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The Maun Science Park from a construction perspective

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University: University of Applied Sciences Konstanz

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Examiner: Prof. Dr. -Ing. Michael Bühler

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Anlage zur Bachelor-Thesis von

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Table of contents

List of Figures

1. Introduction

1.1. Work subject

This bachelor thesis deals with a cooperation project in Botswana, which is to be implemented by teachers and students of the University of Applied Sciences in Konstanz and some experts from all over the world. Furthermore, it deals with the question, what is the difference between classical and hybrid project management, which is applied here and how it is possible to create a supply chain for this project. Since these topics belong to the field of construction operations, the title of this paper is: "The Maun Science Park from a construction operations perspective."

1.2. Relevance of the topic

German Development Minister *Dr. Gerd Müller*, said in a guest article in the Handelsblatt: *"We need a paradigm shift and understand that Africa is not the continent of cheap resources, but the people there need infrastructure and a future."*[1]

Africa ranks second among the world's most populous continents (Attachment 1).[2] The birth rate clearly indicates that the population is growing faster compared to the rest of the continents (Attachment 2).[3]This may also be the reason why no continent in the world has more people living below the poverty line than Africa (Attachment 3).[4]
Nevertheless, this continent offers some opportunities. Among other things, this is also due to high economic growth rates, which exceed the 5% mark. The reasons for this growth are large raw material deposits, the growing young population and the improved framework conditions.[5] In particular, the infrastructure situation is considered one of the biggest challenges in Sub-Saharan Africa. A business survey conducted regularly by the World Bank found that 28.6% of all companies say that transportation is a major constraint in Africa. These constraints can have a massive impact on business success.[6]

[1] Dr. Müller, Gerd: Handelsblatt, September 13, 2016.
[2]Cf. Statista, www.statista.de, Weltbevölkerung nach Kontinenten, [as of 05.11.2020].
[3] Cf. Statista, www.statista.de, Natürliche Wachstumsrate der Bevölkerung nach Kontinenten, [as of 05.11.2020].
[4] Cf. Statista, www.statista.de, Anteil der Bevölkerung unter der absoluten Armutsgrenze nach Weltregionen, [as of 05.11.2020].
[5] Cf. Carlowitz, Philipp/ Röndigs, Alexander: Distribution in Afrika: 2016; p.1.
[6] Cf. Carlowitz, Philipp/ Röndigs, Alexander: Distribution in Afrika: 2016; p.2.

With its 55 countries, Africa is very unevenly structured and thus requires different approaches in the individual regions. Nevertheless, all countries have one thing in common: the need to create jobs, reduce dependence on raw material exports and capital goods, and increase local value creation.

Therefore, the African market offers great potential in the near future. Nevertheless, there are many challenges ahead, some of which are related to global warming or further expected population growth. Thus, parts of the annual funds required for infrastructure development are not secured.

Maun, which is the capital of the North West District, is home to about 60,000 people. These people penetrate further and further into the animal world. This often leads to human-environment conflicts. In order to counteract these conflicts, a cooperative project is to be created, which will later serve as a blueprint for the newly conceived urban development in Africa.

Teachers and students from the University of Applied Sciences in Constance are working together with experts from all over the world to implement this project in Botswana. [7]

The vision is to create a science park that is completely self-sufficient. Through this, the future inhabitants should live and develop the ecological interaction between humans and the environment. Illustration one shows an animated image of the project to be created.

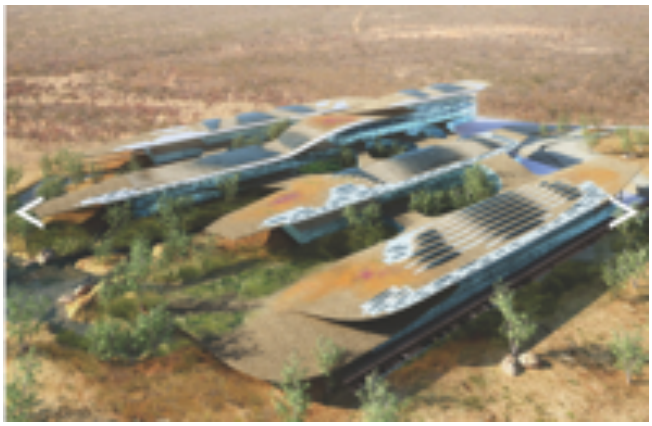

Figure 1: Maun Science Park (Animated)[8]

[7] Cf. Wochenblatt, www.wochenblatt.net, Studierende der HTWG beteiligt an Planung eines autarken Stadtteils, [as of 02.11.2020].

[8] Fig. Adopted without change from Archdaily, www.archdaily.com, SHoP: Out of Practice, [as of Jan. 11, 2021].

1.3. Methodical procedure

This thesis consists of five different chapters. Following the introduction, chapter two provides an overview of the economy and problems on the continent of Africa.

In chapter three, the Maun Science Park project is presented and a stakeholder analysis is carried out. The differences between classic project management and hybrid project management are also explained.

Chapter four looks at supply chain management and the possibility of digitization. Finally, we will look at how such management is also possible in Maun and what approach would be required.

Chapter five concludes with a critical summary of the entire project and a possible outlook for the future.

2. Opportunity Continent Africa

Unfortunately, Africa's image is still characterized by poverty, hunger and war. However, it is time to perceive Africa as an economic partner and future market and not just as a recipient of development aid.[9]

Many countries in Africa are experiencing sustained economic growth. Growth rates have mostly been well in excess of 5%. In general, this growth is expected to continue in the future, albeit at a slower pace. However, as this is starting from a low level, Africa still has much to do to catch up with other regions. Accordingly, it is necessary to develop Africa's industrial base.

To adapt Africa's industrialization, it requires coordination with extractive industries and the modernization and expansion of the agricultural and food sectors. It is also necessary to create jobs for the rapidly growing population.[10]

2.1. Industries

The continent of Africa is rich in many different raw materials and resources. Nevertheless, according to the United Nations Development Program, around 20 African countries are at the bottom of the "low human development" range.[11] Gross domestic product is also the lowest of all continents (Attachment 4).[12]

Africa is also probably the poorest continent in the world. Half of all people living there live below the poverty line. According to the World Bank, a person is considered poor if he or she has less than $1.25 a day to live on. Widespread poverty primarily affects nutrition, education and health.[13] The average life expectancy in Sub-Saharan Africa (year 2018) is 61 years (Attachment 5).[14] Nevertheless, Africa is experiencing economic growth due in part to

[9] Cf. Bundesverband der deutschen Industrie e.V., www.bdi.eu, Chancenkontinent Afrika, [as of 09.12.2020].
[10] Cf. Europäisches Parlament: Afrikas Wirtschaftswachstum: 2016; p.1.
[11] Cf. UNDP: Bericht über menschliche Entwicklung: 2015; p.252.
[12] Cf. Statista, www.statista.de, BIP in ausgewählten Weltregionen in jeweiligen Preisen im Jahr 2019, [as of 09.12.2020].
[13] Cf. SOS Kinderdörfer, www.sos-kinderdoerfer.de, Armut in Afrika, [as of 09.12.2020].
[14] Cf. The World Bank, www.data.worldbank.org, Life expectancy at birth, total(years) - Sub-Saharan Africa, [as of 09.12.2020].

increased commodity prices and foreign investment.[15] The four most important economic sectors in Africa are agriculture, processing of existing raw materials, industry or handicrafts, and the financial sector.

2.1.1. Agriculture

Agriculture is of great importance in Africa. Depending on the state, it contributes between 10-70% to GDP.[16] Nevertheless, the continent of Africa spends annually, for the import of food, about 35 billion US dollars. The agricultural sector employs about 70% of the population, but it contributes to only 30% of the value added. Productivity can be increased enormously through education, training and extension, and access to knowledge.[17]

2.1.2. Raw materials

Africa is rich in raw materials and natural resources, which play an important role in many African economies. Likewise, the continent has many non-renewable resources that are of global economic interest, such as gold, oil, ores and diamonds.[18]

But how does the contradiction arise between the wealth of resources and the poverty of many inhabitants? The reason is the strong dependence of national economies on raw material exports. However, the population does not benefit from the revenues of these exports, because rather the further processing of these products takes place in other regions of the earth.[19]

2.1.3. Industry and craft

Processing plants for the materials exist in only a few countries in Africa. As a result, Africa is one of the continents with the least developed economies. The reason for this is the unstable sociopolitical conditions that prevail in most African countries. This makes Africa unattractive for large investors, as they need secure framework conditions. These include stable political

[15] Cf. Bremer, Patrick: Die wirtschaftliche Lage in Afrika: Zwischen Aufschwung und anderen Herausforderungen: 2016; p.39.

[16] Cf. Hamburger Bildungsserver, www.bildungsserver.hamburg.de, Die afrikanische Landwirtschaft im Klimawandel, [as of 09.12.2020].

[17] Cf. Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, www.bmz.de, Ernährung und Landwirtschaft, [as of 09.12.2020].

[18] Cf. Gesichter Afrikas, www.gesichter-afrikas.de, Informationen zu Subsahara Afrika – Menschen, Länder und Kulturen, [as of 09.12.2020].

[19] Cf. Brot für die Welt, www.brot-fuer-die-welt.de, Reich an Bodenschätzen und doch arm, [as of 09.12.2020].

conditions, infrastructure, a reliable power supply and a trained workforce. All of this makes it difficult to establish economic sectors.[20]

2.1.4. Financial sector

The financial sector is also a major economic sector in Africa. Local banks in particular set the tone. However, they are characterized by instability and corruption. For these reasons, industry and government rely on international banks. Approximately $148 billion seeps into so-called black channels every year, accounting for 25 % of GDP.[21]

2.2. Problems in the environment

It is difficult to grasp the cause of Africa's economic underdevelopment. This is because the problems generated in the continent's environment can be both a cause and a consequence.

2.2.1. Diseases

Due to the tropical climate, but also due to poverty, infectious diseases are a major problem. These include malaria, Ebola and AIDS. Due to a lack of education or insufficient medical care, these diseases are spreading more rapidly.[22]

2.2.2. Civil wars

Wars and civil wars also contribute to the continent's poverty. From an economic perspective, this leads to infrastructure being destroyed and investors being deterred.

2.2.3. Corruption

In addition, corruption is a not insignificant problem. The focus here is on the inefficiency of the administrations of some African states. The problem is caused and exacerbated by unqualified personnel, inefficient bureaucratic procedures and the lack of control mechanisms.[23]

[20] Cf. Afriwhere, www.afriwhere.de, Industrie & Handwerk in Afrika, [as of 09.12.2020].
[21] Cf. Frankfurter Allgemeine Zeitung, www.faz.net, So viel Geld verliert Afrika jedes Jahr durch Korruption, [as of 10.12.2020].
[22] Cf. SOS Kinderdörfer, www.sos-kinderdoerfer.de, Armut in Afrika, [as of 10.12.2020].
[23] Cf. Hechler, Hannes: Die Ursache der Korruption in Afrika- Eine Frage der Kultur?: 2003; p.15.

2.2.4. Mismanagement

In addition, the revenues generated by export goods are not invested in the country itself, but are transferred abroad.

2.2.5. Infrastructure

A functioning infrastructure is necessary for good development. This poses major challenges for most countries in Africa. According to studies by the World Bank, an improvement in infrastructure could increase the economic growth rate by 2%.[24]

The most important goals here are access to electricity and the expansion of transport infrastructure.

[24] Cf. Gemeinsam für Afrika, www.gemeinsam-fuer-afrika.de, Infrastruktur in Afrika, [as of 10.12.2020].

3. Maun Science Park in Botswana

As described in chapter two, there are many challenges in Africa. The Maun Science Park should be seen as an opportunity to find solutions to these problems together.
The vision is to transform a diamond and mining focused society, into a knowledge society.

3.1. Project presentation

Together with international scientists, teachers and students of the University of Applied Sciences in Constance are working on the implementation of a self-sufficient and sustainable urban district in Maun, Botswana.
The aim of this project is to create a blueprint for Africa and the whole world. It aims to represent a symbiotic coexistence of humans, animals and the environment. The leader of this project *Vasilis Koulolias*, social entrepreneur and professor at Stockholm University, said about it:
"Scientists are developing sustainable technologies for space colonies. Why shouldn't we use them for our future here on Earth?"[25]

With the help of the 4IR Strategy, a Living Lab with 25 smart homes is to be created. The term 4IR stands for the fourth industrial revolution, or Industry 4.0, and originated with a future project of the German federal government. The goal of this is to increase and network production. Figure two shows the various stages of the industrial revolution.[26]
The major industry associations ZVEI, VDMA and Bitkom have established the following definition in a joint project:

"The term Industry 4.0 stands for the fourth industrial revolution, a new stage in the organization and control of the entire value chain over the life cycle of products. This cycle is oriented to the increasing individualized customer requirements and extends from the idea, the order through development and manufacturing, the delivery of a product to the end customer (...), including the associated service. (...)"[27]

[25] Cf. Wochenblatt, www.wochenblatt.net, Studierende der HTWG beteiligt an Planung eines autarken Stadtteils, [as of 27.11.20].
[26] Cf. Pistorius, Johannes: Industrie 4.0-Schlüsseltechnologien für die Produktion: 2020; p.5.
[27] Bitkom e.V., VDMA e.V., ZVEI e.V.: Umsetzungsstrategie Industrie 4.0: Ergebnisbericht der Plattform 4.0: 2015; p.8.

The 25 smart homes will provide space for local families, but also scientists from all over the world and will be networked with each other. The lab collects the data, which is not just about general life in the building. Rather, it is also about, for example, energy production, food production, modularity, education (schools, clinics), infrastructure but also animal-human conflict.

3.1.1. The Maun Code

In the conversation with Prof. Dr. -Ing. Michael Bühler on November 24, 2020, the Maun Code emerged in connection with the project presentation. This states the following. Sustainability will develop through the integration of our technological capabilities, our culture, and our social achievements. This results in the integration of the individual and collective spheres. To integrate all these aspects of humanity, a systematic code is postulated to guide a prototype habitat and proof-of-concept.

It covers all four perspectives that must be considered in the design process. Namely, the internal and external individual and collective perspectives. These four are also subdivided again into further four fields and result in a structure of 16 perspectives, which have to be covered and coordinated. Each decision has to be made by a person who has the highest competence in his field. For example, technical decisions by a technician or engineer, cultural decisions by people from the respective cultural group.

<u>Focus on People - Inner Individual Perspective</u>

This is understood as a broad approach to helping the individual self-find his or her self-identity and purpose by considering but not being limited to the following:

Human needs, usability, art and aesthetic expression, spiritual identity, health and safety.

<u>Technology driven - External Individual perspective</u>

In our technological world, the integration of technology in balance with the individual and collective spheres will enable new life possibilities. Technology is a powerful engine for innovation, but it must be used as a tool. It must be understood in the context in which it is used. Technology competencies and deep understanding are key factors for integral development.

Culture encompassing - Inner Collective Perspective

Humans are social beings. Shared values, common purposes and social norms based on long evolving cultural patterns are part of the human being in our living spaces. The inner collective perspective must be considered in a design and production process.

Systems Thinking - External Collective Perspective

The external collective perspective is the enabler at the collective level. Governance structures, protocols, and processes form networks of people working together for a common purpose. By integrating and leveraging digital technologies to manifest such collective structures, mobilization platforms can be created to enable co-creative processes with large groups through a multi-level approach.

3.1.2. Stakeholder analysis

Stakeholder management deals with the people interested in the project. It is important to find out who is a possible supporter, affected party or even an opponent. For the success of a project, it is important to address these questions as early as possible.[28]

According to the legal definition in DIN 69901-5, a stakeholder is: "The entirety of all project participants, stakeholders and interested parties whose interests are directly or indirectly affected by the course or outcome of the project."[29]

Stakeholder management is intended to increase project success, which is why it can be useful to define the success criteria together with the project stakeholders. Stakeholders can be divided into four groups:[30]

- Sponsors: They are committed to the project by supplying materials and helping to define requirements.

- Skeptics: they argue against the project, but provide important guidance on risk management.

[28] Cf. Meyer, Helga/ Reher, Heinz-Josef: Projektmanagement: 2016; p.58.
[29] DIN e.V. (Ed.), DIN 69901-5:2009-01: 2009; p.12.
[30] Cf. Meyer, Helga/ Reher, Heinz-Josef: Projektmanagement: 2016; p.59.

- Opponents: They are the opponents of the project but also indifferentists who must be persuaded to cooperate.

- Neutrals: They are neutral towards the project. Nevertheless, they must be monitored, as they can also change their position on the project.

Accordingly, these assessments can be used to develop strategies to prevent conflicts between opponents and supporters.[31] See Stuttgart 21 (Attachment 6).[32]

In the context of this bachelor thesis, five interest groups are considered:

1. Maun population
2. Government of Botswana
3. Suppliers
4. Africa population
5. Owner *Vasilis Koulolias*

1. Maun population

The population of Maun can be divided into the group of neutrals with tendencies toward skeptics. For them, the project offers a great opportunity to improve and expand their economic sectors. Nevertheless, they may have a negative attitude due to projects that have already failed and for which foreign investors are responsible.

2. Government of Botswana

The government of Botswana is one of the sponsors. This is particularly important because it has the greatest influence on the whole project. The government - just like the people of Maun - sees an opportunity for their economy.
However, due to the high influence of the government, it is important and essential to maintain its goodwill by firmly involving it in the planning process.

[31] Cf. Meyer, Helga/ Reher, Heinz-Josef: Projektmanagement: 2016; p.60.
[32] Cf. Spiegel, www.spiegel.de, Bürgerkrieg im Schlossgarten [as of 28.11.2020].

3. Suppliers

The suppliers tend to fall into the category of skeptics. For them, the delivery of the building materials is the first priority, yet construction will be done with new technologies and materials that are not common in Botswana. This could cause skepticism on the part of the suppliers.

4. Africa population

The same applies to the population of Africa as to the population of Maun. Nevertheless, these should primarily be counted among the neutrals, since they can judge the project from a certain distance and are thus only indirectly affected.

5. Owner *Vasilis Koulolias*

The developer *Vasilis Koulolias* must of course be one of the promoters. Together with the government of Botswana, he has the greatest influence on the project. For him, it is a chance to create something revolutionary for Africa and for the whole world. Since Vasilis will always be a promoter of this project, it is not necessary to pay special attention to him.

In order to illustrate the evaluation of the stakeholders, there is the so-called stakeholder portfolio, as shown in figure three. This allows the influences and views of the individual stakeholders to be classified.

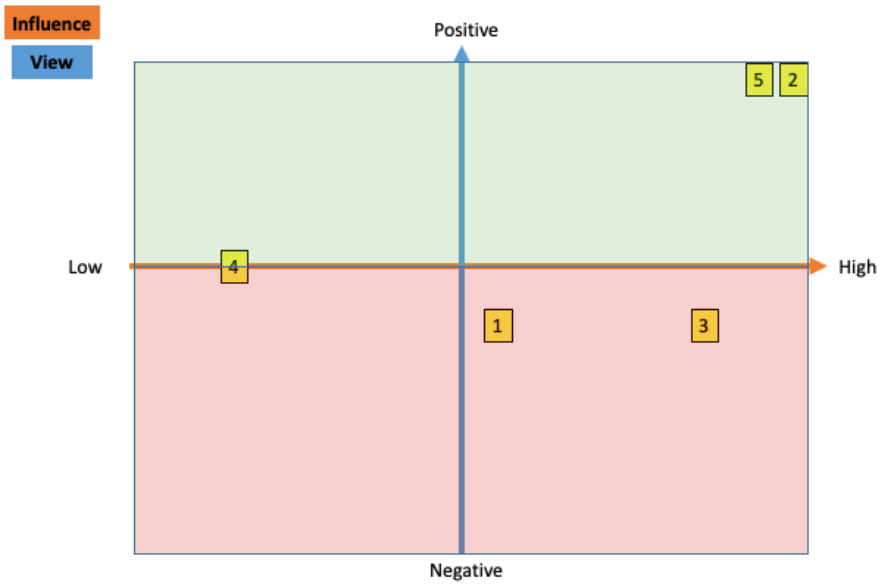

Figure 2: Stakeholder portfolio[33]

[33] Fig. Own representation

The stakeholder portfolio creates four different quadrants. Since the upper two quadrants are on the positive side and include the developer and the government of Botswana, the focus is primarily on the third and fourth quadrants in the negative area. Especially with increasing influence of the project, strategies have to be considered to shift the respective protagonists towards the positive view.

In the case of the people of Maun, this could be achieved by involving them in the project at an early stage. In addition, one should respond to their wishes and try to implement them. Suppliers can be attracted primarily by future projects. However, this presupposes a successful construction project.

3.2. Project Management

Projects are unique in the construction industry, as they are always different due to their changing framework conditions. Project management serves to provide a framework for the complex orders and to steer them to a successful conclusion.

3.2.1. Definition

According to DIN 69901, project management is the "totality of management tasks, organization, techniques and resources for the initiation, definition, planning, control and completion of projects. "[34]

ISO standard 21500 defines project management as "the application of methods, tools, techniques and competencies in a project. It includes the [...] interaction of the different phases of the project life cycle".[35]

What is a project?

The term "project" comes from the Latin word "proiectum", which according to the Duden means "that which is thrown forward".[36]

- A project is an undertaking that has the status of a unique specimen due to ever-changing framework conditions.[37]

What does management mean?

The term comes from the Latin "manus agare," which means "to lead by the hand or to lead and guide by the hand. "

- Coordination of work-sharing, multi-personally assigned activities in alignment with coordinated goals and under economical use of resources.[38]

Project management can thus be summarized as the management, decision-making, planning, organization, and responsibility of large-scale projects that are also unique, complex, time-

[34] DIN e.V. (Ed.), DIN 69901-5:2009-01: 2009; p.14
[35] DIN EN ISO, DIN ISO21500:2012: 2012; P.10
[36] Cf. Duden, www.duden.de, Projekt [as of 23.01.2021].
[37] Cf. Albert, Andrej/ Schneider: Bautabellen für Ingenieure: 2018; p. 1.18.
[38] Cf. Prof. Dr.-Ing. Rickers, Uwe: Skript Projektmanagement Einführung: 2020; p.17.

limited, results- and resource-oriented, and concentrated in their approach.[39] A project manager has the task to take over the interests of the client and to implement them as far as possible. In addition, project management is the need to link costs, quality and deadlines.

Figure 3: Magic triangle of project management[40]

This figure is the so-called magic triangle of project management. It is intended to illustrate the interdependence of the three components of cost, quality and deadlines by showing that a change in one component inevitably causes a shift in the other two components.

<u>Relationship between cost and construction time:</u>

Figure five shows a parabola open at the top. The shorter or longer the construction time, the higher the costs. This may be due to acceleration costs (shorter construction time) or longer lead times (longer construction time). In successful project management, one must find the right target time in which the relationship between costs and construction time is most favorable.

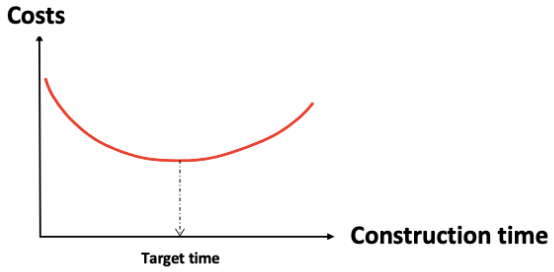

Figure 4: Relationship between costs and construction time[41]

[39] Cf. Prof. Dr.-Ing. Rickers, Uwe: Skript Projektmanagement Einführung: 2020; p.18.
[40] Fig. Taken changed from Prof. Dr.-Ing. Rickers, Uwe: Skript Projektmanagement Einführung: 2020; p.26.
[41] Fig. Taken changed from Prof. Dr.-Ing. Rickers, Uwe: Skript Projektmanagement Einführung: 2020; p.27.

Relationship between costs and quality

Figure six also shows a parabola open at the top. From this, it can be concluded that poor quality can lead to rework costs. But too high a quality can also lead to oversizing, which drives up costs. It would be advisable to produce only the contractually agreed quality (target quality).

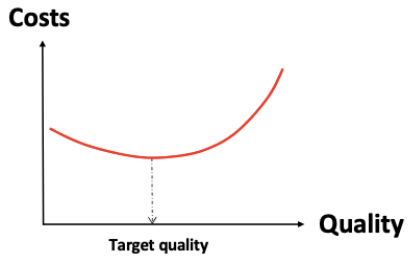

Figure 5: Relationship between costs and quality[42]

Relationship between quality and construction time

Figure seven shows a parabola open at the bottom. It shows the relationship between quality and construction time. It can be seen that a construction time that is too short has an impact on quality. Too short a time frame can lead to hectic and excessive demands. Nevertheless, too long a time frame can also lead to a drop in quality. This happens due to lack of concentration. Here, too, one must find the appropriate average value.

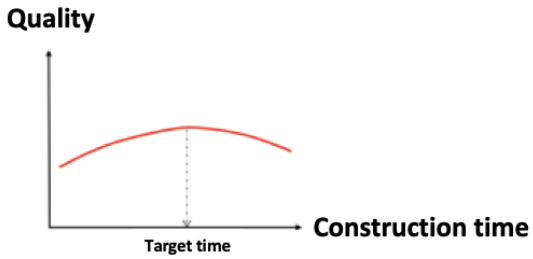

Figure 6: Relationship between quality and construction time[43]

3.2.2. Service phases according to HOAI in classic project management

From the rough to the detailed means for the treatment of the problems the emergence of different work packages, which are divided again rum into phases. Thus, they are logically and

[42] Fig. Taken changed from Prof. Dr.-Ing. Rickers, Uwe: Skript Projektmanagement Einführung: 2020; p.28.

[43] Fig. Taken changed from Prof. Dr.-Ing. Rickers, Uwe: Skript Projektmanagement Einführung: 2020; p.29.

temporally separated from each other.[44] The development of a solution can thus be divided into different stages. In the construction industry, the individual phases are usually based on the service phases of the HOAI:[45]

Service phase 0 - project development:

If essential planning and monitoring objectives have not yet been agreed, service phase 0 applies. For this purpose, the architect must develop a planning basis for determining the exact objectives. Once this has been prepared, the architect submits it to the client together with a cost estimate.

Service phase 1 - Basic evaluation

Here it is important to find out the requirements and ideas of the client. The next phases are then discussed verbally with the client and defined in terms of deadlines. In this service phase it is important to clarify the essential questions. An important and quite crucial question, which is harder to answer than thought, is: "Why this project?"

Service phase 2 - preliminary planning

After the financing has been clarified and the initial discussions have been held, the next service phase is the preliminary planning. The architect creates a first concrete draft as well as a cost estimate. Details do not yet play a role in this phase of planning. Here, as the word preliminary planning already describes, the focus is purely on the design and use of the building.

Service phase 3 - Design planning

After the client is satisfied with the design and cost estimate, more detailed elaboration of the preliminary design is carried out. Thus, the building is completely planned and created. Any requirements are now included in the planning. Here, the ultimate goal is to create a concept that is also feasible and in which all problems are taken into account.

Service phase 4 - Approval planning

As the term "approval planning" implies, this service phase is about using the previous designs to apply for approval of the project. It is important that all the results of the design are packaged

[44] Cf. Kuster, Jürg/ Bachmann,Christian/ Huber, Eugen/ Hubmann, Mike/ Lippmann, Robert/ Schneider, Emil/ Schneider, Patrick/ Witschi, Urs/ Wüst, Roger: Handbuch Projektmanagement: 2019; p.22.

[45] Cf. Building Radar, www.buildingradar.com, Bauphasen [as of 30.01.2021].

in plans that can be approved. However, these should also meet and cover the requirements of the building authorities. With the submission of the designs and the other forms to be submitted, as well as calculations, the application for the project is made.

Service phase 5 - Detailed design

In this service phase, the architect works together with specialist planners to further develop the previous designs and carries out a mass determination. The mass determination, which reflects the quantities of building materials, can then be used to draw up bills of quantities. Once this has been done, further details are discussed by also involving the tradesmen who have already been commissioned. The plans that have now been drawn up form the basis for the subsequent construction work.

Service phase 6 - Preparing the award of contract

In this phase, the contracts are awarded to the individual companies. This is done by compiling all the tender documents, holding talks with the individual companies and obtaining the cost estimates. The contracts for the individual specialist firms should be prepared by the architect.

Service phase 7 - Participation in the awarding of contracts

The bills of quantities are now sent to the individual specialist companies. They can complete the bid documents by entering the prices for each individual item. Because all companies receive the same documents, a direct price comparison of the individual trades is possible. Within a set deadline, the bid documents are returned to the architect, which can then be evaluated and checked.

All the offers can be used to create a price comparison list, which allows you to quickly see which companies are cheap and which are expensive.

Work phase 8 - object supervision

For the architect, this service phase represents the most extensive task area. The first step is the creation of a construction schedule. Here, the exact time windows are defined that the individual specialist companies have for the creation of the project.

According to this schedule, the construction management supervises the work and verifies compliance with the building permit. The invoices that are now sent in are checked and renegotiated by the construction management. The final step is the acceptance and remaining work.

Work phase 9 - Documentation and project completion

This service phase is not generally related to construction management. Rather, it involves an inspection of the building and a determination of defects.

In this context, a key task is to ensure compliance with the statute of limitations and the elimination of defects.

3.2.3. Waterfall problems

Classic project management, as described in the previous chapter, follows a linear process and consists of several phases (performance phases). After each completed phase, a new one is initiated. This is called the waterfall model.[46] Figure eight shows a schematic representation of this model.

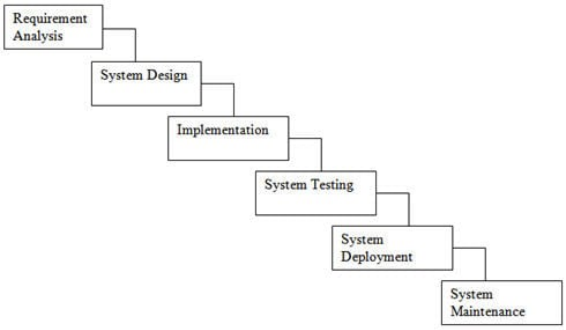

Figure 7: Illustration of the waterfall model[47]

This model has several strengths and weaknesses. On the one hand, it is easy to understand and follow, and good quality results can also be achieved.[48] On the other hand, the waterfall model has two major disadvantages: The end user is not involved in the production process and there is little room for changes and adjustments. This model should therefore only be used for projects where requirements and processes can be precisely described in the planning stage and where the processes change only slightly. Stuttgart 21 is a well-known negative example of the weaknesses of the waterfall model.[49]

[46] Cf. Projectwizards, www.projectwizards.net, Das Wasserfallmodell im Projektmanagement einsetzen, [as of 14.12.2020].
[47] Fig. taken unchanged from Softwaretestinghelp, www.softwaretestinghelp.com, What is SDLC Waterfall Model?, [as of 11.02.2021].
[48] Cf. Stöhler, Claudia/ Förster, Claudia/ Brehn, Lars: Projektmanagement lehren: 2018; p.25.
[49] Cf. Projectwizards, www.projectwizards.net, Das Wasserfallmodell im Projektmanagement einsetzen, [as of 14.12.2020].

Other advantages and disadvantages in classic project management: [50]

+ The project sequence is planned in advance
+ The final date can be agreed
+ Utilization of resources can be optimized
+ The costs can be contractually agreed
+ Planning, monitoring and control are understandable for all management levels

- Not suitable for projects with unclear requirements
- No flexibility
- Planning changes lead to delays
- Premature termination = complete failure
- Accelerations can hardly be perceived or decelerations can hardly be compensated for

Classical project management is often used as a pejorative term to classify others as more efficient. Nevertheless, it is often overlooked here that other types of management build on the classic and also require a certain framework.

[50] Cf. Project Magazine, www.projektmagazin.de, Traditionelles Projektmanagement, [as of 20.01.2021].

3.2.4. Principle of the "Tree of life

The Maun Science Park departs from classic project management and uses a hybrid model. This assumes that there must be a structural framework for a project. This can be approached with the waterfall method. The complex part is handled with an agile method.[51]

Agile project management refers to the approach where the project team has high tolerances on time, cost, scope, and quality, and where the client's involvement is required. The focus is on the work to be delivered and the acceptance of the user.[52]

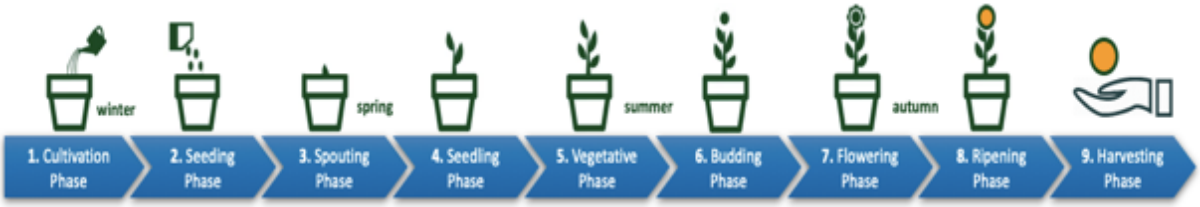

Figure 8: The phases of the "Tree of life" life cycle concept[53]

The structural framework is divided into nine different phases based on classic project management, see figure nine:

<u>1st phase = cultivation phase = demand planning</u>

Successful project management always starts with gathering stakeholder requirements. A project manager must find out their wishes so that there are no surprises during construction that would exceed the project budget and time frame. In addition, this phase is to strengthen partnerships with local authorities (stakeholder management) and think about financing for the country.

<u>2nd phase = seeding phase = MSP land development</u>

In this phase, the access is considered and the different zones are divided. In addition, the environmental impact is studied and evaluated, the connections are made and further thought is given to the financing.

[51] Cf. Digicomp, www.digicomp.ch, Hybrides Projektmanagement, [as of 14.12.2020].
[52] Cf. Project Magazine, www.projektmagazin.de, Agiles Projektmanagement, [as of 14.12.2020].
[53] Fig. taken unchanged from Prof. Dr.-Ing. Bühler, Michael: Power Point Tree of life: 2020; p.1.

3rd phase = sprouting phase = construction visitor center

Here, the design for the change of use is determined and a visitor center is created. In this center, people from Maun can take a look at the Maun Science Park to be built and thus raise criticism as early as possible, which can then still be taken into account.

4th phase = seedling phase = project design office

In this phase, the various possible uses are defined. In the Maun Science Park, these include the laboratories, a school, shopping stores and much more.

5.phase = vegetative phase = construction of a school

As described in chapter two, education is a major challenge in Africa. For this reason, a school is to be created in this phase in order to provide the adolescents with a secure future.

6th phase = budding phase = design of the laboratory units

Since the Maun Science Park also consists of laboratories, this phase will take a closer look at the design of the laboratory units. It is designed what exactly should be studied and how the floor plans of this should be.

7th phase = flowering phase = construction of the laboratory units

While phase six was devoted to the design of the various laboratory units, phase seven is devoted to the structural implementation.

8th phase = ripening phase = research in the laboratories

Probably the most important point of the whole project takes place in this phase. Since the Maun Science Park is intended to serve as a blueprint for Africa and the world, work is done here in the laboratories on what is going well or what needs to be improved.

9th phase = harvesting phase = research results

The results from phase eight are compiled and evaluated here. Conclusions must be drawn from them and decisions made on what to improve in future projects. This should serve to eradicate errors and move closer to a perfect project.

This structural framework, which was created on the basis of classic project management, makes an important contribution. However, due to the complex tasks required in the Maun Science Park, failure can quickly occur.
The agile method is used for this in hybrid project management.

A popular framework for agile project management is the so-called Scrum method.
In Scrum, there are three different roles:

- Product owner (technical and content management)
- Team
- Scrum Master (Method Specialist)

There is no classic project manager. The aim of this method is that solutions are sought and found at chosen intervals by motivated and specialized teams (Maun Code). These solutions then flow into new cycles.[54]
The advantage of the whole thing is that changes can be dealt with quickly, since the planning always concerns only one cycle, which is then implemented. Nevertheless, the phase system is not unimportant, because at the start of a new project it is important to create a structured framework to roughly orient oneself.

[54] Cf. Kuster, Jürg/ Bachmann,Christian/ Huber, Eugen/ Hubmann, Mike/ Lippmann, Robert/ Schneider, Emil/ Schneider, Patrick/ Witschi, Urs/ Wüst, Roger: Handbuch Projektmanagement: 2019; p.21.

4. Supply Chain Management (SCM)

Supply chain management (SCM) has been propagated for some time and is an important part of project management. One reason for this is that successful SCM promises competitive advantages that other companies cannot achieve.[55]

4.1. Definition of supply chain management

Here, all companies are involved that are part of the delivery and creation of the product. Thus, it extends from the raw material supplier to the end consumer.
This network is also referred to as a value network and is by no means final.[56] Rather, the value creation partners involved and the relationships within the system can change.

The following figure shows an example of supply chain management:

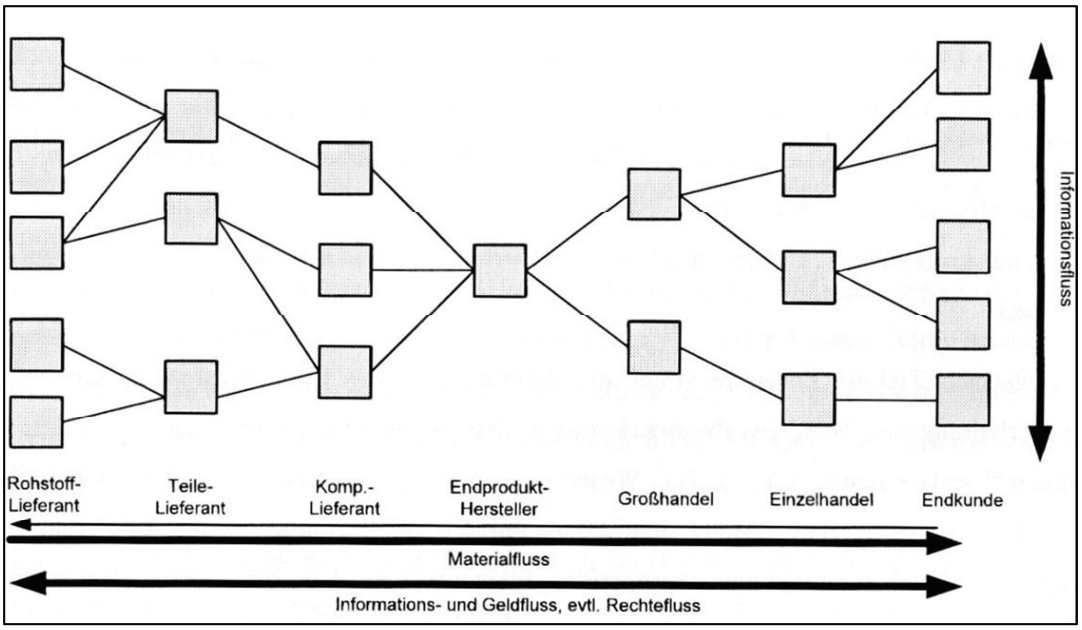

Figure 9: Exemplary representation of supply chain management[57]

[55] Cf. Cohen, Shoshanah/ Roussel, Joseph: Strategisches Supply Chain Management: 2004; p.1.
[56] Cf. Beckmann, Holger: Supply Chain Management: 2004; p.1.
[57] Fig. taken unchanged from Beckmann, Holger: Supply Chain Management: 2004; p.2.

Characteristics of a supply chain:[58]

- It documents all processes from raw material procurement to service performance.
- It should create a customer benefit
- It crosses borders
- The coordination is carried out by a continuous coordination system
- The subject of the supply chain are development, procurement, production and distribution processes.
- All stakeholders and logical processes are included.

4.2. Supply Chain Management Goals

The tasks of SCM are derived from economic and social requirements and are based on general corporate guidelines.[59] Therefore, the participants in modern supply chains pursue cost, quality or performance improvements in particular. This results in a logistics target triangle (Figure 12).

Cost Improvement:

One part which can contribute to cost improvement is the reduction of product goods which have to be moved in the warehouse. This can be done through demand to the end customer. In addition, an optimization of the entire network contributes to this.

The "Just in Time" principle, which comes from lean management, can also lead to greater utilization of transport vehicles. However, this requires detailed planning.

Quality improvement:

A major problem with supply chains is their lack of transparency. Through them, no collaborative activity takes place, which means that the end consumer has no particular influence on the quality of the final product. The change to a transparent supply chain could significantly increase quality.

[58] Cf. Beckmann, Holger: Supply Chain Management: 2004; p.2 f.
[59] Cf. Werner, Hartmut: Supply Chain Management: 2017; p.29.

Time Improvement:

Optimized coordination can lead to time improvement. This is mainly done by preventing potential danger spots that could lead to a delay.

4.3. Digitization of a supply chain

Many companies are facing challenges in the course of the digital transformation. Therefore, business processes must be critically scrutinized and adapted. SCM must also face up to the change. Supply chains are characterized by a high degree of intransparency. One way to change this is the blockchain technology.[60]

4.3.1. Blockchain

IBM CEO *Rometti Virginia M* said on the topic of blockchain:

"We estimated that the application of blockchain to global supply chains alone could result in more than 100$ billion in efficiencies."[61]

Blockchain technology enables supply chains to be better monitored. Logistics and supply chains are paper-based and complex affairs. Freight documents are the most important tool here. At each handover, an independent party assures that the right goods have been delivered. If the paperwork is lost, the goods are stuck for now. Blockchain technology aims to change this by creating a digital twin, thus ensuring the six-eyes principle.[62] This results in a variety of potential applications, such as tracking and tracing goods, insuring counterfeit goods, simplifying customs procedures, or even detecting counterfeit goods. According to a DHL study, a global potential value increase of $1.8 trillion would be possible through the use of smart objects in logistics.[63] Despite expected efficiency gains, most blockchains have not been developed beyond the concept stage.[64]

<u>Mode of operation:</u>

Blockchain can be assigned to the generic term distributed ledger technology (DLT). This refers to a system that functions without a central control authority and in which information can be stored in a data structure consisting of blocks.[65]

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[60] Cf. Weissenberger Solutions, www.weissenberger-solutions.de, Wie die Blockchain das Supply Chain Management verändert, [as of 11.12.2020].
[61] Rometti, Virginia M.: IBM, www.ibm.com, Blockchain will do for trusted transactions what the Internet did for information, [as of 23.01.2021].
[62] Cf. Mühlberger, Annette: Technik+Einkauf magazine: 2018; p.36.
[63] Cf. Schröder, Meike/ Wegner, Kirsten: Logistik im Wandel der Zeit - Von der Produktionssteuerung zu vernetzten Supply Chains: 2019; p.527.
[64] Cf. Schröder, Meike/ Wegner, Kirsten: Logistik im Wandel der Zeit - Von der Produktionssteuerung zu vernetzten Supply Chains: 2019; p.528.
[65] Cf. Hinkeldeyn, Johannes: Blockchain-Technologien in der Supply-Chain: 2019; p.5.

A block is the data structure of a blockchain, which contains the necessary information. As illustrated in Figure 13, the bottom line contains the data on the transactions in the blockchain, which are encoded in a different format depending on the platform. To ensure that no unauthorized transfer can take place, each input is signed with a private key. Subsequently, a Merkle tree is created from the transaction data. The block header contains a timestamp, the version, a reference to the previous block and a target value that indicates the difficulty of the cryptographic puzzle to be solved.[66]

Figure 10: Components of a block[67]

With the help of the cryptographic puzzle, the addition of the puzzle is realized. Each participant of the network tries to solve this puzzle. If a solution is found, another block can be added to the blockchain and forwarded to the other participants. Thus, a chain of blocks is created (Figure 14), in which each block refers to the one before it. These references result in security against manipulation.[68]

[66] Cf. Fill, Hans-Georg: Blockchain: 2020; p.11.
[67] Fig. taken unchanged from Fill, Hans-Georg: Blockchain: 2020; p.11.
[68] Cf. Fill, Hans-Georg: Blockchain: 2020; p.12.

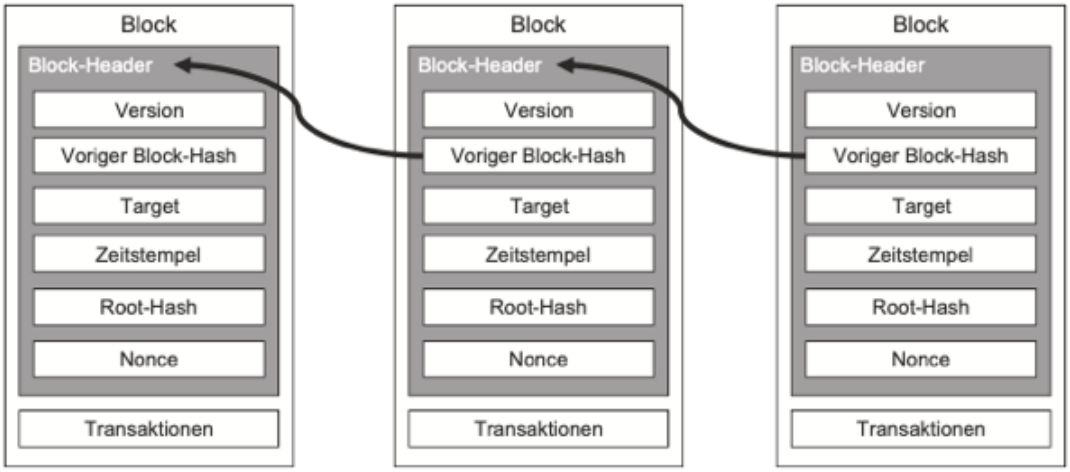

Figure 11: Components of a block[69]

4.3.2. Smart Contracts

Blockchains can be used not only for the transfer of values, but also for the decentralized execution of program codes. Behind this is the idea expressed by *Nick Szabo of having* contracts executed automatically. This is what he called "smart contracts."[70]

In 1996 he said about it:

"(...) A smart contract is a set of promises, specified in digital form, including protocols within which the parties perform on these promises.“[71]

Smart contracts work on the basis of if-then logic. When a predefined event occurs, a predefined action is executed.[72]

Nick Szabo explained the principle of operation using a vending machine. When you enter a fixed amount of money, you receive the designated merchandise, without the involvement of another human being.

<u>That's how smart contracts are supposed to work, too:</u>[73]

- They are triggered by auditable results (inbound transaction)
- The event is processed by your program code (check transaction)
- Based on the event, a relevant action is taken (issuance of the goods)

[69] Fig. taken unchanged from Fill, Hans-Georg: Blockchain: 2020; p.12.
[70] Cf. Hinkeldeyn, Johannes: Blockchain-Technologien in der Supply-Chain: 2019; p.28.
[71] Szabo, Nick: Smart Contracts: Building Blocks for digital Markets: 1996; S.1.
[72] Cf. Wilkens, Robert/ Falk, Richard: Smart Contracts: 2019; p. 12.
[73] Cf. Wilkens, Robert/ Falk, Richard: Smart Contracts: 2019; p. 11.

Thus, the integration of smart contracts can automate workflows and partially replace manual processes. In supply chain management, smart contracts could be used, for example, in order processing, procurement, picking, shipping and communication.

4.3.3. Blockchain platforms

In recent years, a number of blockchain platforms have been developed. Since the focus of this chapter is on supply chain management, we will particularly highlight smart contracts functionalities here.

Bitcoin:

It is the largest and best-known blockchain and represents the starting point of the entire blockchain. The basic application purpose of this blockchain is a virtual, decentralized payment system. Via its own programming language, called Bitcoin Script, the possibility is determined whether and with which circumstance the Bitcoin contained per transaction may be spent.
Each transaction contains a programmed logic. Whoever has the private key to the Bitcoin address specified in the transaction has the right to use the Bitcoin. Bitcoin transactions can basically be set to certain conditions. For example, one could program a time period in which an amount may be used. For example, when a supplier has delivered on time.[74] Nevertheless, the options here are limited and therefore rarely encountered in combinations with payments.[75]

Ethereum:

In contrast, Ethereum represents more extensive infrastructures for the application of smart contracts. This blockchain is freely programmable for applications that can be used in many areas.[76] Although Ethereum has a similar means of payment to Bitcoin in the form of Ether, it serves more as a means to an end here. This is because it gives developers the opportunity to take over the distribution of their apps themselves and to provide more security on the buyer's side.[77] The Ethereum Blockchain relies on the current state of the Blockchain, known as the "World State".

[74] Cf. Hinckeldeyn, Johannes: Blockchain-Technologien in der Supply-Chain: 2019; p.22.
[75] Cf. Hinckeldeyn, Johannes: Blockchain-Technologien in der Supply-Chain: 2019; p.23.
[76] Cf. Singhal, Bikramaditya/ Dhaneja,Gautam/ Sekhar Panda, Priyansu: Beginning Blockchain: 2018; p.291.
[77] Cf. Dev Insider, www.dev-insider.de, Was ist Ethereum und wie funktioniert der Ether?, [as of 12.12.2020].

The simplified process of a transaction through a smart contract is as follows:

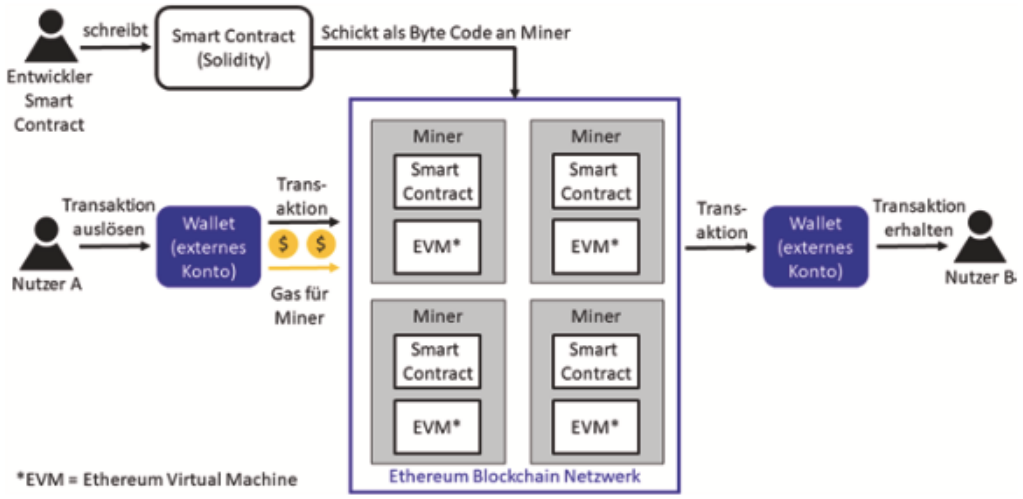

Figure 12: Simplified functionality of the Ethereum Blockchain.[78]

A smart contract is written using the "Solidity" programming language. Now the program code is compiled into byte codes and distributed to the miners. In order to execute the byte code of the smart contract, each miner uses a software called Ethereum Virtual Machine. His wallet now forms the necessary interface to be able to use the smart contract. Now the transaction is distributed to the miners and the execution is triggered. For this, a user must pay a price (gas price), which was set by another. If this price is sufficient for the execution of the smart contract, the transaction is stored in the blockchain.[79]

Despite extensive smart contract functionality, supply chain applications with Ethereum remain limited to special cases. The reason for this is the low throughput, which can be increased in the future.

<u>Hyperledger:</u>

Hyperledger is available as open source and is the blockchain project of the Linux Foundation. It does not introduce its own currency, but serves to build blockchains of the connected companies.[80]

[78] Fig. taken unchanged from Hinckeldeyn, Johannes: Blockchain-Technologie in der Supply Chain: 2019; p.23.
[79] Cf. Hinckeldeyn, Johannes: Blockchain-Technologie in der Supply Chain: 2019; p.24.
[80] Cf. Blockchain Insider, www.blockchain-insider.de, So funktioniert der Hyperledger, [as of 12.12.2020].

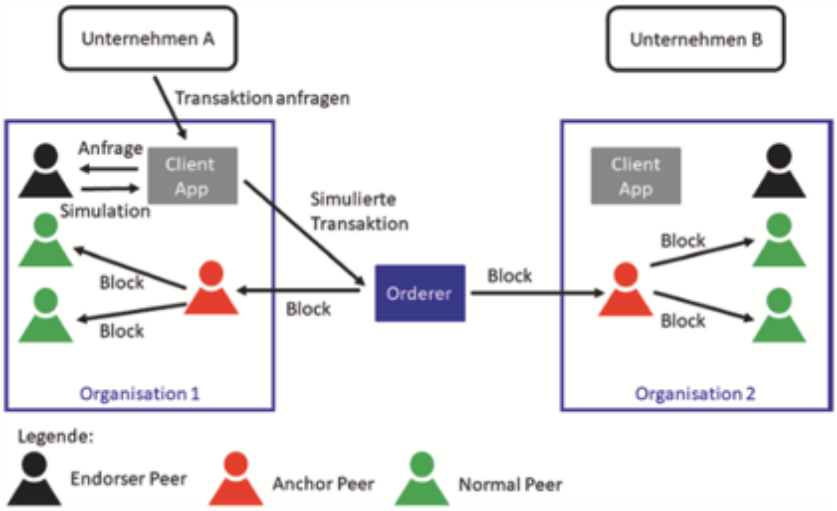

Figure 13: Functionality of the Hyperledger Blockchain[81]

The network is divided into organizations, which group nodes together. The different types of nodes are called peers and authenticate themselves via certificates. A normal peer has a copy of the blockchain, while an anchor peer acts as an interface to the outside world.

The endorser peer receives transactions, verifies certificates and content, and simulates the execution of the smart contract (called chaincode). An orderer peer serves as a communication channel between organizations, collecting and confirming transactions and passing them on to anchor peers. The normal peers then store these blocks. The advantage of all this is that not all peers have to execute the chaincodes, which leads to a better scalability of the system.[82]

Moreover, a quick creation of blockchain applications and easy access to it is a relief for businesses.[83]

4.3.4. Vulnerabilities and risks

The security of their data plays an important role for companies. Therefore, trust in the system must be achieved. Since competing companies are often involved in a supply chain, attacks on data integrity and attempts at manipulation must be ruled out. To achieve this, it is necessary to provide fail-safety, transparency and traceability of the transaction.

[81] Fig. taken unchanged from Hinckeldeyn, Johannes: Blockchain-Technologie in der Supply Chain: 2019; p.25.
[82] Cf. Hinckeldeyn, Johannes: Blockchain-Technologie in der Supply Chain: 2019; p.26.
[83] Cf. Blockchainwelt, www.blockchainwelt.de, Hyperledger- Blockchain für Unternehemen, [as 12.12.2020].

4.4. Creation of a supply chain in Maun, Botswana

As with a large construction project, SCM requires a blueprint. Without this plan, it is easy to lose track of the many components that must be assembled within a given framework. This architecture defines the processes to continuously improve and develop the supply chain.[84]

4.4.1. Definitions

Construction logistics can be divided into three areas based on the logistics of stationary industry:

- Supply or procurement logistics
- Construction site or production logistics
- Disposal logistics

Information logistics also plays an important role in improving the implementation of these phases and achieving an increase in quality and cost efficiency.[85] Figure 17 is intended to illustrate construction logistics in general.

According to *Grosvenor E. Plowman, the* following definition is often found in practice:
"Logistics means ensuring the availability of the right good, in the right quantity, in the right condition, in the right place, at the right time, for the right customer, at the right cost."[86]

<u>Supply or procurement logistics:</u>

It is the link between the building material manufacturer or supplier and the production site (construction site). The main tasks are to determine the demand for building materials, to determine the total number of transports required, to procure the building materials and to coordinate the flow of building materials to the construction site in terms of time and space.[87]

a) Time coordination

There are many transports to coordinate, with a wide variety of building materials and construction equipment. In shell construction, there are only a few building materials, but the

[84] Cf. Cohen, Shoshanah/ Roussel, Joseph: Strategisches Supply Chain Management: 2004; p.57.
[85] Cf. Schach, Rainer/ Schubert, Nadine: Logistik im Bauwesen: 2009; p.59.
[86] Baumgartner, Helmut: Das Beste der Logistik: 2008; p.231.
[87] Cf. Hofstadler, Christian: Bauablaufplanung und Logistik im Baubetrieb: 2007; p.42.

number of trades increases with the expansion and technology, which also increases the effort for logistics.[88]

b) Spatial coordination

A concept for construction site traffic must be created for larger construction projects, which considers the traffic connection and the situation within the construction site installation areas.[89]

Transport to the construction site depends on the following criteria:[90]

- Existing infrastructure
- Specifications of the building owners and local framework conditions
- Location of building material supply sources
- Terrain conditions and possible interim storage
- Time constraints

Therefore, according to *Boenert/Blömeke, the* easy accessibility of the transfer points, the appropriate choice of means of transport, route planning and land use must be laid down in the logistics concept.[91]

<u>Construction site or production logistics:</u>

It covers the logistical tasks on the construction site. This includes all transfer movements in connection with storage, handling and transport.[92]

The transition from procurement to production logistics takes place on the delivery areas. The building materials are then temporarily stored in storage areas or directly installed. They are moved on the production site with the help of conveyors. A distinction is made here between:[93]

- Spatial conveyors (e.g. crane)
- Horizontal conveyors (e.g. forklift trucks)
- One-dimensional conveyors (e.g. conveyor belt)

[88] Cf. Hofstadler, Christian: Bauablaufplanung und Logistik im Baubetrieb: 2007; p.42.
[89] Cf. Hofstadler, Christian: Bauablaufplanung und Logistik im Baubetrieb: 2007; p.43.
[90] Cf. Boenert, Lothar/ Blömeke, Michael: Logistikkonzepte im Schlüsselfertigbau zur Erhöhung der Kostenführerschaft: Bauingenieur: 2003; S. 278.
[91] Cf. Boenert, Lothar/ Blömeke, Michael: Logistikkonzepte im Schlüsselfertigbau zur Erhöhung der Kostenführerschaft: Bauingenieur: 2003; S. 278.
[92] Cf. Schach, Rainer/ Schubert, Nadine: Logistik im Bauwesen: 2009; p.61.
[93] Cf. Hofstadler, Christian: Bauablaufplanung und Logistik im Baubetrieb: 2007; p.44.

- Vertical conveyors (e.g. concrete pump)

Disposal logistics:

Disposal logistics deals with the removal of residual materials. These substances include, among others:

- Excavation
- Debris
- Construction site waste
- Hazardous waste
- Road construction

It also includes the return of site equipment, formwork, scaffolding and construction equipment.[94] As landfill capacity becomes increasingly scarce, disposal logistics will become more important and have an impact on pricing.[95]

Rough and detailed planning:

Rough and detailed planning is applied to logistics planning depending on the stage of the project, thus obtaining results for duration, resources and costs.[96]

4.4.2. Creation of a supply chain in Maun, Botswana

As described in Chapter 4.3.1, construction logistics can be divided into three areas. Supply or procurement logistics, construction site or production logistics and disposal logistics.

These three areas can be worked through in six steps:

1. Determination of the building material requirements
2. Procurement of the building materials
3. Determination of the required transports
4. Coordination
5. Logistic tasks
6. Waste

[94] Cf. Schach, Rainer/ Schubert, Nadine: Logistik im Bauwesen: 2009; p.62.
[95] Cf. Hofstadler, Christian: Bauablaufplanung und Logistik im Baubetrieb: 2007; p.47.
[96] Cf. Hofstadler, Christian: Bauablaufplanung und Logistik im Baubetrieb: 2007; p.47.

This chapter explains the procedure of the individual steps and illustrates them using Rammed Earth (Attachment 7).

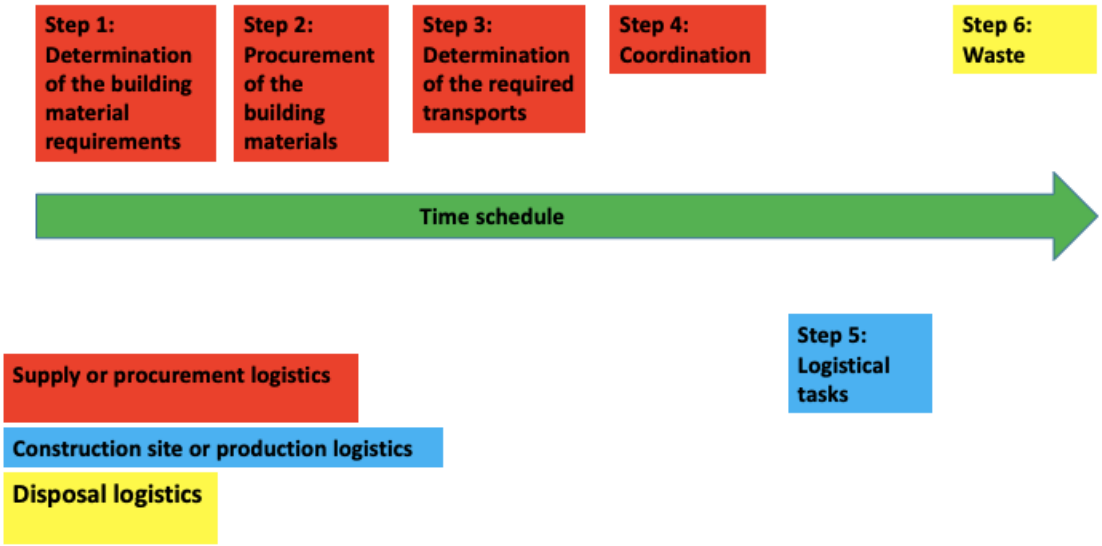

Figure 14: Timing of the supply chain[97]

<u>Step 1: Determining the building material requirements</u>

The calculation of building material requirements is of particular importance to the construction expert. In order to be able to manufacture a certain component, the necessary partial quantities of aggregates, binders and additives are required. These are needed in order to order them in good time and thus avoid a standstill on the construction site.[98]

1) <u>Procedure</u>

For the calculation of the building material requirements, it is important to create the architecture of the building. Once this has been done, the object can be digitized with the help of various CAD programs. The materials to be used are then selected. In Maun-Science-Park, these are to be sustainable or local building materials.

With the help of various programs, such as ITWO from RIB and the CAD file created, a mass determination can be carried out from this.

[97] Fig. Own illustration.

[98] Cf. Cremmer, Rolf/ Dippel, Frank: Baustoffbedarf: 1996; p.127.

2) Example based on Rammed Earth

Once the quantities of building materials have been calculated with the help of a program or manually, all additives and required auxiliary materials can now be determined.
Determination of all the necessary materials can be carried out with the help of a building materials package. Since the mass determination only gives the total volumes or areas, it is useful to calculate the material for one cubic meter or square meter.

Building material package Rammed Earth for one cubic meter of wall with d = 20cm

Required formwork:

$$\frac{1m^3}{0{,}2m} = 5m^2$$

You need 5m2 of formwork for one side of the wall to create one cubic meter. But since you need to form two sides, the figure is multiplied by two.

- 10m2

Earth:

1m3 of earth-moist soil corresponds to 0.65m3 of compacted mass.[99]

$$\frac{1m^3}{0{,}65m^3} = 1{,}54m^3$$

For one cubic meter of soil, you need 1.54m3 of uncompact earth-moist soil.

- 1,54m3

Additives:

Sand, clay, gravel and stabilizers are also used as additives in a Rammed Earth component. These additives are used as required or depending on the condition of the earth. They ensure the stability, strength and cohesion of the respective components.

[99] Cf. Schroeder, Horst: Lehmbau: 2018; p.177.

The ideal mix for a Rammed Earth product is, 15-18% clay, 32% silt, 30% sand and 23% soil aggregates.[100]

Compaction equipment:

Compression is performed by manual, electric or pneumatic compressor.

Work package for one cubic meter of Rammed Earth:

Shuttering	10m2
Soil moisture uncompact soil	1,54m3
Additives	According to need and condition of the earth
Compactor	Manual, Electric or Pneumatic

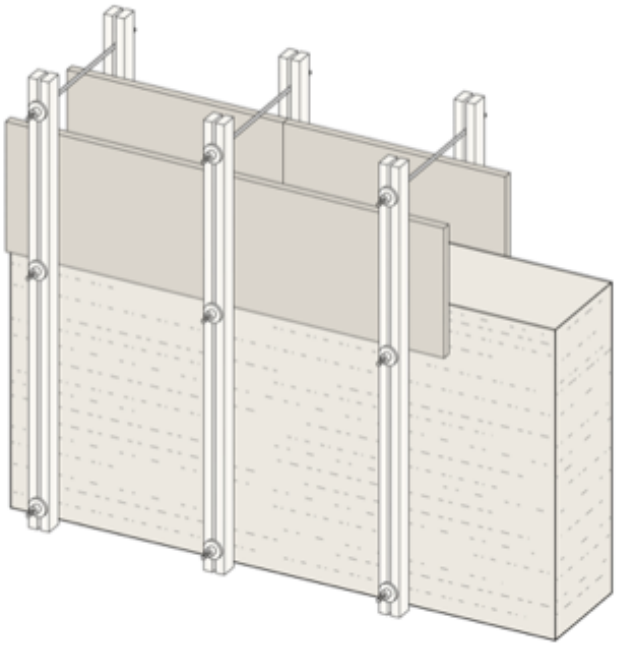

Figure 15: Load-bearing wall Rammed Earth[101]

Step 2: Procurement of the building materials

The procurement of building materials is an important part for a construction company. It includes the supply of the necessary construction resources for the construction work, such as operating materials, building materials, tools, equipment or even external services. In practice,

[100] Cf. Lyamuya, Paul Kinanawa/ Alam, Kazi Nurul: Earth Construction in Botswana: Reviving and improving the Tradition: 2013; S.7.

[101] Fig. taken unchanged from Dachverband Lehm, www.dachverband-lehm.de, Tragende Wände aus Lehm, [as of 08.01.2021].

this is understood as "purchasing". The procurement is connected with costs. This is determined by the procurement price as well as the procurement additional costs (e.g. transport, storage).[102]

1) Procedure

The building materials to be procured and used in the Maun Science Park should be characterized by sustainability. Much of the environmental impact occurs in the supply chain. It is therefore important for companies to address these social impacts. A major problem with supply chain sustainability is lack of transparency. One sees the contracted supplier, but not its subcontractors.

As described in chapter 4.2, digitization of this chain would create a certain transparency. Another option would be to order the products directly from the producer. In terms of sustainability, however, it must be ensured that the building materials are local and occur in the vicinity. Once this has been done, it is possible to obtain quotes from the various suppliers and thereby choose the most suitable supplier.

2) Example based on Rammed Earth

As described in step 1, you need the following components to create a Rammed Earth component:

- Earth + aggregates
- Shuttering
- Compaction equipment

Earth + aggregates:

Paul Marais said in an interview:

"(...) I think cement is a major disaster in terms of global warning. So I have tried to move away from cement. In fact, I built in Johannesburg a massive 460m² house, totally cement free. The total house was built from earth of the side. (...)"[103]

From this it can be concluded that it is possible to create Rammed Earth components with the earth that is excavated from the construction site. Later in the interview, he added that it does

[102] Cf. Bauprofessor, www.bauprofessor.de, Beschaffung, [Accessed 08.01.2021].
[103] Cf. Marais, Paul: Zoom QnA with Paul Marais 5 June 2020: 05.06.2020: min. 15:52.

not matter what condition the earth is in. It is only necessary to ensure that it is in a good condition. This, he said, could be achieved through aggregates.

On the one hand with lime and with the other component called Crusher Dust, which are small stones with a diameter of 2mm-7mm.

These surcharges can be obtained about 60km from Maun in Toteng. Here is a company called: "Toteng Mining Company Botswana". All the additives needed for a rammed earth component can be ordered from them.

Figure 16: Route Toteng - Maun[104]

Formwork:

For the formwork, anything from system formwork to simple timbers can be used. As a rule, contractors working with Rammed Earth use lightweight timbers that can be carried by a maximum of two people.

These timbers are then stabilized with steel supports and can be used multiple times.

In order to create sustainability, it would be possible, for example, to make the formwork from trees that have to be felled when construction begins.

Compaction equipment:

The compaction equipment is provided by the contracted specialist companies.

Step 3: Determination of the required transports

[104] Fig. taken unchanged from Google Maps [as of 09.01.21].

When determining the required transports, one should proceed according to the pull or just-in-time principle.

A distinction is made between classic project management (push principle) and lean management (pull principle). In the former, the goods are delivered as soon as they are produced, regardless of whether they are needed or not. This contrasts with lean management, in which the goods are delivered "just-in-time", thus preventing unnecessary intermediate storage and counteracting damage or loss.

1) Procedure

To describe the JIT or pull principle, the "5R "s result:

The right product, at the right time, in the right quantities, in the right quality, at the right place.

The most important thing to implement such a principle is the flow of information, or in Japanese the term Kanban.[105]

From this, it can be concluded that it is important that if a building material is no longer available, another one is ordered directly. This is important in order not to jeopardize Just In Time, as can be seen from the previous explanations and could be implemented using smart contracts.

2) Example based on Rammed Earth

At the beginning, it is necessary to create a schedule, taking into account the transportation of building materials. With Rammed Earth, you need to pay attention to the following:

- The formwork should only be on site during the specified time period, so as to keep costs as low as possible.
- There should be no empty runs of the trucks by moving only small quantities.
- Deadlines should be met to prevent intermediate storage.
- The necessary equipment must be available with competent working personnel and the right materials handling equipment.

Step 4: Coordination

Coordination is an important part of supply and procurement logistics. It must take place in order to ensure an orderly process on the construction site and thus prevent chaos.

[105] Cf. Bertagnolli, Frank: Lean Management: 2018; p.84.

It is largely dependent on the elevation and floor plan design.

The following points should be noted here:[106]

- The transfer points must be easily accessible.
- The means of transportation must match the means of conveyance.
- The access roads, storage areas and traffic routes must be thoroughly planned.
- Work must not be obstructed by deliveries (obstruction notice).
- Create storage areas only in areas where they will not interfere.

The importance of coordination grows with the progress of construction, due to the increase of different trades.

1) Procedure

First and foremost, it is important to create a site layout plan. Here, the following steps should be taken into account:[107]

- The site plan must be provided by also showing the property lines.
- The bill of quantities must be looked through in order to extract any construction details, special requirements or even deadlines.
- The structural plant must be represented.
- Dimensioning of large equipment and scaffolding.
- Dimensioning of the media supply or disposal.
- Arrangement of construction site security.
- Development of various protection concepts (noise, fire).
- Plausibility check.

2) Example based on Rammed Earth

Here, you should plan which large equipment but also other means of conveyance you need for Rammed Earth. It is also important to consider in which form it will arrive at the construction site and at which points of the construction site the approach is best.

Storage areas are also used, if necessary, as temporary storage space or even as space for unneeded formwork.

[106] Cf. Hofstadler, Christian: Bauablaufplanung und Logistik im Baubetrieb: 2007; p.44.
[107] Cf. Schach, Rainer/ Otto, Jens: Baustelleneinrichtung: 2008; p.318.

Step 5: Logistical tasks

While the first four steps deal purely with the movement of building materials outside the construction site, this step deals with the movement inside the construction site. More precisely, it is about the materials handling equipment that is used.

1) Procedure

The rational design of the means of transport consists mainly in determining the capacities correctly in order to prevent under-performance or over-equipping.

- Cranes, wheel loaders or forklifts are recommended for handling building materials. If possible, direct handling to the individual floors should also be aimed for.
- For vertical transports, take construction site cranes, but also construction elevators, which are located on the outside of the building. However, this must also be taken into account in step four, that the delivery areas are located near the vertical conveyors.
- The building materials are then moved horizontally with forklifts, conveyor belts, wheel loaders or even excavators. Manual transports are to be avoided for time-related reasons.

2) Example based on Rammed Earth

The choice of the appropriate material handling equipment depends on the respective building material. In the case of rammed earth, a wheel loader with a large bucket volume is recommended for handling building materials and for horizontal transport.
For vertical transport, a fixed site crane would be considered.

Step 6: Waste

As already described in chapter 4.4.1, disposal is an important issue, now and in the near future. Especially in the sense of sustainability.

1) Procedure

The procedure in this step is relatively simple. Through the choice of materials, the respective construction residues are already predetermined.

2) Example based on Rammed Earth

At Rammed Earth, a waste container for construction debris is an option. For the cut or waste pieces of the formwork would be a wooden container to use.

5. Conclusion and outlook

Africa's countries are very diverse. While some have already become emerging economies, others are still among the most underdeveloped countries in the world. Unfortunately, most of them will not succeed in changing this in the foreseeable future.

The Maun Science Park in Botswana offers a great opportunity for Africa, but also for the rest of the world. It can show how it is possible with new technology to create a sustainable blueprint and thus enable coexistence between humans and the environment.

Project management is a major challenge in connection with this project. Due to the ever-changing framework conditions and the high number of stakeholders, the implementation of a hybrid model is essential. As described in chapter three, an agile method must be able to respond to any short-term changes.

Supply chain management is an important part of project management. Especially in things like transparency and sustainability. Nevertheless, it represents a major challenge in Botswana. Due to the partly poor infrastructure and the new building materials, it remains to be seen if a smooth implementation is possible. The steps, which were explained in this work, refer to an implementation, as it is usual in Germany. Here one must act with foresight and thus possibly be able to make changes.

In general, the project has a good chance of being successful. Nevertheless, there is a great risk behind it.
On the one hand, a failure would make future implementations much more difficult; on the other hand, a lot of money is attached to this project. It will be important to involve the people or the population as early as possible in the plans, but also to accept suggestions. The new materials and working methods will also present us with great challenges, as many have not yet been used on such a large scale.

But if this does not happen, something can emerge that can change and improve the lives of large segments of the population in Africa and around the world.

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Attachment

Attachment 1: World population by continent of the year 2020

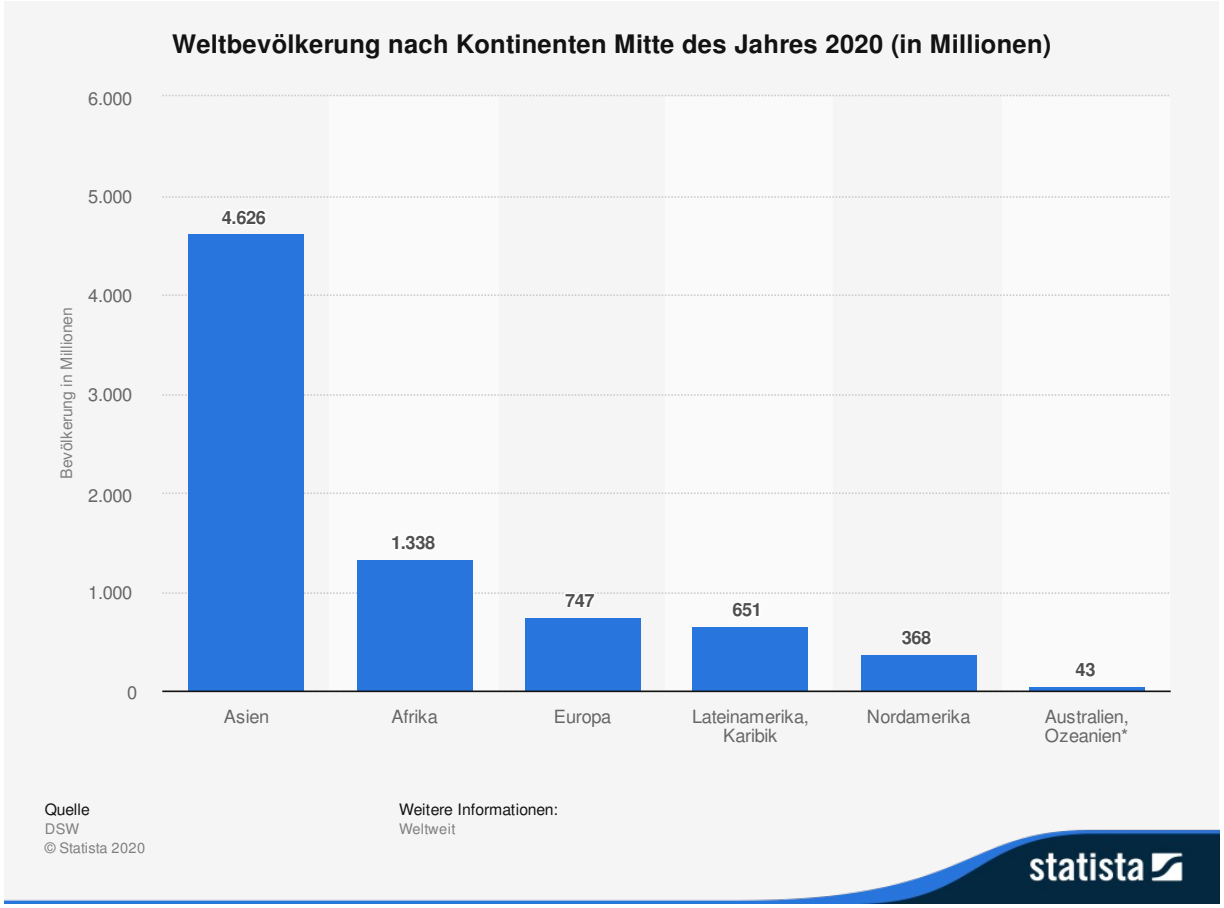

Figure 17: World population by continent (Attachment)[108]

[108] Fig. taken unchanged from Statista, www.statista.de, Weltbevölkerung nach Kontinenten, [as of Nov.05.2020].

Attachment 2: Natural growth rate of the population in 2020

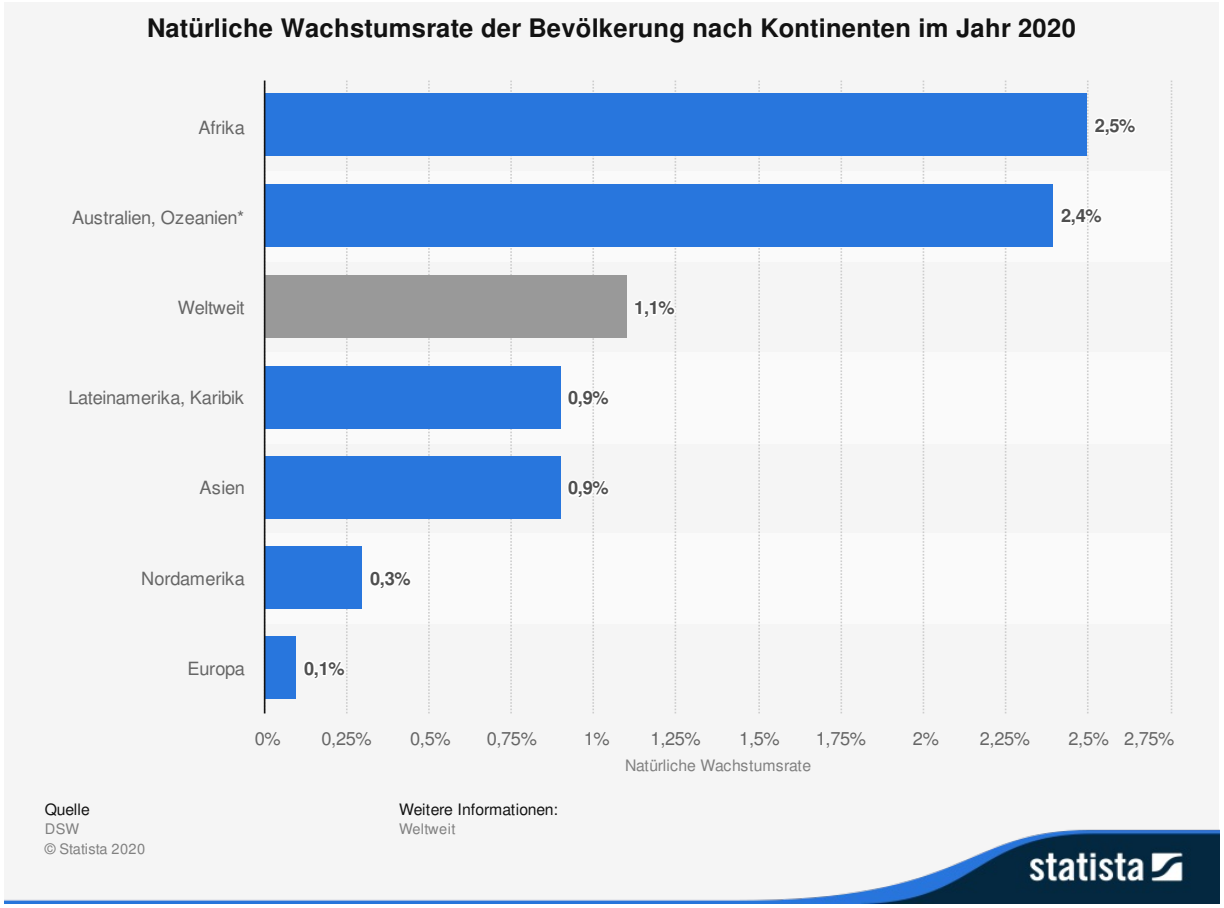

Figure 18: Natural growth rate of the population (Attachment)[109]

[109] Fig. taken unchanged from Statista, www.statista.de, Natürliche Wachstumsrate der Bevölkerung nach Kontinenten, [as of Nov.05.2020].

Attachment 3: Share of population below the absolute poverty line by world region

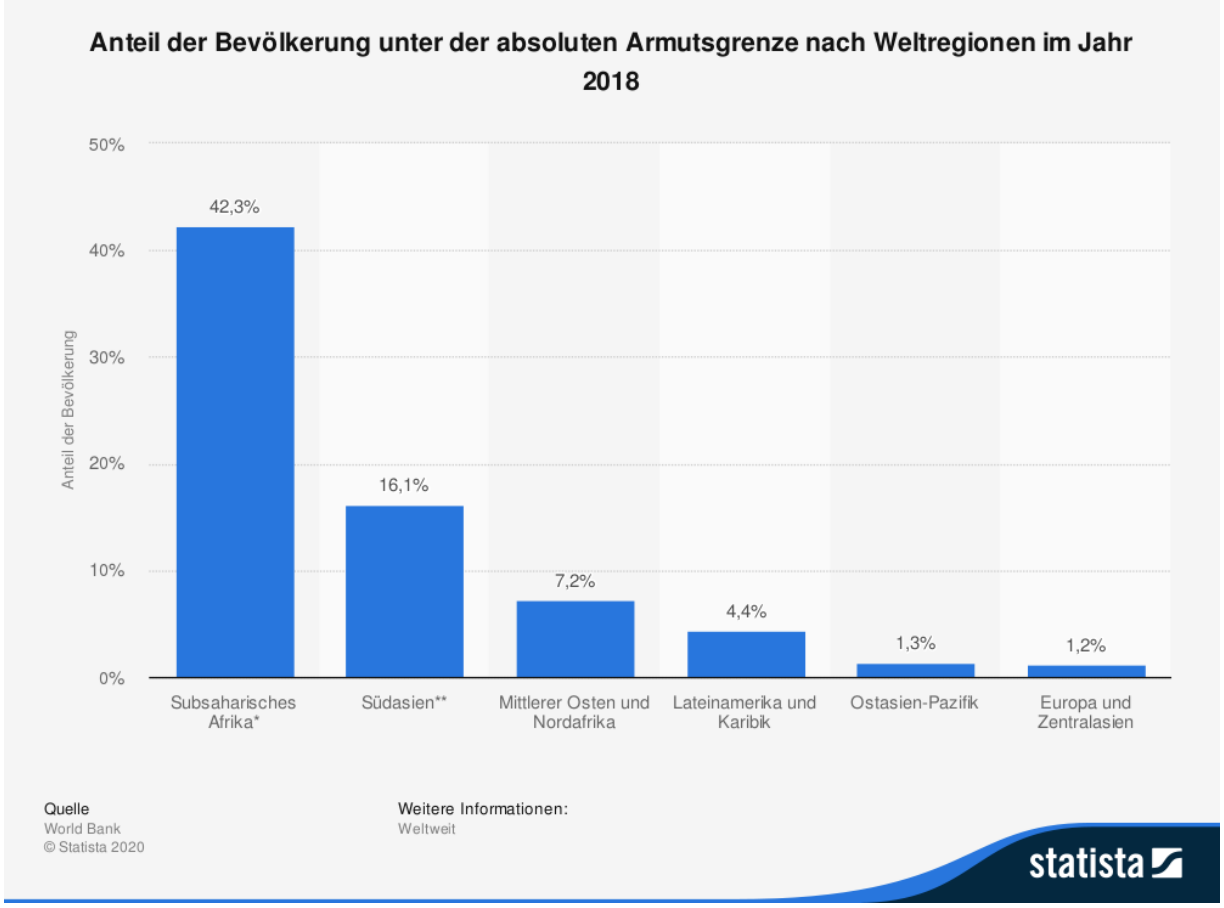

Figure 19: Share of population below the absolute poverty line by world region (Attachment)[110]

[110] Fig. taken unchanged from Statista, www.statista.de, Anteil der Bevölkerung unter der absoluten Armutsgrenze nach Weltregionen, [as of Nov.05.2020].

Attachment 4: Gross domestic product (GDP) in selected world regions

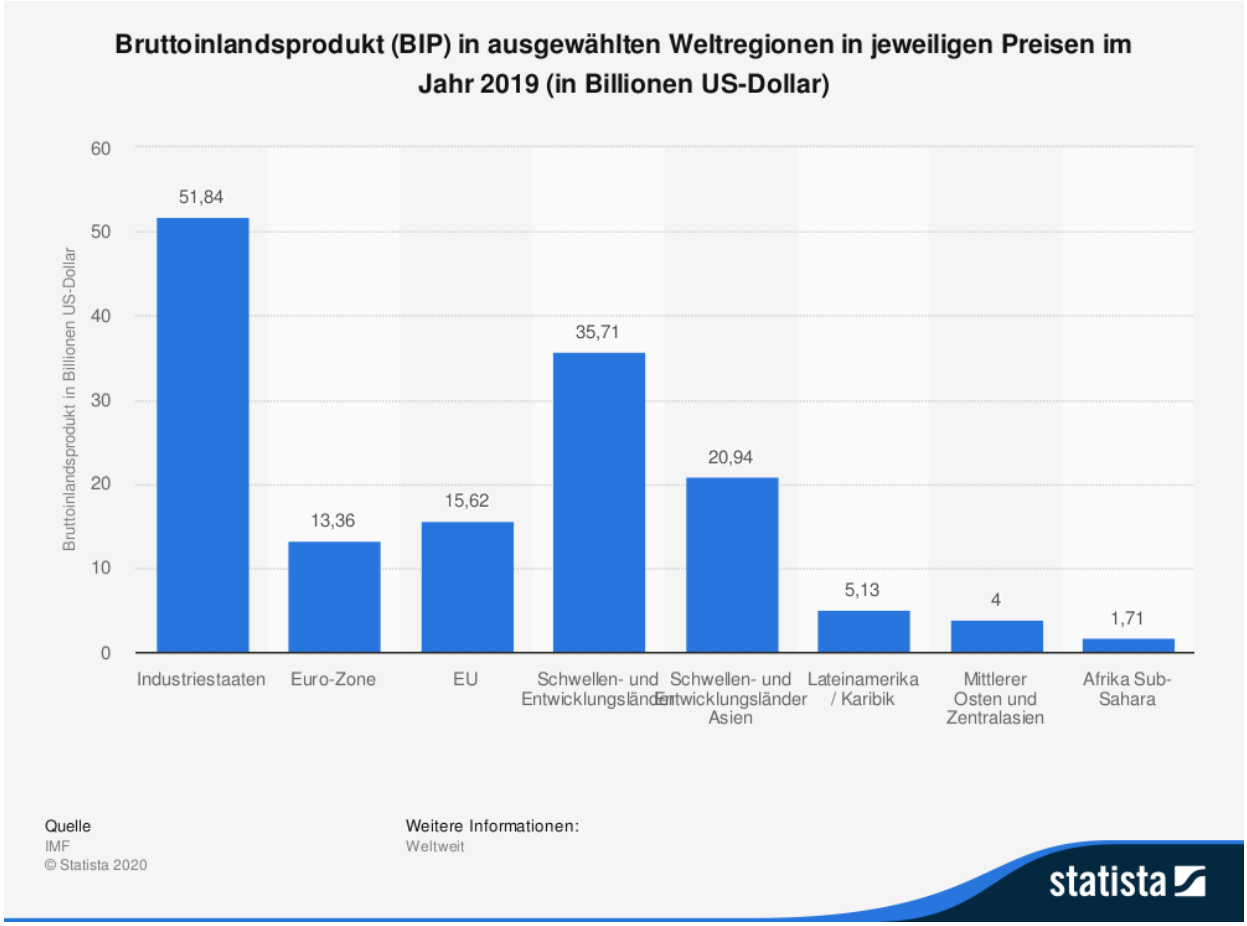

Figure 20: Gross domestic product (GDP) in selected world regions (Attachment)[111]

[111] Fig. taken unchanged from Statista, www.statista.de, BIP in ausgewählten Weltregionen in jeweiligen Preisen im Jahr 2019, [as of Dec.09.2020].

Attachment 5: Life expectancy in sub-Saharan Africa

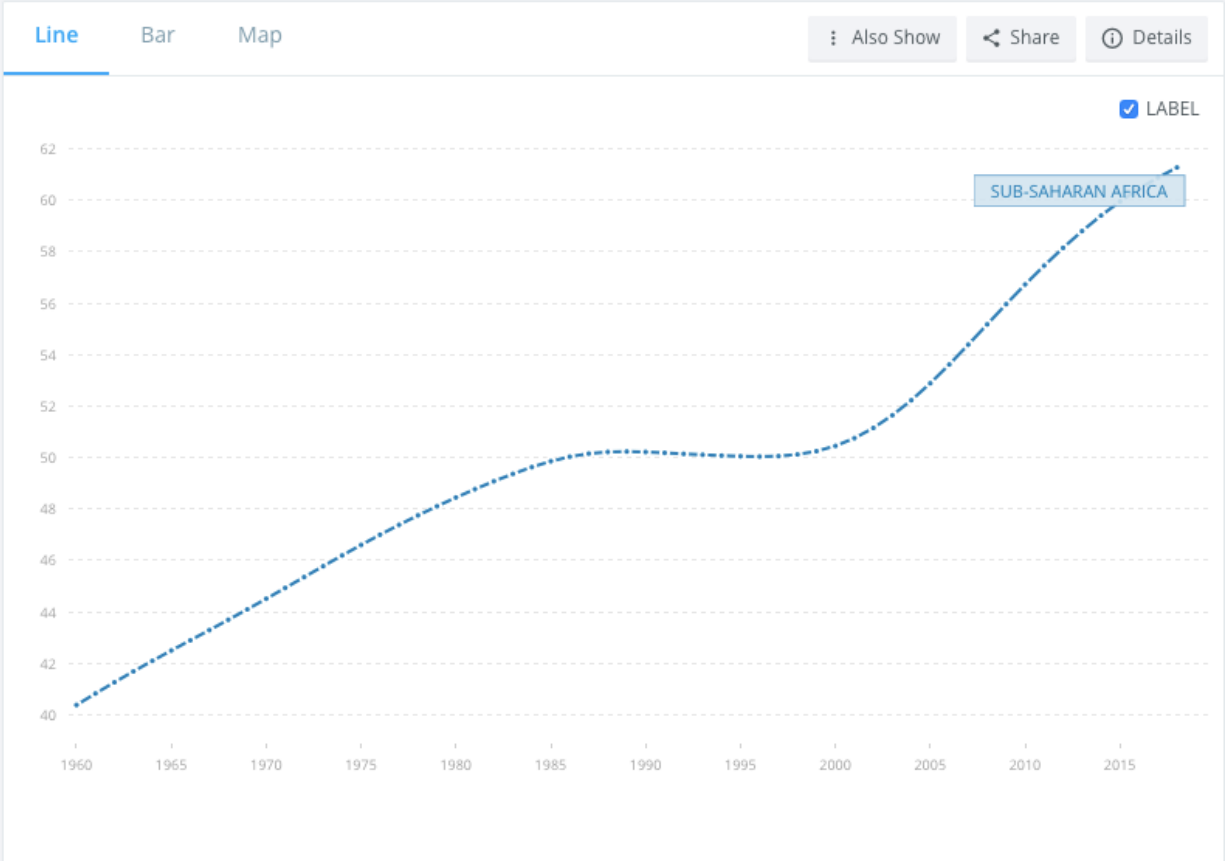

Figure 21: Life expectancy in sub-Saharan Africa (Attachment)[112]

[112] Fig. taken unchanged from The World Bank, www.data.worldbank.org, Life expectancy at birth, total(years) – Sub-Saharan Africa, [as of Dec.09.2020].

Attachment 6: Black Thursday in Stuttgart

The Stuttgart 21 project is a good example of a conflict between opponents and supporters: Stuttgart 21 is a negative example of poor stakeholder management. Stakeholders in a project always include the local population. Since they are often on the side of the skeptics, it is essential to include them.

If this does not happen, in the worst case it can lead to scenes like the so-called "Black Thursday" in Stuttgart on September 30, 2010.

The police were ordered to clear the area in the context of construction work for the groundwater plant. This action led to large-scale riots, in which about 400 people were slightly injured and 50 students were among them.[113]

Such actions do not serve a successful project continuation and are therefore counterproductive. Rather, a peaceful discussion would have been helpful here, in which each party can make its points of view known and find a solution together.

Figure 22: Black Thursday(Attachment)[114]

[113] Cf. Spiegel, www.spiegel.de, Bürgerkrieg im Schlossgarten [as of Nov. 28, 2020].

[114] Fig. taken unchanged from Stuttgarter Nachrichten, www.stuttgarter-nachrichten.de, Der Schwarze Donnerstag wirkt nach [as of Nov. 28, 2020].

Attachment 7: Rammed Earth

Rammed Earth:

Rammed Earth can be translated into German as Stampflehm (STL). It is a technique with which walls, floors or even foundations can be created. The whole component is built from the natural materials such as earth, lime, clay or even gravel.

Procedure:

The creation of Rammed Earth works in the final effect like the creation of a concrete wall. The only difference is in the material.

The first step is to place a system formwork from both sides. Then the natural materials are poured in 10cm - 40cm thick layers and compacted with the help of a manual tamper or by hand. Once this is done, it is necessary to directly remove the formwork in order not to destroy the surface structure.

Figure 23: Ruins of a palace from rammed earth (Attachment)[115]

[115] Fig. taken unchanged from Schroeder, Horst: Lehmbau: 2018; p.9.

Figure 24: Prefabricated rammed earth blocks (Attachment)[116]

[116] Fig. taken unchanged from Schroeder, Horst: Lehmbau: 2018; p.154.

Figure 25: Compaction rammed clay by means of compressed air rammer (Attachment)[117]

[117] Fig. taken unchanged from Schroeder, Horst: Lehmbau: 2018; p.152.