In the age of the Fourth Industrial Revolution, digitization is playing an increasingly important role not only in our economy, but also in our society. A key technology here is artificial intelligence. According to expert opinions, AI also has the potential to overcome, for example, gender inequality which is one of the sustainable development goals. Thus, the aim of this chapter is to investigate whether AI can contribute to sustainable development, especially to the achievement of the SDGs. For this, the author has conducted six expert interviews and identified on the one hand AI application scenarios, which can contribute to the achievement of the SDGs, and on the other hand crucial aspects, which must be given for the use of AI in a sustainable development context. As a result, she found that the greatest potential for the use of AI can be seen in the SDGs which can be assigned to the infrastructure level. Furthermore, she developed a framework for the classification of the aspects that shows where these aspects need to be addressed in order to facilitate and develop the use of AI for sustainable development. These results can provide a basis for further research.
Content

1 Introduction 149
2 Theoretical foundations 150
  2.1 Artificial intelligence 150
  2.2 Sustainable Development Goals 152
3 Methodical approach 153
4 Results and discussion 155
  4.1 Application scenarios that contribute to sustainable development 155
  4.2 Crucial aspects for the usage of AI as a supporter of sustainable development and their implications 158
  4.3 Limitations and further research needs 161
5 Conclusion and outlook 162
1 Introduction

In the age of the Fourth Industrial Revolution, digitization is playing an increasingly important role not only in our economy, but also in our society. A key technology here is artificial intelligence (AI) and thus also the most important accelerator of the second wave of digitization. AI will play an increasingly decisive role for industry.¹ For example, the sales of artificial intelligence business applications are expected to reach $1,622.4 million in 2018 and will have increased more than 19 times by 2025.²

However, AI is not only rapidly gaining importance for industry, but also for administrations, society and our daily lives.³ According to Jayathma Wickramanayake, United Nations Secretary-General’s Envoy of Youth, AI can be seen as an opportunity to overcome, for example, gender inequalities.⁴ Gender equality is one of 17 Sustainable Development Goals (SDGs), which were adopted at the United Nations Sustainable Development Summit 2015. These SDGs are in the heart of Agenda 2030, which created the common basis for reconciling global economic progress with social justice and shaping it within the earth’s ecological limits.⁵ Admittedly, it is implied that AI can contribute to the achievement of the SDGs, but there is no concrete evidence of how this can happen.

Thus, the aim of this chapter is to investigate whether AI can contribute to sustainable development, especially to the achievement of the SDGs. Therefore it is necessary to verify whether AI-based application scenarios can be identified. Furthermore, the question remains which prerequisites or factors must be given that AI can be used in this context. In concrete terms, this raises the major research question (MRQ):

**MRQ:** Can AI contribute to sustainable development and thus act as a supporter of sustainable development?

In order to be able to answer this, it is essential to answer the following sub-research questions (SRQ):

**SRQ1:** What is known as AI?

**SRQ2:** Are there AI applications that can contribute to the achievement of the SDGs and, if so, to which goals do they contribute?

---

¹ Bitkom e.V./DFKI 2017, pp. 8-9.
² Statista 2018.
³ Bitkom e.V./DFKI 2017, p. 8.
⁴ UNYouth Envoy 2018.
⁵ United Nations 2015.
SRQ3: Which aspects are crucial for the use of AI-based applications in a sustainable development context?

As I explained above, there is no concrete evidence that examines the relationship between AI and sustainable development as a whole, no matter whether through a qualitative or quantitative study. For this reason, the study of AI as a supporter of sustainable development is relevant.

2 Theoretical foundations

2.1 Artificial intelligence

By introducing a model of artificial neurons and therefore drawing on the knowledge of the basic physiology as well as the function of neurons in a brain and a formal analysis of propositional logic, McCulloch and Pitts (1943) published the first work that is now recognized as AI.6 AI has developed into an interdisciplinary field of research since the formation of concepts at the end of the 1950s. Therefore, the term AI is not defined uniformly.7

In connection with AI buzzwords like deep learning or machine learning arise. In Figure 1 can be seen that AI contains different disciplines such as deep learning, representation learning and machine learning.8 Machine learning is used for many but not all approaches to AI and is the only viable approach that can operate in complex real-world environments. So, it is a technique that enables computer systems to improve with data and experience. Deep learning, which is a type of machine learning, is more flexible and achieves greater power because it can represent the world as a nested hierarchy of concepts.9 Abstract representations are computed in terms of less abstract ones and defined in relation to simpler concepts. Thus, deep learning is to some extent representation learning and this is a type of machine learning.10

6 Russell/Norvig 2016, p.16.
At the German Research Center for Artificial Intelligence, for example, AI is understood to have the property of displaying human-like intelligent behaviors.\textsuperscript{11} The Turing Test was designed in 1950 to test whether a computer is acting humanly intelligent. Here, a human interrogator must state whether a human or a machine gave the answer. If this is not possible, the test is considered as passed.\textsuperscript{12} In Table 1 we see that Russell und Norvig (2016) distinguish three more categories of AI definitions besides \textit{Acting Humanly}.

This classification distinguishes between the \textit{thought process} and the \textit{reasoning} in the upper categories, and the \textit{behavior} in the lower categories. On the other hand, a distinction is made on the basis of the yardstick of performance. In the left categories, success is measured in terms of fidelity to \textit{hu-}

\textsuperscript{11} Bitkom e.V./DFKI 2017, p. 14.
\textsuperscript{12} Luger 2009, p. 13.
man performance and on the right side, it is measured by an ideal performance measure, the so-called rationality.\textsuperscript{13}

<table>
<thead>
<tr>
<th>Thought processes/reasoning</th>
<th>Human performance</th>
<th>Ideal performance/rationality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinking Humanly</td>
<td>“[…] the exciting new effort to make computers think […] machines with minds, in the full and literal sense.”\textsuperscript{14}</td>
<td>Thinking Rationally “[…] is the study of mental faculties through the use of computational models.”\textsuperscript{15}</td>
</tr>
<tr>
<td>Acting Humanly</td>
<td>“[…] is the property of an IT system to show &quot;human-like&quot;, intelligent behavior.”\textsuperscript{16}</td>
<td>Acting Rationally “[…] may be defined as the branch of computer science that is concerned with the automation of intelligent behavior.”\textsuperscript{17}</td>
</tr>
</tbody>
</table>

| Behavior                    | | |
|-----------------------------| | |

Table 1: Categories of AI definitions
(Source: Own elaboration, based on Russell/Norvig 2016, p. 2.)

2.2 Sustainable Development Goals

At the 55\textsuperscript{th} General Assembly of the United Nations, the so-called Millennium Summit, it was decided that nothing must remain untried in order to save people from poverty and enable everyone to live a decent life. This Millennium Declaration represents a reorientation of development policy in which the interdependencies between problems are viewed holistically. In 2001, eight Millennium Development Goals (MDG) were derived from this declaration and were revised and further developed in 2015.\textsuperscript{18} The 17 SDGs and their targets contained in the Agenda 2030 for sustainable development came into force on the 1\textsuperscript{st} January 2016. The SDGs are intended to build on the MDGs and thus eradicate all forms of poverty.\textsuperscript{19}

The 17 SDGs were categorized by Waage/Yap into three levels based on their intended outcomes\textsuperscript{20}. The central level, which includes all SDGs that can be recognized as people-centered goals, is called well-being. SDGs that

\textsuperscript{13} Russell/Norvig 2016, p.1.  
\textsuperscript{14} Haugeland 1989, p. 2.  
\textsuperscript{15} Charniak/McDermott 1985, p. 6.  
\textsuperscript{16} Bitkom e.V./DFKI 2017, p. 14.  
\textsuperscript{17} Luger 2009, p. 1.  
\textsuperscript{18} Michelsen/Adom\c{s}ent 2014, p. 22.  
\textsuperscript{19} United Nations 2018a.  
\textsuperscript{20} Waage/Yap 2015, pp. 80-82.
belong to this level are SDG 1, SDG 3, SDG 4, SDG 5, SDG 10 and SDG 16. The next level is the middle level. It contains all SDGs that are related to networks and production, distribution and delivery mechanisms (SDG 2, SDG 6, SDG 7, SDG 8, SDG 9, SDG 11 and SDG 12). This is the infrastructure level. The last outer level includes the SDGs that are associated with the management of global resources (SDG 13, SDG 14, and SDG 15). This is why this level is called natural environment. 21 SDG 17 is not assigned to any of these three levels “because it is a cross-cutting goal relating to goals at all levels”. 22

3 Methodical approach

In the literature two different research strategies can be identified: the qualitative and the quantitative research. Quantitative methods provide the breadth and qualitative methods provide the depth. 23 Since a very detailed statement can be made for qualitative methods, even on the basis of a very small sample, 24 I have decided to take a qualitative approach for this empirical work and therefore conduct expert interviews. I have chosen an interview guide as an information collection tool due to the fact that an interview guide not only serves to ensure the comparability of the interviews, but also serves as a reminder for the interviewer. 25 So, in order to answer my research questions, I chose the following structure for my interview guide:

21 Waage/Yap 2015, pp. 80-82.
22 Waage/Yap 2015, p. 82.
1. What do you understand by artificial intelligence?

2. Did you or your organization thought about the application of AI or do you already use AI as a supporter of sustainable development?

Yes

In which application areas do you use or can you think of the usage of AI?

No

Why don’t you think about that (e.g. organizational structure, costs)?

3. Which aspects are crucial for the usage of AI as a supporter of sustainable development?

Figure 2: Interview guide
(Source: Own elaboration.)

For the selection of the research institutes I followed the approach of homogeneous sampling. In my opinion it is only useful to interview such research institutes that concentrate on doing research in the field of AI.

On the other hand, the strategy of criterion sampling forms the basis for the selection of industrial companies, so that they had to fulfill certain criteria. The companies have to differ from each other to such an extent that they can be associated with different industries. At the same time, they should meet the following criteria: sustainability must be grounded in their corporate strategy, digitalization and especially AI must be applied, and they need to operate worldwide. This should ensure that there is a possibility that AI and sustainability can be linked.

I conducted the interviews in May and June 2018 and all interviews were conducted personally, on-site in the respective organizations. The interviews were scheduled for 15-20 minutes and lasted between 8:50 and 37:55, but on average 17 minutes.

In order to answer my research questions, I conducted a qualitative content analysis. Therefore, I formed the categories for classifying the application scenarios contributing to sustainable development and the crucial aspects for the usage of AI as a supporter of sustainable development.

I have identified the application scenarios and examples that contribute to sustainable development. For this, I used the 17 SDGs, which were introduced in section 2.2, as guidance. It is important to note that an application scenario does not necessarily have to be assigned to just one category.
To be able to make a statement about the necessary aspects for the use of AI for sustainable development, I have formed the categories by inductive category formation, i.e. directly at the material. Here, I followed Kuckartz's guideline for the formation of categories on the material. First, I defined the objective of category building, namely the identification of essential aspects for the use of AI. Then, I determined the category type and the abstraction level as well as the type of coding unit.

4 Results and discussion

4.1 Application scenarios that contribute to sustainable development

In this section, I first identified application examples that contribute to sustainable development. I was able to determine ten SDGs – SGD 2, SDG 3, SDG 6, SDG 7, SDG 8, SDG 9, SDG 10, SDG 11, SDG 12 and SDG 13 – that AI can help to achieve. The following five scenarios have been proved relevant in this study.

<table>
<thead>
<tr>
<th>Application scenario number</th>
<th>Brief description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application scenario 1 (AS1)</td>
<td>Traffic control /flow regulation in cities</td>
</tr>
<tr>
<td>Application scenario 2 (AS2)</td>
<td>Monitoring the environment by sensor data</td>
</tr>
<tr>
<td>Application scenario 3 (AS3)</td>
<td>Quality size forecasting</td>
</tr>
<tr>
<td>Application scenario 4 (AS4)</td>
<td>Making renewable energies plannable</td>
</tr>
<tr>
<td>Application scenario 5 (AS5)</td>
<td>Secure food supply</td>
</tr>
<tr>
<td>Application scenario 6 (AS6)</td>
<td>Malaria prevention</td>
</tr>
</tbody>
</table>

Table 2: Identified application scenarios
(Source: Own elaboration)

One application scenario for AI is *traffic control and flow regulation in cities (AS1)* where AI could be used to adapt traffic lights to each other in an intelligent way over intersections. Rather than having pre-programmed switching patterns, the entire traffic flow in a city could be modeled. This innovative, intelligent traffic control optimizes the route and thus saves energy and fuel so that a more efficient use of resources can be facilitated. It thus modernizes and retrofits the infrastructure (SDG 9). It will also provi-

27 Interview 1.
de access to sustainable transport systems. In addition, road safety can be improved and thus, AS1 helps to achieve SDG 11.

Considering the ongoing climate change and the resulting efforts for climate protection, e.g. water quality, monitoring the environment by sensor data (AS2) can help identify problem areas. By gathering data from a sensor network and analyzing this data by AI, an emitting pollutant can be identified, localized, monitored and it can be intervened early. This can mitigate climate change and also improve early warning.28 The immediate adoption of measures to combat climate change and its effects are objectives of SGD 13. For example, by reducing water pollution and minimizing the release of hazardous substances and chemicals (SDG 6), the access to water and therefore the security of water quality could be ensured.

Another application scenario that was mentioned in one interview was quality size forecasting (AS3). By training and feeding an AI application with relevant data, all parameters in a production process and thus the process itself can be controlled by this AI. The fact that it is possible to set the quality level so that less energy is consumed in the production process or that no more ingredients are used that are harmful to the environment makes the industrial processes more environmentally friendly and saves resources (SDG 9).29

AS4 tries to make this supposedly unplannable energy plannable and predictable by doing load predictions and by giving recommendations for action. So, by making renewable energies plannable (AS4) and reducing the mismatch of generation and consumption, resource efficiency is also improved and sustainable consumption and production patterns are ensured (SDG 12). This can help to decouple economic growth from environmental degradation and thus contribute to the achievement of SDG 8. The aim of AS4 is that a lot of energy will be used exactly when renewable energy suppliers produce a lot of energy. Furthermore, the share of renewable energies in the global energy mix is to be significantly increased.30 SDG 7 calls for access to affordable, reliable, sustainable and modern energy for all which AS4 can help to achieve. Due to the fact that this application scenario was developed in research, scientific research will be improved in order to expand the technological capacities worldwide and to make better use of existing ones (SDG 9).

28 Interview 1.
29 Interview 3.
30 Interview 4.
SDG 2 includes, among other things, the sustainability of food production systems and the use of resilient agricultural methods. This should ensure better adaptation to environmental changes. AI can be used to secure food supply (AS5) by evaluating satellite data, recognizing anomalies on fields based on the spectral colors and then give recommendations to the farmers.\textsuperscript{31}

To ensure healthy lives and promote well-being for everybody at all ages, the elimination of malaria epidemics plays an important role (SDG 3). Based on the identification of malaria cases, the migration patterns and the upcoming weather conditions, AI can analyze the data and forecast where the potential of malaria infections will increase. Furthermore, the AI application can send out a warning and recommendations for action.\textsuperscript{32}

The following figure summarizes all SDGs to which the AI-based application scenarios contribute as well as the assigned levels which were introduced in section 2.2.

This figure shows that most of the application scenarios contribute to SDGs that are related to the middle level, namely to the level of infrastructure. These goals primarily concern essential functions of modern society and thus go beyond individuals, households and communities.\textsuperscript{33} I see the most potential in AI-based applications for sustainable development that contribute to growth in well-being while at the same time reducing negative effects on the environment and pollution as well as intensity of the use of resources, especially exhaustible resources.

\textsuperscript{31} Interview 5.
\textsuperscript{32} Interview 5.
\textsuperscript{33} Waage/Yap 2015, p. 82.
Figure 3: Assignment of AI-based application scenarios to relevant SDGs embedded in the levels of sustainable development
(Source: Own elaboration, based on Waage/Yap 2015 p. 81, United Nations 2018b.)

4.2 Crucial aspects for the usage of AI as a supporter of sustainable development and their implications

The following Figure 4 shows the crucial aspects for the usage of AI as a supporter of sustainable development which I have identified. I will explain them below.
Figure 4: Crucial aspects for the usage of AI as a supporter of sustainable development
(Source: Own elaboration)

Through the qualitative content analysis, I was able to identify five main aspects – data, know-how, responsibility, recognition by the user, organizational culture – for the use of AI as a supporter for sustainable development. However, the data aspect clearly plays a predominant role. The reason for this is the fact that AI needs training data in order to be applied. According to experts, nowadays optimization problems can also be solved without data or with only a small amount of data. A prerequisite for this is a low complexity of the facts. But with increasing complexity, the relevance of the data also increases.34 In order to solve these complex mathematical models, not only the amount of training data but also their quality as well as the variety of data is decisive.35

However, the generation of data is associated with some barriers. On the one hand, the publication of data by companies or organizations is a major challenge. This means that without data publication, it is not possible to build comprehensive systems in order to create added value for everyone whether society, environment or the organizations themselves.36 Often the organizations are also not allowed to publish or get these data. Due to the

34 Interview 4.
35 Interview 2.
36 Interview 1.
high level of data protection in Germany, data acquisition for training AI is very time-consuming for many organizations. In this context, certainly a distinction must be made between public or general data and data from which it is possible to draw personal conclusions.\textsuperscript{37}

In addition to the aspect of legal use of the data, trusting in the correct use of the data also plays a role in the publication and permission of use. This means that the party providing the data must trust that the data will be used exclusively for a specific purpose.\textsuperscript{38} In order to be able to use the data at all, on the one hand, it is important to know which parameters have to be set in order to model the process.\textsuperscript{39} On the other hand, it is necessary to know how the data is used so that you can draw conclusions from it.\textsuperscript{40}

Another crucial aspect for the usage of AI as a supporter of sustainable development is the organizational culture. The organization has to set the target to achieve sustainable development, integrate it in everyday work so that all employees work for the achievement of the organization’s target. For this, the recognition by the user plays an important role for organizations. As long as the user does not recognize and appreciate the efforts to achieve sustainable development, the incentive for organizations to adopt this approach is not very strong.\textsuperscript{41} According to the experts, the incentive here must lie in the business case and thus in the organization itself. This approach goes hand in hand with the aspect of responsibility. This means that in order to use AI for sustainable development at all, the organization must feel responsible for sustainable development.\textsuperscript{42}

From this discussion the factors can be divided into social aspects and organizational aspects. Some aspects depend on both social as well as organizational aspects. From the aspect of legality of data use, it can be derived that society is in charge to create a suitable environment for the use of AI as a supporter of sustainable development. The sense of responsibility towards sustainable development needs to be established in organizations and in society. Only in this way a common appreciation of the users can be created and trust can be built. This could create a basis for breaking down the barriers for data release and thus providing access to a variety of high-

\begin{itemize}
  \item \textsuperscript{37} Interview 4.
  \item \textsuperscript{38} Interview 1.
  \item \textsuperscript{39} Interview 3.
  \item \textsuperscript{40} Interview 1.
  \item \textsuperscript{41} Interview 6.
  \item \textsuperscript{42} Interview 5.
\end{itemize}
quality data. My schematic representation of this allocation in a sustainable development context can be seen in the following figure:

![Figure 5: Framework for the classification of social and organizational aspects in a sustainable development context](https://doi.org/10.5771/9783748903192-147)

**Figure 5: Framework for the classification of social and organizational aspects in a sustainable development context**
(Source: Own elaboration)

### 4.3 Limitations and further research needs

I see a limitation in the fact that the application scenarios are all real and thus exist. However, apart from one organization, no AI itself uses or researches AI for sustainable development. This is partly because the sample was not large enough to make valid statements and because the industrial companies in particular are so large and therefore, it is probable that AI is used in other departments. So, further research is required to confirm the application scenarios, extend them and thus prove that AI can contribute to sustainable development. Furthermore, the question remains to what extent AI can contribute to this.

Since the model is based on my considerations and no literature neither identifies the crucial aspects nor distinguishes them into social, organizational or mixed categories, I see the greatest need for research here. I especially see this need because these aspects have to be given to be able to use AI at all. It is particularly interesting whether there are other indispensable
aspects for the use of AI as a supporter of sustainable development and whether these fit into the model so that recommendations for action can be derived for society and organizations.

5 Conclusion and outlook

The aim of the present chapter was to investigate whether AI can contribute to sustainable development. I wanted to show this by analyzing whether there are AI applications that contribute to the achievement of SDGs. By identifying application scenarios and assigning them to SDGs, I was able to show that AI applications for sustainable development already exist. In particular, I found that most of the applications could be assigned to SDGs that are related to the infrastructure level. This suggests that the largest potential for AI use can be seen in applications that contribute to growth in well-being while at the same time reducing negative effects on the environment and pollution as well as intensity of the use of resources, especially exhaustible resources.

In addition, the interviews enabled me to identify crucial aspects for the use of AI-based systems. These aspects can be divided into social and organizational aspects. Thus, I was able to provide a model that shows where these aspects need to be addressed in order to facilitate and develop the use of AI for sustainable development. However, these results still need to be confirmed and, if necessary, extended by further research.

References


