MAUN SCIENCE PARK:

Digitization in the agricultural sector of Botswana - curse or blessing?

Hannes Heckel, [redacted]

HTWG Constance | WIM 7 | Project Thesis

Table of Contents

List of Figures

List of Shortcuts

HDFS	Hadoop Distributed File System
IoT	Internet of Things
ASF	Apache Software Foundation
PaaS	Platform as a Service
IaaS	Infrastructure as a Service
SaaS	Software as a Service
CPI	Corruption Perceptions Index
GDP	Gross Domestic Product
MSP	Maun Science Park
GHI	Global Hunger Index
EDI	Enabling Digitalization Index
IMD	World Digital Competitiveness ranking
BMEL	Federal Ministry of Food ans Agriculture

Obligatory Declaration of Academic Integrity

I, Hannes Heckel (matriculation number: [redacted], hereby assure that I have written this scientific paper entitled "Maun Science Park: Digitalization in the Agricultural Sector - Curse or Blessing? "and that I have not used any sources or aids other than those indicated, that all statements taken verbatim or in spirit from other writings are clearly indicated, and that the work has not yet been part of a course or examination in the same or a similar version.

Hannes Heckel

Constance, 22.06.2022

1. Introduction

A self-sufficient, sustainably managed and ultra-modern district in Botswana - the heart of Africa - seems at first to be a utopian goal to outsiders. Too many people still think of Africa in terms of wild animals and untouched nature. However, such utopian goal is exactly the vision that an international research team, consisting of scientists and students from various universities and research institutes, is pursuing worldwide. As Nelson Mandela once said: „vision without action is just a dream, action without vision just passes the time, and vision with action can change the world." [1] Under the name "Maun Science Park", a blueprint for a self-sufficient, sustainably managed district using highly modern technology is to be created for Africa and the whole world.

1.1. Problem Definition

The autarky of a district depends on many factors. One of the most crucial factors, besides financial factors, is the independence in food production and food acquisition. Sustainable and efficient agriculture could serve as a cornerstone of autarkry. However, Botswana consists largely of the Kalahari Desert. Rainfall is low and the climate is very dry. How can agriculture be made efficient and sustainable despite these quite difficult, weather conditions? One possible solution is: Digitization of the agricultural sector.

1.2. Aim

The aim of this paper is to demonstrate the importance of agriculture and how it can be made even more sustainable and efficient through the benefits of digitization. As a basis for this, agriculture and digitization are first illuminated in general and then placed in context. Furthermore, the integration of digitalization in agriculture will be described and illustrated and discussed on the basis of a concrete use case.

[1] (AlOlaimy, 2013), downloaded 01.04.2022

1.3. Procedure

Right at the start, in order to create a basic understanding of the country and the culture, Botswana at large will be discussed. The importance of agriculture and digitalization in Botswana and the problems that exist will also be examined. In addition, digitalization and Big Data, as well as the importance of their analysis and extraction, and their exponentially increasing relevance that will continue to exist in the future, is going to be illuminated. Subsequently, the role played by Cloud Computing during these processes and, ultimately, the integration of digitalization in agriculture will be addressed and discussed on the basis of a concrete case of application.

2. Botswana

The Republic of Botswana, also known as Botswana, is located in southern Africa. The name is derived from the "Tswana" people, who make up the majority of the population in the country of Botswana. The national language is English, but Setswana is also widely spoken. Botswana is a landlocked country and borders Zambia to the north, Zimbabwe to the east, South Africa to the south and Namibia to the east.

Figure 1 Map of Botswana (Source: Overcross, 2014)

The country covers an area of approximately 581,730 square kilometers. With about 2.3 million inhabitants, which corresponds to about four inhabitants per square kilometer, Botswana is one of the most sparsely populated countries in the world. [2] A similar number of people living in Paris live in an area about the size of France.

Botswana gained its independence from the British in 1966 and since then has had a free democratic system and a government legitimized by regular elections. The government is led by Head of State and Government Mokgweetsi Masisi. The most important goals of domestic policy are to strengthen democracy, reduce youth unemployment and eliminate poverty. [3] The high diamond income and the democracy that has prevailed since 1966 have made the country one of the most financially and politically stable and secure countries in Africa. With a CPI, Corruption Perception Index, of 55, Botswana ranked 45th out of 180 countries worldwide in 2021 and second next to the Seychelles in Africa among the countries with the highest integrity. [4]

Another special feature of Botswana and unique in the world is that 40 percent of the country is under conversation. [5] The most famous nature reserve, the Okavango Delta,

[2] (botswana.eu, 2022), downloaded 01.04.2022
[3] (Auswärtiges-Amt, 2022), downloaded 01.04.2022
[4] (Transparency-International, 2022), p.2
[5] (Overcross, 2014), downloaded 01.04.2022

is the largest inland delta in the world and is considered as one of the most beautiful and species-rich nature reserves in Africa. Since 2014, the Okavango Delta is a UNESCO World Heritage ~~Site~~. With the Chobe National Park, Botswana established the largest national park in Botswana in 1967. Because of its immense elephant population, the national park gained great fame far beyond the country's borders. [6] Another natural spectacle is the Makgadikgadi Pans National Park. This is home to one of the largest salt pans in the world. [7] The Okavango Delta, the Chobe National Park and the Makgadikgadi Pans attract numerous tourists from all over the world every year.

With an average of 4 inhabitants per square kilometer, the country is one of the most sparsely populated in the world. The geographical distribution of Botswana's population is very uneven. Almost 60 percent of Botswana's inhabitants live in cities, and more than three quarters are concentrated in a narrow strip in the east of the country. [8] Among others, the capital Gaborone with 230,000 inhabitants, Francistown with 100,000, Molepolole with 67,000, Mogoditshane with 60,000, Lobatse with 30,000 and Selebi Phikwe with 50,000 inhabitants are located there. This makes Botswana one of the most urbanized countries in Africa. [9]

Rang	Land	Urbanisierungsgrad in % der Gesamtbevölkerung	Jahr
1	Monaco	100%	2018
74	Ungarn	71,4 %	2018
75	Irak	70,5 %	2018
76	Italien	70,4 %	2018
77	**Botswana**	**69,4 %**	**2018**
78	Ukraine	69,4 %	2018
79	Bolivien	69,4 %	2018
80	Estland	68,9 %	2018

Figure 2 Degree of urbanization in percent (Source: Weltbank, 2019)

[6] (Berger, 2019), downloaded 01.04.2022
[7] (info-botswana, 2022), downloaded 01.04.2022
[8] (botswana.eu, 2022), downloaded 01.04.2022
[9] (Weltbank, 2019)

2.1. Climate

Botswana is located in the southern hemisphere in the center of the South African continent and has a subtropical semi-desert climate. The semi-arid climate means that on average precipitation is lower than evaporation. The dry season can last between six and nine months. In total, the annual precipitation in Botswana is between 250 and 500 millimeters. During the summer months, temperatures range from 30 to 35 degrees Celsius during the day, while during the winter months temperatures range from 20 to 25 degrees Celsius during the day. At night, temperatures can reach around freezing point. [10]

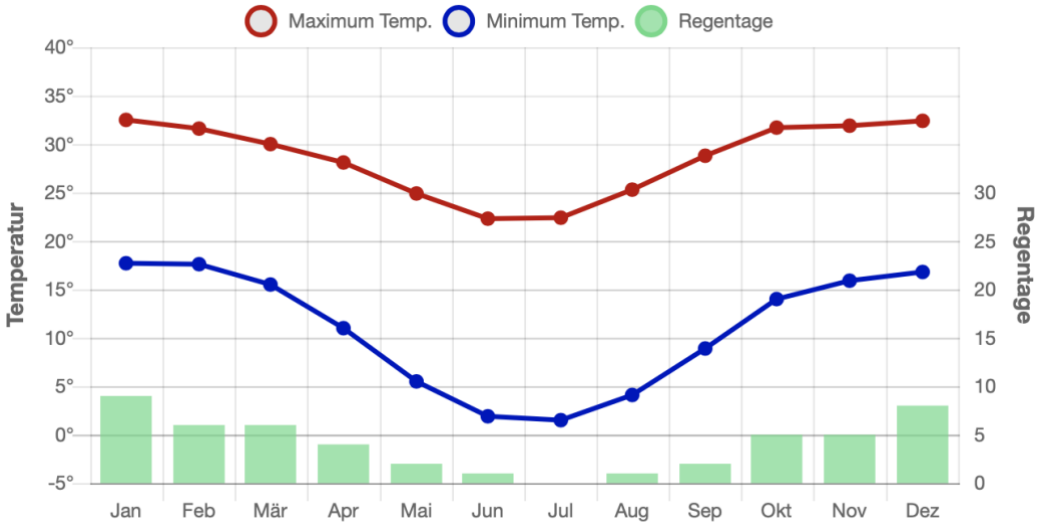

Figure 3 Climate diagram Gaborone (Source: Wetter Kontor, 2022)

Climate change is accompanied by many problems and poses major challenges for Botswana. Agriculture is strongly affected by the increasing drought and the increased occurrence of climatic disasters, such as extreme cold but also severe heat waves. There are increased crop failures and weak yields. The water supply in Botswana is also threatened by climate change. Rising temperatures and stagnating rainfall are making it more difficult for groundwater to recharge, which is currently the main source of drinking water in the villages.

[10] (Wetter-Kontor, 2022), downloaded 01.04.2022

2.2. Economy

Botswana has long been considered one of the 25 poorest countries in the world. [11] The country developed from an ivory exporting region to a corn growing and cattle breeding area for the British market, to a labor force exporter to South Africa. About two-thirds of the male population was employed in South Africa. The economic boom came with the discovery of diamond deposits. Further deposits let Botswana become the African state with the lowest debt rate and the strongest currency by 1990. Meanwhile, 70 to 80 percent of Botswana's foreign exchange earnings come from diamond exports.[12]

Figure 4 Botswana: Gross Domestic Product (GDP) per capita at current prices from 1980 to 2020 and projections to 2026 (Source: Statista, 2021)

In 2016, the government launched an economic restructuring with the Vision 2016 project, since the risk of an economic crisis was too high due to the strong dependence on the diamond market. Especially since the diamond deposits are not inexhaustible. Now, the search for further mineral resources is to be intensified, tourism is to be further promoted and jobs are to be created in agriculture.

[11] (Africa-Business-Guide, 2022), downloaded 03.04.2022
[12] (botswana.eu, botswana.eu, 2022), downloaded 03.04.2022

2.3. Education

The education sector is one of the crucial points of Botswana's development policy. The dependence on foreign specialists is too strong in many areas of society. As a countermeasure, more than 27 percent of the state budget is being invested in the education sector.[13] Although there is no compulsory schooling, there is now a 95 percent enrollment rate. Of these, 70 percent complete elementary school. In about 600 elementary schools nationwide, children can complete seven years of elementary school free of charge. Afterwards, they can obtain a higher education entrance qualification in a further five years at one of the 130 secondary schools. In secondary school, fifty euros in tuition is charged per school year.[14] In Botswana's education system, girls and boys have equal access to education.

In recent years, the number of students with university entrance qualifications has risen from just under 10,000 (2009) to more than 16,000 (2016). The majority of students are enrolled at the University of Botswana in the capital Gaborone. Approximately 13,000 students can complete their degrees here at the bachelor's, master's or even PhD level. The second major state university is the Botswana International University of Science and Technology. This educational institution offers space for about 6,000 students. The universities focus on mining, IT, manufacturing and production technology, materials science, biotechnology, civil infrastructure and agricultural sciences. [15]

[13] (Auswärtiges-Amt, 2019)
[14] (botswana.eu, botswana.eu, 2022), downloaded 03.04.2022
[15] (DAAD, 2022), downloaded 03.04.2022

The literacy rate in Botswana was 86.8 percent in 2013 (see Figure 5). [16] This figure is one of the highest in all of Africa and is expected to continue to rise in the coming years.

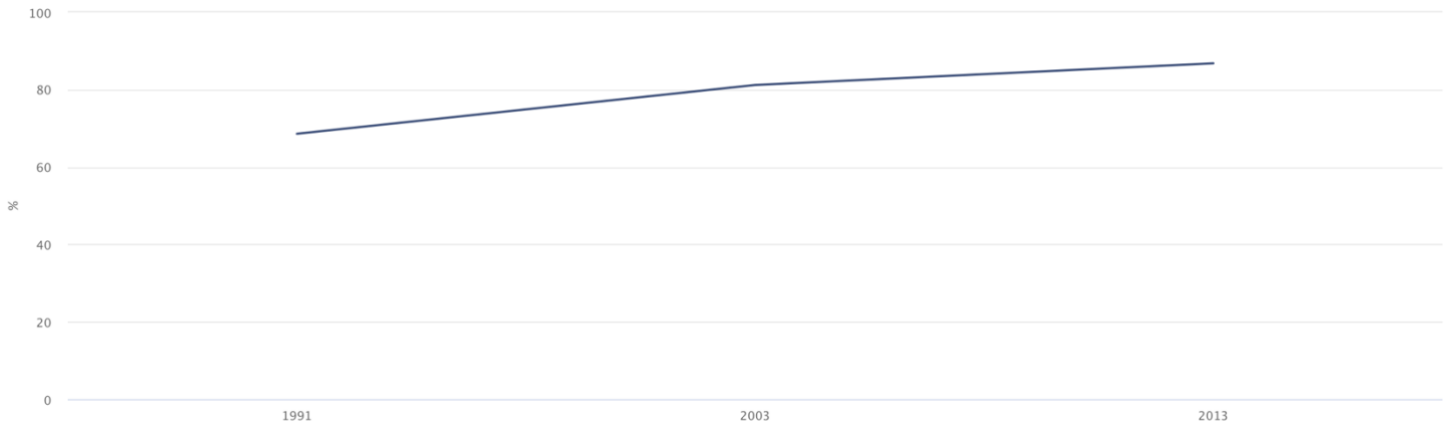

Figure 5 Percentage of the population over 15 that can read and write. (Source: Weltbank, 2022)

The government's work over the next few years will focus on significantly improving the quality of education by reforming the school system, starting with better preschool education (kindergarten and preschool). [17]

[16] (Tilasto, 2022), downloaded 03.04.2022
[17] (Auswärtiges-Amt, 2019)

3. Maun

Maun is the capital of the North West District and is located in the north of Botswana. With more than 60,000 inhabitants, it is one of the largest cities in Botswana. The geographical proximity to the Okavango Delta and Chobe National Park power makes Maun the hub for safaris. In addition to an airport, there is also a field station of the University of Botswana and the Okavango Research Center. They conduct a research and science center for the Okavango Delta. This is intended to increase understanding of the wilderness and the wildlife. In addition, Maun is to become the home of the Maun Science Park.

Figure 6 Map of Maun and surroundings (Source: info Botswana, 2022)

3.1. Maun Science Park

Under the name "Maun Science Park", a pioneering project is to be realized in Maun. A blueprint for a self-sufficient, sustainably managed district for Africa and the whole world, equipped with highly modern technology and infra-structure as well as research and educational facilities. The Maun Science Park is designed to counter emerging conflicts and enable coexistence between people and wildlife. "An international exchange between the population, companies, students and scientists from all over the world forms the basis of the project." [18]

The residents are to live, research and develop the ecological interplay between humans and the environment in a kind of real laboratory. [19] The MSP Smart Living Lab, or L.Lab, is a pilot project consisting of 25 smart homes to test innovative

[18] (HTWG, 2020), downloaded 04.04.2022
[19] (HTWG, 2020), downloaded 04.04.2022

technologies to improve the quality of life of residents and to increase the efficiency and operation of their community.[20]

Another building block of the MSP will be the MSP School of Design and Engineering, short a.school. The school will be established in cooperation with the Ministry of Education and is expected to become one of Africa's leading schools for design and engineering. In close cooperation with universities worldwide, the school will focus on further developing and improving the technologies developed and used at L.Lab. The a.school will develop solutions for social and technological change and will be located directly on the grounds of the Maun Science Park. [21]

In addition, the MSP Business Incubator is to be established on the MSP site. This is intended to facilitate the development of start-ups that develop intelligent life solutions. By facilitating contacts and providing financing, management and consulting services, the start-ups can grow and develop new sustainable technologies. [22]

The project has an impact on many areas of the residents' lives as well as on the infrastructure of the city of Maun:

- **Energy:** Sustainable energy production and efficient energy use.
- **Agriculture:** Providing an independent food supply, utilizing the high economic potential of the area.
- **Construction:** Development of sustainable housing units from regional building materials
- **Waste:** Environmental protection through reuse and recycling, minimization of waste production.
- **Water:** provision of clean water, recycling of dirty water
- **Health:** Expansion of health care system, prevention of diseases

[20] (Maun-Science-Park, 2022), downloaded 04.04.2022
[21] (Maun-Science-Park, Maun Science Park, 2022), downloaded 04.04.2022
[22] (Maun-Science-Park, Maun Science Park, 2022), downloaded 04.04.2022

4. Agriculture

The Gabler Wirtschaftslexikon defines agriculture as "economic activities in which soil and livestock are involved as production factors alongside labor, capital and know-how, and whose central outputs are agricultural products." [23] In addition to growing food and animal feed, agriculture also includes the breeding of livestock and forestry.

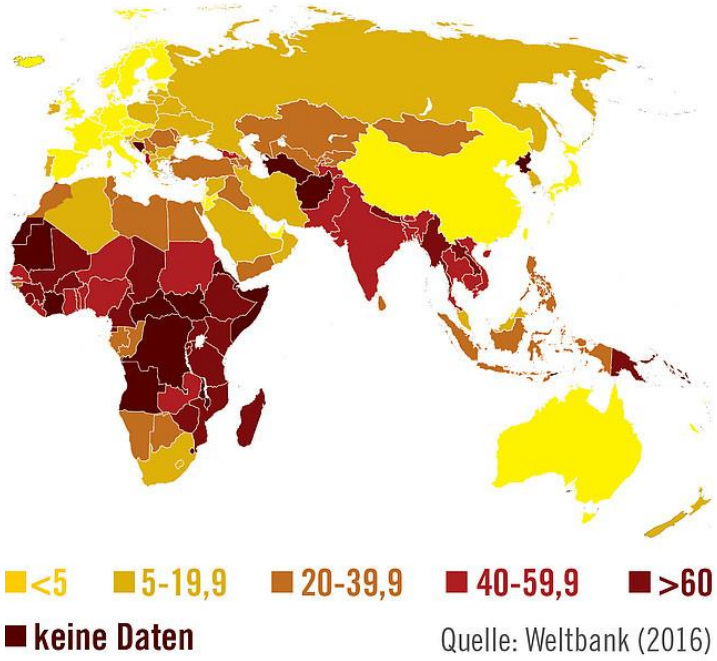

Figure 7 Percentage of all employees working in agriculture in 2011 - 2015. (Source: Weltbank, 2016)

Agriculture is one of the most important growth and future industries in the world and is still the most vital source of income as well as the largest economic sector in the world today. One third of all working people are employed in agriculture. [24] In view of the steadily growing world population and limited fossil energy sources, its importance for the safe supply of food as well as for the production of energy from renewable raw materials will continue to increase. Agriculture contributes not only quantitatively but also qualitatively to the improvement of the food situation. Whereas at the beginning of the twentieth century a farmer produced just enough food for four people, by 1950 he was feeding ten. Today, thanks to modern production methods, one farmer feeds about 140 people. [25] Modern sustainable agriculture, in addition, is even able to reliably produce high-quality products even under adverse conditions.

Modern agriculture has set itself the goal of sustainably increasing yields without being able to open up significant amounts of new agricultural land. On the contrary, it tries to make intelligent and sustainable use of the land at its disposal and

[23] (Berwanger, 2022), downloaded 13.04.2022
[24] (Weltagrarbericht, 2022), downloaded 13.04.2022
[25] (Industrieverband-Agrar, 2022), downloaded 13.04.2022

contributes to the preservation of natural areas worthy of protection, such as forests, moors and grasslands. In addition, modern agriculture stands for the preservation and maintenance of cultural landscapes.

4.1. Agriculture in Botswana

The total percentage of arable land has declined slightly since 2000. In 2019, the total area of arable land on the planet reached 4.75 billion hectares. Just under 1.57 billion hectares of this is agricultural land, mainly for growing grain or animal feed. 3.2 billion hectares are used for grazing. It is interesting to note that despite this negative global trend, agricultural land in the tropics has grown in recent decades. Closely linked to this is the growing share of tropical countries in global agricultural production and the consequence that "tropical countries [...] are becoming increasingly important in the production of agricultural goods and the world's food supply." [26]

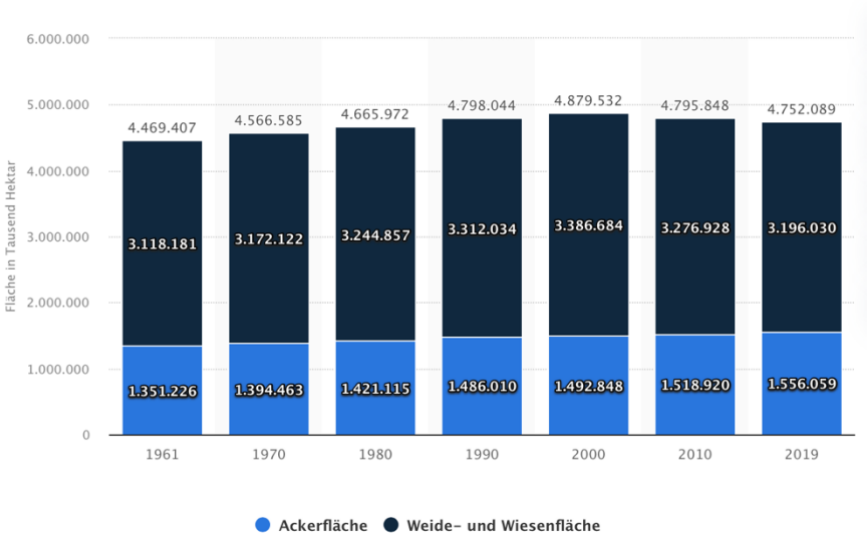

Figure 8 Development of global cropland and pasture land area from 1961 to 2019. (Source: Statista, 2022)

In Africa, 57 percent of the population lives in rural areas and 53 percent depend on agriculture for their subsistence. [27] In Botswana 40 percent of the working population is engaged in agriculture, while agriculture accounts only for 2 percent of GDP. Therefore, almost half of the working population generates only a small part of the GDP [28] which illustrate the underutilized high potential of agriculture in Botswana. As

[26] (Statista, 2022), downloaded 13.04.2022
[27] (Weltagrarbericht, 2022), downloaded 13.04.2022
[28] (botswana.eu, 2022), downloaded 13.04.2022

a consequence, the government launched plans under the name Vision 2016 to restructure agriculture in Botswana. Through flood regulation in the Okavango Delta and increased cultivation of millet and maize, the GDP is to be increased. [29]

The majority – nearly 80 percent – of agricultural activities in Botswana are based on cattle breeding. However, cattle breeding has proved to be problematic as it is the main reason for the overgrazing of agricultural land, some of which is already barren, and thus for the further spread of deserts.
In addition to meat production, the difficult soil and climatic conditions offer few opportunities for the cultivation of pulses, corn and cereals. Furthermore, many areas of the country do not allow for intensification of agriculture due to their climatic conditions. As a consequence, Botswana is dependent on large quantities of food imports from South Africa, as crop yields are insufficient to feed the population. [30]

Another problem in the agricultural sector is its inadequate infrastructure. The lack of roads, warehouses and processing facilities is associated with the loss of about 40 percent of the local food produced in Africa. [31] Thus, the expansion of infrastructure is considered a promising development potential for the Republic of Botswana in order to ensure economic stability and fight hunger in the future. In the 2021 Global Hunger Index, Botswana ranks 88th out of 116 countries for which sufficient data is available to calculate the 2021 GHI scores. With a GHI score of 23.2, Botswana falls into the "severe" category. [32]

4.1.1. Water Supply

In 2016, Botswana's total water demand was approximately 170 million cubic meters. It can be assumed that water demand has steadily increased since then. Of the total 201 million cubic meters of water withdrawn from the environment, the water supply industry accounted for about 48%, or 96 million cubic meters, while the remaining 52%, or 105 million cubic meters, was withdrawn directly by self-suppliers. Thus, about 95%

[29] Cf. (botswana.eu, 2022), downloaded 13.04.2022
[30] Cf. (lernhelfer.de, 2022), downloaded 13.04.2022
[31] (Chimtom, 2015), downloaded 13.04.2022
[32] Cf. (Welthunger-Index, 2022), downloaded 13.04.2022

of the population has access to drinking water. [33] However, these sources are limited in quantity and quality and are very unevenly distributed throughout the country. The largest available surface water resources are in the eastern and northeastern parts of the country, while the majority of the population lives in the southeastern part of the country. This is also where most of the fertile arable land is located. [34]

The agriculture sector used the largest amount of water in 2016 with 83 million cubic meters, which accounts for 48 percent of total water use in Botswana. The second largest water users were households at 23 percent, mining at 16 percent, other industries at 7 percent, and government at 6 percent. [35]

Persistent droughts as a result of climate change have also led to serious water supply problems in southern Africa, with increasingly severe consequences not only for agriculture but also for the population directly. In Botswana, rainfall has recently been well below the long-term average. As a result, most of the large reservoirs are currently only at 10-30 percent of their capacity. [36] Many rivers carry very little water or are completely dry. The aquifers are also being overused. Due to the dry climate, Botswana currently relies for about two-thirds of its water on fossil water reserves, which are located at depths of 40 to 70 meters beneath the Kalahari. The increasing consumption of these non-regenerating reserves poses a major challenge for the future. More water is being withdrawn from them than is being replenished via natural recharge.

Botswana's renewable water resources are 50 percent dependent on other countries, meaning that the country must share most of its surface water resources with its neighbors. The most important water sources are the Rinpopo, Chobe, Zambezi and Cubango rivers in the north of the country. [37] Due to climatic factors such as the high evaporation rate in the adjacent wetlands and reservoirs, the low total precipitation, as well as the large temporal and local variations in precipitation, the amount of water leaving the land is less than the amount flowing into it. This significantly limits the amount of available water resources. The effects of these factors are expected to be

[33] (Statistics Botswana, 2016), downloaded 13.04.2022
[34] (botswana.eu, botswana.eu, 2022), downloaded 13.04.2022
[35] Cf. (Ministry of Land Management, Water and Sanitation , 2017)
[36] (Bundesanstalt-Geowisschenschaften-Rohstoffe, 2018), downloaded 13.04.2022
[37] (FAO, 2013)

exacerbated by climate change. Furthermore, the annual water demand of 340 million cubic meters in 2035 is expected to exceed the country's projected available water resources. [38]

4.1.2. Land Areas

The largest part of Botswana's land area, with almost 80 percent, is occupied by the desert and semi-desert region of the Kalahari.[39] However, this desert and semi-desert area does not exclude agricultural use. In 2018, approximately 260,000 of the country's 581,730 square kilometers were used for agricultural purposes. [40] This corresponds to 45 percent of Botswana's total area. However, only about 20 percent of the country's land is suitable for grazing and cattle breeding and fertile farmland exists only on the border with South Africa, where most of the population lives. [41]

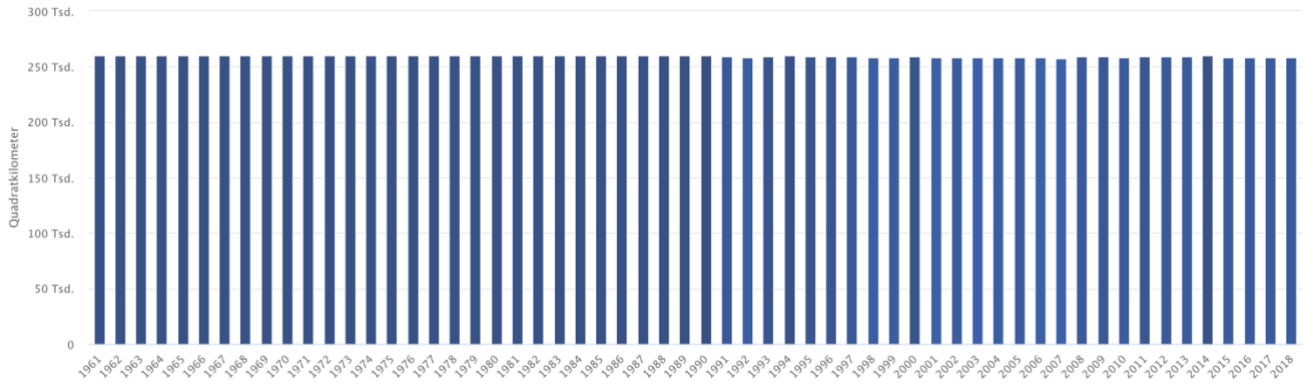

Figure 9 Botswana agricultural land in square kilometers from 1961 to 2018. (Source: Tilasto, 2022)

The high level of agricultural activity in cattle breeding (almost 80 percent) on only 20 percent of the agriculturally used land, as shown in Chapter 4.1, once again demonstrates the immense development potential of agriculture and, in particular, the cultivation of food and animal feed.

[38] Cf. (Borgwardt & Endress, 2022)
[39] (botswana.eu, botswana.eu, 2022), downloaded 14.04.2022
[40] (Tilasto, Tilasto, 2022), downloaded 14.04.2022
[41] (botswana.eu, botswana.eu, 2022), downloaded 14.04.2022

5. Digitization

"In the next ten years, we will be at a point where almost everything is digitized." [42]. As early as 2013, the CEO of Microsoft, Satya Nadella, recognized the explosive nature and great development potential of digitization. Nadella was right: it is the year 2022 and more fundamental structures are being revolutionized by technological developments than ever before. Digitization has long since made its way into private life, business and industry.

5.1. Definition

But what is digitization? In simplified terms, digitization can be understood as the transformation of analog processes into digital ones. In concrete terms, this means that more and more processes, events or even production steps are controlled by computers, that data and databases as well as networks play a major role and that previous analog structures are being disruptively changed. [43] Characteristics of digitization are the virtualization and networking of the real world, the sharing of data and the platform-based organization of supply chains. What is special about this is that data and data models are not subject to physical wear and tear and can therefore be used simultaneously and repeatedly by several players. At the same time, this opens up a high scalability of business models and their organization via platforms. [44] A platform on the Internet is, in the narrower sense, an Internet network that enables its members to use a wide variety of functions, such as chat systems, file-sharing networks, or even forums. [45] These include social networks but also the SAP systems of large companies.

Digitization is fundamentally changing society. Most people today own a smartphone, use ~~a~~ social network, or order a product from Amazon. The latest weather and traffic data can be accessed via various digital devices. In addition, homes have a voice

[42] (Mittelstand 4.0, 2020), downloaded 25.04.2022
[43] Cf. (Oxford Languages, 2022), downloaded 25.04.2022
[44] Cf. (Bundesministerium für Wirtschaft und Klimaschutz, 2022), downloaded 25.04.2022
[45] (exporo, 2022), downloaded 25.04.2022

assistant or intelligent systems for monitoring and controlling lights, heating, and blinds.

Digitization has also made its way into the economy. The so-called "Industry 4.0" has long since indicated the digital transformation. In concrete terms, this means that more and more processes, procedures and also production steps are being controlled by computers, that data, databases, as well as networks, are playing a major role and previous analog structures are being broken up and changed.

Developments in the field of digitalization are offering new opportunities in almost all areas through innovative technologies such as the Internet of Things, or IoT for short, which is the networking of computing devices embedded in everyday objects via the Internet allowing them to send and receive data. Furthermore, digitization is creating entirely new ways of doing things that did not exist before. New technological advances are creating new jobs, globalizing societies and markets, and breaking up entrenched, conservative structures. [46]

According to the Federal Ministry of Economics and Climate Protection, a distinction can be made between four dimensions of digitization. [47]

- **Digital products:** non-physical data-based services that - alone or embedded in physical goods - provide benefits to a customer
- **Digital processes:** data-based representation of reality for the organization and control of processes
- **Digital networking:** extent to which individual processes are connected in digital overall systems
- **Digital business models:** Digital products are provided to customers for a fee

"Digitalization is penetrating almost every area of our lives and offers us opportunities - but also some risks. That's why it's so important to be able to deal with digital transformations and the world in digital transition." [48]

[46] Cf. (studihub.de, 2021), downloaded 25.04.2022
[47] (Bundesministerium für Wirtschaft und Klimaschutz, 2022), downloaded 25.04.2022
[48] (studihub.de, 2021), downloaded 25.04.2022

5.2. Big Data

„Data is the new gold. And analytics is the machinery that mines, molds, and mints it.” [49] This quote from Peter Ghavami illustrates the relevance of data and its processing in today's society.

Large amounts of data are generated every day. Almost everyone owns a smart phone, and even machines are fully automated and monitored. Almost every area of life generates and processes data, which means that the amount of data generated is increasing exponentially. This huge amount of data is called Big Data. The challenge that arises from this constantly growing flood of data is to generate and process data in such a way that meaningful information can be extracted from it. This extraction falls under the term "Big Data Analytics".

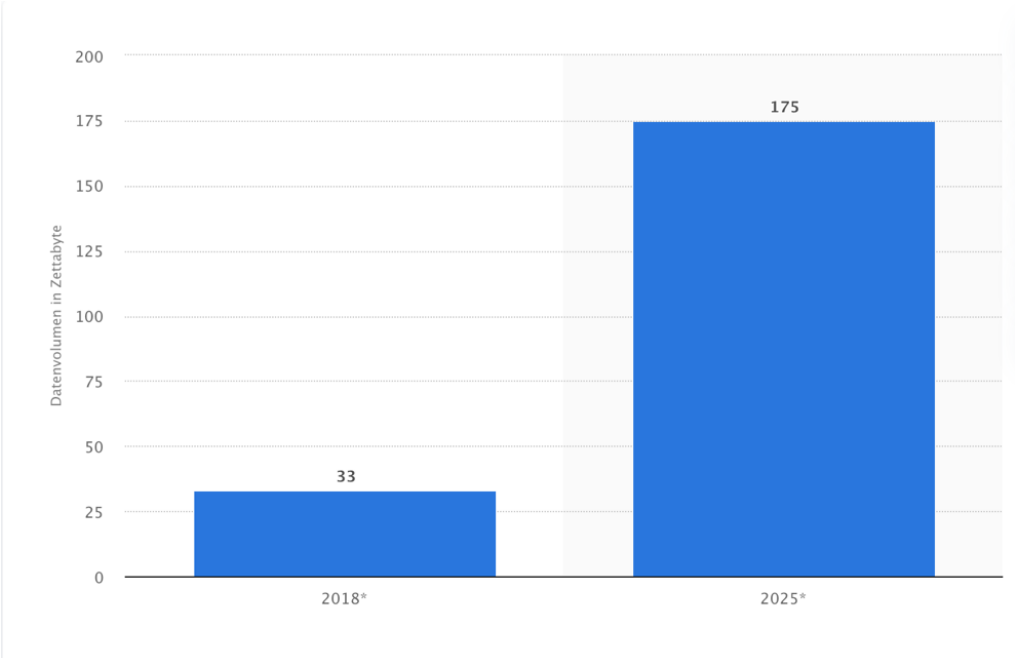

Figure 10 Forecast of the volume of digital data generated annually "Big Data" worldwide

[49] (Ghavami, 2020), p.3

5.3. Big Data Analytics

„Big data is high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation.” [50]

This definition of "Big Data" covers only a small part of the overall meaning. In fact, Big Data can be divided into three major key attributes, the "three V's". The name comes from the English terms volume, velocity and variety. [51]

The term “volume” refers to the amount of data that is generated or already exists. This can mean entire data sets, tables, processes, or just individual data. However, for most companies, the amount of data is no longer measured in gigabytes, but in terabytes and higher.

When we talk about “velocity”, we mean the speed with which the data is evaluated. Many applications, such as autonomous driving, require that data can be evaluated in real time.

“Variety” is used to illustrate the variety of data. Nowadays, this could not be more different since data from different systems come together in different formats and have to be stored. A distinction is made between structured, semi-structured and unstructured or multi-structured data.

In addition to the three key attributes described, further "V's" were added to expand the definition to include additional properties.

The “value” is intended to represent the added value for the company. Since Big Data applications are associated with high investment costs, it is essential for companies to deploy these applications in the right places in order to generate benefits.

[50] (Gartner., 2022), downloaded 01.04.2022
[51] Cf. (Andreas Meier, 2016), p.11 ff.

“Veracity” is used to assess the significance of the data. Since huge amounts of data are available, this does not mean that they are also significant in the specific application.

In the future, big data and big data analytics will play a much more important role than before. The statistics (Figure 10) illustrate how quickly the volume of data is increasing. The figure shows that the amount of data will increase fivefold in just seven years. Many international companies have understood the direction in which the future is moving. Products and machines are becoming increasingly intelligent and are collecting more and more data from their immediate environment. These smart products and smart machines are only the beginning towards the direction of the "Internet of Things". In the future, it is to be expected that not only people will be able to interact with systems or machines, but that they will also be able to interact with each other. As an example, one could assume a machining center that, in addition to its primary capabilities such as turning and milling, independently recognizes when, for example, defective bearings need to be replaced. As a result, the machine can independently order the required bearings or a technician and pay for these services via blockchain technology.

5.4. Cloud Computing

With the unprecedented growth rate of data from various sources - be it social media, government organizations, enterprises, etc. - the challenge of storing and processing these huge amounts of data arises. However, data is one of the most valuable assets for any industry. It would be fatal to not get this data processed or even lose it. Cloud computing" offers a solution to this problem.

The Duden dictionary defines cloud computing as: "The use of IT infrastructures and services that are not kept on site on local computers but are leased as a service and accessed via a network (e.g., the Internet)." [52]

In simple terms, "cloud computing" means providing an IT infrastructure via a network. Examples include computing power, data storage (IaaS), ready-made software (SaaS) and the programming environment (PaaS).

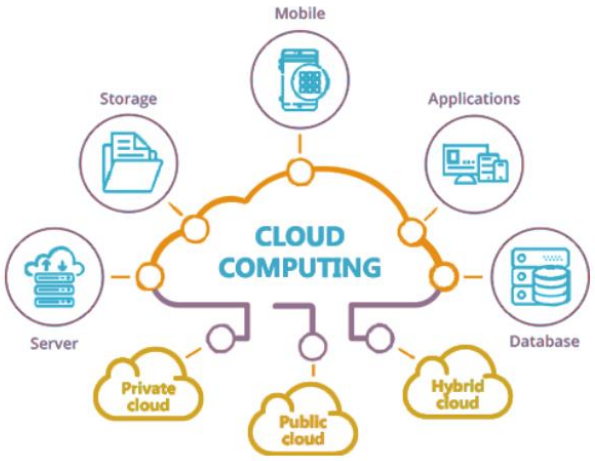

Figure 11 Cloud Computing Model

At the heart of the entire cloud concept is the provision of services as a combination of highly virtualized data centers, the use of modern network technologies and integrated network infrastructure. [53] This is divided into the public cloud, private cloud, community cloud and hybrid cloud. The public cloud is public and is freely available to every user. In the private cloud, the provider is usually also the operator and user of this cloud and is located in the same network as the user. The community cloud is an fusion of several private clouds, which is made available to selected users. The hybrid cloud combines the different cloud types.

[52] (Duden, 2021), downloaded 21.10.2021
[53] Cf. (Christian Metzger, 2011), p.12 ff.

5.5. Digitization in Botswana

Most African countries have a lot of catching up to do in the area of digitization. Botswana is no exception. This is evidenced by a wide variety of indexes. The EDI, Enabling Digitization Index, does not look at the status of digitization implementation, but at the ability of national economies to enable successful digitization. ~~The~~ African countries are in the last quarter of the 115 countries listed. Only South Africa in 51st place is ahead of Botswana (72nd). [54] Another index, the IMD, World Digital Competitiveness ranking, analyzes and evaluates the ability of countries to adopt and explore digital technologies. With a score of 33, Botswana is behind South Africa with 43.64. The ranking is led by the USA with a score of 100. [55] Even though Botswana lags behind in a global comparison, it is one of the most digitally advanced countries in Africa next to South Africa.

Digital progress in Botswana correlates closely with the efforts of the government. The predecessor of the current president, Mokgweetsi Masisi, Ian Khama, established a high-level advisory board to support the government in developing measures to promote the private sector. Digitalization was seen as a decisive factor in these measures. A young politician, Bogolo Kenewendo, was appointed to the panel as a new member in 2017. She was considered a proponent of digitization. In a very short time, Bogolo Kenewendo saw an impressive upswing in her political career. Under Mokgweetsi Masisi, Bogolo Kenewendo rose to the political top and became Minister of Investment, Trade and Industry. As minister, she continuously placed great emphasis on digitization and implemented several projects in this area. One of them is the digitalization of the registration process for companies. The young politician is also a member of the High-level Panel of Digital Cooperation, which is intended to promote international cooperation in the digital age. The panel was established by UN Secretary-General António Guterres and is chaired by Melinda Gates as well as Alibaba founder Jack Ma. [56]

Other government efforts include the intensification of the SmartBots digitization strategy. SmartBots is Botswana's new proposal to drive change in the economy,

[54] (GTAI, 2019), downloaded 03.05.2022
[55] (Statista, Statista, 2022), downloaded 03.05.2022
[56] Cf. (Kayawe, 2019), downloaded 03.05.2022

government and society through a series of strategic initiatives and projects. One of the focus areas of the SmartBots Digitization Strategy is digitization and innovation, as well as participation in the development of data-driven products and services that leverage digital technologies. [57]

[57] Cf. (SmartBots, 2022), downloaded 03.05.2022

6. Digitalization in agriculture

Digitalization has now found its way into all areas of public and private life. This also applies to agriculture. The former German Federal Minister of Food and Agriculture, Julia Klöckner, is convinced that "Digitization is an investment in moving forward, in sustainable agriculture, in the next generation." [58]

The following chapters will explain in more detail the possibilities offered by modern agricultural technologies and how they can be successfully used for future-proof and sustainable agriculture. The opportunities, but also the associated risks in relation to Botswana will also be discussed.

6.1. Agriculture 4.0

The term "Agriculture 4.0" was coined some time ago to describe digitization in agriculture. But what is meant by the term Agriculture 4.0?

Agriculture 4.0 is one and the most modern of the four great agricultural revolutions and is the implementation of digitalization in agriculture. Over time, agriculture has evolved from initial mechanization through hydropower and steam to the digitization of earlier analog technologies and the integration of cyber-physical systems (see Figure 12). According to the German Federal Ministry of Food and Agriculture (BMEL), the term digitization has two meanings. On the one hand, it refers to the transfer of information from analog to digital storage. On the other hand, it describes the automation of processes and business models by networking digital technology, information and people (see Figure 12). The areas of sensor technology, robotics, automation, artificial intelligence and big data are assigned to digitization. [59]

[58] (Bundesministerium für Ernährung & Landwirtschaft, 2021)
[59] Cf. (Bundesministerium für Ernährung & Landwirtschaft, 2021)

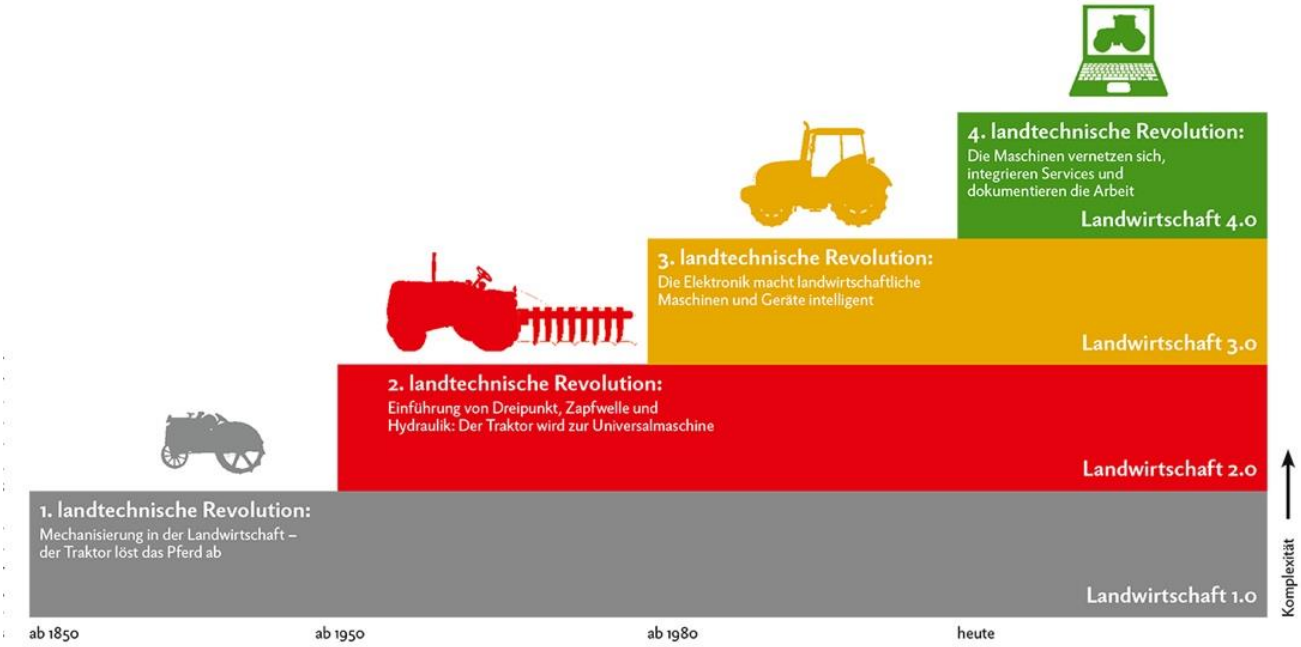

Figure 12 development agriculture to agriculture 4.0

Thanks to digital applications, it is now possible to optimize not only individual process parts, but entire supply chains. It enables the collection, processing and systematic evaluation of ever-increasing volumes of data and offers a wide range of opportunities for livestock farming, arable farming and grassland management. Many farms around the world are already using digital solutions to deploy resources more efficiently, to farm more animal-friendly, to produce high-quality food sustainably and to simplify work processes. These include Farm Management Platforms, Smart Farming, Big Data and the distribution of the food and goods produced. Furthermore, a large part of bookkeeping, funding applications and administration already takes place digitally.

6.1.1. Smart Farming

Smart farming is about networking equipment, machinery and systems as well as creating databases for forecasting and decision support in order to optimize agricultural processes. [60]

[60] Cf. (wirtschaft digital, 2022), downloaded 28.05.2022

Large parts of agriculture are anchored outside in nature. The climate of a region determines which types of fruit and vegetables are grown and which types of animals can be kept. Basically, the climate determines which form of agriculture can be implemented in a region. Precise information about agricultural land, such as soil conditions, water supply and other quality characteristics, as well as weather data, can lead to a more careful use of resources and higher product quality. [61]

For example, sensors are used to optimize many work processes. On the one hand, data about the weather and soil conditions can be collected and evaluated. In addition, sensors can be used to determine the biomass of plant stands. In this way, the use of fertilizers and pesticides can be adjusted in a targeted manner. In addition, information on the plant population and machine data can be collected. Merging the various data allows for a timed and targeted soil cultivation or harvesting process. [62]

Another smart farming measure is the use of drones. These drones can collect a wide range of data and provide farmers with important information about the condition of their fields. Equipped with high-tech cameras, drones fly over several hectares of land in a very short time. Certain color filters allow to draw conclusions about the condition of the plants. Water and fertilizer shortages as well as plant diseases and weeds can also be localized. In addition, the drone is used for crop protection. For example, numerous farms now fly over their corn fields to drop capsules containing eggs of the Trichogramma ichneumon wasp at regular intervals. These wasps are the natural counterpart to a dreaded corn pest. [63]

In the future, harvesting will be fully automated so that farmers can easily monitor the process on a computer and perform quality checks in the field if necessary. Autonomous agricultural robots could be used to independently apply fertilizers and seeds or remove weeds.

[61] Cf. (Bundesministerium für Ernährung & Landwirtschaft, 2021)
[62] Cf. (Bundesministerium für Ernährung & Landwirtschaft, 2021)
[63] Cf. (Bundesinformationszentrum Landwirtschaft, 2021)

6.1.2. Big Data in Agriculture

Agriculture 4.0 means that more and more data is being collected in agriculture. This data must be processed and analyzed in an appropriate manner. This is the only way to derive benefit from the data. This so-called Big Data and the importance of analyzing it has already been explained in detail in chapters 5.2. and 5.3.

Considering the constantly growing world population, the agricultural industry faces the problem of high demand. More efficient methods must therefore be developed to meet future demand. One solution to this could be data collected locally, by individual farmers, in a global database. Big Data enables the simulation of scenarios in very complex systems. The analysis of these huge amounts of data can reveal new relationships and explain complex phenomena. This makes research on agricultural land virtually possible and could lead to more sustainable and efficient agriculture. [64]

6.1.3. Real-time Analytics through Cloud Applications

Chapter 5.4. already dealt in detail with cloud applications and the various cloud types. This chapter will focus on how the cloud application can be used for more productive and sustainable agriculture.

Figure 13 digital structures of agricultural enterprises

Unlike traditional local storage with subsequent analysis, data can be analyzed in real time through a cloud application. You are free to decide whether and with whom you want to share this data and from which location you want to access the data. In terms of agriculture, this means that the data collected through smart farming (Chapter 6.1.1.) and the connected sensors can be evaluated in real time. Via a network, the data is made available for further evaluation. This network (see Figure 13) can then be used to control harvesting robots, drones or sprinkler systems. If the

[64] Cf. (Eser, 2018), downloaded 28.05.2022

temperature is too hot and the soil too dry, the sprinkler system can be triggered automatically. If it is too wet, the sprinkler system can be interrupted until the soil is too dry again.

The collected real-time data can now be bundled in a farm management platform. Examples are the crop yields, the precipitation of the last week or the weather. In the case of a larger agricultural enterprise, communication as well as time recording could be done via a platform, which is an internet network that enables its members to use various functions such as chat systems, exchange platforms or forums. [65] The operator is flexible in the design and in who should access the platform. The presentation can take place as a website or as an app.

The cloud application is therefore crucial for productive and sustainable agriculture, as it makes it possible to flexibly access and evaluate the large amount of data.

6.2. Agriculture 4.0 in Botswana

The previous chapters have dealt in detail with digitalization in the agricultural industry in general. The technologies of Agriculture 4.0 as an example offer many opportunities, such as the sustainable and economical use of resources, the quality of products and increased efficiency of production. However, the technical innovations are also accompanied by some challenges and risks. The following chapters will focus on the opportunities and risks of Agriculture 4.0 in relation to Botswana.

[65] Cf. (EXPORO, 2022), downloaded 28.05.2022

6.2.1. Opportunities

Botswana covers an area of approximately 581,730 square kilometers. With about 2.3 million inhabitants, which corresponds to about four inhabitants per square kilometer, Botswana is thus considered one of the most sparsely populated countries in the world. In addition, Botswana's fertile soils are severely limited and found in the same parts of the country. A balanced distribution of food throughout the country is therefore a major challenge for agriculture in Botswana. Another major problem is, according to expert Ngala Killian Chimtom, a Botswana farmer, ~~is~~ that about 40 percent of the food produced in Africa is lost due to inadequate infrastructure. [66] Also, land degradation of the already few fertile soils, water scarcity, heavy dependence on South Africa, and a share of agriculture in GDP of only two percent [67] are major challenges for agriculture in Botswana. The measures and possibilities of Agriculture 4.0 presented in chapter 6.1. could contribute to an improvement of Botswana's overall agricultural situation.

In addition to the construction of new roads, warehouses and processing plants, digitization/ Agriculture 4.0 could improve the waste of agriculturally produced food. By collecting and analyzing measurement data, it is possible to plan ahead with harvests and crop failures and to initiate food distribution at an early stage. In addition, the exchange across national borders could be expanded and over- and underproduction could be distributed to the surrounding countries. In a exchange or sales platform, farmers or the government could optimize the utilization of production and compensate for crop failures across borders. In addition, a large part of the agricultural enterprises are small farmers. An online platform could help farmers to share their knowledge and experience and benefit from each other. Subsequently, the distribution of food could be more structured, and losses could be reduced to a minimum.

Land degradation due to over-agriculture can also be stopped by digitalization. Through drone flights and measurements of biomass by sensors, early conclusions can be drawn about soil conditions. The sustainable use of the dwindling resource of water can also be optimized through digitization. Once again, drone flights and sensors can be used to determine soil moisture. Dry parts of the field can be distinguished from

[66] Cf. (Chimtom, 2015), downloaded 29.05.2022
[67] (botswana.eu, 2022), downloaded 29.05.2022

moist ones. In this way, the use of water as a resource is reduced to a minimum. The modern technologies can also be used for animal welfare.

By using modern technologies, agriculture becomes more sustainable as resources are used more sparingly and the loss of farm-produced food is reduced. In addition, farming becomes more efficient, and the quality of products improves. Smart farming and real-time analytics through cloud applications can detect potential crop failures early and take action. In addition, plant and animal welfare is increasingly in the foreground, which immensely improves output quality as well as free time gained through measures such as drones and sensors can be used in other projects, such as expanding the farm or developing another source of income. More efficient agriculture would directly lead to less dependence on South Africa and an increase in GDP.

6.2.2. Risks

In addition to the opportunities for digitizing the agriculture in Botswana presented in section 6.2.1., there are also some challenges and risks that need to be overcome.

One is the mobile network. In most cases, the implementation of modern technologies requires a stable mobile network, otherwise the technologies cannot work and communicate smartly with each other. In this context, it is not only the area coverage of the network that is important, but also its quality. Figures 14 to 16 show the network coverage and its quality. Blue stands for 2G, green for 3G, orange for 4G and red for 4G+. It is obvious that the area coverage is distributed very unevenly and is mainly located in cities. The quality is predominantly in the 4G range. The uneven network coverage means that the use of a large number of technologies would only be possible to a limited extent.

Figure 14 network coverage BTC

Figure 15 network coverage Orange

Figure 16 network coverage Mascom

Another crucial point is the investment costs. The acquisition of the required technologies is associated with large costs. Many outdated devices do not have the interfaces for autonomous communication and would have to be replaced. In addition, there are the costs of installing the sensors, acquiring the drones and equipping them with computers. The increased energy consumption due to a large number of electronic consumers must also be financed.

Not to be neglected is Botswana's digital shortfall. Botswana may be one of the most advanced countries in Africa in terms of digitalization. However, it still lags behind in a global comparison. In addition, the country lags behind in education. Yet, the government's investment in education is starting to make an impact. The number of children, young people and adults receiving education has risen sharply (see section

4.2). Nevertheless, the standard of education is still not as high as in Europe. As a result, the population's ability to adapt to modern technologies in agriculture is limited. However, the basic technical understanding and readiness for digitization must be given in order to avoid being overtaxed by the measures, as excessive demands lead to demotivation and ultimately to frustration.

7. Application Example

After an illustrative presentation of Agriculture 4.0, a technically very advanced application example from Germany will now be presented and the feasibility of implementing it in Botswana will be discussed.

Figure 17 BoniRob of the Osnabrück University of Applied Sciences

The BoniRob is an autonomous robot developed for plant phenotyping. Plant phenotyping is described by the German Federal Ministry of Education and Research as "a relatively new branch of plant research in which the appearance (phenotype) of plants is quantitatively analyzed and measured. Researchers record the architecture of roots or the number of leaves, for example." [68] Without the use of pesticides, the BoniRob can push all weeds back into the soil and thus ensure the undisturbed growth of the plants. The BoniRob is a BMEL-funded research project of the Osnabrück University of Applied Sciences in cooperation with experts from various companies. [69] The BoniRob is largely equipped with optical sensors such as laser distance sensors, 3D time-of-flight cameras, light grids, color cameras and spectral imaging. These provide information about the geometry of the plants. In addition, the BoniRob is equipped with complex navigation algorithms to navigate the Roboter across the field without injuring plants. The several sensors collect a large amount of data, which must be analyzed, evaluated, and stored in a database in real time. The data is exchanged via two different networks. [70]

The need for such a robot or similarly complex technologies would exist in Botswana, as it probably does in all agricultural areas around the world. The resource-saving use of pesticides would have a positive effect on soil quality and would be a major step

[68] (Bundesministerium für Bildung und Forschung, 2022), downloaded 14.06.2022
[69] Cf. (Bundesministerium für Ernährung & Landwirtschaft, 2021), p.15
[70] Cf. (Hochschule Osnabrück, 2022)

towards sustainable agriculture. Another advantage would be the time saved compared to the manual weeding or spraying of pesticides. Despite the many advantages already mentioned in chapter 6.2.1, it is questionable whether such complex technologies could already become established in Botswana. The use of such technologies requires a digital infrastructure, such as a nationwide mobile network or the trained handling and analysis of big data. Without a nationwide network, the networks could not work, and the databases could not be accessed. However, these are basic requirements for communication between machine and machine as well as the Internet of Things. It is also questionable whether the population of Botswana is willing to adapt and invest. Despite the high standard of education in Africa, technical understanding is not yet as high as in industrialized nations. Successful implementation of such technologies, however, requires the approval and understanding of the population, since they have to work with the technologies, as excessive demands lead to demotivation and ultimately to frustration.

In Botswana, instead of implementing new and highly complex technologies, existing infrastructure and technologies could be used. For example, remote sensing with satellite systems could be brought to the forefront. Instead of using highly advanced and expensive drones, existing satellites could be used to analyze the ground. In this way, conclusions can be drawn from space about the vitality and biomass of the crop and thus the condition of the plants can be determined. In addition, soil differences can be used to determine the dryness of the soil. [71]

[71]Cf. (Dr. Martin Weis, 2019), p.13 & 14

8. Conclusion

The aim of this project was to identify the opportunities and risks of digitalization in the agricultural sector in Botswana and to discuss them on the basis of a specific application example. To this end, the status quo in Botswana was first worked out and the Maun Science Park was presented in general. Subsequently, the two major pillars of Agriculture 4.0, digitalization and agriculture, were presented and then placed in the context of Botswana.

Returning to the main question of the paper, "Digitization in Botswana's agriculture - curse or blessing?", it can be stated that it is difficult to come to a clear conclusion. The literature research revealed that Agriculture 4.0 certainly has the potential to be the solution for sustainable and self-sufficient agriculture. However, it is difficult to apply it due to the complexity of the agricultural situation in Botswana and the Maun Science Park. The challenges of the climate, the problems in infrastructure and the backlogs in education limit the applicability of Agriculture 4.0 too much.

Thus, the challenges outweigh the benefits. Agriculture 4.0 does not address the main problems of agriculture and food security in Botswana. Although the country grew to become one of the most prosperous countries in Africa due to its strong economic development in recent decades, basic structures are still lacking. For agriculture, these include, regardless of the prevailing climatic conditions, the lack of infrastructure for the operation, cultivation and sale of agricultural products, as well as the lack of political support for agricultural projects and innovations. Only a greatly reduced and simplified form of Agriculture 4.0 would be conceivable and useful at the current time.

Digitization in agriculture is expected to increase in the future. The design of data processing, around Big Data analysis and extraction, will therefore continue to play an increasingly important role in managing the flood of data and thus deriving value from the data generated. Learning how to deal with Big Data in agriculture and creating a digital infrastructure will play an increasingly important role.

Returning to the quote from the introduction, "Vision without action is just a dream, action without vision just passes the time, and vision with action can change the world." [72] it can be emphasized that problems, no matter how utopian they may seem at first, must be tackled if we are to make the world a better place and meet the challenges of the future. It remains exciting to see how Botswana will meet the challenges of agriculture and food security and how the Maun Science Park will contribute as a blueprint for a more sustainable Africa.

[72] (AlOlaimy, 2013), downloaded 01.04.2022

Bibliography

Africa-Business-Guide. (2022). *Africa-Business-Guide*. Von https://www.africa-business-guide.de/de/maerkte/botsuana

AlOlaimy, L. (08.. Dezember 2013). *wamda.com*. Von https://www.wamda.com/2013/12/6-inspiring-quotes-entrepreneurs-nelson-mandela

Andreas Meier, M. K. (2016). *SQL - & NoSQL - Datenbanken.* Springer.

Auswärtiges-Amt. (2019). *Botsuana: Kultur und Bildung*.

Auswärtiges-Amt. (2022). *Auswärtiges Amt*. Von https://www.auswaertiges-amt.de/de/aussenpolitik/laender/botsuana-node/innenpolitik/219548 abgerufen

Berger, S. (01.. August 2019). *skyscanner*. Von https://www.skyscanner.de/nachrichten/inspiration/safaris-die-schoensten-nationalparks-in-afrika

Berwanger, D. D. (2022). *Gabler Wirtschaftslexikon*. Von https://wirtschaftslexikon.gabler.de/definition/landwirtschaft-41331

Borgwardt, H., & Endress, J. (2022). *Conception of a Vertical Farm for the Maun Science Park in Botswana.* Konstanz.

botswana.eu. (2022). *botswana.eu*. Von https://botswana.eu/land-leute/bevoelkerung/

botswana.eu. (2022). *botswana.eu*. Von https://botswana.eu/land-leute/wirtschaft/

Bundesanstalt-Geowisschenschaften-Rohstoffe. (01.. Februar 2018). *BGR*. Von https://www.bgr.bund.de/DE/Gemeinsames/Oeffentlichkeitsarbeit/Pressemitteilungen/BGR/bgr-2018-02-01_wasserversorgung-suedliches-afrika.html

Bundesinformationszentrum Landwirtschaft. (15.. Januar 2021). *Bundesinformationszentrum Landwirtschaft*. Von https://www.landwirtschaft.de/landwirtschaft-verstehen/wie-funktioniert-landwirtschaft-heute/wofuer-braucht-man-drohnen-in-der-landwirtschaft

Bundesministerium für Ernährung & Landwirtschaft. (2021). *Digitalisierung in der Landwirtschaft Chancen nutzen – Risiken minimieren.*

Bundesministerium für Wirtschaft und Klimaschutz. (2022). *de.digital*. Von https://www.de.digital/DIGITAL/Navigation/DE/Lagebild/Was-ist-Digitalisierung/was-ist-digitalisierung.html

Chimtom, N. K. (23.. Dezember 2015). *afrika.info*. Von https://afrika.info/botswana-wachstumsmotor-landwirtschaft/

Christian Metzger, T. R. (2011). *Cloud Computing: Chancen und Risiken aus technischer und unternehmerischer Sicht.* Hanser.

DAAD. (2022). *Deutscher Akademischer Austauschdienst*. Von https://www.daad.de/de/laenderinformationen/afrika/botsuana/ueberblick-bildung-und-wissenschaft/

Duden. (2021). *Duden*. Von https://www.duden.de/rechtschreibung/Cloud_Computing

Eser, A. (27.. September 2018). *Digitale Welt*. Von https://digitaleweltmagazin.de/data-science-in-der-landwirtschaft-wie-wir-mehr-ernte-produzieren-koennen/

exporo. (2022). *exporo*. Von https://exporo.de/wiki/online-plattform/

EXPORO. (2022). *exporo*. Von https://exporo.de/wiki/online-plattform/

FAO. (2013). *Review of World Water Resources by Country.*

Gartner. (2022). *gartner.com*. Von https://www.gartner.com/en/information-technology/glossary/big-data

Ghavami, P. (2020). *Big Data Management.* De Gruyter.

GTAI. (01.. Oktober 2019). *GTAI*. Von https://www.gtai.de/de/trade/afrika-uebergreifend/branchen/digitalwirtschaft-steht-in-afrika-vor-grossen-herausforderungen-163050

HTWG. (28.. Mai 2020). *HTWG*. Von https://www.htwg-konstanz.de/hochschule/magazin/weltraumtechnologie-fuer-nachhaltiges-leben-auf-der-erde/

Industrieverband-Agrar. (2022). *Industrieverband-Agrar*. Von https://www.iva.de/praxis/landwirtschaft-deutschland

info-botswana. (2022). *info-botswana*. Von https://www.info-botswana.com/de/aktivitaeten-und-sehenswuerdigkeiten/makgadikgadi-nxai-pans/makgadikgadi-pans-nationalpark

Kayawe, B. (25.. April 2019). *afrika.info*. Von https://afrika.info/juengste-ministerin-setzt-auf-digitalisierung/

lernhelfer.de. (2022). *lernhelfer.de*. Von https://www.lernhelfer.de/schuelerlexikon/geografie/artikel/wirtschafts-und-sozialraeumliche-struktur-der-republik-botsuana#

Maun-Science-Park. (2022). *Maun Science Park*. Von https://www.maunsciencepark.com/smart-living-lab.html

Maun-Science-Park. (2022). *Maun Science Park*. Von https://www.maunsciencepark.com/school-of-design-and-engineering.html

Maun-Science-Park. (2022). *Maun Science Park*. Von https://www.maunsciencepark.com/business-incubator.html

Ministry of Land Management, Water and Sanitation . (2017). *Botswana Water Accounting Report.* Botswana.

Mittelstand 4.0. (05.. Juni 2020). *Mittelstand 4.0*. Von ttps://www.kompetenzzentrum-planen-und-bauen.digital/kos/WNetz?art=News.show&id=724

Overcross. (2014). *overcross.com*. Von https://www.overcross.com/de/country-info/view/id/46#Politik-Wirtschaft

Oxford Languages. (2022). *Oxford Languages*. Von https://languages.oup.com/google- dictionary-en/

SmartBots. (2022). *smartbots*. Von https://smartbots.gov.bw

Statista. (2022). *Statista*. Von https://de.statista.com/statistik/daten/studie/1196555/umfrage/anbauflaechen-und-weideflaechen-weltweit/

Statista. (18.. März 2022). *Statista*. Von https://www.statista.com/statistics/1042743/worldwide-digital-competitiveness-rankings-by-country/

Statistics Botswana. (15.. August 2016). *Statistics Botswana*. Von https://botswana.opendataforafrica.org/cixonyg?target=Proportion%20of%20population%20using%20improved%20drinking%20water%20sources.%20Age%20group%20Total.%20Sex%20Total.%20Location%20Rural

studihub.de. (12.. Mai 2021). *studihub.de*. Von https://www.studihub.de/digitalisierung-die-besten-30-zitate-und-sprueche/

Tilasto. (2022). *Tilasto*. Von https://www.tilasto.com/land/botswana/bildung-und-wissenschaft/alphabetisierungsgrad-alter-15-und-hoeher-gesamt

Tilasto. (2022). *Tilasto*. Von https://www.tilasto.com/land/botswana/geographie-und-landwirtschaft/landwirtschaftliche-nutzflaeche

Transparency-International. (2022). *CORRUPTION PERCEPTIONS INDEX 2021.*

Weltagrarbericht. (2022). *Weltagrarbericht*. Von https://www.weltagrarbericht.de/themen-des-weltagrarberichts/baeuerliche-und-industrielle-landwirtschaft.html

Weltagrarbericht. (2022). *Weltagrarbericht*. Von https://www.weltagrarbericht.de/themen-des-weltagrarberichts/baeuerliche-und-industrielle-landwirtschaft.html

Weltbank. (2019). *Länder und Territorien sortiert nach Urbanisierungsgrad.*

Welthunger-Index. (2022). *Welthunger-Index*. Von https://www.globalhungerindex.org/de/botswana.html

Wetter-Kontor. (2022). *wetterkontor.de*. Von https://www.wetterkontor.de/de/klima/klima-land.asp?land=bw

wirtschaft digital. (2022). *wirtschaft digital*. Von https://www.wirtschaft-digital-bw.de/aktuelles/thema-des-monats/smart-farming