaceuticals distribution and wholesaling is required and could include ensuring product safety and security, vendor and contract supplier qualification, good distribution practices, handling and distributing food supplements, additives and herbal medicines, warehouse management, ICT to support the wholesaling supply chain etc.

SAGMA (2014) argues that existing trainers are unlikely to offer hands-on training in Good Manufacturing Practices since a mock industry set-up is required. It recommends the possibility of setting up a simulated factory environment at the Kilimanjaro School of Pharmacy (KSP), the Muhimbili University of Health and Allied Sciences (UHAS) in Tanzania or the Tshwane University of Technology in South Africa.

As indicated in Annexure C below, typical positions that are trending in SADC correspond to the list above.

5.1.4 EMERGING SKILLS

The major drivers in future skills demand in the pharmaceutical industry are expected to come from new technologies and industry restructuring:

- As new blockbuster (small molecule) drugs for large, general populations become harder to find, new biological approaches that target smaller populations are getting more attention. This will increase the demand from fields such as biogenetics, computational biology, bioinformatics and big data management. Biotechnology in pharmaceuticals is believed to bring many potential benefits to the developing world through its potential impact on typical diseases in the developing world namely HIV/AIDS, Malaria, tuberculosis, hepatitis B virus, Ebola virus, Corona virus etc. The major advantages of biotechnology for the developing world is listed as its potential for more effective vaccines, safer methods of vaccine and drug delivery, cheaper storage methods (e.g. vaccines and drugs that do not need refrigeration) that could facilitate rural access, combating drug resistance, acceleration of drug discovery though bioinformatics (the application of computer hardware and software to store, retrieve and analyse large quantities of biological data) at relatively low investment costs and the provision of lower cost solutions to the rising incidence of non-communicable diseases in Africa (e.g. insulin for diabetics) (Hefferon, 2013 and Acharya et.al., 2004);
- Micro or small molecule pharmaceuticals are also gradually being overtaken by research into the potential of nanoparticles nanomedicine e.g. in TB research (Mothibe, 2018);
- Skills in big data management are currently applied to open up the African continent for clinical trials. Only 2% of the clinical trials conducted globally occur on the African continent. The African Academy of Sciences led an effort to identify gaps, elicit stakeholder interest via a pilot project, and eventually obtained funding to develop an open-access platform that will bring together key players in the clinical trials space to increase their visibility, provide site feasibility intelligence important in decision making and encourage continuous engagement among stakeholders;

- Digital and other emerging technologies play an increasingly important role in the distribution of the pharmaceutical products, e.g. E-commerce, tele-pharmacies, automated dispensers, and smart lockers are enabling direct distribution of medications to people across Africa and Asia. Drone technology is already applied in the distribution of essential medicines in rural places in Africa.

5.2 SKILLS DEMAND FOR POLICY DEVELOPMENT

5.2.1 SADC PRIORITY SUB-SECTORS

The objective of the SADC Pharmaceutical Programme is to ensure the availability of essential medicines with particular reference to diseases with a high morbidity rate in the SADC (HIV/AIDS, TB, Malaria). As indicated in Table 8 below, the programme includes five main sub-groups in the pharmaceutical industry namely Anti- Retrovirals, Anti TB drugs, Anti-Malaria drugs, the bed-net value chain, condoms and a selected group of essential health commodities (e.g. syringes, IV fluids) .

Table 11: SADC Priority Sub-Sectors, Pharmaceuticals Processing

Pharmaceutical sub-sector	Countries identified for the VC
Anti Retrovirals (ARVs)	DRC, Malawi, South Africa, Tanzania, Zambia, Zimbabwe
Anti TB drugs	DRC, Namibia, South Africa, Zambia, Zimbabwe
Anti –Malarials	DRC, Madagascar, Namibia, SA, Tanzania
Bed net value chain	Malawi, Tanzania
Condoms	Botswana, DRC, Malawi, Namibia, South Africa
Health commodities (syringes, IV fluids, surgical equipment, lab reagents and materials, methylated spirit)	Malawi, Namibia

Source: SADC (2017)

5.2.2 REQUIRED SKILLS TO FACILITATE DEVELOPMENT OF THE SADC VALUE CHAIN

The experience with COVID-19 will probably lead SADC countries to re-examine their supply chains for critical health and livelihood related products. This is likely to lead to a surge of local and possibly regional content initiatives with respect to the need to produce

pharmaceuticals, medical supplies, and equipment domestically. Different skills to enhance local pharmaceutical production capacity will therefore be applicable for the development of national value chains in the different SADC countries (e.g. improving Good Manufacturing Practice (GMP), technical production skills etc.). Despite this possible trend it might still be beneficial for SADC countries to cooperate in terms of a single (larger) market for APIs for ARVs, TB or malarial drugs. Other skills that could also benefit the region include:

- Improved regional manufacturing capabilities to manufacture reagents, intermediaries, specialised solvents and equipment (glass lined vessels, valves instruments) that currently have to be imported at high costs;
- Quality control and regulatory compliance;
- Data analysis skills consumption data to address inadequate estimation of needs and forecasting of medicine requirements;
- Skills in educating consumers in the appropriate use of medicines;
- Multi-disciplinary skills to improve access to essential medicines including health economists that can assess the impact of different funding models for pharmaceutical products in developing countries and pharmaceutical marketing specialists.

5.3 IDENTIFIED COURSES AND PROGRAMMES

The demand for the following main courses or academic programmes has been identified above:

1. Existing degrees and diplomas based on the organic growth of the formal core sectors of the pharmaceutical value chain. According to Table 9 above there could annually be an additional demand for some 133 high skilled workers in the SADC mineral-processing sectors. The degrees and diplomas that would most likely be in higher demand area are illustrated in Table 10 (columns 1 and 2) above.
2. Short courses, degrees and diplomas that respond to technological changes and other change drivers relevant to the VC. In this regard the up-skilling of some 50% of the close to 6,000 people currently employed in high skilled positions across SADC could be relevant. Apart from the current workforce being up-skilled through these programmes, the short courses and programmes could also form part of the standard degree and diploma programmes identified in point 1) above rolled out to the growing workforce. Topics of the educational programmes could include:

    - Degrees related to the field of biotechnology and nanomedicine including biogenetics, computational biology, bioinformatics and big data management related to biotechnology;
    - Degree courses in the management and protection of big pharmaceutical data; health statistics – health economics;

- Short courses in digital distribution of medicines (e.g. e-commerce, tele-pharmacies, automated dispensers, and smart lockers).

3. Short courses linked to the objectives for the development of the regional pharmaceutical value chain in SADC could include the following topics:

- Improving GMP practice, technical production skills;
- Improved regional manufacturing capabilities to manufacture reagents, intermediaries, specialised solvents and equipment;
- Quality control and regulatory compliance;
- Data analysis skills (consumption data and inadequate estimation of needs and forecasting of medicine requirements);
- Consumer education.

5.4 SUPPLY SIDE RESPONSES

As indicated above, the pharmaceutical value chain is still limited in the SADC, with market demand mostly met via imports. For this reason, the responses of higher education institutions when indicating that new and emerging skills are being addressed should be carefully assessed. From a cursory glance at responses, pharmacy programmes are included in building pharmaceutical manufacturing capacity, but not necessarily the management and dispensing of pharmaceuticals.

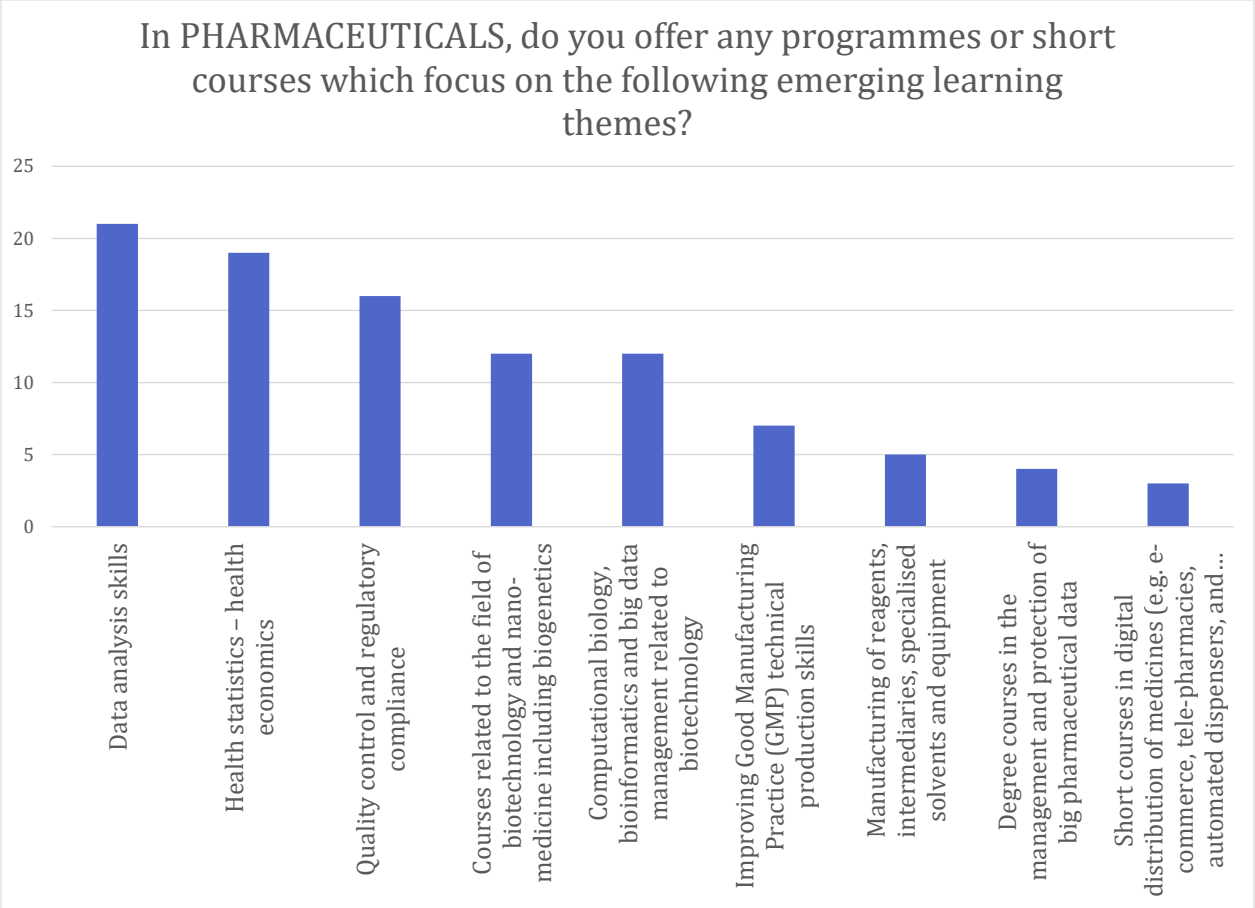
The sample institutions indicated that there are programmes addressing some emerging skills in the region.

The **top emerging** learning themes covered are:

1. Data analysis skills;
2. Health statistics – health economics;
3. Quality control and regulatory compliance.

The prevalence of programmes reduces with biotechnology and computational biology and the **least prevalent** of the learning themes among the sampled institutions are:

1. Short courses in digital distribution of medicines (e.g. e-commerce, tele-pharmacies, automated dispensers, and smart lockers);
2. Degree courses in the management and protection of big pharmaceutical data;
3. Manufacturing of reagents, intermediaries, specialised solvents and equipment.



4. Figure 7: Prevalence of emerging pharmaceutical learning themes in regional programmes

	Courses related to the field of biotechnology and nano-medicine including biogenetics	Computational biology, bioinformatics and big data management related to	Degree courses in the management and protection of big pharmaceutical data	Health statistics – health economics	Short courses in digital distribution of medicines (e.g. e-commerce, tele-pharmacies,	Improving Good Manufacturing Practice (GMP) technical production skills	Manufacturing of reagents, intermediaries, specialised solvents and equipment	Quality control and regulatory compliance	Data analysis skills
Angola	**X**		**X**	**X**			**X**	**X**	**X**
Higher Polytechnic Institute of Malanje	X			X				X	
Óscar Ribas University									X
Universidade Agostinho Neto				X					X
Universidade José Eduardo dos Santos			X				X	X	
Botswana				**X**		**X**		**X**	**X**
BA ISAGO University				X				X	X
Botho University				X					X
Botswana Open University									
University of Botswana									
eSwatini			**X**						
Eswatini Medical Christian University			X						
Lesotho									
Lesotho College of Education									
Malawi	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Mzuzu University	X			X		X	X	X	X

	Courses related to the field of biotechnology and nano-medicine including biogenetics	Computational biology, bioinformatics and big data management related to	Degree courses in the management and protection of big pharmaceutical data	Health statistics – health economics	Short courses in digital distribution of medicines (e.g. e-commerce, tele-pharmacies,	Improving Good Manufacturing Practice (GMP) technical production skills	Manufacturing of reagents, intermediaries, specialised solvents and equipment	Quality control and regulatory compliance	Data analysis skills
Unicaf University									
University of Malawi	X	X	X	X	X	X		X	X
Mauritius	**X**	**X**		**X**					**X**
Open University of Mauritius									
University of Mascareignes									X
University of Mauritius	X	X		X					X
Mozambique				**X**				**X**	
Instituto Superior de Contabilidade e Auditoria de Moçambique									
Instituto Superior Politécnico de Manica (ISPM)									
Universidade Lurio				X				X	
Namibia			**X**	**X**				**X**	**X**
The International University of Management			X	X				X	X
University of Namibia									

	Courses related to the field of biotechnology and nano-medicine including biogenetics	Computational biology, bioinformatics and big data management related to	Degree courses in the management and protection of big pharmaceutical data	Health statistics – health economics	Short courses in digital distribution of medicines (e.g. e-commerce, tele-pharmacies,	Improving Good Manufacturing Practice (GMP) technical production skills	Manufacturing of reagents, intermediaries, specialised solvents and equipment	Quality control and regulatory compliance	Data analysis skills
South Africa	**X**	**X**		**X**		**X**	**X**	**X**	**X**
North-West University	X			X		X	X	X	X
Sol Plaatje University									
Stellenbosch University									
University of the Free State		X		X				X	X
Walter Sisulu University									
Tanzania	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**
Blue Pharma College of Health									
Dar Es Salaam Institute of Technology									X
Kaole Wazazi College of Agriculture									
Kilimanjaro Agricultural Training Centre									
Nelson Mandela African Institution of Science and Technology	X	X		X				X	X
St. Joseph University in Tanzania	X	X		X	X				X
St. Maximilliancolbe Health College						X	X	X	
Zambia	**X**	**X**							

	Courses related to the field of biotechnology and nano-medicine including biogenetics	Computational biology, bioinformatics and big data management related to	Degree courses in the management and protection of big pharmaceutical data	Health statistics – health economics	Short courses in digital distribution of medicines (e.g. e-commerce, tele-pharmacies,	Improving Good Manufacturing Practice (GMP) technical production skills	Manufacturing of reagents, intermediaries, specialised solvents and equipment	Quality control and regulatory compliance	Data analysis skills
Chalimbana University									
Copperbelt University	X	X							
Zambian Open University									
Zimbabwe	**X**	**X**		**X**			**X**	**X**	**X**
Bindura University of Science Education	X			X					
Catholic University of Zimbabwe									X
Midlands State University		X		X				X	X
National University of Science and Technology									
University of Zimbabwe	X	X		X			X		

6 COUNTRY PROFILES

6.1 ANGOLA

The table below shows that the majority of employment in Angola is informal employment with only 22% of jobs being classified as formal. Of the formal employed, only 5% is employed in the manufacturing sector compared to 18% in the agriculture sector and 11% in the mining sector. The formal agro-processing sector could employ some 65,000 people - almost half of the formal employment in the manufacturing sector.

The formal agro-processing industry is mainly centred in large firms involved in sugar cane processing, maize processing and beverages. There is as yet limited downstream processing of horticulture (vegetables and beans) for the growing urban markets. Cereal production is increasing and there are signs of industrial processing and marketing of maize, wheat and rice. A large milling company (Grande Moagens de Angola) was recently established as a joint venture between Angolan and international investors. The establishment of agro-industrial parks is high on the government agenda but has not yet yielded much in terms of new investments in agro- processing.

Various research organisations focus on increased productivity of the agricultural sector. In 2018 the agriculture research sector was restructured in an attempt to revive the old institutions. Five new institutes were established focusing on corn, beans and soya, staples, livestock and bio-veterinary research.

Angola is rich in minerals (oil, iron-ore, diamonds, gold, platinum, nickel etc.) and its mining sector, specifically offshore oil and gas dominates economic output. Downstream processing of minerals is however still limited to mainly steel (ADA steel) and the refining of oil (Lobito oil refinery).

Angola does not have local pharmaceutical manufacturing facilities but mainly distributes generic medicines produced outside the country. The country however does have a Medical Research Centre.

Table 12: High level employment estimates for Angola, 2018

Indicator	Value (number)
Population ‘000	29,250
Formal employment	1,300,000
Formal employment agriculture	234,000
Formal employment mining	143,000
Formal employment manufacturing	65,000
Formal employment agro-processing	32,500
Formal employment mineral processing	2,600

Formal employment pharmaceuticals	-
Informal employment	4,700,000
Total employment	6,000,000
Informal as % of total employment	78%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web search

6.2 BOTSWANA

As indicated in the table below, the formal agro-processing sector in Botswana employs about 12,500 people, mainly in grain milling, bakery products and processed meat. Within the mineral processing value chain, the diamond cutting industry employs the majority of people. The beneficiation of soda ash and very basic metal processing (nickel and copper matte) are other major mineral processing industries. Botswana has no local pharmaceutical manufacturing capacity yet, and mainly distributes generics manufactured outside the country. The Botswana Vaccines Institute produces vaccines for the animal health market that are distributed across the SADC.

The Botswana National Food Technology Research Centre (NARFTC) conducts research in the agro-processing space and has links with other research organisations in Botswana and South Africa. While Botswana does not produce pharmaceuticals, it does conduct research in the health arena through the Centre for the Study of HIV and AIDS.

Table 13: High level employment estimates for Botswana, 2018

Indicator	Value (number)
Population ‘000	2,289
Formal employment	406,000
Formal employment agriculture	6,464
Formal employment mining	8,115
Formal employment manufacturing	38,100
Formal employment agro-processing	12,500
Formal employment mineral processing	5,800
Formal employment pharmaceuticals	-
Informal employment	287,600
Total employment	693,600
Informal as % of total employment	41%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web searches

6.3 COMOROS

As indicated in the table below, formal employment plays a small role in the Comoros labour market with most people involved in either subsistence or informal activities. The formal manufacturing sector is dominated by food processing activities such as vanilla, distilling ylang-ylang into perfume essence, and yoghurt. Agriculture- related research in Comoros is moreover linked to International and Francophone research institutions that contribute through the public Research Institute for Agriculture, Fishing and the Environment.

Table 14: High level employment estimates for Comoros, 2018

Indicator	Value (number)
Population '000	851
Formal employment	55,000
Formal employment agriculture	1,500
Formal employment mining	-
Formal employment manufacturing	11,000
Formal employment agro-processing	11,000
Formal employment mineral processing	-
Formal employment pharmaceuticals	-
Informal employment	153,000
Total employment	208,000
Informal as % of total employment	74%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web searches

6.4 DEMOCRATIC REPUBLIC OF THE CONGO

As indicated in the table below, only 16% of employment in the DRC is in the formal sector. Formal employment is furthermore dominated by mining and agriculture with the manufacturing sector only employing 11% of the formal workforce. Agro-processing mostly focuses on the processing of sugar, maize and cassava (flour), beverages (beer) and wood and paper products.

The mineral processing value chain is characterised by copper smelting (Lubumbashi) and a cobalt hydrometallurgical plant (the state-owned Gécamines copper smelter).

There are a number of local generic pharmaceutical manufacturers. There is however a challenge with regard to the local perception that locally manufactured medicines are of inferior quality. The exception is the large Pharmakina group that manufactures quinine as active ingredient for malaria medicine.

There are a number of institutions that conduct research in the field of agriculture and agro-processing, namely the National Agricultural Study and Research Institute (INERA), the Agri-Food Research Centre (CRAA) and various faculties of agriculture at the Universities of Kinshasa (UNIKIS) and other national universities. The Centre for Geological and Mineral Research conducts research in the area of mineral processing.

Table 15: High level employment estimates for DRC, 2018

Indicator	Value (number)
Population ‘000	91,724
Formal employment	1,300,000
Formal employment agriculture	469,082
Formal employment mining	606,075
Formal employment manufacturing	148,000
Formal employment agro-processing	51,800
Formal employment mineral processing	10,000
Formal employment pharmaceuticals	2,200
Informal employment	6,700,000
Total employment	8,000,000
Informal as % of total employment	84%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web search

6.5 ESWATINI (SWAZILAND)

The manufacturing sector plays a relatively larger role in the formal economy of Swaziland, employing some 25% of the formal workforce. The food and wood processing sub-sectors play the dominant roles and include the processing of beef, honey, soft drink concentrate, timber and wood pulp. The Faculty of Agriculture (UNISWA) does research related to agricultural production. While there is no formal manufacturing production facility in Swaziland, the Swaziland Institute for Research in Traditional Medicine, Medicinal and Indigenous Food Plants (SIRMIP) is active in research in traditional African medicines.

Table 16: High level employment estimates for Swaziland, 2018

Indicator	Value (number)
Population ‘000	1,159
Formal employment	185,000
Formal employment agriculture	37,674
Formal employment mining	1,380
Formal employment manufacturing	46,000
Formal employment agro-processing	17,600
Formal employment mineral processing	-
Formal employment pharmaceuticals	-
Informal employment	115,000
Total employment	300,000
Informal as % of total employment	38%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web search

6.6 LESOTHO

The manufacturing sector plays a relatively larger role in the formal economy of Lesotho, employing some 20% of the formal workforce. Most are employed in food processing. There is also activity in the processing of hides that is exported to Bloemfontein for further processing into leather that is used in the South African auto industry as upholstery in vehicles. The Department of Agricultural Research of the University of Lesotho conducts research in environmentally safe and economically viable technologies for agriculture and agro- processing.

Table 17: High level employment estimates for Lesotho, 2018

Indicator	Value (number)
Population ‘000	2,183
Formal employment	250,000
Formal employment agriculture	87,500
Formal employment mining	3,000
Formal employment manufacturing	50,000
Formal employment agro-processing	48,000
Formal employment mineral processing	-
Formal employment pharmaceuticals	-
Informal employment	114,000

Total employment	364,000
Informal as % of total employment	31%

6.7 MADAGASCAR

The Malagasy economy is dominated by subsistence and informal activities. Agro-processing consists of local processing of rice as well as fisheries. The primary agricultural sector is characterised by low productivity rice and sugar production. The local coffee and vanilla trade is currently ailing. The country also experiences a challenge with the illegal logging of indigenous forests consisting of ebony, rosewood etc. There is some inland aquaculture (tilapia) that was introduced in the 1950s. The public National Centre for Applied research on Rural Development (FOFIF) is involved in research in the local agricultural sector.

Mineral production is limited to basic chromite beneficiation by Kraomita Malagasy (Kraoma) but is at such a low level that it is still considered as mining.

There is one producer (Bionexx) of Artemisinine (the only one in SADC) that provides the active ingredient for the world's only WHO approved anti-malaria drug. Some 10 000 small farmers provide Artemisia on a regular basis to Bionexx and provide a supplementary valuable cash income for local rice farmers. There are two NGO research institutions in the pharmaceutical sector namely the Malagasy Institute of Applied Research (IMRA) and the Pasteur Institute of Madagascar.

Table 18: High level employment estimates for Madagascar, 2018

Indicator	Value (number)
Population ‘000	24,933
Formal employment	683,000
Formal employment agriculture	511,920
Formal employment mining	678
Formal employment manufacturing	44,000
Formal employment agro-processing	8,000
Formal employment mineral processing	-
Formal employment pharmaceuticals	450
Informal employment	3,317,000
Total employment	4,000,000
Informal as % of total employment	83%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web search

6.8 MALAWI

Formal employment plays a small role in the Malawi economy and the manufacturing sector furthermore plays a very small part in formal employment. Food processing (e.g. Carlsberg Malawi, the processing of tobacco, tea, sugar, soya, macadamia nuts) are dominant activities within the value chain. Another large agro-processing.

> *Malawi's key challenge is infrastructural development especially in the areas of energy and telecommunications… if these are addressed the rest will automatically follow.*
>
> Robert Kalima
> Centre for Open, Distance and eLearning, Mzuzu University

industry revolves around textile/ yarns. There are a number of public research organisations involved in agricultural research including the National Aquaculture Centre. The University of Malawi (Bunda College of Agriculture) also hosts the Centre for Agricultural Research and Development.

The Lilongwe University of Agriculture and Natural Resources has an African Centre of Excellence for Aquaculture and Fisheries Science, and the College of Medicine at the University of Malawi hosts the Malawi African Centre of Excellence for Public Health and Herbal Medicine.

There are 4 to 5 local generic pharmaceutical manufacturers in Malawi. Pharmanova is the largest in the value chain, followed by Crown pharmaceuticals and Kentam products. The Centre for Reproductive Health at the University of Malawi (College of Medicine) conducts research in the health sector.

Table 19: High level employment estimates for Malawi, 2018

Indicator	Value (number)
Population ‘000	17,563
Formal employment	353,000
Formal employment agriculture	208,451
Formal employment mining	707
Formal employment manufacturing	9,000
Formal employment agro-processing	3,500
Formal employment mineral processing	-
Formal employment pharmaceuticals	1,300
Informal employment	2,647,000
Total employment	3,000,000
Informal as % of total employment	88%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web search

6.9 MAURITIUS

Formal employment in Mauritius is dominated by the tourism sector. The manufacturing sector plays a small part in formal employment. The agro-processing industry is dominated by food production and is driven by fish production and beverages. The sugar industry also plays a role in the local economy but is characterised by low productivity levels. There are two public agricultural research institutes in the country, one dedicated to the sugar industry and the other (Food and Agricultural Research (FARC)) to other crops and livestock. There are some mineral processing activities in Mauritius linked to the local diamond cutting industry. Mauritius imports diamonds from other SADC countries for further beneficiation. The country positioned itself to partake in the growth of the global jewellery industry as part of its export strategy.

Table 20: High level employment estimates for Mauritius, 2018

Indicator	Value (number)
Population '000	1,266
Formal employment	380,000
Formal employment agriculture	23,584
Formal employment mining	1,239
Formal employment manufacturing	49,000
Formal employment agro-processing	14,100
Formal employment mineral processing	3,000
Formal employment pharmaceuticals	-
Informal employment	164,000
Total employment	544,000
Informal as % of total employment	30%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web search

6.10 MOZAMBIQUE

Formal employment in Mozambique only contributes about 20% to total employment. The formal manufacturing sector is furthermore underdeveloped. It is dominated by food processing activities such as the processing of cashew, sugar, tobacco and prawns. There are also some textiles and timber processing activities in the agro-processing value chain. Agricultural research is mainly conducted through the Mozambique Institute of Agricultural Research at the Eduardo Mondlane University. There is potential for wood processing and the coffee industry has recently seen a revival with Nespresso investing in a coffee estate of origin in the country.

The mineral processing value chain is much smaller than agro-processing with only a few sub-sectors active in the country including cement, aluminium (Mozal), steel (ArcelorMittal) and gas processing (Temane gas plant). The Universidade Eduardo Mondlane has a Centre of Studies in Oil and Gas Engineering and Technology.

In 2017 the Brazilian – Mozambique ARV manufacturing unit opened after ten years of negotiating. Like the rest of the SADC, Mozambique also has to import the Active Pharmaceutical Ingredient (API) for ARVs from India.

Table 21: High level employment estimates for Mozambique, 2018

Indicator	Value (number)
Population '000	27,844
Formal employment	900,000
Formal employment agriculture	207,000
Formal employment mining	18,000
Formal employment manufacturing	45,000
Formal employment agro-processing	40,500
Formal employment mineral processing	4,500
Formal employment pharmaceuticals	90
Informal employment	3,600,000
Total employment	4,500,000
Informal as % of total employment	80%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web searches

6.11 NAMIBIA

The formal economy of Namibia is relatively developed in comparison with other SADC countries discussed above. The manufacturing sector is however still small and dominated by food processing sub-sectors e.g. beef, fish, dairy products.

Mineral processing also plays some role in the manufacturing sector although the level of beneficiation is fairly low. This could also be ascribed to the high capital outlays required in mineral beneficiation compared to market size. Mineral processing industries include diamond cutting, copper concentrates, salt refinery and steel production.

There are three pharmaceutical manufacturing companies mainly focusing on generic medicines and condoms. Companies include Dore manufacturing, Fabupharm and the Commodity Exchange (condoms). Fabupharm also plans to enter the ARV market but finds it challenging to compete against large multinationals in landing government contracts.

Table 22: High level employment estimates for Namibia, 2018

Indicator	Value (number)
Population ‘000	2,414
Formal employment	445,000
Formal employment agriculture	22,000
Formal employment mining	10,000
Formal employment manufacturing	24,000
Formal employment agro-processing	15,200
Formal employment mineral processing	1,500
Formal employment pharmaceuticals	200
Informal employment	280,000
Total employment	725,000
Informal as % of total employment	39%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web searches

6.12 SEYCHELLES

The formal economy of Seychelles is dominated by tourism and food processing - mainly fish products and beverages.

Table 23: High level employment estimates for Seychelles, 2018

Indicator	Value (number)
Population ‘000	97
Formal employment	7,000
Formal employment agriculture	560
Formal employment mining	-
Formal employment manufacturing	3,800
Formal employment agro-processing	2,000
Formal employment mineral processing	-
Formal employment pharmaceuticals	-
Informal employment	7,000
Total employment	14,000
Informal as % of total employment	50%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web search

6.13 SOUTH AFRICA

The manufacturing sector of South Africa is fairly well-diversified and employed about 11% of the formal labour force although the sector experienced low growth the past decade. The agro-processing value chain is dominated by food processing, followed by wood and paper products and textile and leather products. The food processing industry is concentrated around 20 plus large national (Pioneer, Tiger Foods, Capespan etc.) and multi-national companies (Nestle, Unilever, Parmalat etc.) producing about 90% of output and employing 75% of workers. Processing companies are supported by local technology companies and some branches of international companies for example Tetrapak, Molenaar, Anderson Engineering operating on technological levels on par with international companies (Harcourt, 2011). Research related to agro-processing is covered by various universities, the Agricultural Research Council (and 33 affiliated commodity organisations) as well as the CSIR Advanced Agriculture and Food Research Unity.

Metal processing involves aluminium processing, steel production (including complete steel products), diamond polishing and cutting, metal alloys for steel production (ferrochrome, cobalt, copper, manganese etc.), PGM products and gold bullion and finished products. The South African mineral processing industry has moved further down the value chain than the other SADC countries and in some cases (e.g. copper) imports less processed minerals from other SADC countries. The diamond polishing business in South Africa declined from 5000 employees to 400 employees in 2016. As is the case with other SADC countries, basic metal smelting activities came under pressure due to slower growth in the Chinese construction sector and over-capacity in terms of smelters globally due to China opening a number of their own facilities. Raw exports of metals like chrome increased due to better prices offered by international smelters compared to South African smelters. Mintek and the Minerals Council are active in mineral processing research in South Africa.

South Africa also has some local pharmaceutical manufacturing capacity. Generic over-the-counter medicines manufactured locally by eight multi-nationals (e.g. Adcock Ingram, GlaxoSmith etc.) dominate local pharmaceutical production. Limited in-house research is conducted by these generic multi-nationals in South Africa. In terms of ARVs, four multinational manufacturers – Aurobindo (India), Cipla (India), Hetero (India) and Mylan (India) – supplied nearly 80% of ARVs to low- and middle-income countries in 2015. Only six companies in the SADC manufacture ARVs, which altogether covers only 15 % of the SADC generic ARV market. Two of these companies are located in South Africa namely Aspen Pharmacare (Port Elizabeth), and Sonke/Sun Pharma (Roodepoort). South Africa is planning to produce the Active Pharmaceutical Ingredient (API) for ARVs in the near future. The API for ARVs represents around 70 to 80 % of the cost of ARVs. South Africa furthermore also produces TB and Anti-malaria medicines mainly through high tech biotechnology firms active in the research of these diseases and sponsored by international donor organisations like the Bill Gates Foundation. Condoms are also being set up as an emerging industry in South Africa that is sponsored by the National

Empowerment Fund. There are currently three local condom manufacturers in the country.

Various universities in South Africa focuses on applied research for Africa diseases (e.g. TB, Malaria, HIV) including the Drug Discovery and Development Platform (H3-D) that represents a collaborative effort between the Universities of Cape Town, Pretoria, Stellenbosch as well as the pharmaceutical industry. A few multinational biotech firms (Kapa technologies) also have research facilities in South Africa. These need to be incorporated in further supply surveys.

Table 24: High level employment estimates for South Africa, 2018

Indicator	Value (number)
Population '000	57,726
Formal employment	13,360,000
Formal employment agriculture	784,440
Formal employment mining	471,245
Formal employment manufacturing	1,450,000
Formal employment agro-processing	455,700
Formal employment mineral processing	260,000
Formal employment pharmaceuticals	12,000
Informal employment	3,440,000
Total employment	16,800,000
Informal as % of total employment	20%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web search

6.14 TANZANIA

The manufacturing sector plays a relatively large role in the Tanzanian formal economy and employs about 17% of the formal workforce. Most of the manufacturing workforce is employed in the agro-processing value chain mainly food processing e.g. dairy products, canned fruit and vegetables, canned fish, grain milling, bakery, beverages and tobacco products. The textile industry is also a large agro-processing sub-sector employing almost 40% of the agro-processing workforce in Tanzania. The METL Group is the largest textile producer in Sub-Saharan Africa with four textile mills (three in Tanzania and one in Mozambique). Agro-processing related research is conducted by the independent Centre for Agricultural Mechanisation and Rural Technology.

Under a new mining law, mining companies may not export any raw minerals for processing outside the country. Tanzania's mineral processing value chain includes the processing of cement, coal, diamonds and natural stone. Rare earth minerals and bauxite

(key components of the electric vehicle supply chain) are also emerging as an industry in the country. Gas and the downstream processing of gas for the energy sector is expected to become more important in the future.

Higher education initiatives include the Nelson Mandela African Institute of Science and Technology with the Collaborating Centre for Research, Evidence, Agricultural Advancement and Teaching Excellence and Sustainability, and the Water Infrastructure and Sustainable Energy Centre for the Future, and the Sokoine University of Agriculture with the African Centre of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development and the Southern African Centre for Infectious Disease Surveillance.

Tanzania hosts the only manufacturer of treated bed nets against Malaria in the SADC. A-Z Textiles is a family owned business that partnered with the WHO. In addition, there are five generic pharmaceutical manufacturers in the country (e.g. Pharma, Shely, Zenufa). A state-owned ARV manufacturer (TPI) closed down a couple of years ago but recently re-opened. Various organisations conduct research in the field of medicine in Tanzania including the public National Institute for Medical Research, two higher educational Institutions (Muhimbili University Medical College and the Tumaini University/Kilimanjaro Christian Medical College) as well as the NGO Ifakara Health Research and Development Centre. Research topics cover HIV/AIDS and Malaria.

Table 25: High level employment estimates for Tanzania, 2018

Indicator	Value (number)
Population ‘000	54,199
Formal employment	2,800,000
Formal employment agriculture	160,000
Formal employment mining	37,000
Formal employment manufacturing	480,000
Formal employment agro-processing	220,800
Formal employment mineral processing	28,800
Formal employment pharmaceuticals	5,200
Informal employment	7,200,000
Total employment	10,000,000
Informal as % of total employment	72%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web search

6.15 ZAMBIA

The agro-processing industry is the dominant manufacturing sector in Zambia employing some 68 000 workers in the formal economy in 2018. Food processing (e.g. grain milling, meat and hides) dominates within the value chain (66% of employment) followed by fibres and textiles (20%) and timber products (14%). Some 80 firms are part of the miller association of Zambia processing grain (maize, sorghum, millet). Of these 20 are large-scale, 27 medium and 31 small. In addition, there are thousands (7000 in 2007) of smaller hammer mills operating in remote rural areas that are not affiliated to any association. The presidential empowerment initiative funds (PEIF) programme aims to set up at least 300 solar hammer mills across the country to boost agro-processing in under-developed areas. This presents an opportunity for the local provision of agro-processing machinery, parts and repairs. There is limited locally produced advanced milling machinery and parts in Zambia which forces companies to import machinery with long waiting periods (Chigumira, 2019).

The Zambian minerals value chain is characterised by capital intensive production by multi-nationals operated largely by expats. The industry imports machinery from abroad (including South Africa). Zambia has in recent years made strides with local participation in the copper manufacturing industry. The industry faces infrastructure challenges, high transport costs, unreliable electricity and skills (Hampwaye et. al. 2015).

The Copperbelt University has an Africa Centre of Excellence for Sustainable Mining and this was also reflected in the supply side survey results.

Zambia has five licensed generic pharmaceutical manufacturers producing 4% of the medicines for the local market. NRB Pharma is one of the largest local manufacturers that currently produce anti-TB medicine. The company plans to produce ARVs and anti-malarials once it receives WHO approval. Zambia's public Tropical Diseases Research Centre (TDRC) focuses on Malaria research.

Table 26: High level employment estimates for Zambia, 2018

Indicator	Value (number)
Population '000	16,887
Formal employment	932,000
Formal employment agriculture	94,000
Formal employment mining	68,000
Formal employment manufacturing	80,000
Formal employment agro-processing	60,800
Formal employment mineral processing	7,200
Formal employment pharmaceuticals	500
Informal employment	1,868,000
Total employment	2,800,000

Informal as % of total employment	67%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web search

6.16 ZIMBABWE

Research capabilities, skilled employment and production capacity declined since the country's economic decline in the early 2000s. The food processing industry is the major industry within the agro-processing value chain and includes some grain milling, sunflower oil, peanut butter, fruit juice, dried fruit and vegetables. The value chain experiences lack of marketing skills, lack of packaging materials, lack of access to raw materials, failure to meet regulatory requirements, low tech and low productivity levels.

While the country is rich in minerals (coal, uranium, ferrous metals, base metals, diamonds, platinum etc.) unprocessed mining still contributes to the bulk of Zimbabwe's export basket despite the ban on export on raw minerals that aimed to improve beneficiation. This ban was lifted in 2015. Raw chrome and some basic processed ferrochrome are exported in Zimbabwe. There are four major ferrochrome smelters in Zimbabwe (Zimbabwe Mining and Smelting company, Zimbabwe alloys, Riochrome and Oliken). Afrochine smelting (a Chinese subsidiary) recently entered the market. Platinum in Zimbabwe mining is done by three subsidiaries of South African firms namely Zimplat (Impala Platinum), Unki (Anglo Platinum) and Mimosa (Impala Platinum). Mimosa and Unki export platinum as concentrate while Zimplat exports platinum as matte. When the export ban of raw materials was lifted, Zimbabwe government gave the mining firms until 2017 to establish a base metal refinery (Dube, 2016).

There are nine licensed pharmaceuticals manufacturers in Zimbabwe (5 generic) supplying 10% of local consumption. 50% of their supply goes to the government health supply chain. Firms include Varichem (ARV producer), Caps Pharma (reopened again in 2020 after being closed down), Pharmanova and Datlabs. The country's main academic and research institutions experienced a dramatic decline in skilled staff due to the brain drain that occurred in the country since the early 2000's.

Table 27: High level employment estimates for Zimbabwe, 2018

Indicator	Value (number)
Population '000	14,849
Formal employment	1,300,000
Formal employment agriculture	169,000
Formal employment mining	65,000
Formal employment manufacturing	104,000
Formal employment agro-processing	23,000
Formal employment mineral processing	200

Formal employment pharmaceuticals	1,300
Informal employment	3,700,000
Total employment	5,000,000
Informal as % of total employment	74%

Sources: Based on data from the ILO (2020), SADC (2015) and (2015); web searches

7 FINDINGS OF SKILLS DEMAND ASSESSMENT

The skills demand analysis has been conducted on the basis of determining demands at a country and potential regional level, and in so doing addressing the requirements of regional integration and development in response to industrialisation objectives.

To this end, the current skills demand (high and medium skills) of the different value chains within the formal economy was analysed, including current skills shortages as well as trends to forecast future skills demand. In addition to the current and emerging economic realities facing the value chains, the study also focusses on policies (i.e. desired outcomes) for the value chains and attempts to identify the skills that might be needed to realise these outcomes.

The analysis has provided an indication that the skills demand in each value chain consists of the following categories:

1. Existing degrees and diplomas based on the organic growth of the formal core sectors of the different value chains. The forecasted demand is highest for the agro-processing sector; followed by mineral processing (skills per annum) and pharmaceuticals. The highest demand is forecasted for honours degrees and higher, while some 10-13% could be on diploma-level;
2. Upgrading of trade certificates to occupational certificates at TVET level to up-skill medium skilled workers currently employed in the agro-processing and mineral processing VCs;
3. Short courses and short learning programmes to build skills that respond to technological changes and other change drivers relevant to the sector to up-skill the current workforce in each value chain. This could involve some 50% of the current workforce within each value chain as well as new workers in points 1 and 2 above;
4. Short courses or post-graduate degrees linked to the actualisation of regional policy objectives related to each value chain.

As indicated in Table 28 below, the policy direction or most possible skills demand trends anticipated in the value chains will largely determine what type of skills programme would become more relevant in terms of value add. Such demand trends will inter alia depend on the underlying value systems based on the different possible worlds of work forecasted in Section 2 above.

Table 28: Expected skills development demand scenarios

Underlying value system	Policy direction/ anticipated future trend	Type of skills demand that is more relevant
Regionally fragmented; focus on internal more inclusive, socially responsible production structures (focus on the value of being human with in close-knitted society)	Productivity increases: product security; import replacement – inward looking but with strong regional value chain participation potential	Medium-small firms, informal, technical and soft research – focus on appropriate- scaled technologies and ownership structures and emerging technologies with humanistic focus
Regionally fragmented, innovative and individualistic (focus on being part of global trends, development of youth, creativity and innovation)	Increased local competitiveness, niche products within regional global value chains – inward looking but with strong regional value chain participation potential	Small, medium firms, technical research - strong focus on emerging 4th industrial revolution technologies
Globally/regionally integrated with strong collective local/regional focus – focus on being human in a global society	Responsible and efficient value chains that maximises social and environmental benefits, using niche regional value chains to position SADC in global value chains – outward looking (regional and global)	Large firms, pharma (small) – technical and soft research with focus on emerging technologies with a social and environmental focus
Globally/regionally integrated with focus on the loyalty to large corporates and brands	Productivity increases, improve SADC as attractive investment for global corporate sector - outward looking (regional and global)	Large firms, technical skills with focus on emerging skills

For example, and by way of illustration in applying the above value systems, if the expectation and desired policy direction is a regionally fragmented SADC where the emphasis is on boundaries of national states being paramount and where human-centric values (human rights) are seen as the centre of SADC philosophies, the focus of the courses and programmes could fall on the skills needs of small and informal enterprises in each of the value chains, skills aligned to improve the social development impact of each value chain, as well as degrees and diplomas that are scaled towards appropriate,

indigenous technologies that maximise social impact in the region. This would imply a focus on skills demand categories (1) and (4) above, with a further focus on degrees and diplomas in (1) more suitable to the needs of SMMEs.

Alternatively, a stronger emphasis on regional and global integration and the backward and forward linkages between countries within the identified value chains may imply a stronger emphasis on categories (2) and (3).

It is to be expected that all four of the potential scenarios will apply to varying degrees within the region, and that skills development initiatives could also respond accordingly to varying degrees. The Industrialization Strategy itself acknowledges the need for national policy making, while advocating a regional perspective.

This analysis emphasises the importance of credible interaction between HEI and other tertiary skills development institutions with representatives of industry within the selected value chains to determine and confirm relevant demand trends. It furthermore illustrates the necessity of the consideration of a regional development focus in skills supply interventions.

8 SKILLS SUPPLY AND GAP ASSESSMENT

8.1 REGIONAL OUTLOOK FOR COLLABORATION AND NETWORK BUILDING

8.1.1 COLLABORATIVE PROGRAMMES

In addition to the results shown for learning programmes addressing emerging learning themes in each of the value chains, higher education institutions were also asked about their intentions for cross-boundary collaboration and student recruitment. What emerges is a picture of increasing collaboration in places, and whilst there are still some challenges for institutions, there is a definite intent from many institutions to expand their regional outlook and recruitment footprint, in particular as a key element of institutional growth. This does not necessarily per se strengthen value chain development in the region, but could be an important contributing factor.

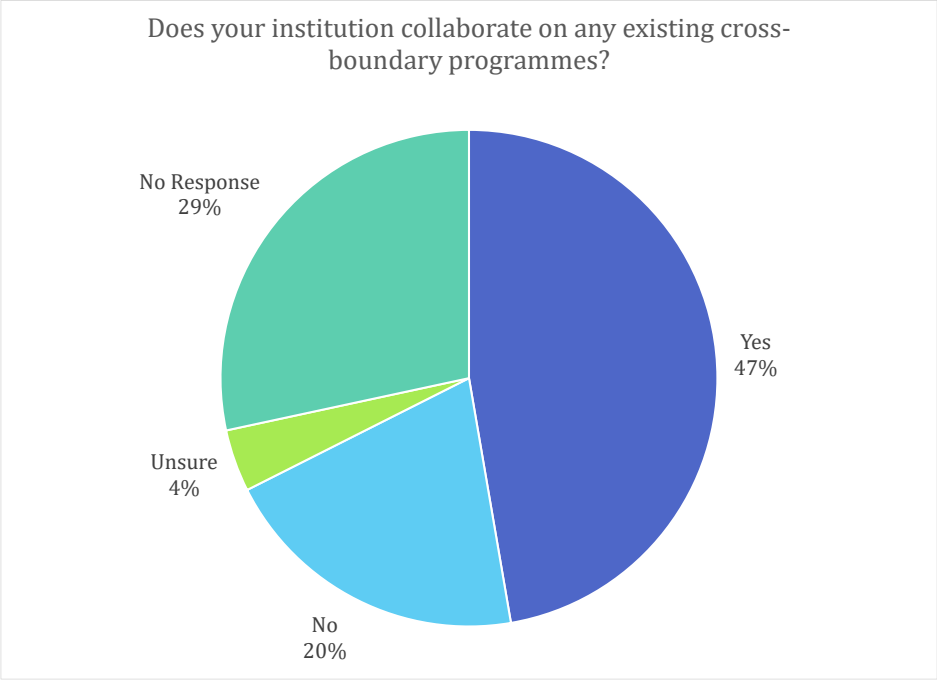


Figure 8: Existence of regional collaboration programmes

Selected examples of the above include:

Higher education institution	Example of collaborative programmes
Nelson Mandela African Institution of Science and Technology, Tanzania	A number of postgraduate students participated in research exchange programmes. Collaboration is pursued via a data driven Innovation Incubation Centre.
Catholic University of Zimbabwe	Collaborates with the Catholic University of Milan to deliver a Masters in Impact Entrepreneurship, which

	targets i.a. new businesses and start- ups in order to drive innovation and industrialization.
Universidade Lurio, Mozambique	The Faculty of Engineering won an international award via its membership of Cambridge Global Challenges for knowledge transfer between industry and academia.
Universidade José Eduardo dos Santos, Angola	In partnership with the French food institute SUPLIMA the university is implementing a master's degree in food technology with the support of the French embassy.

A number of universities indicated international collaborations, but do not necessarily have a SADC or region- specific focus. Universidade Lurio in Mozambique for example runs a joint programme with Sokoine University of Agriculture in Tanzania focusing on food security and nutrition, under the leadership of the German institutions University of Hohenheim and ZALF in Germany. Its Faculties of Agriculture and Engineering are also involved in the establishment of 15 start-ups within the scope of an AfDB grant.

These examples and others where international universities are involved point to the role funding plays in determining where collaborative research or learning programmes occur, and how they are pursued.

8.1.2 STUDENT RECRUITMENT

Of the higher education institutions sampled, 68% indicated that they have a strategic focus of expanding their student numbers through attracting students from other SADC member states.

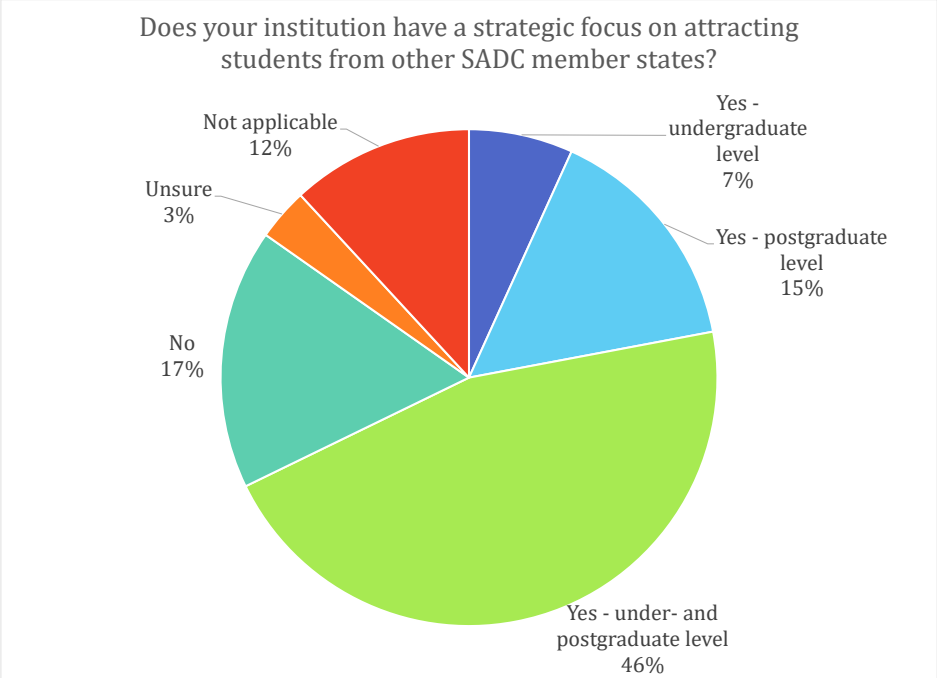


Figure 9: Institutional strategies to recruit from within SADC

In some cases, like with the Instituto Superior Politécnico de Manica in Mozambique, curricula are being designed with the purpose of allowing for regional student mobility. In Namibia universities reserve a quota for enrolment of SADC students. Bindura University of Science Education in Zimbabwe is even planning to establish campuses in other countries of the region.

Other universities opt for virtual delivery mechanisms. These include Botho University in Botswana, offering blended and distance learning programmes to students in Botswana, Lesotho and Namibia, and Unicaf, situated in Malawi, but which has a student component of 70% of its students outside Malawi.

Across most countries the strategic emphasis on broadening the student base is emphasized as strategically important, but a number of institutions also listed the challenges to implementing these strategies. These include:

- Language barriers;
- Infrastructure shortages;
- In adequate student support services;
- The impacts of COVID-19 on student mobility.

8.1.3 KNOWLEDGE CO-PRODUCTION

A large majority (72%) of the institutions in the sample indicated that they are planning to, or already have processes in place, to jointly develop programmes with other institutions in the SADC region.

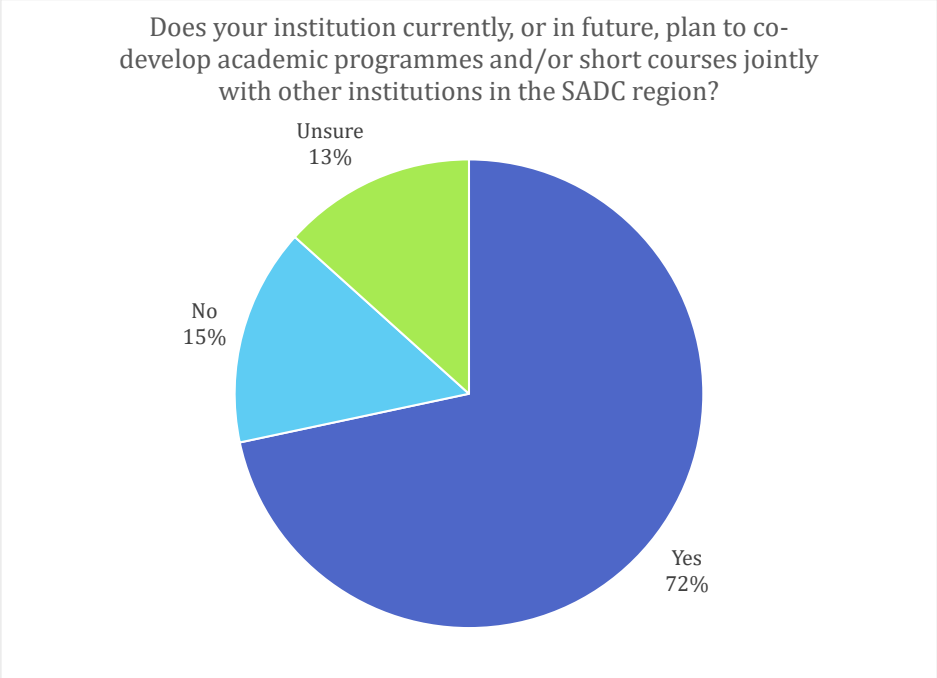


Figure 10: Institutions planning joint development of programmes

When assessing detailed comments, it seems, however, as if many institutions are still in the planning phase, with few concrete examples of existing partnerships available:

- Unicaf, based in Malawi, develops joint curricula within its own local partner networks in Zambia and Zimbabwe, while still exploring the potential of other university partnerships.
- Universidade José Eduardo dos Santos in Angola has short courses in food technology to support agro- processing skills training, and is planning to partner with more experienced universities to improve their programmes.
- Chalimbana University in Zambia is actively seeking partnerships where there are complimentary programmes which can be joined with what they have in place.
- Mzuzu University through the Centre for Open, Distance and eLearning has started offering short courses in preparation for the collaborative regional short course development.

- Bindura University for Science Education in Zimbabwe has established Centres of Excellence in Climate Change and Food Security as well as in Disaster Risk Management; which have a national and regional focus. The aim for these is to develop short courses that will attract regional participation.
- The Nelson Mandela African Institution of Science and Technology in Tanzania is targeting alumni from SADC universities, research organisations and industry to forge collaborative development partnerships.
- Botswana Open University is offering one module on Gender which was developed at the SADC level.
- On the regulatory side there is also increasing regional collaboration, with Namibia's National Council for Higher Education (NCHE) signing Memoranda of Understanding with regional counterparts in Lesotho and Zimbabwe to share experiences. It also works with the Association of African Universities to offer short courses in improving external quality assurance.

> *We believe strongly in running courses using a consortium of universities, so as to optimize on human resources and facilities found in all the institutions involved. We are convinced that we are complementary and if we collaborate more closely in the pedagogical and research sides, we can function at a much higher level than we have been doing so far; furthermore there are many common issues in the SADC region. We have already started this approach for islands in the Indian ocean like Reunion, Madagascar, Comoros and other public universities in Mauritius. We eagerly want to extrapolate this philosophy from the Indian ocean countries to a bigger region like the SADC.*
>
> Dr Radhakhrishna SOMANAH Director General: University of Mascareignes, Mauritius

8.2 EXISTING TEACHING AND LEARNING PROGRAMMES

Figure 4 above showed that, according to higher education institutions in the initial research sample, the largest majority of existing teaching, learning and research programmes were in the agro-processing value chain, confirming the demand analyses in terms of size and employment numbers vis-à-vis the other two value chains. There does not yet seem to be the same number of short courses available across these value chains in the region.

In the supply side survey, institutions were asked to "Please list up to five programmes or qualifications your institution offers, which will benefit employers in the agro-processing, mineral beneficiation, or pharmaceuticals industries." The results below show the existence of many potential valuable programmes for the region, but most of these are currently single university focused and tied to existing institutions. It is also evident that some programmes are less relevant to the purpose of the SADC Industrialisation Strategy.

Country	Institution	Programme	AP	MB	PH
Angola	Universidade José Eduardo dos Santos	BSc in Agronomy	X		
		MSc in Agronomy & Mineral Resources		X	
		BSc / MSc in Forestry	X		
		BSc / MSc in Veterinary Sciences	X		
		BSc Food Processing	X		
	Higher Polytechnic Institute of Malanje	Research projects within the Department of Health Sciences: Survey of ethno-pharmacological knowledge of local people Supporting local healers regarding the safe use of medicinal plants Preliminary phytochemical essays Entrepreneurship in pharmaceutical sciences			X
Botswana	BA ISAGO University	BA Landscape Architecture	X		
		BCom Transport Management and Logistics		X	
		BSc Climate Change	X		
	Botho University	BSc (Hons) in Jewellery Management and Design		X	
eSwatini	eSwatini Medical Christian University	Pharmacy			X
		Radiography			
		Nursing			
		Social Work			
		Psychology			
Malawi	University of Malawi	Bachelor of Pharmacy Biomedical sciences			X
		Diploma in Industrial Laboratory Technology			X
		Diploma in Metallurgy and Mineral Processing Engineering		X	
		Diploma in Mining Engineering		X	
		Bachelor of Food Science and Technology	X		
		Bachelor of Metallurgy and Mineral Processing Engineering		X	

Country	Institution	Programme	AP	MB	PH
		Master of Science in Herbal medicine			X
	Mzuzu University	B.Sc. Renewable Energy		X	
		B.Sc. Fisheries and Aquaculture	X		
		B.Sc. Biological Medicine			X
		B.Sc. Hospitality Management			
	Unicaf University	BSc Supply Chain Management		X	X
		BA Business Administration	X	X	X
		BSc in Finance	X	X	X
		MBA with wide range of specialities	X	X	X
		PhD with specialities in business, marketing, finance	X	X	X
Mauritius	University of Mauritius	BSc (Hons) Agricultural Science and Technology	X		
		BSc (Hons) Biotechnology			X
		Bachelor of Science in Agribusiness Economics & Management	X		
		BSc (Hons) Biomedical Sciences			X
	University of Mascareignes	Masters in Energy Efficiency and Sustainable Development	X		
		Masters in Artificial Intelligence and Robotics	X	X	X
		Masters in Civil Engineering	X	X	
		Masters in Sustainable Development Management	X	X	
		BSc in Electrotechnics and Renewable Energy	X		
Mozambique	Instituto Superior Politécnico de Manica (ISPM)	Food processing technologies programme	X		
		Agriculture engineering programme	X		
		Forestry engineering programme	X		
		Animal production and processing programme	X		
		Biotechnology	X		

Country	Institution	Programme	AP	MB	PH
	Instituto Superior de Contabilidade e Auditoria de Moçambique	Accounting, Public Accounting			
	Universidade Lurio	Mechanical Engineering		X	
		Geological Engineering		X	
		Ethnobotany – Alcohol production from cane sugar	X		
Namibia	University of Namibia	Food Science and Technology	X		
	International University of Management	Degree in Business Information Systems/ Technology			
		Degree in Finance Management	X	X	X
		Degree in Marketing Management			
		Degree in Business Administration			
		Certificate in Pharmacist Assistant		X	
South Africa	University of the Free State	PGDip Sustainable Agriculture	X		
		MSc Food Security	X		
		Masters in Environmental Management	X		
	Sol Plaatjie University	BSc Data Science	X	X	X
		Diplomas in ICT			
		Bachelor of Education Intermediate Phase (with science education specialisation)			
		Bachelor of Education Senior/FET Phase (with science education specialisation)			
		BCom			
	North West University	Animal Production	X		
		Crop Production	X		
		Pharmacy Engineering			X
		B Eng Chemical Engineering with Minerals Processing		X	
		M Eng Chemical Engineering		X	
		PhD Chemical Engineering		X	

Country	Institution	Programme	AP	MB	PH
		Short Learning Programme in Minerals Processing (as from 2021)		X	
	Stellenbosch University	BSc Agriculture	X		
		BEng(Process Engineering)		X	
Tanzania	Nelson Mandela African Institute for Science & Technology	Sustainable Agriculture	X		
		Industrial Pharmacy and Regulatory Science			X
		Global Health and Biomedical Science			X
		Food and Nutrition Sciences	X		
		Biodiversity and Ecosystem Management	X		
		Materials Science and Engineering		X	
		Sustainable Energy Science and Engineering	X	X	
		Food Science and Biotechnology	X		
		Sustainable Agriculture	X		
		Health and Biomedical Sciences			X
		Masters and PhD in Sustainable Agriculture	X		
		Masters and PhD in Food Science and Biotechnology	X		
		Masters and PhD Global Health and Biomedical Sciences			X
		Masters and PhD in Human Nutrition and Dietetics			X
		Master's in Public Health Research			X
		Master's and PhD in Food Science and Biotechnology (FoSB)			X
		Master of Science and PhD in Sustainable Agriculture (SA)	X		
		Master of Science and PhD in Health and Biomedical Sciences (HBS)			X
		Master's and PhD in Materials Science and Engineering (MaSE)		X	
		Master's and PhD in Information and Communication Science and Engineering (ICSE)			

Country	Institution	Programme	AP	MB	PH
	Kilimanjaro Agricultural Training College	Tractor Power and Farm Machinery	X		
		Harvesting and Post-harvesting Techniques	X		
		Animal Power	X		
	Kaole Wazazi College of Agriculture	Diploma in General Agriculture	X		
		Diploma in Agriculture Production	X		
		Diploma in Animal Health and Production	X		
		Vocational Training on Horticultural Production	X		
		Vocational Training in Animal Husbandry	X		
	St Joseph University of Tanzania	Technician Certificate in Pharmaceutical Sciences Level 5 with a duration of 2 years (4 semesters)			X
		Ordinary Diploma in Pharmaceutical Sciences NTA Level 6 with a duration of 3 years (6 semesters)			X
		Ordinary diploma in Mechanical engineering		X	
		Bachelor's degree in Mechanical Engineering		X	
		Bachelor's degree in Medicine			X
	Dar es Salaam Institute of Technology	Leather Products Technology	X		
		Footwear Design and Pattern Engineering	X		
		Leather Processing Technology	X		
		Leather Craft Tanning	X		
		Leather Goods Making	X		
	St Maximilliancolbe Health College	Pharmaceutical sciences			X
		Clinical Medicine			X
		Accredited Drug Dispensing outlets			X
		Accredited Drug Dispensing Outlet Owners			X
Zambia		Biotechnology			X

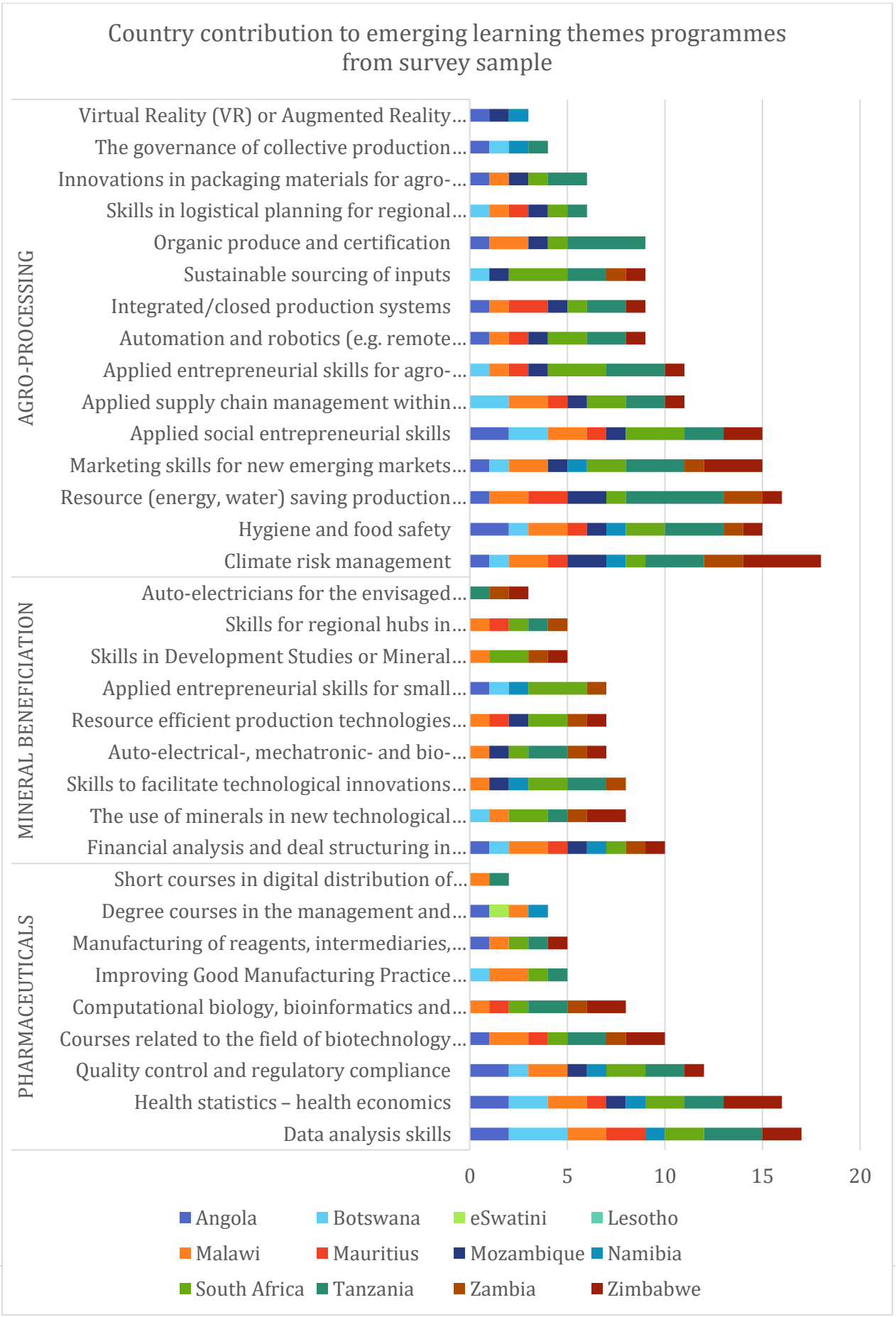
Country	Institution	Programme	AP	MB	PH
	Copperbelt University	Mineral and Metallurgical Engineering		X	
		Chemical Engineering		X	
		Mining Engineering		X	
		Environmental Engineering	X	X	
	Zambian Open University	BSc Agriculture Business	X		
		BSc Agriculture Economics	X		
		BSC Animal Science	X		
		BSC Horticulture	X		
		BSC Plant Science	X		
	Chalimbana University	Bachelor of Agricultural Education	X		
Zimbabwe	Catholic University of Zimbabwe	Masters in Impact Entrepreneurship	X	X	X
		Bachelor of Business Management and Information Technology	X	X	X
		Diploma in Project Management			
		Certificate in Project Management			
		Bachelor of Social Science in Development Studies	X		
	Midlands State University	Crop Production and Agriculture	X		
		Chemical Technology		X	X
		Materials Engineering		X	
		Agronomy	X		
		Geology		X	
	Bindura University of Science Education	BSc Honours in Chemical Technology			
		BSc Hons in Agricultural Engineering			
		MSc in Food Security and Sustainable Agriculture			
		MSc in Biotechnology			
		MSc in Entrepreneurship and Innovation			
	University of Zimbabwe	BSc Hons. Agricultural Processing Plant Design and Systems Engineering	X		

Country	Institution	Programme	AP	MB	PH
		MSc Food Processing Systems and Technology	X		
		MSc Advanced Mineral Processing and Extractive Metallurgy		X	
		BSc Hons. Drug Discovery and Therapeutics			X
		BSc Hons. Pharmaceutical Chemistry			X

What is initially apparent from the results above is that many of the programmes and qualifications listed as supporting industrialisation, do not necessarily address some of the more cutting-edge skills required for the future world of work.

When taking a comparative view of teaching and learning programmes that address emerging learning themes, as highlighted individually, it shows that mineral beneficiation themes are least well represented among the initial sample of institutions canvassed.

Below is a breakdown per country (no. of institutions) which indicated they have incorporated emerging learning themes in programmes.


Country contribution to emerging learning themes programmes from survey sample
AGRO-PROCESSING
MINERAL BENEFICIATION
PHARMACEUTICALS
Virtual Reality (VR) or Augmented Reality…
The governance of collective production…
Innovations in packaging materials for agro-…
Skills in logistical planning for regional…
Organic produce and certification
Sustainable sourcing of inputs
Integrated/closed production systems
Automation and robotics (e.g. remote…
Applied entrepreneurial skills for agro-…
Applied supply chain management within…
Applied social entrepreneurial skills
Marketing skills for new emerging markets…
Resource (energy, water) saving production…
Hygiene and food safety
Climate risk management
Auto-electricians for the envisaged…
Skills for regional hubs in…
Skills in Development Studies or Mineral…
Applied entrepreneurial skills for small…
Resource efficient production technologies…
Auto-electrical-, mechatronic- and bio-…
Skills to facilitate technological innovations…
The use of minerals in new technological…
Financial analysis and deal structuring in…
Short courses in digital distribution of…
Degree courses in the management and…
Manufacturing of reagents, intermediaries,…
Improving Good Manufacturing Practice…
Computational biology, bioinformatics and…
Courses related to the field of biotechnology…
Quality control and regulatory compliance
Health statistics – health economics
Data analysis skills
0
5
10
15
20
Angola
Botswana
eSwatini
Lesotho
Malawi
Mauritius
Mozambique
Namibia
South Africa
Tanzania
Zambia
Zimbabwe

8.3 OBSTACLES FOR IMPROVED REGIONAL COLLABORATION

The three greatest obstacles identified by higher education representatives for a regional delivery model to supply appropriate teaching and learning programmes to meet regional demand are:

- Financial resources; Technological infrastructure;
- Regional alignment of not only policies, but qualifications and accreditation systems;
- Institutional capacity.

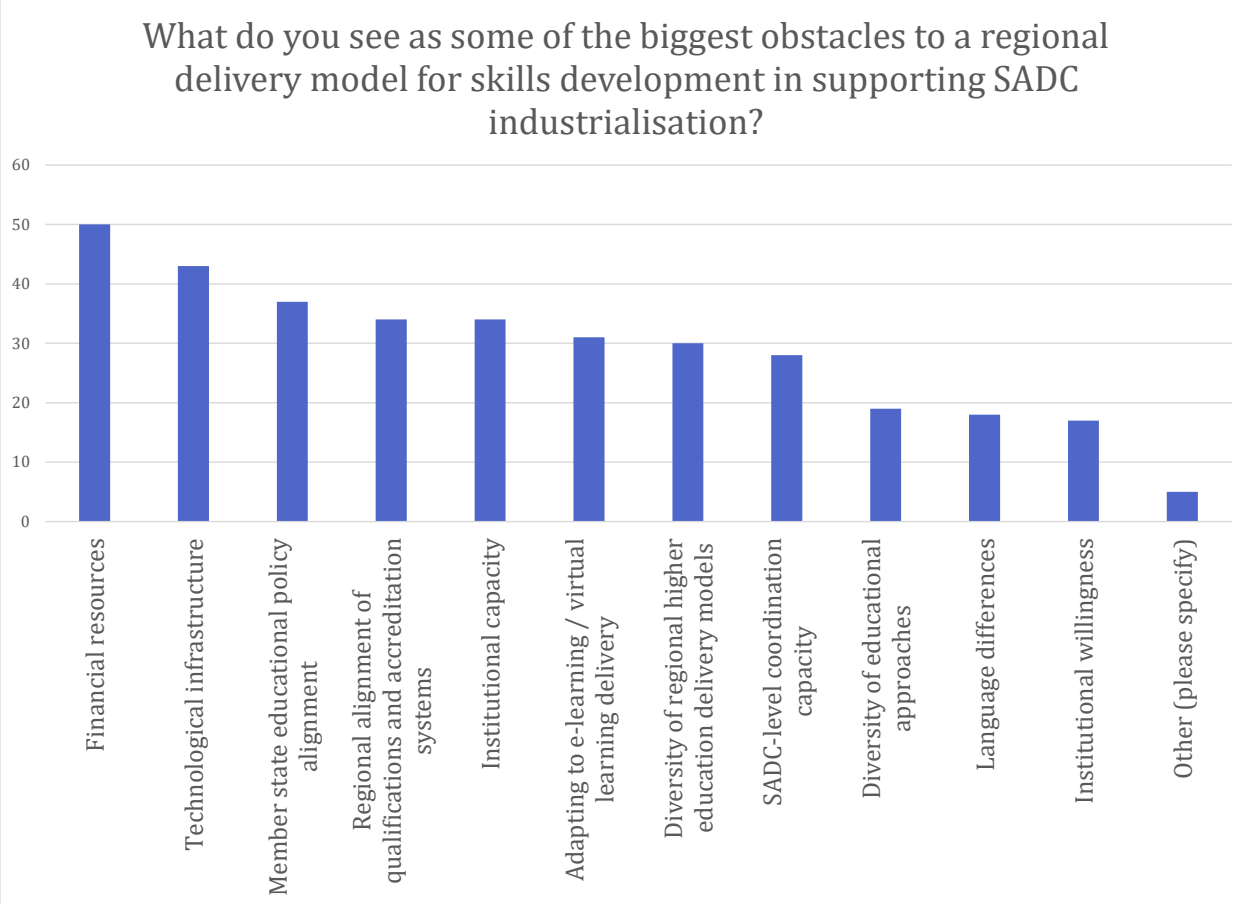


Figure 11: Obstacles to a regional delivery model for industrialisation skills supply

Additional obstacles added were the lack of political will to develop regional solutions and the inevitable discussions over university autonomy in a regional system.

The diversity of national education infrastructure and systems, linked to a high disparity in resources between countries and universities, linked to chronic underfunding experienced in many countries are the constant challenges mentioned. To address these are not simple, as SADC has experienced time and again with implementing regional programmes. What seems positive is a genuine regional interest in sharing and

collaborating, if by doing so can alleviate pressures of finances and delivery of teaching and learning

8.4 ENGAGEMENTS WITH VALUE CHAIN INDUSTRY REPRESENTATIVES

The confirmation and validation of the skills supply requirements of the value chains in response to the demand analysis in a regional context with relevant industry role players is an essential step in determining research priorities and curriculum relevance, and specifically the need for regional collaboration.

There is need for regular industry-academia consultations in order for the institutions to provide skills needed by industry in order to address the graduate unemployment situation in SADC.

Seth T. Akweshie Managing Director, FINACCO GROUP

Collaboration between academia and industry is regarded as a critical component of efficient national innovation systems, and for that matter of any regional skills development initiatives. Traditionally such collaboration has generally been research-focused, where industry has provided funding for university researchers to tackle strategic projects that drive industry innovation, development and/or contribute to economic growth.

University-industry partnerships are less well established when it comes to authentic participation in curriculum design and delivery models. Curriculum design refers to a planned sequence of learning experiences for an entire degree programme. It includes consideration of programme aims, student learning outcomes, learning activities and assessment tasks mapped across a whole programme.

Notwithstanding professional learning (skills and attributes), usually outlined by a professional body as for example in the case of engineering, and expected to be addressed in the curriculum, participation of industry in the design of curriculum is less prevalent.

Although it can be assumed that the programme content of the institutions surveyed relevant to the value chains, as well as teaching and learning methods, have been in accordance with in-country accreditation and quality assurance requirements, it does not necessarily imply that institutions have adequately confirmed the need for their current programme offerings with industry.

Preliminary input regarding industry viewpoints has been obtained through the surveying, and in consultation with selected industry representatives. These confirm a general lack of structured and regular engagement on a national or regional level. Industry level engagement directly with individual institutions is typically the norm where it takes place, and it has been pointed out that this does not always have the long-term focus that, for example, the Industrialisation Strategy has.

Key factors to consider in any further consultations in this regard include:

- Accommodating the need for a regional response to the value chain skills development requirements, implying participation and input from industry role-players with an interest in regional value chains;
- Structuring the mechanisms for academia and industry collaboration within the agreed upon delivery model for the proposed regional skills development initiative;
- Considering the content of the required interaction with industry on the basis of the gaps in skills supply identified;
- Determining the relevance of industry input in respect of any proposed program content in accordance with any applicable Regional Qualifications Framework.

Against the above background, an approach to determine the relevance of the underlying SADC value system as outlined in Section 7 *supra*, and to develop detailed responsive programme curricula would require the further structured input of relevant industry stakeholders, HEIs and technical and developmental research organisations.

Such input could be solicited on the basis that between 50 and 100 large firms in the SADC are responsible for some 70% of formal employment across all the value chains. There are furthermore approximately 52 technical R&D institutions and some 20 R&D institutions with a development focus related to the value chains.

It may be useful to have country targets that are disseminated through the Ministries if they are not already in place. Scheduled project updates will also help. Maybe half year reports.

Monica Mureriwa, Director Marketing and Public Relations, Catholic University of Zimbabwe

Such numbers could therefore provide a statistically representative sample to scientifically inform the demand for skills by each value chain, and in the final analysis of specific programme content. Such grouping could furthermore form the basis of any further academia and industry consultation mechanisms going forward.

It is widely recognised that a lack of work- readiness, combined with a mismatch between industry requirements and skills possessed by graduates, are major causes of youth unemployment worldwide. The establishment of partnerships between academia and industry has been emphasised, as illustrated in the case study below of a Francophone Africa initiative

Case study: Building more resilient pathways to youth employment

Various frameworks have been developed to address the challenge of transitioning skilled graduates to the labour market, including Work-Integrated Learning (WIL), an approach to training that integrates class- based instruction with on-the-job practice. The WIL framework is regarded as an effective mechanism in contributing to graduate

employability. Furthermore, it creates opportunities for employers to access a pool of skilled individuals who can make meaningful contributions to the workplace.

Work-Integrated Learning is defined as a model and process of curricular experiential education which formally and intentionally integrates a student's academic studies within a workplace or practice setting. WIL experiences include an engaged partnership of at least: an academic institution, a host organization and a student. WIL can occur at the course or programme level and includes the development of learning outcomes related to employability, personal agency and life-long learning. The emphasis is on providing education and training programmes that respond to industry needs and job market dynamics.

As reported in University World News (14 August 2020) the African Institute for Mathematical Sciences (AIMS) has embarked on an initiative to introduce WIL and the advancement of science, technology, engineering and mathematics (STEM), as well as its adaptation to the African context, and with programmes being offered at centres in Cameroon, Rwanda and Senegal.

In assessing these and other questions, the major gaps identified for further research and action are:

8.4.1 GAP 1: EXISTING PROGRAMMES WHICH ADDRESS REGIONAL SKILLS NEEDS MAY NOT NECESSARILY RESPOND ADEQUATELY TO DEMAND

A constant refrain from both industry and higher education is that the process of engagement to discuss skills demand for the three value chains is not sufficiently structured and focused. Where there are programmes which address demand directly, these are often the result of direct engagements between industry and individual institutions, rather than the result of regional or national strategic initiatives. In many cases, the demand analysis might have been done internally by the university concerned, and based on an analysis of global curriculum trends.

8.4.2 GAP 2: THE SADC REGION IS SEEN AS AN EDUCATION MARKET GROWTH OPPORTUNITY, BUT WITHOUT LINKING ACTIONS TO EXISTING STRATEGIC OBJECTIVES

Regional frameworks like the SADC Industrialisation Strategy are not necessarily visible to, or deemed relevant by, higher education institutions, when developing their institutional strategies

> *[A key challenge is] Universities embracing the traditional way of Teaching and Learning, and Research, being proud more of publications than solving societal and industrial challenges.*
>
> Dr Michael Haule, Chief Admissions Officer, Nelson Mandela African Institution of Science and Technology

While regional expansion, attracting students from SADC and collaborating across borders are all widely shared objectives by higher education institutions, they are not necessarily informed by national or regional strategies. This also applies to the SADC Protocol on Higher Education and Training. Where there is a match, it is often because of the same macro trends being evaluated, not because of direct engagement.

8.4.3 GAP 3: THE SKILLS DEMAND IDENTIFIED REQUIRES A MULTI-LEVEL ACADEMIC OFFERING

To implement an effective skills development approach that addresses industry demand requires different tiers of the education sector to function in tandem. As indicated in the demand analysis in this report, the range of potential qualifications range from TVET to postgraduate level. This requires both tiers of the education system to function optimally, and ideally for some coordination to take place on the national levels.

8.4.4 GAP 4: INSTITUTIONAL READINESS AND CAPACITY REMAIN A KEY OBSTACLE TO ANY SUCCESSFUL IMPLEMENTATION OF TARGETED REGIONAL PROGRAMMES

Institutional capacity ranked high as a factor in responses related to the achievement of industrialisation objectives. Factors highlighted in previous SARUA research for curriculum innovation to actively take place, include inculcating a leadership style of innovation within an institution, removing inter-disciplinary barriers and structures that prevent collaboration and actively support the development of new and cutting edge programmes. These are often lacking in the region.

8.4.5 GAP 5: REGIONAL DIFFERENCES IN ACCREDITATION SYSTEMS COMPLICATE A REGIONAL APPROACH

Higher education respondents listed this as a key obstacle, and for a shared delivery model to work, there needs to be more alignment in systems, and more parity in infrastructure and technology support.

8.4.6 GAP 6: MANY EXISTING ACADEMIC PROGRAMMES DO NOT YET OFFER THE NECESSARY DYNAMIC AND NEW CONTENT WHICH WILL MAKE THE REGION COMPETITIVE

A number of qualifications and programmes exist to support the skills demand, and many are listed in the report. While it is acknowledged that it is an initial list, it is necessary to understand whether they actually contribute to new ways of thinking, the new world of work, or new ways of knowledge co-creation. Are the programmes on offer the cutting-edge programmes required by SADC and are the curricula relevant to the demand?

8.5 OPTIONS FOR REGIONAL DELIVERY MODELS TO ADDRESS INDUSTRIALISATION SKILLS DEMAND

8.5.1 SELECTED VIRTUAL AND NETWORK UNIVERSITY MODELS

This part of the report considers virtual and network university models as possibilities for the regional delivery of educational and training opportunities in the three value chains. Typically, the virtual models function as networks of participating institutions. Documented practices and models of virtual universities in Africa and internationally such as the Virtual University for Small States of the Commonwealth (VUSSC), COMESA Virtual University and Pan African University, the European Consortium of Innovative Universities (ECIU) and the ASEAN University Network (AUN), have been reviewed.

The Virtual University for Small States of the Commonwealth (VUSSC) is a network of small countries committed to the collaborative development of free content resources for use in an educational context. Participating SADC countries include Botswana, Eswatini, Lesotho, Mauritius, Namibia and Seychelles. VUSSC works with national institutions of member countries to build capacity and expertise in online collaboration, eLearning and information and communication technologies (ICT) in general. Participating educational institutions work together on the design, development, and delivery of post-secondary, skills-related courses and university-level programmes in areas that enhance their economic, financial, social and community growth.

The VUSSC initiative has developed a Transnational Qualification Framework (TQF) as a means through which courses offered within the VUSSC environment can be understood and compared, thereby paving the way for exchange and transfer of courses, facilitating international recognition of small states' qualifications and improving labour mobility.

The Common Market for Eastern and Southern Africa (COMESA) is a free trade area with 21 Member States stretching from Tunisia to Eswatini. The COMESA Virtual University is an initiative that was launched with a virtual Masters of Regional Integration (MRI) degree programme at the Kenyatta University of Kenya, designed for government officials working in divisions or units dealing with trade, integration and cooperation issues; students intending to work as trade officers, trade policy analysts, advisers, researchers, trade attachés, and private sector trade practitioners among others.

The Pan African University is an initiative of the Commission of the African Union to revitalize higher education and research in Africa, and consists of campuses in the following disciplines and locations that are hosted at the different PAU Institutes that offer only post-graduate qualifications (Masters and Doctoral) as follows:

- Water and Energy Sciences (including Climate Change) (PAUWES, Algeria)
- Basic Science, Technology and Innovation (PAUSTI, Kenya)
- Life and Earth Sciences (including Health and Agriculture) (PAULESI, Nigeria)
- Governance, Humanities and Social Sciences (PAUGHSS, Cameroon)
- Space Sciences (PAUSS, South Africa).

The Pan African University was established to advance Africa's goal of enhancing its competitiveness and growth through the creation of high quality higher education and research capabilities.

The implementation structure of the PAU was based on the selection of existing universities, on a competitive basis, to host the regional PAU Institutes and Centres.

PAU offers full scholarships to all students enrolled into its programmes following a competitive admissions process.

So called network university models are also regarded as relevant to a regional skills development initiative. An illustrative example is the European Consortium of Innovative Universities (ECIU), a network of universities who are united by a common profile, and offer a variety of different exchange programmes to students within the ECIU network throughout Europe, and driven by factors such as:

- Strengths in engineering and social sciences.
- Committed to the encouragement of innovation and entrepreneurship.
- Close ties to industry and to their regions.
- Committed to developing unconventional forms of teaching and learning.
- Research-intensive.
- Sustain and nurture internationally-minded staff.
- High quality education with international focus.
- Experiment with new forms of management and administration.
- Invest to play a significant role in European policy-making in the fields of research, innovation and education.

The ASEAN University Network (AUN) is an Asian university association. AUN was initially established in 1994 with the idea of establishing a formal university, but obstacles related to funding, location and leadership necessitated the founding of a network of existing institutions. In its early years (1995–1999), the AUN focused mainly on the sharing of knowledge and experiences and on small-scale student and staff exchange. As from

1999, the collaborative activities became more complex with programmes like joint curriculum development, co-operation in ICT and the establishment of sub-networks.

Currently, AUN is composed of 30 universities across 10 ASEAN countries.

An assessment of the virtual and network university examples considered as part of this project indicates the following of relevance to any proposed model for a SADC initiative:

- Institutions have light governance structures, and have been established in partnership with existing institutions;
- Funding models include a strong reliance on scholarships in the case of the PAU, and a combination of scholarships and fees for the others;
- Harmonised qualification frameworks are necessary to accommodate the trans-national nature of offerings, exchange and transfer of courses, facilitating international recognition of qualifications and improving labour mobility;
- Programmes offered include existing or adapted courses, and in the case of PAU only post graduate degrees;
- Research output has been prioritised as at the PAU;
- Apart from the Governance, Humanities and Social Sciences campus of PAU, the other campuses all focus on Science, Technology, Engineering and Mathematics (STEM) qualifications.

8.5.2 CENTRES OF EXCELLENCE AND SPECIALISATION

The SADC Protocol on Co-operation in Education and Training, 1997, emphasises the required collaboration of member states in respect of Higher Education and Training, and highlights the roles and functions of proposed Centres of Excellence and Specialisation. It is specified that the criteria for the selection of such Centres should be in terms of an equal opportunity to bid by the relevant Universities in the region as issued by the SADC, and appointed by the relevant Sub-sector on Education and Training Technical Committee.

SADC has developed a framework guideline on the establishment and strengthening of Centres of Excellence (CoE) and Centres of Specialisation (CoS).

The framework specifies that “Centres of Excellence are research capacity entities that are aimed at generating knowledge and developing human capacity in critical areas of research in order to maximise the use of scarce resources and expensive research facilities. The thrust of SADC CoEs will be on building research capacity on identified areas and thereby assist the region in translating research into the commercialization of products and services. There will be strong partnerships with industry, the private sectors, government and relevant industrialization role players.”

The framework specifies that “Centres of Specialisation are entities that offer education and training programmes in critical and specialised areas and thereby increase the stock of trained personnel relevant in the region. The SADC CoS focus on training and

education at all levels (certificate, diploma and degrees, etc), with strong linkages with industry and research institutions."

CoEs typically enable researchers to collaborate across disciplines and institutions on long-term projects by using existing capacity and resources, and working on projects that are locally relevant and internationally competitive and enhance the pursuit of research excellence and capacity building.

CoS aim to model ways in which industry and employers can partner with HEIs and other relevant bodies to revitalise the delivery of trade and occupational qualifications to meet industry standards and the needs of the economy.

The World Bank has provided support to the setting up of Centres of Excellence in terms of its African Centres of Excellence (ACE) programme at universities in Eastern and Southern African countries to strengthen postgraduate training and research in priority sectors, under a project being coordinated and administered by the Inter-University Council for East Africa (IUCEA) of the inter-governmental association the East African Community, and based in Uganda. The Centres in SADC countries are as follows:

Malawi

Lilongwe University of Agriculture and Natural Resources
African Centre of Excellence for Aquaculture and Fisheries Science.

University of Malawi – Malawi College of Medicine
African Centre of Excellence for Public Health and Herbal Medicine.

Mozambique

Universidade Eduardo Mondlane
Centre of Studies in Oil and Gas Engineering and Technology

Tanzania

Nelson Mandela African Institution of Science and Technology
Collaborating Centre for Research, Evidence, Agricultural Advancement and Teaching Excellence and Sustainability.
Water Infrastructure and Sustainable Energy Centre for the Future

Sokoine University of Agriculture
African Centre of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development Southern African Centre for Infectious Disease Surveillance

Zambia

Copperbelt University
Africa Centre of Excellence for Sustainable Mining

University of Zambia
Africa Centre of Excellence for Infectious Diseases of Humans and Animals

The SADC Secretariat is currently finalising a CoE and CoS study that will provide further background on the criteria for selection and identification for purposes of a skills development initiative.

The relevance of the CoE and CoS models for the participation of proposed partner universities in regional value chain skills development initiatives has to be determined with due recognition of the SADC Protocol guidelines on collaboration. Such proposed next steps to collaboration are outlined under Recommendations, *infra*.

9 RECOMMENDATIONS

This baseline study has been conducted on the premise of the SADC Industrialisation Strategy, namely that the supply of high-level skills and the creation of knowledge is regarded as an essential building block for wealth creation and industrial development in knowledge-based economies.

International experience, as well as particularly in Africa, has illustrated the potential benefits of well co- ordinated mechanisms harnessing the existing capacity of HEIs and other tertiary skills development institutions in addressing skills demand challenges through collaborative approaches.

9.1 SKILLS DEMAND AND SUPPLY

The study has indicated the priority skills demand categories and has provided a baseline response to the existing skills supply gaps that a proposed skills development initiative should consider and address, and which include:

- Existing programmes which address regional skills needs may not necessarily respond adequately to demand related to all skills requirement elements of value chains, and insufficient collaboration with industry has been identified;
- The SADC region is seen as an education market growth opportunity, but actions are not sufficiently linked to existing strategic objectives related to skills development;
- Skills demand categories identified require a stronger level of a multi-level academic offering and knowledge co-production approaches;

- Institutional readiness and capacity remain a key obstacle to any successful implementation of targeted regional programmes;
- Regional differences in accreditation systems complicate and constrain a comprehensive regional approach;
- Many existing academic programmes do not as yet offer the necessary dynamic and new content which will contribute to regional competitiveness.

Overall, the baseline study has identified several areas where additional and further interaction with HEIs and other skills development stakeholders is required, in order to agree on the detail of an appropriate value adding regional skills development response, and specifically the optimal delivery models to be considered. Engagements have confirmed the following stakeholder categories illustrated in the Table below:

Entities	Perspectives required	Future role(s)	Level of engagement
SADC universities	Programmes on offer and in development to support SADC industrialisation value chains.	Future contribution as network partners (content, programmes, delivery models)	DVC or Director of programmes
Centres of Excellence and Specialisation	Current programme research and/or short courses on offer to support SADC industrialisation value chains.	Future contribution as network partners (content and programmes)	Director or head of programmes
TVET sector institutions	Programmes on offer with potential for upgrading to regional degree programmes in support of scarce skills development.	Consultative partners in conversion of programmes	Director or head of programmes
Distance education associations and institutions	Education delivery models and existing programmes which could be offered in partnership with SUT across the region.	Future contribution as programme development and/or implementation partners	Director or head of programmes

Entities	Perspectives required	Future role(s)	Level of engagement
Private education providers	Existing short course programmes and technology platforms to be considered in programme offerings.	Potential delivery partners for short courses.	CEO or general manager
International Development Agencies	Funded programmes that address critical skills, to understand existing landscape and gap.	Involvement as potential future funders and/or sponsors of key programmes i.t.o. development and customisation	Country and regional office director
SADC member state representatives (higher education focus)	National plans and/or education strategies to address SADC value chains in universities.	Continuous engagement to ensure there is no fragmentation and/or duplication of initiatives	Director General / Permanent Secretary and director
National regulatory bodies for programme registration and accreditation	Current processes and potential national level obstacles to implementing regional programmes	Guidance on national level programmes and progress on regional alignment of accreditation frameworks and systems	Director
Regional regulatory bodies	Progress on regional integration, mobility and support to cross-member initiatives and programmes.	Progress reports and guidance on regional alignment progress	Director

The representatives identified for future engagement per HEI that responded to the survey have been listed in Annexure D, *infra*.

The skills demand analysis has identified the following categories of skill supply requirements:

i. The forecasted demand is highest for the agro-processing sector; followed by mineral processing (skills per annum) and pharmaceuticals. The highest demand is forecasted for honours degrees and higher, while some 10-13% could be on diploma-level;
ii. The following categories of formal qualifications are relevant in addressing the current and projected demand:

- Programmes that are offered by SADC universities, and where the existing capacity is sufficient to address SADC's needs. As these universities will continue to enrol students in such programmes, their relevance, content and interest in respect of a SADC role is to further be assessed.
- Existing programmes, but with a need for additional capacity: An assessment of a SADC role in providing capacity development, e.g. by making additional enrolments possible through e-learning. (E.g. using a shared revenue model with the university that is the academic owner of the programme).
- New programmes that could be developed through the SADC network - where no or inadequate existing programmes exist.

iii. Upgrading trade certificates to occupational certificates at TVET level to upskill medium skilled workers currently employed in the agro-processing and mineral processing VCs;
iv. Short courses and short learning programmes to build skills that respond to technological changes and other change drivers relevant to the sector to up-skill the current workforce in each value chain. This could involve some 50% of the current workforce within each value chain as well as new workers in points 1 and 2 above;
v. Short courses or post-graduate degrees linked to the actualisation of regional policy objectives related to each value chain.

The provision of education and training opportunities may also include a range of capacity development initiatives related to *inter alia* teaching and learning, curriculum development and accreditation and quality assurance.

9.2 GOVERNANCE AND OPERATIONAL FRAMEWORK FOR THE VALUE CHAINS

In order to provide a mechanism and structure to further assess and address the gaps identified, the next steps would require the establishment of a network of interested participating HEIs and other stakeholders to consider the findings of the demand and supply baseline report, and to agree on an appropriate response to the skills development requirements, and the type of co-ordination and governance required regionally.

It is proposed that consideration be given to the feasibility of establishing a “network of universities” model as an appropriate mechanism for addressing the demand for skills development in the three value chains. As stated in section 1 of this report, this recommendation is made with specific reference to the three value chains, and is not a

recommendation on the SUT in general, as Eswatini currently is developing a proposal on the SUT, as commissioned by the SADC.

In such terms, the initial understanding related to the conceptualisation and establishment of a SADC University of Transformation will be addressed through a proposed SADC Network of Universities model for each value chain. The benefits of such an approach are illustrated through the network university model examples referenced in Section 8.6.1 *supra*, namely the European Consortium of Innovative Universities and the ASEAN University Network.

Such a proposed SADC Network of Universities can coordinate collaboration amongst SADC universities and other education providers within each value chain to include:

i. The Presentation of existing programmes (which are academically owned by a specific university).
ii. Initiation and coordination of the development and delivery of programmes in areas for which there is no suitable existing programme; or where existing programme supply in terms of student demand is not adequate.
iii. Developing a menu of accredited formal and non-formal courses which are available in an online learning format from which students can choose in order to expand their choices of available courses. These courses will be available online, and the university at which the student is registered will recognise these courses.
iv. The development of curriculum material for new programmes or the revision of existing programmes.
v. Academic exchanges between university academic staff.
vi. The SADC Network of Universities within each value chain will be able to source the expertise of academic staff across SADC to support its work.

The governance, management and administrative structures that the SUT should provide to support the partner institutions within each value chain should develop organically and the input of partner institutions is required in determining such structures, which should grow as the SUT develops.

In this light, the report does not make recommendations on specific structures and positions, and merely states that there is a need for the necessary systems, structures and capacity to support coordinated collaboration amongst participating institutions from various educational sectors within each value chain.

It is further recommended that:

i. For each value chain, there should be a convener institution (such as a university) (on a rotating basis) which coordinates a network of institutions that provides education and training opportunities.
ii. Each value chain network has the primary responsibility for its academic governance. It conducts academic planning for each value chain, and appoints a coordinator for the value chain who reports into the relevant governance structure.

iii. There could be one institution / organisation that exercises overall academic governance over the work of the value chain networks, provides the necessary administrative, logistical and technological support to each value chain network, and possibly also conducts policy analysis and planning (including foresight activities). The network is self-governing, but receives administrative support from the proposed governance structure.

9.3 NEXT STEPS

In order to make progress in expanding the baseline established in this report, to agree on the content and implementation of a SADC skills development initiative and the establishment of a SADC Network of Universities, the following next steps are proposed:

i. Issue the required Calls for Expression of Interest to HEIs and other stakeholders to participate in the establishment of a network of universities model proposed above, as well as to apply to be accredited as Centres of Excellence or Specialisation in accordance with the criteria for the selection of such Centres specified in the SADC Protocol, namely in terms of an equal opportunity to bid by the relevant Universities in the region as issued by the SADC, and appointed by the relevant Sub-sector on Education and Training Technical Committee.
ii. Further engage the necessary SADC, industry and university structures in the different member states to validate the demand and supply findings and further develop a model of regional skills demand-supply engagement and delivery as recommended.
iii. Initiate a follow-up research process with national-level representatives to gather information on additional higher education institutions, as well as industry representatives as outlined in Section 8.4 *supra.*
iv. Conduct a needs analysis amongst interested institutions on the types of support that each value chain network would require, as the basis for the development of a concept paper on the necessary governance and operational framework to support each value chain network.

Lastly, due recognition is required regarding the funding support that will be required to maintain the momentum established through this baseline skills demand and supply analysis exercise. Although conducted during the unique circumstances of the COVID lockdown as imposed throughout the region, the level of participation through the on-line consultations and surveying has provided a strong baseline viewpoint, as well as interest to be involved in further planning towards the implementation of the concept, and which should be considered in going forward.

The implementation of a dedicated initiative making a meaningful impact on the provision of the required scarce skills within the SADC region in the identified value chains, and towards industrialisation strategy objectives in general, will require adequate and sufficient capacity and resources.

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10.1 DATA SOURCES

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10.2 GENERAL LITERATURE

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10.3 INTERVIEWS

Name	Institution	Date
Herman Marais	Agrivie Africa Food and Agribusiness Investment Fund	1 May 2020
Pierre de Groot	TTM Associates LTD	23 April 2020
Thabile Makgala	Impala Platinum	4 May 2020
Nico van der Hoven	Bauba Resources Ltd	30 April 2020
Mustak Ally	Minerals Council	17 August 2020
Prof Sandra van Wyk	North West University	25 August 2020

ANNEXURE A: SNAP-SHOT OF TRENDING SADC POSITIONS IN THE AGRO-PROCESSING VALUE CHAIN. MAY 2020

Position	Required qualifications
Project manager (Angola)	B. – Master's degree in agricultural economics, marketing or business management
Head of Sales - Food and Beverage (SA)	Degree in Business Administration, Food Technology
Project engineer Dairy – Food & Beverage Processing (SA)	Chemical Engineering / Electrical Engineering degree (mechanical, refrigeration, structural skills are well supported)
SHEQ Administrator (SA)	Relevant Diploma Minimum of 2 – 3 experience
Maintenance Technician (SA)	N6/Diploma with a Trade Test in Electrical, Instrumentation, Mechanical, Millwright or Equivalent technical qualification
Service Engineer (SA)	University Bachelor in automation, process or mechanical engineering or equivalent
Quality Control Technologist (SA)	Relevant Tertiary Qualification
Chief Engineer: Maintenance and SHE (SA)	B.Eng. (a bachelor's degree in Electrical or Mechanical Engineering) + Department of Labour safety examination (GCC)
Production Officer - Biscuit Manufacturing Industry (Angola)	B.Sc in Food Technology -MS/M.Sc. (Science) in Food Technology
Quality inspector (foods) (Botswana)	Certificate in food science /food technology certificate in agro chemicals
Development Technologist (SA)	Degree/Diploma in Food Technology or Food Science
Industrial Engineering In-service Trainee (SA)	Currently studying towards Diploma in Industrial Engineering
Feedmill Production/Plant Manager (SA)	A University Degree or Diploma in Production Management, Business Management or Operations Management
Quality Control Technologist (SA)	Relevant Tertiary Qualification
Automation Engineer (SA)	Qualified Instrument technician; N6 Instrumentation

Position	Required qualifications
Millwright – food processing (SA)	Trade Tested – Millwright
Production Manager (SA)	Relevant Engineering Qualifications
Technician (packaging) (SA)	Trade tested and qualified as an artisan (Millwright/Electrician)
Production Team Leader (SA)	Chemical / Mechanical / Industrial Engineering or Operations Management; SHEQ
Food Quality & SHEQ Manager (SA)	BTech or BSc in Food Science, Microbiology or Chemistry
Service Team Leader, food storage(SA)	Technical Trade Qualification (Refrigeration, Electrical, Millwright)
Logistics Graduate (SA)	B Com Logistics
Production Manager (SA)	Mechanical Engineering qualification
Packaging Manager (SA)	Degree or Diploma in Mechanical Engineering
Production Sublimation Graphic Designer and Printer (Clothing Industry) (SA)	Adobe illustrator; Microsoft office; Coreldraw graphics suite; Monti Antonio Flat Press
Production Manager - Hire Resolve, Port Elizabeth	National Diploma in Production
Maize Miller (SA)	GMF Modules: 3 to 4 years
Maintenance Planner/Scheduler (SA)	Strong understanding of OSHA safety practices and procedures; Strong knowledge of CMMS systems
Millwright – food processing (SA)	Diploma in Mechanical or Electrical Engineering; Understanding of Quality Control and Quality Assurance
Quality Manager (SA)	Industrial Engineering Qualification or equivalent ; Knowledge of ISO 9001 and FSSC 22 000 practices and standards
Laboratory Supervisor (food industry)	Tertiary Qualification in Food Technology
Project Manager and Agribusiness Specialist (DR Congo)	Business Administration, Agronomy, Agricultural Economy or related field; development of supply chain, economic development

Position	Required qualifications
Finance Manager - Agro-Processing (Tanzania)	Chartered Accountant
Head of Operations - Groundnuts (Peanuts) (Malawi)	Field and crop experience
HR Manager - Human Resources Manager (Botswana)	B Degree or Equivalent tertiary qualification. A post graduate qualification in labour law will be an added advantage
Grain pack house & maintenance manager (Zambia)	Product and field experience
General manager (food industry) (Botswana)	Qualification such as MDP, SMDP, EDP or MBA Tertiary qualification in transport management, supply chain or logistics management
Senior agronomist (Lesotho)	BSc Agric in Agronomy / Soil Science PhD in plant genetics advantageous
Horticulture & crop farm manager (Zambia)	Agricultural Diploma / Degree Qualification in Horticulture highly advantageous
Textile Production Engineer (SA)	Industrial engineering diploma or degree
Manufacturing Technologist (Clothing) (SA)	Technology/Production or related qualification
Maintenance Manager (paper and wood) SA	4 Year B Degree in Engineering, National Higher Diploma in Engineering or equivalent with Recognition of Previous
Hardwood Checker(SA)	Matric (Maths and Science) or N3 Pulp and Paper N3 Pulp & Paper/Matric with Maths & Physical Science
Project Engineer (paper and pulp) SA	minimum of BEng degree or equivalent in mechanical / process / thermal engineering
Millwright (paper and wood) (SA)	Relevant diplomas
Electrical engineer (paper and wood (SA)	Relevant degree
Mechanical Engineer (PrEng) (paper and wood) (SA)	Relevant degree
Sales Engineer – Paper Industry Water Treatment chemicals (SA)	BA/B.Sc. in a chemistry, chemical engineering, pulp and paper or similar

ANNEXURE B: SNAP SHOT OF TRENDING SADC POSITIONS IN THE MINERAL PROCESSING VALUE CHAIN, MAY 2020

Position	Required qualifications
Quality control analyst (Malawi)	BSc in Chemistry, BSc in Biology or BSc in Environmental Science
Mineral Processing Metallurgist (SA)	BSc (Hons)/ BEng / B Tech in Chemical Engineering or Mineral Processing plus Excellent Microsoft Visio and Microsoft Projects skills.
Principle Metallurgy – Africa	Project Management Technical / Mineral Processing/Metallurgical Engineering Degree
Chief Mineral Process Engineer (SA)	Degree in Metallurgy/Engineering or Processing.
Process Manager: Iron Ore (SA)	Degree in Metallurgy or Chemical Engineering
Junior Process Engineer (SA)	BSc / BEng Metallurgy
Senior Manager Metallurgy (SA)	BSc Degree in Metallurgical Engineering / Chemical Engineering/ equivalent
Fitter or Millwright (Mineral Processing) (SA)	Relevant qualification
Mineral Process Engineer (SA)	Chemical Engineers and/or Metallurgists
Ore Processing Manager	Degree / Diploma preferably in the fields of Extractive or Chemical Engineering
Process Manager (Gold / Processing / Tailings / Laboratory (West Africa)	Metallurgical or Chemical Degree or Diploma (BSc degree, HND Extractive Metallurgy or similar)
Senior Planners	Mineral Processing Candidates should be proficient in Primavera 6 and MSP software
Process Superintendent (DRC)	Degree/Diploma Metallurgy/Mineral Processing
Process Operator Plant (SA)	National Certificate Mineral Processing Level 1 or equivalent Minerals Processing Qualification
Fitter or Millwright Mineral (SA)	Millwright/N3 Trade Papers
Processing project manager (SA)	Tertiary qualifications in related technical fields such as commerce, engineering, or construction
After Sales and Services Unit Manager (SA)	Mining equivalent relevant Degree is essential
Business Development / Sales Manager (SA)	Diploma or Diploma in a relevant Technical Sales discipline is essential

Plant Manager (SA)	National Diploma or Engineering Degree (Metallurgy / Chemical)
Mineral Processing Specialist (SA)	B.Sc. Metallurgical Engineering / Chemical Engineering,
Repair Centre Manager (Pumps / Repairs / Business Development / Fabrication)	Engineering Degree, Diploma or similar qualification.
Procurement & Sourcing Manager	BSc or BEng with a solid track record in Supply chain and Sourcing and Procurement
Technical Sales Specialist	Degree or diploma in a suitably technical discipline is essential
Marketing Manager	B Com Marketing/or Mech Eng)
Quality Assurance Engineer-Copper Casting	BSc in Engineering/Science Discipline
Environmental Officer	B. Degree in Environmental management or B. Tech in Environmental Management
SHEQ Manager -	National Diploma in Quality Management or Safety Management
Instrument Mechanician	Mechanic Trade Test Certificate

ANNEXURE C: SNAP-SHOT OF TRENDING SADC POSITIONS IN THE PHARMACEUTICAL VALUE CHAIN, MAY 2020

Position	Required qualifications
Quality control analyst (Malawi)	BSc in Chemistry, BSc in Biology or BSc in Environmental Science
IT Support Engineer	(Cloud and Security) BSc Computer Science preferred Certifications such as MCP, MCSE, MCSA, CCNA, CCNP, CISSP, CISM will be preferred
Medical Scientific Specialist (Oncology)	Coastal RegionsM.Sc / PhD / MBChB or related scientific qualification HPCSA / SAPC registered
Pharmaceutical Technical Learning Facilitator	National Diploma / Bachelors in biotechnology / chemical engineering or related
Pharmaceutical Sales Representative Generics	BCom or BSc Degree

Pharmaceutical Specialist Manager	Master Degree in Public Health
Quality Manager - Pharmaceutical Manufacturing	Degree in Microbiology/Biology and or equivalent • Sound QMS, ISO 13485, ISO 9001, ISO 17025 and IVD Directive experience
Manager - Pharmaceutical Manufacturing	MBA adds value but only if coupled with experience • GMP manufacturing experience preferred
Mechanical Technician (Pharmaceutical)	Qualified Mechanical Technician
Medical Sales Specialist	Related tertiary education. Proficient on MS Office and SALSA Basic selling skills Customer/relationship development
Operations Manager Pharmaceutical Industry	Matric or Equivalent Business/marketing related tertiary education
Engineering Manager Pharmaceuticals	Degree in Mechanical/Electrical Engineering or equivalent
Distribution Warehouse Manager Pharmaceutical Industry	Degree in Logistics will be an advantage
Senior Buyer (Pharmaceutical)	valid relevant Tertiary qualification
Lab Supervisor (pharmaceutical Company	BSc Microbiology
Manager Pharmaceutical Manufacturing	BSc in the Engineering or Life Sciences
Pharmaceutical Product Development Manager	Health Science qualification or Commercial Bachelor's Degree B.Comm or relevant Business Degree/Diploma
Production Technician– Pharmaceuticals	Relevant qualification
Test Officer: Pharmaceutical Chemistry	B Degree / National Diploma in Chemistry or a related discipline
Pharmaceutical Brand Manager	B Pharm/ relevant medical degree
Responsible Pharmacist	Pharm degree • Registration as a pharmacist with the South African Pharmacy Council (internship and community service completed

	in South Africa) • Proficient computer skills in Ms Office, Word, Excel and PowerPoint

ANNEXURE D: OFFICIALLY DESIGNATED CONTACT PERSONS FOR FURTHER ENGAGEMENT IN THE HIGHER EDUCATION SECTOR

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