Sustainable Food Systems Vol. 4

Maike Meuser

# A Simulation Game on Sustainable Diets and their Contribution to the Sustainable Development Goals (SDGs)

## its Effect on Learning Outcomes to Support Education for Sustainable Development (ESD)

kassel university press

Sustainable Food Systems
Nachhaltige Lebensmittel- und Ernährungssysteme
Vol. 4
Band 4

Maike Meuser

# A Simulation Game on Sustainable Diets and their Contribution to the Sustainable Development Goals (SDGs) – its Effect on Learning Outcomes to Support Education for Sustainable Development (ESD)

kassel university press

Master thesis in the Department of Organic Food Quality and Food Culture, University of Kassel
Supervisor: Dr. Lilliana Stefanovic

This publication includes an appendix with a synopsis of the data collected in the work, which was published online at KOBRA (Kasseler Online Library, Repository and Archive), the digital archive for the scientific documents of the University of Kassel: https://doi.org/doi:10.17170/kobra-202201105391



Bibliographic information published by Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data is available in the Internet at http://dnb.dnb.de.

ISBN: 978-3-7376-1011-7
DOI: https://doi.org/doi:10.17170/kobra-202201105391


https://kup.uni-kassel.de

Cover layout: Jörg Batschi, Tübingen
Printing Shop: Print Management Logistik Service, Kassel

Printed in Germany

## Table of Content

## List of Abbreviations

| | |
|---|---|
| DGE | Deutsche Gesellschaft für Ernährung |
| ESD | Education for Sustainable Development |
| ETH | Eidgenössische Technische Hochschule |
| FAO | Food and Agriculture Organization |
| GAP ESD | Global Action Program on Education for Sustainable Development |
| GHG | Greenhouse Gas |
| LCA | Life Cycle Assessment |
| LCI | Life Cycle Inventory |
| LCIA | Life Cycle Impact Assessment |
| M | Mean |
| MDGs | Millenium Development Goals |
| Napuro | Nachhaltige Putz-Roboter |
| NVS II | National Consumption Study II (Nationale Verzehrsstudie II) |
| OECD | Organisation for Economic Co-operation and Development |
| SCP | Sustainable Consumption and Production |
| SD | Standard Deviation |

| | |
|---|---|
| SDGs | Sustainable Development Goals |
| SFSP | Sustainable Food Systems Programme |
| SIMULME | SIMulationsspiel für Umweltfolgen von LebensMittelEinkäufen |
| UGB | Unabhängige Gesundheitsberatung |
| UN | United Nations |
| UNCED | United Nations Conference on Environment and Development |
| UNESCO | United Nationals Educational, Scientific and Cultural Organization |
| USDA | US Department of Agriculture |
| WCED | World Commission on Environment and Development |
| 10YFP | 10 Year Framework Programmes on Sustainable Consumption and Production Patterns |

## List of Figures

## List of Tables

## Abstract

The interest in sustainable diets has gained importance in research and the United Nations (UN) agencies. Especially in industrialized countries, a change of consumption patterns is urgently needed to overcome global environmental, social and economic obstacles. Nutrition is acknowledged to be linked to all 17 Sustainable Development Goals. Hence, a change of nutrition can be a major contribution to achieve the SDGs. A promising method in Education for Sustainable Development (ESD) presents the simulation game. ESD is an action and experiential teaching method to make systemic connections in sustainable development more tangible.

Using the internet-based software *simcision* and a system thinking approach, a simulation game about sustainable diets was developed to contribute to achieve the SDGs. The aim was to visualize the interrelations of the SDGs in the field of nutrition. This was applied in a second step as a tool in five test runs to assess young adults' cognitive and affective learning outcomes and opinions on the game. In total, 31 people between the age of 16 and 32 years participated in the pre-tests. Data was collected by developed pre- and post-game questionnaires using a mixed-method survey design. This included quantitative and qualitative analysis methods. Paired sample t-tests and a qualitative analysis served to answer the research question whether the simulation game influences the test players' learning outcomes to support ESD to achieve more sustainable diets.

The quantitative analysis revealed significant cognitive outcomes of the test players (expertise: $p < .001$; $d = 1.29$; understanding: $p < .001$; $d = 1.15$). No significant affective outcomes were observed (importance: $p = .08$; $d = .32$; understanding: $p = .43$; $d = .14$). Though, in the qualitative analysis it is feasible to recognize possible

effects of the simulation game on affective learning outcomes to develop competences like system thinking, collaborative decision-making in complex systems, critical thinking skills as well as changing perspective. Therefore, it may positively affect attitudes towards a shift to more sustainable consumption patterns. However, this connection needs to be carefully drawn. Conclusively, the simulation game may contribute to support ESD as an experiential teaching method. It increases the creation of learning outcomes which may add to the development of the participants' competences regarding sustainable diets and therefore to contribute to achieve the SDGs.

# 1 Introduction

Diets and modern eating habits play a crucial role in numerous ecological, social and economic challenges which our food system is currently facing. Substantial scientific evidence was created in the past years which proves that diets not only have an impact on human health (like obesity, overweight, micronutrient deficiencies or undernutrition), but also on the environment. Diets can be hold accountable for about one-third of the total environmental impact in the Western world (Berger and Schrader, 2016; Willett et al., 2019). Especially the consumption patterns of “well-nourished” people in industrialized nations are considered problematical. These often consist of a high amount of meat, more and more high-processed foods as well as products from all over the world. This results in a hight demand of resources (Bilali et al., 2019; Brunner and Schönberger, 2005). Further global challenges are expected with regard to food waste. Around one third of the globally produced food is wasted (FAO, 2011). Due to population growth, changing lifestyles and more affluent nutritional habits also in transition countries, the demand for food is rising (Brunner and Schönberger, 2005).

The Agenda 2030, adopted by the UN in 2015, presents an action plan for sustainable development to overcome global ecological, social and economic obstacles (UN, 2015). Core part are the universal and transformational Sustainable Development Goals (SDGs). The 17 goals are considered a network of goals which is inter-linked by similar targets (Blanc, 2015). Therefore, the systemic nature of the Agenda 2030 needs to be addressed in an integrated way (Coopman et al., 2016; Griggs et al., 2017). To achieve the SDGs until 2030, changing food consumption patterns is crucial. As stated by the authors of the Global Nutrition Report 2017, nutrition

is even characterized as an "[…] indispensable cog, without which the SDG machine cannot function smoothly" (Hawkes and Fanzo, 2017, p. 44). Hence, a change of nutrition following an integrated and holistic approach is urgently needed to enhance the outcomes across the SDGs and to eliminate the causes of malnutrition (Hawkes and Fanzo, 2017). To reach this, besides governments and the public sector, the civil society needs to be involved in the transformation process (UN, 2015). Especially in societies within industrial states, it is necessary to shift consumption patterns towards more sustainable diets (Brunner and Schönberger, 2005).

However, it is less clear how the shift to more sustainable diets can be accomplished as no holistic consensus exists of "[…] what a sustainable diet might comprise" (Macdiarmid et al., 2012, p. 632). Most studies on sustainable diets focus on the above-mentioned health and environmental dimensions. Economic or social impacts are mostly less considered (Meybeck and Gitz, 2017). In particular, the social context of diets is left behind in most studies on nutrition and sustainability (Brunner and Schönberger, 2005). Koerber et al. (2012) even define five dimensions of sustainable diets which are considered equally important – environment, society, economy, health and culture. This variety of approaches makes it difficult to assess sustainable diets as part of sustainable development in a holistic manner to achieve a transformation of the society with more sustainable diets. Furthermore, due to this knowledge gap, consumers are only little aware of the systemic relationships between their behavior and sustainability dimensions. It is crucial to understand that meaningful purchase decisions can only be made when the overall context is considered (Hansmann et al., 2001).

Education for Sustainable Development (ESD) is recognized as a key instrument to achieve sustainable development (Rieckmann, 2017). Especially participatory teaching and learning methods are

discussed in ESD to empower learners, to promote behaviour change and to motivate to take action for sustainable development. One way to teach sustainability is the implementation of an action learning approach, in particular simulation games, to enhance cognitive and affective learning outcomes (Gatti et al., 2018) and to foster competences like systemic thinking, change of perspective, awareness of the multidimensionality and complexity of a problem (Leicht et al., 2018). However, "[…] little is known as of yet about its effects on behavioural change, especially in the context of sustainable nutrition" (Berger and Schrader, 2016, p. 2).

As one of the first, the internet-based simulation game *Sustain2030* by *iCONDU GmbH* explicitly focuses on the SDGs and its interlinkages. It is based on the *German Strategy for Sustainable Development* (iCONDU GmbH, 2018). The software of *Sustain2030* will be the framework for the following plan of developing and testing a simulation game on sustainable diets and their contribution to the SDGs.

The aim of the simulation game is to make the basic understanding of the system connections of nutrition and sustainable development tangible to promote sustainable diets. Some simulation games on sustainable diets already exist. However, none of these games refer to the totality of sustainability dimensions in the form of the SDGs.

In this thesis, a simulation game on sustainable diets and their contribution to the achievement of the SDGs is developed. The research hypothesis states that

> *"the simulation game influences the test players' learning outcomes and therefore supports ESD."*

The research question *"Does the simulation game on sustainable diets and their contribution to achieve the SDGs have an effect on*

*test players' learning outcomes to support ESD to achieve more sustainable diets?"* consists of four subquestions:

a) How do (sustainable) diets contribute to achieve the SDGs?
b) What effects does the simulation game have on the test players' learning outcomes about sustainable diets and how does it contribute to achieve the SDGs?
c) How does the simulation game support ESD to achieve more sustainable diets?
d) Does the simulation game support ESD to achieve more sustainable diets?

To answer the research questions, this thesis is structured as follows:

Chapter 2 provides theoretical background information about the concept of sustainable development, the SDGs and the impact of nutrition on the SDGs. It also gives a review of different approaches to define sustainable diets as well as insight of the concept of ESD including respective learning outcomes and the simulation game as a teaching method in ESD. This first part of the thesis serves as a framework for presenting the methodology of developing the simulation game on sustainable diets and their contribution to achieve the SDGs based on the game *Sustain2030* by *iCONDU GmbH* in chapter 3. The game structure and course of play as well as the methodology of the data collection and data preparation is described. The results are presented in chapter 4 including the sample description, the simulation performance of conducted trials as well as the quantitative and qualitative analysis results on cognitive and affective learning outcomes followed by a discussion in chapter 5 and a conclusion in chapter 6.

In the present paper, the terms "consumption" and "diets" concentrate on the daily nutritional consumption in private households without considering the out-of-home sector. This is

consistent with other research studies by Brunner and Schönberger (2005, p. 191 et seq.) and Eberle (2007). Furthermore, sustainable diets are defined with respect to the research project "Ernährungswende" by Eberle (2007). Learning outcomes are tested on the cognitive (expertise and understanding) and affective (importance and usefulness) dimensions in accordance with the survey by Gatti et al. (2018) who followed a similar research hypothesis and research question. Key competences in ESD such as "Gestaltungskompetenz" by de Haan (2010) are also outlined. All relevant terms and their definitions can be found in the glossary (see chapter 8).

# 2 Theoretical Background

The current state of research is described in the following chapter. It presents a profound basis for the development and evaluation of the simulation game on sustainable diets and its contribution to achieve the SDGs. It comprises the concept of sustainable development, the SDGs including an overview of their monitoring and the systemic approach in the specific context of nutrition as well as three approaches to assess sustainable diets and the concept of ESD with elaborations on simulation games as a teaching method in ESD.

## 2.1 Sustainability and Sustainable Development

The first written nomination of the word “sustainable” can be traced back to Johann Carl von Carlowitz who uses the German term “nachhaltig” in his work on forestry "Sylvicultura oeconomica Sylvicultura oeconomica oder haußwirthliche Nachricht und Naturmäßige Anweisung zur wilden Baum-Zucht" in 1732. Carlowitz describes the challenge of conserving forest resources and replanting trees to make "sustainable" and continuous use of the forest possible which is indispensable for its survival (von Carlowitz, 1732).

Many discussions about the term “sustainability” took place rooting from different concepts on phenomena like “[…] interrelationships among rates of population growth, resource use, and pressure on the environment” (Kidd, 1992, p. 2). The United Nations (UN) applied the term for the first time in 1978 in a document concerning "eco-development" which refers to equitable distribution between developing and developed countries (Kidd, 1992).

Nowadays, the terms “sustainability” and “sustainable development” are used as synonyms for the concept of sustainable development.

By 2007, nearly 300 different definitions of both terms existed (Johnston et al., 2007). However, the most cited definition of sustainable development was published in 1987 in the *World Commission on Environment and Development* (WCED) by the UN in "Our common future" also known as the Brundtland Report:

> "Sustainable is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Hurlem, 1987, p. 43).

According to this definition, the economic, ecological and social boundaries are taken into account to contribute to the prosperity of the present and future generations. Economy, environment and society are intertwined and need to be addressed equally to promote sustainable development (Glavič and Lukman, 2007; Hurlem, 1987). The concept including these three pillars is also often referred to as the *3P model* (People, Planet and Prosperity) or the *Triple Bottom Line* (People, Planet, Profit) (Gatti et al., 2018).

In 1992 at the *UN Conference on Environment and Development* (UNCED) in Rio de Janeiro, the *Agenda 21* and the *Rio Declaration on Environment and Development* were adopted to bring actions to sustainable development at global, national and local levels. In 2000, the UN adopted the *Millennium Development Goals* (MDGs) including eight goals to overcome global challenges like extreme poverty and hunger, poor education, gender inequality, poor health, ecology and partnerships and integrate them into national policies and programs (Griggs et al., 2014). A success achieved by the MDGs was "[…] the target to halve the number of people living on less than US$1.25 a day […]" (Griggs et al., 2014, p. 1). However, many other goals were not reached so that a follow-up program was introduced. The Sustainable Development Goals (SDGs)

succeeded the MDGs as reference goals for sustainable development (Griggs et al., 2014).

## 2.2 The Agenda 2030 and the Sustainable Development Goals

At the UN General Assembly, the UN member states passed as a voluntary commitment the resolution for the Agenda “Transforming Our World: the 2030 Agenda for Sustainable Development” (short: Agenda 2030). It is comprised of the three *P’s* People, Planet and Prosperity together with Peace and Partnership. The core of the agenda are the universal, transformational and inclusive SDGs which are considered an action plan for sustainable development to overcome global ecological, social and economic challenges. It encompasses 17 goals, 169 targets and shall be achieved with the help of all member states by 2030 (see figure 1; UN, 2015).


*Figure 1: The Sustainable Development Goals (SDGs; UN, 2019)*

In contrast to the MDGs which particularly addressed the countries of the Global South, the SDGs hold all states accountable (UN, 2015). The agenda addresses not only governments and the private sector to implement the goals, but also the civil society and every human being across the world. All countries of the Global South and the Global North shall align to these goals by promoting prosperity while protecting the planet. Due to this universality "[…] every country can be considered as developing and all countries need to take urgent action" (Rieckmann, 2017, p. 6).

### *2.2.1 SDG Implementation and Monitoring*

In 2017, the UN General Assembly applied a global framework which provides indicators and the most recent statistical data to monitor the SDG implementation process and inform global stakeholders on follow-up policy strategies (UNS Commission, 2017). Besides this official monitoring tool, the *Sustainable Development Report* together with the included *SDG Index and Dashboard Report* provides an "[…] assessment of countries' distance to achieving the SDGs" (Sachs et al., 2018, p. viii). It is annually developed by independent experts of the United Nations' *Sustainable Development Solutions Network* (SDSN) and the *Bertelsmann Foundation* to evaluate quantitatively the achievement of the SDGs for each UN member state. Germany as an example, is ranked on the sixth place in the recently published SDG index and Dashboard report 2019 behind Austria, France and the top ranked Scandinavian countries (Sachs et al., 2019).

To implement the SDGs in Germany, in 2016 the German government admitted the Agenda 2030 by adopting the *German National Sustainability Strategy* (Die Bundesregierung, 2016). In this revised version of the Strategy of 2002, indicator-based political

goals are phrased for each of the 17 SDGs to identify the need for action in the respective subject area. The state of achievement of each SDG is evaluated based on these indicators by the German Federal Statistical Office and presented in the strategy (Die Bundesregierung, 2016).

Even though this strategy shall lead the process of policy development based on the SDGs, the implementation is a complex venture due to the indivisibility of the agenda (Weitz et al., 2018). The 17 goals are not to be seen individually but rather as a network of goals. The goals are inter-linked by similar targets (Blanc, 2015). Therefore, the systemic nature of the Agenda 2030 needs to be addressed in an integrated way (Coopman et al., 2016; Griggs et al., 2017). Several authors have tried to map the interactions between the goals as this might help to prioritize actions based on the respective effectiveness (e.g. Blanc, 2015; Nilsson et al., 2013; Weitz et al., 2018). However, the key question on how the goals and targets interact with each other is not answered yet consistently due to its complex and the specific contextual character (Weitz et al., 2018).

### *2.2.2 SDGs and Nutrition*

In the specific context of nutrition, several authors point out that sustainable diets are directly related to several of the goals such as hunger (SDG 2), health (SDG 3), climate change (SDG 13), natural resources (SDG 14 and 15) and biodiversity (SDG 15) (Aleksandrowicz et al., 2016; Chen et al., 2019; Willett et al., 2019). Based on the systemic and integrated nature of the SDGs, all 17 goals need to be considered. This was implemented by several initiatives. The *Food and Agriculture Organization* (FAO) of the United Nations recognized that food and agriculture are key actors to achieve the SDGs as these fields are connected to all 17 goals.

Moreover, it underlines those respective actions are urgently needed (FAO, 2016).

Also, the *Global Nutrition Report 2017* (Hawkes and Fanzo, 2017) points out that all 17 SDGs are linked to (mal)nutrition, so improving nutrition can catalyse the outcomes within and between all SDGs. Therefore, the authors characterize improved nutrition even as an "[…] indispensable cog, without which the SDG machine cannot function smoothly." (Hawkes and Fanzo, 2017, p. 44). Hence, a change of nutrition is urgently needed to enhance the outcomes across the SDGs and to overcome the causes of malnutrition (Hawkes and Fanzo, 2017).

Furthermore, a different view on the SDGs gives the so-called "wedding cake" illustration of the SDGs which was developed by the *Stockholm Resilience Centre* at the Stockholm University (Stockholm Resilience Centre, 2016). In this illustration, SDG 6, 13, 14 and 15 represent the environmental dimension at the bottom, followed by the social dimension including SDG 1, 2, 3, 4, 5, 7, 11 and 16 in the middle and the economic dimension with the SDGs 8, 9, 10 and 12 on top. Lastly, SDG 17 is arranged in a fourth row and represents partnerships which are important within the whole system (see figure 2).


*Figure 2: The SDG "wedding cake" illustration (Stockholm Resilience Centre, 2016)*

This layered approach of the three sustainability dimensions illustrates that economies and societies are part of the biosphere. This implies that efficient economy is needed to serve societies to give them the possibility to build up equity which evolves within the safe operating space of a stable and resilient planet. At the *Stockholm EAT Food Forum* in 2016, the key-note speakers Johan Rockström and Pavan Sukhdev stated that food is directly and indirectly connected to all the SDGs which can be seen in the wedding cake illustration (Stockholm Resilience Center, 2016).

Besides seeing the SDGs from a holistic perspective, an important leverage effect in the specific context of nutrition has SDG 12 dealing with Sustainable Consumption and Production (SCP). Considering this goal, it is important to take care of both, changing

production systems on one hand and achieving more sustainable consumption patterns on the other hand. Two important sub-goals of SDG 12 worthy to mention are SDG 12.3 and SDG 12.1. These focus specifically on the implementation of sustainable diets by achieving less food waste (SDG 12.3) and by implementing the so-called *10 Year Framework Programmes on Sustainable Consumption and Production Patterns* (10YFP). This is a UN member states commitment for the implementation of actions to achieve inter alia more sustainable diets (SDG 12.1; UN 2012).

SDG 12.3 deals with halving the global food waste at the retail and consumer level as well as the reduction of food losses along production and supply chains (UN, 2015). Achieving more sustainable consumption patterns is a very important aim as million tons of food produced for consumption are lost or wasted every year worldwide. This accounts for nearly one third of the world's harvest. In low-income countries, technological, financial and managerial challenges such as lack of storage, infrastructure or cooling systems increase food losses and waste along food supply chains. In transitioning and industrialized countries, the problem particularly relates to a respective consumer behaviour (FAO, 2011). In Germany, every citizen disposes in average 81.6 kg food per year (BMEL, 2012). This corresponds to a value of approximately 235 € per person per year (Kranert et al., 2012). Raising awareness on this economic loss and recognizing the interlinkage, could lead to a higher appreciation of food.

SDG 12.1 specifically calls for the implementation of the 10 YFP (UN, 2015). It is a commitment made by UN member states at the *Rio+20 conference* in 2012 to implement actions in the respective framework. The framework consists of six programs. Based on these, a shift to more sustainable consumption and production

patterns in high-, middle- and low-income countries shall be enhanced. The six programs are: *Sustainable Public Procurement*, *Consumer Information for SCP*, *Sustainable Tourism*, *Sustainable Lifestyles and Education*, *Sustainable Buildings and Construction*, and *Sustainable Food Systems* (UN, 2012). Especially the *Sustainable Food Systems Programme* (SFSP) focuses on implementing SCP along the food supply chains worldwide. Besides *Sustainable Buildings and Construction,* all the other programs are interrelated to food production and consumption. Furthermore, reaching more sustainable diets is one of several focus topics of the SFSP (Koerber, 2018).

## 2.3 Sustainable Diets

The concept of sustainable diets was first introduced in the early 1980s by Gussow and Clancy. The authors recommended that healthier diets are not only healthy for humans but also for the environment (Gussow and Clancy, 1986). Back then, the concept was mostly ignored and food globalization as well as the industrialization of the agricultural system increased. But the interest increased due to growing scientific evidence which proved that current dietary trends are not sustainable (Donini et al., 2016). It was only in 2006 at the *Conference of the Parties of the Convention on Biological Diversity* that the interdisciplinary character of nutrition and biodiversity was acknowledged (Burlingame and Dernini, 2012). In 2010 at a symposium on *Biodiversity and sustainable diets* organized by the FAO and *Bioversity International*, a consensus position on a definition on sustainable diets was given. Sustainable diets are

> "[…] those diets with low environmental impacts, which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful

> of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources" (Burlingame and Dernini, 2012, p. 264).

Even though this definition exists for almost a decade "[…] there are still many gaps in our understanding of what a sustainable diet might comprise" (Macdiarmid et al., 2012, p. 632). Different scientific approaches to sustainable diets were established in the past including life-cycle assessments (LCAs) of diets to analyse the environmental impact of diets (e.g. Chen et al., 2019; Jungbluth, 2000; Meier, 2013), principles on sustainable nutrition to provide consumers' recommendations for action (e.g. Koerber Kv et al., 2012) and social-ecological approaches to reveal dietary styles in the context of sustainability (e.g. Eberle, 2007; SinusSociovision, 2002).

### *2.3.1 Life-Cycle Assessments of Sustainable Diets*

Many studies about sustainable diets assessed the impact of diets on the environmental dimension by using life-cycle assessments (e.g. Alarcon and Gerritsen, 2014; Chen et al., 2019; Garnett et al., 2015; Hallström et al., 2015; Jones et al., 2016; Lang and Barling, 2013; Meier and Christen, 2013; Nelson et al., 2016; Springmann et al., 2016; Tilman and Clark, 2014; Ulaszewska et al., 2017; Willett et al., 2019).

In accordance with the standards 14040/14044 of the International Organization for Standardization (ISO), the LCA is

> "a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO, 2006a, 2006b, p. 3).

It is comprised of four standardized consecutive steps: The goal and scope definition phase to set respective system boundaries, the Life Cycle Inventory (LCI) analysis phase to collect input and output data within the system, the Life Cycle Impact Assessment (LCIA) phase to provide additional information for the LCI and lastly the interpretation phase in which results are summarized and discussed (ISO, 2006a, 2006b).

The research project by Meier (2013) is an example for analysing the impact of usual dietary habits and dietary models using an LCA according to ISO standard 14040/44. In this study, the environmental impact of the food intake in Germany was evaluated based on data of the National Nutrition Surveys I and II of the years 1985-89 and 2006 (Nationale Verzehrsstudie II; NVS II) and compared to the environmental impact of dietary models. The aim was to clarify the "[…] ecological potentials of healthy, nutritionally-balanced diets" (Meier, 2015, p. 5).

The system boundaries were set at the production stage and the point-of-sale (cradle-to-store). The indicators used to assess the environmental impact were comprised of greenhouse gas (GHG) emissions, ammonia emissions, land use, water use (blue), phosphorus use and primary energy use (see table 1) (Meier, 2013).

*Table 1: Impacts of environmental indicators on humans and nature. $CO_2e$ = $CO_2$-equivalents (taken from Meier, 2015)*

| **Environmental indicator** | **Impacts on humans and nature** |
|---|---|
| Greenhouse gas emissions (in $CO_2e$) | Global warming, climate change, shifting of climate zones, extreme weather (droughts, flooding etc.) and resulting conflicts and migration |
| Ammonia emissions (in $NH_3$-emissions) | Acidification and eutrophication of water and soil, loss of ecosystem services, odours |
| Land use | Soil vitality, displacement of other ecosystems and their biodiversity, loss of ecosystem services |
| Blue water use | Water depletion, water scarcity, water stress and resulting water conflicts |
| Phosphorus use | Depletion of finite resources (resulting in resource conflicts), radioactivity, water eutrophication |
| Primary energy use | Depletion of finite resources such as coal, crude oil, natural gas (resulting in resource conflicts) |

The included dietary recommendations[1] are the official recommendations of the *German Nutrition Society* (Deutsche Gesellschaft für Ernährung; DGE). An alternative recommendation is the one of the *Federation for Independent Health Consultation* (Unabhängige Gesundheitsberatung; UGB). It is based on the concept of wholesome nutrition. This model includes less meat and more legumes as well as vegetables. Not only health criteria are considered in these recommendations, but also ecological and social criteria. However, they were not further considered in the analysis by Meier (2013). Besides, the author included plant-based dietary recommendations of the US Department of Agriculture (USDA) and US Department of Health for an ovo-lacto vegetarian diet (including egg and dairy products but no fish or meat) and a vegan diet (with no animal-sourced products but with a higher amount of soy-based milk, legumes, nuts and seeds) (Meier, 2013).

Meier (2013) concludes that adapting diets according to the investigated dietary recommendations can have the potential to save up to 90 % of the effects of the environmental indicators. Each of the four dietary recommendations has a lower impact on the environmental indicators compared to the food intake assessed by NVS II in 2006. The ovo-lacto vegetarian and the vegan diet have the biggest potentials for change except for the indicator of blue water use. In vegan diets the blue water use is the highest because of the consumption of nuts whose cultivation is very water intensive. The lowest deviation is associated with the official DGE recommendation of a varied wholefood diet. It ranges in a two-digit

[1] A table of Meier (2013) listing the amounts of foods and beverages in the respective diet can be found in the extended annex.

percentage range which shows that the implementation of official dietary guidelines is nutritionally healthy and environmentally friendly compared to observed intakes (Meier, 2013).

In general, many other LCA-studies (e.g. Aleksandrowicz et al., 2016; Chen et al., 2019; Nelson et al., 2016; Springmann et al., 2016; Tilman and Clark, 2014; Willett et al., 2019) come to similar conclusions stating that shifting to healthy diets is not only good for humans but also for the environment as the most significant decreasing effect is identified by replacing energy-, water- and land-intensive animal sourced foods with plant-based foods (Willett et al., 2019). Especially favourable is the transition to more plant-based diets which align with standard dietary guidelines (Springmann et al., 2016). The EAT Lancet Commission, a transdisciplinary group of international experts, recently confirmed these findings in their report and defined a reference diet which is healthy for human and the planet: The *Planetary Health Diet* which includes a high amount of vegetables, fruits, whole-grains, pulses, nuts and oil with unsaturated fatty acids as well as a low amount of seafoods, poultry and low amounts of red meat, processed meat, sugar, white flour products and starchy foods (Willett et al., 2019). This corresponds to the greatest possible extent to the recommendations of a varied wholefood diet by the DGE (see figure 3; DGE, 2019).


*Figure 3: The Planetary Health Diet (EAT Lancet Commission, 2019) and the "Ernährungskreis" (circle of nutrition) of a varied wholefood diet by the DGE (DGE, 2019).*

Even though a range of publications on the impacts of (healthy) diets on the environment exist, it is difficult to compare the results of the assessment of environmental impact of foods and diets between studies due to varying methodologies for assessments (Masset et al., 2015; Ulaszewska et al., 2017). Limitations are caused by varying LCA approaches in which different indicators, functional units and system boundaries are used as well as the lack of an appropriate unit of expression for diet comparisons (Ulaszewska et al., 2017).

Furthermore, the studies using an LCA-approach analyse solely the environmental impact. Economic, social or cultural impacts are generally left out of consideration (Meybeck and Gitz, 2017) which makes it difficult to assess sustainable diets holistically. Especially the affordability and the cultural acceptability of diets should be included when assessing sustainable diets (Perignon et al., 2017). Therefore, other approaches are needed which contribute to a more

holistic analysis and understanding of opportunities and barriers to reach more sustainable diets (Jones et al., 2016).

### *2.3.2 Nutrition Ecology and the 7 Principles of Sustainable Nutrition*

The terminus of *nutrition ecology* (Ernährungsökologie), established in the 1980's at the University of Giessen, is a complementary and integrated concept of science and practice which deals with the complex relations between the numerous factors in the field of nutrition including not only the impact on health but also on the environment and society (Hoffmann et al., 2011). To provide practical recommendations for consumers, the wholesome diet was established which corresponds to the UGB recommendations outlined above. As pointed out, the concept does not only focus on the amount of foods consumed. Moreover, it offers a holistic approach to world nutrition and global challenges (Brunner and Schönberger, 2005). It includes the so-called *seven principles for a sustainable nutrition* (see figure 4). These are recommendations for action equivalent important to overcome problems in ecological, economic, social, health and cultural challenges at the same time (Koerber Kv & Leitzmann C, 2011; Koerber Kv, 2015; Koerber Kv et al., 2012; von Koerber et al., 2017).

1. Preference of Plant-Based Foods
2. Organic Foods
3. Regional and Seasonal Produced Foods
4. Preference of Minimally Processed Foods
5. Product of Fair Trade
6. Resource-Saving Housekeeping
7. Tasty Meals

*Figure 4: Seven principles for a sustainable nutrition (further developed after Koerber et al., 2012 and Koerber, 2014)*

The principles are phrased in a motivational way and refer to the choice of food products consumers are offered. The principles are arranged by their potential on saving GHG emissions from high to low (Koerber Kv & Leitzmann C, 2011; Koerber Kv, 2015; Koerber Kv et al., 2012; Koerber et al., 2017).

However, there are many obstacles in integrating these principles into reality. Convenience and adapted “old” habits for example make it hard to shift to a more sustainable behaviour. Furthermore, high prices for sustainable products are considered a challenge. The lack of available information about sustainable production or policies and economic growth orientation of societies also inhibits the progress to integrate the principles (Koerber et al., 2017). Furthermore, from a consumer perspective, the applicability of the principles into everyday life is not always given as nutrition is integrated by consumers. Besides, different ways and different requirements in everyday life exist (Brunner and Schönberger, 2005). For example, the principle “Preference of Minimally Processed Foods” is argued to have a positive impact on all five dimensions (see Koerber et al.,

2017). Possible trade-offs can be foreseen from a gender perspective for the social dimension as the question arises, “Who is responsible for the meal preparation in the everyday life of families?”. Even though the employment rate of women rises in Germany, the responsibility for nutrition and housework is still widely seen in females (Brunner and Schönberger, 2005). It demonstrates that socio-economic and socio-cultural factors need to be included when defining sustainable diets in an integrated overall concept (Eberle, 2007).

### *2.3.3 Socio-Ecological Research on Nutritional Styles*

Different nutrition studies included socio-economic and socio-cultural factors in the lifestyle and social-ecological research sector (e.g. Eberle, 2007; SinusSociovision, 2002; Stieß and Hayn, 2005). These studies, especially focusing on nutritional styles, revealed around four to eight nutritional styles which have similar characteristics (Brunner et al., 2007). In the following, the study by SinusSociovision (2002) and Eberle (2007) are presented in more detail as these revealed the most relevant focus on different nutritional styles in Germany.

An important approach is the “Social Milieu-Model" implemented by the independent Sinus institute to conduct psychological and social scientific research and consultation. It is a sociological target group model which identifies groups according to similar lifestyles, attitudes or value orientations and can therefore be differentiated to several social groups. It has especially been used since the 1980s in social sciences and marketing studies (Barth et al., 2017). The institute conducted a food market study based on the social milieu-model which revealed six nutritional types in Germany: the ecological avant-garde, the gourmets, the fit food gourmets, the

fast-food fans, the traditional and the indifferent. These types are based on nutrition and food preferences which are associated with several of the social milieus (Ploeger et al., 2011; SinusSociovision, 2002).

Another approach was conducted by the institute of social-ecological research in the research project "Ernährungswende" (turn of nutrition) in which the authors investigated strategies for a social-ecological transformation in the societal activity environment-nutrition-health in Germany (Eberle, 2007). The aim of the research project was to point out strategies for sustainable and more healthy diets from a consumer perspective. The focus was especially put on everyday actions of consumers. Therefore, seven nutritional styles with different distributions in society were identified by qualitative and quantitative empirical investigations in Germany (Eberle, 2007). They are comprised of

- the uninterested fast-fooder,
- the cheap and meat eater,
- the joyless habitual cook,
- the fitness-oriented ambitious,
- the stressed everyday manager,
- the food-conscious demanding,
- the conventional health oriented.

As part of the research, the authors proposed a definition of sustainable diets from the consumer perspective stating that sustainable diets are

> "[…] needs-oriented/appropriate and suitable for everyday use, socially differentiated and health-promoting, low-risk and environmentally friendly" (Eberle et al., 2004, p. 1).

Considering this definition, especially the first three keywords are crucial in the discussion about sustainability in the field of nutrition

as they refer to the socio-ecological and socio-cultural factors which have been neglected in previous discussions. When it comes to implementing strategies for sustainable diets, it has to be acknowledged that there is not only one sustainable diet. Rather, nutritional behaviour is socially differentiated (Brunner and Schönberger, 2005). To achieve more sustainable dietary patterns in societies, the appreciation of food needs to increase. Koerber et al. (2017) point out that all stakeholders of the food system from farm to fork shall support Education for Sustainable Development (ESD) as it plays a fundamental role in the transformation process.

## 2.4 Education for Sustainable Development

The concept originates from the environmental education established in the 1970s. At the time, especially engaged natural scientists played an important role in imparting knowledge on environmental pollution, resource consumption and population growth. However, it soon became apparent that the acquisition of knowledge about environmental problems does not linearly lead to respective actions. Rather environmental knowledge, environmental awareness and environmental activities are related to each other in a complex and socially dependent way. Therefore, in the course of the Agenda 21, a critical introspection of environmental education led to the further development of the term in a social context (Nagel and Affolter, 2004). Education was highlighted in this action plan as a key function to reach sustainable development (Hurlem, 1987).

In 2002, the UN general assembly entrusted the United Nations Educational, Scientific and Cultural Organization (UNESCO) with the implementation of the “UN Decade of Education for Sustainable Development” (DESD) from 2005 to 2014 “[…] calling on

governments to integrate the principles of sustainability into their educational strategies and action plans" (UNESCO, 2019, p. 4). Since 2015, the program is followed up by the Global Action Program (GAP) on ESD until 2019. In regard to the Global Action Program on Education for Sustainable Development (GAP ESD), ESD can be defined as follows:

> "ESD empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity. It is about lifelong learning and is an integral part of quality education. ESD is holistic and transformational education which addresses learning content and outcomes, pedagogy and the learning environment. It achieves its purpose by transforming society" (UNESCO, 2014, p. 12).

The objective of the program is to scale-up concrete actions in the field of ESD and enhance networks between actors in five priority areas: advancing policy; transforming learning and training environments; building capacities of educators and trainers; empowering and mobilizing youth and accelerating sustainable solutions at local level (UNESCO, 2018).

The fourth action area "empowering and mobilizing youth" is especially important to mention in regard to the present paper. It is important to "[…] support youth in their role as change agents for sustainable development through ESD" (UNESCO, 2014, p. 36) as they need to live the strongest and longest with the consequences concerning global challenges of sustainable development (Leicht et al., 2018). The UN describes youth as an age group between 15 and 24 (UNESCO, 2014). However, due to different local and regional definitions, this age range can vary and is not always commonly described as a period between childhood and adulthood. Especially in non-formal and informal learning settings, youth can

become important drivers. Thereby, non-formal and informal learning includes educational offers for all target groups outside of the formal educational system (schools or universities) (Leicht et al., 2018).

Mentioned in target SDG 4.7 in the Agenda 2030, today ESD is recognized as an important leverage point to obtain a more sustainable society (UN, 2015). To further promote the achievement of the SDGs, the implementation of ESD beyond the GAP ESD is going to be followed up by the program “Towards achieving the SDGs“ (short: ESD for 2030) which starts in June 2020 (UNESCO, 2019).

### *2.4.1 Learning Outcomes in ESD*

Teaching and learning methods in ESD shall be designed “[…] in an interactive, learner-centred way that enables exploratory, action-oriented and transformative learning” (UNESCO, 2014, p. 12). These shall contribute to sustainable development by providing knowledge, skills, values and attitudes for a contribution to sustainable development including critical topics like climate change, biodiversity, disaster risk reduction as well as SCP (UNESCO, 2014). These learning outcomes can be divided into sub-groups including cognitive learning outcomes dealing with the gained knowledge, skill-based learning outcomes including the know-how and the affective learning outcomes dealing with changes in attitude and motivation (Pasin and Giroux, 2011).

Finally, the objective of ESD is to generate key competences like “[…] critical and systemic thinking, collaborative decision-making and developing values and attitudes towards a sustainable future” (UNESCO, 2014, p. 12). According to the *Organisation for Economic Co-operation and Development* (OECD), a competence

is not reducible to cognitive abilities. Rather, the concept of competence also includes ethical, social, emotional, motivational and behavioural components (Bormann and de Haan, 2008). Therefore, ESD goes beyond the accumulation of knowledge and can be seen as innovative learning about context-specific possibilities for problem-solving (De Haan, 2010).

There are a number of concepts which highlight different content requirements of which the competences of ESD should be comprised of (e.g. De Haan, 2010; Rieckmann, 2012; Wiek et al., 2015). Especially in German speaking areas, the acquisition of the so-called "Gestaltungskompetenz" (shaping competencies) is considered a guiding principle of competences in ESD:

> "*Gestaltungskompetenz* means the specific capacity to act and solve problems. Those who possess this competence can help, through active participation, to modify and shape the future of society, and to guide its social, economic, technological and ecological changes along the lines of sustainable development." (De Haan, 2010, p. 320)

The concept includes twelve sub-competences which align with the definition of three core competences developed by the OECD – respectively "Acting in socially heterogeneous groups", "Autonomous action and design ability" and "Interactive use of media and tools" (De Haan, 2010):

1) Gather knowledge in a spirit of openness to the world, integrating new perspectives,
2) think and act in a forward-looking manner,
3) acquire knowledge and acting in an interdisciplinary manner,
4) deal with incomplete and overly complex information,
5) co-operate in decision-making processes,
6) cope with individual dilemmatic situation of decision-making,
7) participate in collective decision-making processes,

8) motivate oneself as well as others to become active,
9) reflect upon one's own principles and those of others,
10) refer to the idea of equity in decision-making and planning actions,
11) plan and act autonomously and
12) show empathy for and solidarity with the disadvantaged.

It is important to consider that these subcompetencies are mutually interdependent and need to be accepted in its interdisciplinary characteristic. As described by de Haan (1993) and outlined by Schneider (2018), the objective of ESD is to support the learners to acquire the above mentioned "Gestaltungskompetenz" with its defined sub-competences. However, due to its complexity it is challenging to empirically measure these effects (Schneider, 2018).

### *2.4.2 Simulation Game as an Action and Experiential Learning Method*

The simulation game is considered an action and experiential learning method. It relies on the self-experience of the players to create knowledge (Pasin and Giroux, 2011). As cited in Pasin (2011) and defined by the Oxford English Dictionary, a simulation is "the technique of imitating the behaviour of some situation or process (whether economic, military, mechanical, etc.) by means of a suitably analogous situation or apparatus, especially for the purpose of study or personnel training" (Pasin and Giroux, 2011, p. 1241). In contrast, a game is defined as "any contest (play) among adversaries (players) operating under constraints (rules) for an objective (winning, victory or pay-off)" (Pasin and Giroux, 2011, p. 1241). Thus, combining these terms, a simulation game is, as described by Ellington (1981)

> "[…] an exercise that possesses the essential characteristics of both games (competition and rules) and simulations (ongoing representation of real-life)" (Ellington, 1981, p. 16).

The simulation game method has been used and developed for decades especially in the military and business education. Nowadays, the method is successfully applied in schools, in extracurricular youth and adult education, in international youth work and in higher education (Dierßen and Rappenglück, 2015). In practice it includes different procedures such as computer simulations, behaviour-oriented role-playing games or board simulation games (Petrik, 2017). A new and dynamic development in simulation games is the use of computers. This is especially helpful to experience complex interactions in a fictive system representing real-life (Petrik, 2017).

Simulation games include individuals or groups who interact actively in specific roles and situations, both with each other and within a simulated decision-making environment (Ballin, 2012). This changes the learning situation from learning about a topic to taking action within the learning topic (Ulrich, 2002). In general, the simulation game method proceeds within a structured framework which consists of three consecutive phases: the preparation, the interaction and the evaluation phase (Pfeiffer and Treske, 2008). In the preparation phase, the topic of the game and the game scenario is presented to give the players an introduction into the area of conflict. Furthermore, the game roles are distributed with associated role cards to the players. The interaction phase consists of the actual game experience with discussions and decision-making in the respective roles and scenario. The evaluation phase is a fundamental component of the game in which the players reflect on what they have learned during the game about everyday reality (Massing, 2007). Thus, it is a learning process with a direct experience followed by a systematic evaluation (Ulrich, 2002).

The core of simulation games is the visualization of interdependency networks to model decision-making environments

and therefore to prepare decisions within complex systems (Ballin, 2012). Using simulations, systemic processes can be reproduced and analysed. Therefore, they support holistic systemic thinking and the development of system competencies in different life areas (Petrik, 2017). The objective of system thinking is "[…] to present the effect structure of a system manageable, better understand the dynamics of the system and to make the consequences of interventions more controllable to avoid unexpected side effects, long-distance reactions and repercussions or to identify starting points in order to counteract them in an appropriate way" (Ballin, 2012, p. 3).

Especially in terms of learning about sustainability-related issues, simulation games have a promising potential (Ulrich, 1997). The objective is to visualize effects of sustainable and non-sustainable behaviour and make them tangible. An important mechanism of simulating the system dealing with sustainability is the implementation of feedback loops. With computer programs or respective tables, the effects of the actions can be visualized or calculated, so the players can make decisions during the game for future actions (Petrik, 2017). This aligns with the model of experiential learning (Kolb, 2014) which is comprised of four phases (see figure 5).

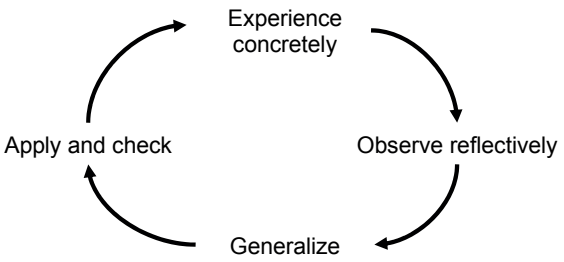


*Figure 5: The four phases of experiential learning (Kolb, 2014)*

During the interaction phase of the game, these steps are run through several times. The players discuss about a game decision and experience the effects at the end of the play round. They observe and reflect on the results by evaluating the visualized model. Furthermore, the players generalize the experiences to apply other experiences in the following play rounds to check the results (Ulrich, 2002).

As described in chapter 2.2.1, based on their systemic nature, the SDGs need to be addressed to understand the interrelations of the goals and to train the decision-making competences for their implementation. Therefore, one of the first simulation games, *Sustain2030*[2] by *iCONDU GmbH*[3] visualizes the interdependency network of the SDGs in the specific context of Germany using the

[2] Access to the *Sustain2030* via https://app.simcision.com/ (a user-account is required)

[3] The *iCONDU GmbH* is an owner-managed consulting company for strategy, organization and process consulting in Ingolstadt. Above all, their interdisciplinary team deals with issues related to complexity, sustainability and digitization.

software *simcision*. The methodological basis of *simcision* is the system thinking approach according to Frederic Vester (Vester, 2002). Aligning with the definition of system thinking, *simcision* can be used to create causal networks with interdependencies between items, develop scenarios, simulate these to analyse them and search for action alternatives. The approach is based on the system thinking methodology of an eight-step-model which is comprised of eight consecutive steps:

1. System delimitation: Decide on the question of interest and perform a stakeholder analysis.
2. System appraisal: Analyse the status quo in the respective scope considering the related indicators.
3. System construction: Identify relevant causal relationships.
4. System dynamics: Modelling momentum and analysing the identified causal relationship.
5. System resources: Taking (budget) restrictions into account.
6. System environment: Considering possible, model effecting events.
7. System interventions: Develop interventions to improve your system.
8. System changes: Comparing different project alternatives and sustainability programs in terms of their contribution to the SDGs attainment.

To develop *Sustain2030*, the eight-step-model was used as a methodological approach in an in-house workshop held at *iCONDU GmbH* to create an interdependency network between the 17 SDGs based on the *German National Sustainability Strategy* (see chapter 2.2.1) and to further develop a simulation game (see table 2).

*Table 2: Eight-step-model used to develop Sustain2030 (iCONDU GmbH, 2018)*

| Steps | Sustain2030 |
|---|---|
| **1. System delimitation** | How can sustainable development in Germany be promoted?<br>17 stakeholders |
| **2. System appraisal** | The status quo for each SDG is based on the SDG Index and Dashboard Report with focus on the German performance |
| **3. System construction** | Relationships identified using the German National Sustainability Strategy and pursuing literature |
| **4. System dynamics** | Strength of the relationships between the SDGs, based on the German National Sustainability Strategy |
| **5. System resources** | Budget refers to money and is associated with SDG 8 |
| **6. System Environment** | 14 different events exist which have an impact on the system and can't be influenced |
| **7. System Intervention** | 36 interventions associated to the different stakeholders |
| **8. System changes** | Comparison and evaluation of simulated scenarios |

In the interaction phase of *Sustain2030,* the players are allocated with one of maximum 17 different stakeholders in Germany. They have to decide as a group about interventions which can help to improve the overall sustainability performance (initial performance: 72,53 %). The status quo of each SDG is displayed in the software below each SDG-icon by showing a percentage as well as a bar representing how close the SDG has been reached so far (see figure 6). Furthermore, the group has a common budget of 40 units which shall be used to invest in interventions. As soon as the group achieves to increase the status quo of SDG 8 to a performance of more than 70 % during the game run, the group “earns” money which they can use in the following rounds for other interventions.


*Figure 6: Sustain2030 initial situation and interdependency network: The status quo of each SDG is shown as percentage below each icon. The bottom left corner shows the initial budget of 40 units. The top right shows the initial total performance of 72,53 %. The grey*

*lines between the SDG present the relations between SDGs (iCONDU GmbH, 2018).*

In the evaluation phase of the game, the software presents charts and bar diagrams for each round with the respective performance on each SDG. Thus, the players can reflect on their chosen interventions and the impact on the system. The learning goals of the game are to understand the interrelations of the SDGs for Germany as well as to train the decision-making competences for implementing the goals. Furthermore, the players should be able to develop actions to be undertaken by each actor group to contribute to achieve the SDGs (iCONDU GmbH, 2018).

Besides learning about decision-making processes in terms of sustainable development on national level as described in *Sustain2030*, nutrition education is also an important pillar of ESD to change people's consumption behaviour towards more sustainable consumption patterns (Koerber et al., 2018). To enhance the environmental knowledge, attitudes and behaviours of scholars, the internet-based simulation game *SIMULME*[4] (SIMulationsspiel für Umweltfolgen von LebensMittelEinkäufen), developed at the Swiss Federal Institute of Technology in Zurich (Eidgenössische Technische Hochschule; ETH Zürich), focuses on the ecological and economic impact of food consumption in Switzerland. The impact is described by four ecological variables (the size of the area occupied by agriculture in Switzerland, the ecological state of the agricultural area, the implementation of fair and humane animal husbandry and the global ecological situation)

[4] access to *SIMULME* via http://www.simulme.ethz.ch/simulme.asp

and four economic variables (unemployment figures, the number of persons employed in agriculture, the average income of farms and the development of consumers' purchasing power) (Hansmann et al., 2005).

The course of play is described by the authors as follows: "Initially, an overview of the ecological-economic situation in Switzerland in the year 2000 is given using these eight variables. Subsequently, the player makes a total of six purchases of meats and vegetables. Each purchase represents the player's typical consumption pattern over the course of 5 years. The game thus addresses a period of 30 years (year 2000 to 2030). A purchase includes answering 13 questions which are of ecological and economic relevance. These questions address five general influence factors: the proportion of vegetables purchased compared to meat, the origin of the vegetables and of the meat, as well as the type of cultivation of the vegetables and the type of production of the meat. The player responds to each question by specifying the proportions of products possessing certain characteristics […]. After each purchase, the player receives feedback on the consequences of his or her consumption pattern by means of a simulation of the development of the eight economic and ecological variables" (Hansmann et al., 2005, p. 365).

The scientific framework of *SIMULME* is based on the analysis of the ecological impacts of food consumption by Jungbluth (2000) as well as expert judgements on the relationships between consumption and economic as well as environmental dimensions. The limitation on purchasing only vegetables and meat, described in detail by Jungbluth (2000) gives a "[…] solid informational basis for the game" (Hansmann et al., 2001, p. 3). Unlike *Sustain2030*, *SIMULME* is played by individuals. The learning goal is to enhance

the environmental knowledge, attitudes and behaviours of scholars. To assess whether the simulation game has an effect on learning effects, the authors developed a questionnaire. It was answered by the scholars and teachers before and after the game and was compared with a control group (Hansmann et al., 2005).

Using questionnaires to assess the learning outcomes of teaching sustainability is a common method in the field of ESD (Rose et al., 2015). For example, the simulation game *Napuro* (Nachhaltige Putz-Roboter) is a business simulation game which includes several companies (each consists of two to four participants) which produce sustainable cleaning robots. The companies compete in a common market and shall implement a sustainability strategy. In test runs performed with business students, the learning outcomes of the students and the course of play was evaluated with pre- and post-game questionnaires (see extended annex; Gatti et al., 2018).

In general, in empirical social studies questionnaires are defined as "[…] a more or less standardized set of questions presented to people for answering, with the aim of using their answers to review the theoretical concepts and contexts underlying the questions. Thus, a questionnaire is the central link between theory and analysis" (Porst, 1996, p. 738). Therefore, the questionnaire includes a selection of questions which are theoretically justified and systematically presented, so the gained data can be used to prove or disapprove the scientific hypothesis of interest (Porst, 2013). An interval scale level defined as Likert-scales is commonly used in questionnaires of empirical social studies to measure attitudes (Porst, 2013). "The principle of a Likert-scale is that positive or negative statements about an issue are given, to which the interviewees can express agreement or rejection in several, pre-defined levels. The given answer options should be constructed in

such a way that the distance between the answer options is as equal as possible and interpretable" (Hollenberg, 2016, p. 19).

The above-described simulation games are the basis for the following development of the simulation game on sustainable diets and their contribution to the SDGs. *Sustain2030* provides the framework of the game, *SIMULME* presents a scientifically proven basis for the content-related development of the course of play. The pre- and post-game questionnaire of *napuro* is used for the development of a valid questionnaire to evaluate the learning outcomes of the developed simulation game.

# 3 Methodology

In this chapter, the methodology of developing and testing a simulation game on sustainable diets and their contribution to achieving the SDGs is described. It consists of four consecutive sections. First, the development of the simulation game is described followed by a description of the game structure and course of play. Afterwards, the survey design is presented including the sampling method and target group as well as the questionnaire development for the test runs. Lastly, the methodology of the data analysis is described. In figure 7 the applied methodology is presented which is based on literature on sustainable diets in chapter 2.3 and the described simulation games in chapter 2.4.

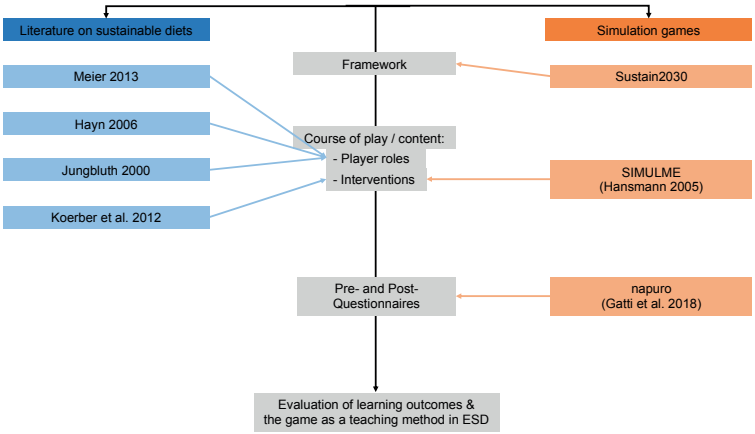


*Figure 7: Overview of the included literature on sustainable diets and simulation games to develop and test the simulation game on sustainable diets and their contribution to the SDGs (author's elaboration based on own data)*

## 3.1 Simulation Game Development

The simulation game *Sustain2030* with its integrated interdependency network between the 17 SDGs embedded in the software *simcision* provides the framework for the following game development. The methodological approach is the eight-step model (see chapter 2.4.2), based on a system thinking perspective. Each step of the model was applied systematically to develop the game structure and course of play. Several steps were taken from *Sustain2030*, others were adjusted. The undertaken changes within each step are presented in table 3 and described in detail in the following.

*Table 3: Eight-step-model used to develop the simulation game on sustainable diets and their contribution to the SDGs based on Sustain2030 (author's elaboration based on own data)*

| **Steps** | **Adjustments** |
|---|---|
| 1. System delimitation | How can sustainable development in Germany be promoted by (sustainable) diets?<br>7 stakeholders based on Meier (2013) and Eberle (2007). |
| 2. System appraisal | "Wedding cake" illustration of the SDG-icons in the initial situation by the Stockholm Resilience Centre (2016). |
| 3. System construction | Extension of the relationships in the system with a special focus on the German food system. |

| | |
|---|---|
| 4. System dynamics | Evaluation of the strength of the added relationships compared to existing relationships. |
| 5. System resources | Budget refers to money and is associated with SDG 12. |
| 6. System Environment | One non-influenceable event developed in the need field of nutrition. |
| 7. System Intervention | 18 interventions mainly based on 5 principles of sustainable nutrition (Koerber et al., 2012) and *SIMULME* (Hansmann, 2005). |
| 8. System changes | Comparison and evaluation of simulated scenarios. |

*Step one (system delimitation)* includes the objective of the game and a stakeholder analysis. The question of interest in this game was elaborated from “How can sustainable development be promoted in Germany?” to “How can sustainable development be promoted in Germany by sustainable diets?”.

The performed stakeholder analysis defined the stakeholders of the system and respectively the game roles which players represent during the game. Therefore, stakeholders in the field of nutrition were analysed. It can be defined as a system in which direct actors in production, manufacturing, trade or catering and consumption as well as indirect actors (e. g. social network, media, schools, state, supply) are integrated and connected to each other (see figure 8; Jungbluth, 2000).

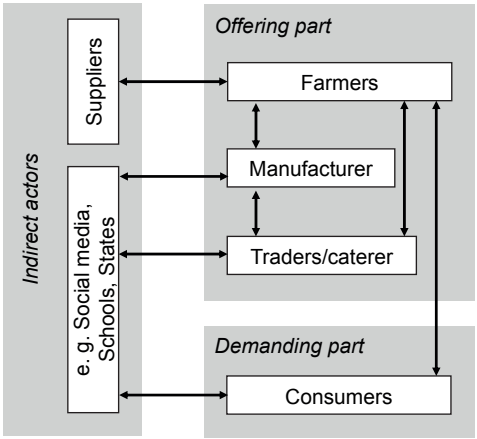


*Figure 8: Direct and indirect actors in the field of nutrition (adapted, based on Jungbluth, 2000)*

The producers (supply side) and the consumers (demand side) are the key players in the food system. However, both act far from sustainable regarded from the perspective of sustainability. Therefore, it is important to make these actors to shapers of a social-ecological change (Teitscheid et al., 2018). To underpin the responsibility of both parts, the roles included in the game represent the supply side (farmer and trader) and the demand side (consumers).

Looking at the supply side of the market, two actors are included in the game. On the one hand, the supermarket is the main interface between food producers and consumers. Therefore, the representative has an important responsibility to make food available for all (Brunner and Schönberger, 2005). On the other hand, farmers who sell their products in direct marketing strengthen the urban-rural relationships between producer and consumers as

they provide regional and seasonal and fresh, unprocessed products. It is an important economic pillar for the farmer aligning with higher transparency, trust, knowledge and experiences in organic farming for the consumer (Brunner and Schönberger, 2005). Both, the supermarket and the farmer in direct marketing provide food products. These differ in quality and origin. Besides, supermarkets and farmers have different strategies to interact with consumers. Therefore, both actors are responsible for producing and retailing food products which shape consumption patterns. In the game, both ways are represented by a discount supermarket and by an organic farmer in direct marketing.

The demand side in the game consists of consumers with different lifestyles and consumption patterns. As described in chapter 2.3, there is not only one sustainable diet. The topic of sustainable diets has to be regarded from different consumer perspectives. Therefore, the nutritional styles described in the social-ecological research “Ernährungwende” (Eberle, 2007) were allocated to the five dietary models analysed by Meier (2013) on their environmental impact (Meier, 2013). Thus, five consumer roles were developed (see table 4 and annex 1.1). Firstly, the cheap and meat eater who represents the consumption of 2006. Secondly, the conventional health oriented who is mainly oriented by the UGB recommendations. Thirdly, the stressed everyday manager who tries to feed her family according to DGE recommendations. Followed by fourth, the food-conscious demanding who tries to feed her family mostly ovo-lacto vegetarian and lastly, the vegan who renounces animal-based food products completely. The vegan character, presented in the paper by Meier (2013), was not identified as a nutritional style by Eberle (2007). Therefore, it was developed according to the other character descriptions. The uninterested fast-fooder, the joyless habitual cook and the fitness-oriented ambitious

were excluded as the characters did not match the dietary models analysed by Meier (2013).

*Table 4: Five consumer roles connect nutritional styles by Eberle (2007) with dietary models by Meier (2013)*

| **Dietary models by Meier (2013)** | **Included characters by Eberle (2007)** |
|---|---|
| Consumption 2006 | Cheap and meat eater |
| UGB recommendation | Conventional health oriented |
| DGE recommendation | Stressed everyday manager |
| Vegetarian (ovo-lacto) | Food-conscious demanding |
| Vegan dietary style | Not included |

As the two studies are fused, it is possible to provide the players not only with information about the roles' everyday life situation and the personal connection to nutritional habits, but also with information about the environmental dimension. To do so, the used indicators by Meier (2013) (see chapter 2.3) were allocated to the respective SDGs – SDG 6 (clean water and sanitation) represents the blue water use, SDG 13 (climate action) the GHG emissions, SDG 14 (life below water) the ammonia emissions and phosphorus use, SDG 15 (life on land) the land use and SDG 7 (affordable and clean energy) the primary energy use. Then, the table by Meier (2013) showing the environmental impact of the usual dietary habits in 2006 compared to the other four models was used to rate the respective impact on a colour-scale from dark green (< -40 %) to red (> -10 %; see table 5). To provide the players with information about the environmental dimension, the five SDGs were presented

with the related colours on the respective consumer role cards (see annex 1.1).

*Table 5: Comparison of environmental impact of the intake from 2006 compared to recommendations and dietary models (in percentages). Red: deviation of the intake in 2006 > -10 %; yellow: deviation < -10 %; light green: deviation < -20 %; green: deviation < - 30 %; dark green: deviation < - 40 % (adapted, based on Meier, 2013)*

| SDG | Environmental indicators | Intake 2006 | DGE | UGB | Ovo-lacto-vegetarian | Vegan |
|---|---|---|---|---|---|---|
| 6 | Water use (blue) | 100 % | -27,0 % | -27,6 % | 82,3 % | 107,8% |
| 7 | Primary energy use | 100 % | -7,6 % | -5,6 % | -22,5 % | -30,3 % |
| 13 | GHG emissions | 100 % | -11,8 % | -12,8 % | -31,1 % | -53,0 % |
| 14 | $NH_3$ emissions | 100 % | -21,6 % | -29,8 % | -49,9 % | -88,9 % |
| 14 | Phosphorus use | 100 % | -12,8% | -15,6 % | -38,2 % | -62,8 % |
| 15 | Cropland use | 100 % | -15,6 % | -18,8 % | -34,1 % | -49,5 % |

*Step two (system appraisal)* includes the analysis of the status quo of each SDG which represents the initial situation of the game. It is based on the *SDG Index and Dashboard Report* (see chapter 2.2.1; Sachs et al., 2018) with specific data for Germany. No further adjustments were made in this step, so the initial situation is identical to *Sustain2030* (see chapter 2.4.2). However, the arrangement of the icons in the initial situation of the game was rearranged to the “wedding cake” illustration of the SDGs which was developed by the Stockholm Resilience Centre (see figure 9 and

chapter 2.3). This integrated structure gives the test players a more comprehensive overview of the sustainability dimensions environment, society and economy within the SDG network compared to the illustration of *Sustain2030*.


*Figure 9: Initial situation of the simulation game on sustainable diets with the "wedding cake" illustration: The status quo of each SDG is shown as percentage below each icon. The bottom left corner shows the initial budget. The top right shows the initial total performance (72,53 %). The grey lines between the SDG presents the relations between SDGs (author's elaboration based on own data).*

*Step three (system construction)* includes the identification of how SDGs are interrelated with one another. *Step 4 (system dynamics)* includes an analysis of the interrelation strengths between the SDGs and the factors they rely on. The general construction is used

of *Sustain2030*. A weak relationship has a magnitude of 10 which means that a state of change by 100 percent of the originating SDG (e.g. SDG 2) results in a 10 percent change of state at the incoming SDG (e.g. SDG 13). However, as described in chapter 2.3, the interactions are highly context specific. Therefore, the construction was adapted with a specific focus on the field of nutrition. No relationships were deleted, but further relationships were identified with relevant literature references[5] between different goals which refer to the food system. To visualize the existing and added relationships, a cross-impact matrix of interactions is presented in figure 10. It was applied in the same way as by Weitz et al. (2018) guided by the question: “If progress is made on target x (rows), how does this influence progress on target y (columns)?” (Weitz et al., 2018, p. 536). The strength of the added relations relates to the existing ones (see annex 1.2).

[5] The literature research was performed in course of a project from the Working Group Sustainable Nutrition. The use of the information was in accordance with the Working Group. Published report focusing on the principles of sustainable nutrition and their contribution to the SDGs can be found here:
https://www.naturland.de/images/Naturland/Was_wir_tun/Engagement/NM19_329_UN-Ziele_Duits_LR.pdf

| | | Influenced SDGS | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SDGs | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| Influencing SDGs | 1 | | **15** | **7** | 7 | 0 | 0 | 7 | 0 | 0 | 15 | 0 | **[10]** | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | | **[10]** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **[12]** | **[12]** | 0 | 0 | 0 | 0 |
| | 3 | 0 | **[7]** | -2 | 0 | 0 | 0 | 0 | 5 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| | 4 | 0 | **10** | **12** | | 20 | 0 | 0 | 7 | 17 | 0 | 0 | **7** | 0 | 0 | 0 | 0 | 0 |
| | 5 | 0 | 0 | 0 | 7 | | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 6 | 0 | 0 | **10** | 0 | 0 | | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 7 | 0 | 0 | 0 | 0 | 0 | 0 | | 2 | 0 | 0 | 10 | 0 | 7 | 0 | 0 | 0 | 0 |
| | 8 | 20 | 0 | 0 | 0 | 20 | 0 | 0 | | 15 | 10 | -12 | 0 | -10 | 0 | 12 | 0 | 0 |
| | 9 | 0 | 0 | 0 | 10 | 0 | 5 | 17 | 10 | | 0 | 7 | **15** | 5 | 0 | 0 | 0 | 0 |
| | 10 | 25 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 20 | 15 |
| | 11 | 0 | **[7]** | **10** | 0 | 0 | **7** | 0 | 0 | 5 | 2 | | 0 | **10** | 0 | 0 | 0 | 0 |
| | 12 | **[7]** | **[7]** | **[15]** | **[10]** | **[5]** | **12** | **[10]** | **[10]** | **5** | **[5]** | **10** | | **[20]** | **20** | **20** | **[2]** | **[2]** |
| | 13 | 0 | **[10]** | 0 | 0 | 0 | 0 | 12 | -10 | 0 | 0 | 12 | **15** | **-2** | **10** | **15** | 0 | 0 |
| | 14 | 0 | **5** | **[5]** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **7** | **-2** | 0 | 0 | 0 |
| | 15 | 0 | **10** | 0 | 0 | 0 | **17** | 0 | 0 | 0 | 0 | 0 | **[15]** | **10** | 0 | **-1** | 0 | 0 |
| | 16 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 20 |
| | 17 | **15** | **15** | 0 | 12 | 0 | **5** | 10 | 2 | 12 | 0 | 7 | **15** | **10** | **15** | **10** | 20 | |

*Figure 10: Cross-impact matrix with existing and added relationships of the system: [x]: added relationships | Bold numbers: direct relation to the German food system | Dark green: strong positive relationship (scoring 15 to 20), light green: positive relationship (scoring 2 to 14), red: negative relationship (-1 to -12) (author's elaboration based on own data)*

A special role is allocated to SDG 12 (SCP) in the game. The implementation of this goal also includes the implementation of other SDGs, especially because sub-goal 12.1 includes the global implementation of the *10YFP programs on sustainable consumption and production* (see chapter 2.2.2). Therefore, SDG 12 has an important leverage effect assuming that it has an effect on all other SDGs within the constructed system.

*Step 5 (system resources)* allocates the game resources to a budget. A certain budget is available for all game players together

as a group. This money shall be invested during the game to execute the interventions (see *step 7*). In the simulation game on sustainable diets, the budget refers to money with a starting budget of 40 units. Unlike *Sustain2030*, the budget is associated to SDG 12 (SCP). Therefore, the group earns extra budget when they exceed SDG 12 with a performance rate of more than 70 %.

*Step 6 (system environment)* includes creating events which occur dependent on time, state or randomly. These incidents can be endogenous, triggered by the status of system elements, or exogenous, triggered from outside of the system and change the sustainability performance. In the simulation game on sustainable diets one event was created – the rotten meat scandal – which occurs in round 4 of the game. It has negative impacts on SDG 3, 9 and 12 (see annex 1.3).

*Step 7 (system intervention)* determines the interventions which the players should discuss about and perform to improve the sustainability performance of Germany within the system. Therefore, this step is the main part of the simulation game development. In total, eighteen interventions were developed. All developed interventions directly impact several SDGs especially on health and environmental dimensions which is based on relevant literature[6]. Moreover, they indirectly affect all other SDGs due to the interdependency network. Information on the effect, the justification

[6] The literature research was performed in course of a project from the Working Group Sustainable Nutrition. The use of the information was used in accordance with the Working Group. Published report focusing on the principles of sustainable nutrition and their contribution to the can be found here:
https://www.naturland.de/images/Naturland/Was_wir_tun/Engagement/NM19_329_UN-Ziele_Duits_LR.pdf

of the effect and the associated price of each intervention is described in annex 1.3.

The first intervention represents the “status quo” of the average consumption in Germany characterized by NVS II which was conducted in 2006 and assessed by Meier (2013). It has a direct impact on health and the environmental dimensions (SDG 3, 12, 13, 14 and 15). It is simulated by the game leader without preceded discussions in the group to visualize the negative impact on the system. Based on this simulation which represents the consumption pattern of the “cheap and meat eater”, the other four consumer roles with their dietary patterns are compared to the simulated one.

Furthermore, “purchase interventions” were assigned to five of the *seven principles of a sustainable nutrition* by Koerber et al. (2012) (see chapter 2.3.2) and were combined with the course of play methodology of the simulation game *SIMULME* (see chapter 2.4.2). Food prices were chosen based on *Sustain2030* and current discussions on food prices (Jäggi, 2018). Table 6 gives an overview of the developed interventions which are described in detail in the following.

*Table 6: Purchase questions with the associated interventions (author's elaboration based on own data)*

| Principles of sustainable nutrition | Purchase questions | Interventions | Price | Impact on SDGs |
|---|---|---|---|---|
| "Preference of plant-based foods" | 1. Of the total amount of bought vegetables and meat is the vegetable proportion… | 0-20%<br>20-40%<br>40-60%<br>60-80%<br>80-100% | 5<br>4<br>3<br>2<br>1 | 1, 3, 6, 12, 13, 14, 15 |
| "Organic foods", "Regional and seasonal products" | 2. Where does the purchased vegetables come from and which quality do they have? | Conventional vegetables (discounter)<br>Conventional regional vegetables (discounter)<br>Organic vegetables (discounter)<br>Regional and seasonal organic vegetables (farmer) | 1<br>2<br>3<br>5 | 3, 6, 8, 12, 13, 14, 15 |
| "Organic foods", "Regional and seasonal products" | 3. Where does the purchased meat come from and which quality do they have? | Conventional meat (discounter)<br>Conventional regional meat (discounter)<br>Organic meat (discounter)<br>Regional organic meat (farmer) | 2<br>3<br>4<br>6 | 3, 13, 14, 15 |
| "Preference of minimally processed foods" | 4. Should convenience products be bought? | Yes, processed foods | 3 | 3, 9, 12 |
| "Resource-saving housekeeping" – Reduce food waste | Joker (in round 3) | Gap-Text concerning food waste in households | 0 | 1, 6, 11, 12, 13, 15 |

The five chosen principles of sustainable nutrition include the principles "preference of plant-based foods", "organic foods", "regional and seasonal products", "preference of minimally processed foods" and "reducing food waste" which is part of the principle "resource-saving housekeeping". These principles have a direct reference to the production and consumption of foods. The principle "Product of Fair Trade" also complies with it. However, the principle is not included in the game because the focus was put on the German food system. Even though fair trade in Germany can be considered as an important pillar of sustainable food systems, it is

rather a topic of the global scale. The principles “tasty meals – enjoyment without regret” was not considered as it is particularly associated with the pleasure of eating.

Fourteen of the “purchase interventions” represent purchase offers by the supply side (farmer in direct marketing and discount supermarket to consumers). These are performed by “purchase questions” which should be answered each round by the players as a group. The questions firstly focus on the proportion of vegetables purchased compared to meat, secondly on the origin (discounter vs. farmer / regional vs. non-regional) and quality (organic or conventional) of vegetables, thirdly on the origin and quality of meat and lastly on the decision to purchase manufactured products (see table 6). The methodology to ask questions in terms of deciding on purchase interventions is based on the simulation game *SIMULME.* In this game purchase questions are answered by the players to visualize the impact on ecological and economic dimensions (see chapter 2.4.2). In addition, the limit to only purchase vegetables and meat aligns with the course of play in *SIMULME* which is based on the scientific evaluation by Jungbluth (2000). Like *SIMULME*, it provides a “[…] solid informational basis for the game” (Hansmann et al., 2001, p. 3).

The intervention “reducing food waste in households” is included in round 3 of the game as a joker. The joker can be used when the players solve the gap text associated with the intervention: “Every citizen ... on average 81.6 kg of food per year ... which corresponds to a value of € 235 per person per year (Kranert et al., 2012). By using the joker, money can be saved and SDG 12 can be supported. The joker is an advertised sub-goal of SDG 12 and therefore particularly important.”

In the last round of the game (fifth round[7]), action cards are unlocked which represent offers made by farmer and representatives of the supermarket to the consumers. These offers aim to simplify the everyday life of the consumers which is necessary to achieve more sustainable diets (see Eberle 2007). On the one hand, the farmer makes the offer to the consumer to join the association for community-supported agriculture. In return, each week they get a shopping basket full of regional and seasonal products with suitable recipes delivered to their homes. On the other hand, the representative of the supermarket noticed the current trend in society that more customers want to consume more sustainably sourced foods but also that more manufactured products are sold (Teitscheid et al., 2018). Therefore, the representative offers more organic and sustainable manufactured foods to consumers.

*Step 8 (system changes)* includes the comparison and evaluation of the simulated interventions. After the decision on interventions is made by the players, the game leader simulates these in the software, so the players can observe the effects within the system. Based on the observations made, the group reflects the results and discusses the interventions for the next simulation round. After the last round, the overall performance is analysed in the evaluation phase of the simulation game.

## 3.2 Game Structure and Course of Play

As described in chapter 2.4.2, the game structure follows the general framework of a simulation game including a preparation, an

[7] It is possible to include more rounds. However, only five rounds were played due to time limitations.

interaction and an evaluation phase. A game lasts approximately 95 minutes (see table 7). Five to seven players are needed to play the game. When playing with less than seven players, the farmer and the representative of the discount supermarket can be excluded. Furthermore, a game leader with expertise in the topic is needed.

*Table 7: Schematic description of the game structure (author's elaboration based on own data)*

| **Simulation game phases** | **Time (min)** |
|---|---|
| Preparation phase<br>- Introduction to the topic<br>- Description of the scenario and the game roles<br>- Distribution of roles<br>- Round of introduction | 30' |
| Interaction phase<br>- 1st round: "Status quo" simulation<br>- 2nd – 4th round: "Purchase interventions"<br>3rd round: Activation of the joker<br>4th round: Event – The rotten-meat scandal<br>- 5th round: Offers made by the supply side to consumers | 45' |
| Evaluation phase<br>- Evaluation of the actions on the 17 SDGs<br>- Evaluation of the game experience | 20' |
| **Total** | **95'** |

In *the preparation phase,* the game leader gives an introduction into the topic of sustainable diets and SDGs followed by an explanation of the game scenario, the game target and the game roles using a power-point presentation projected with a beamer (see annex 1.4).

The game scenario includes representatives from the supply side (a farmer in direct marketing and a discount supermarket) and the demand side (consumers) which sit together. Each round the consumers shall purchase vegetables and meat at the supply side. Together they decide about the amount, the origin and quality of the products as well as whether processed foods shall be purchased. They follow the four purchase questions with the associated purchase interventions to improve the overall performance of the SDGs. However, the challenge is that each consumer has its own life- and nutritional style and is more or less willing and able to change its dietary habits to a more sustainable diet. For food purchases, a joined starting budget of 40 budget points is available to the consumers. The price for each intervention is written on a whiteboard, so everyone can see it. Furthermore, the budget is linked to SDG 12. If the players succeed in increasing SDG 12 to a percentage of more than 70 percent, extra points for the joined budget will be generated.

The learning goal of the game is to get a better understanding of the interrelations of the SDGs in the field of nutrition. Besides, players can learn what sustainable diets and dietary components can contribute to achieve the SDGs from different stakeholder perspectives.

After the introduction, the players are randomly assigned to the seven different game roles. They have time to read the corresponding player cards which provide information on the general activity, the reference to nutrition and its impact on the environmental dimension. Afterwards, they present their corresponding characters. Before the interaction phase and the corresponding course of play starts, the software with the initial situation and the interventions are projected with the beamer. The

game leader simulates the first round of the game visualizing the "status quo" of the average consumption in Germany which represents the intake of 2006 and respectively the dietary habit of the "cheap and meat eater". The effect on the system of the simulation is explained and compared to the possible effects of the dietary consumption models of the other four consumer roles. With the information of the environmental impact on the respective role cards, the players can reflect on their respective impact on the system and understand how the simulation works.

*The interaction phase* is comprised of round 2 to 5 of the game and is considered the core part of the simulation game. The consumers discuss and decide about which food products they purchase together. The supermarket and the organic farmer in direct marketing try to convince the consumers to purchase their products. In every round, the purchase interventions decided by the group are entered into the software to visualize the impact. Feedback about the effects of their decisions is given by bar charts visualizing each SDG's status quo in percentage as well as the overall performance in the top right corner of the software. In the third round, the joker is unlocked. It can be used by the group if they can provide the correct keyword ("reducing food waste in households") for the associated gap text. In round five, action cards are unblocked which represent offers made by the farmer and the representative of the supermarket. The group shall choose one of the offers in case enough budget is available.

*The evaluation phase* consists of the comparison and evaluation of the five simulated play rounds. In the software, the SDGs can be selected individually, so the performance of each round can be visualized, explained and reflected on. The game leader leads the group through all the SDGs and explains the performance.

Afterwards, the players have the opportunity to give feedback on the game experience.

## 3.3 Data Collection

In order to test the hypothesis of this study (see chapter 1), data was collected in a sample of simulation game participants using a pre-post questionnaire design. The following chapter gives a detailed description of the applied sampling and questionnaire methodology.

### *3.3.1 Sampling*

As described in chapter 2.4, young adults are an important target group in ESD. To emphasize the importance of the target group, the definition of the term “young adults” needs to be described more precisely. The UN classifies “youth” or “young adults” to be people between the age of 15 and 24 years (UNESCO, 2014). At the same time, the UN states that in some societies, different ages are associated with the different stages of life. Fares et al. (2007) state that in some cases people aged younger than 15 and older than 24 up to 30 can be defined as young people. In Germany the legitimate definition of young adults is defined by the Federal Ministry of Justice and Consumer Protection as persons between 18 and 27 years (Bundesministerium für Justiz und Verbraucherschutz, 1990). However, from a social perspective, no specific age range can be defined. The term rather combines a specific phase of life when transitioning from puberty to economic independence (Witzke, 2016).

For this paper, the survey was conducted with people between the age of 17 and 30 years being in an educational/ training phase of life or recently started work to become economically independent. Compared to the above-mentioned lower age range starting at the

age of 15 years, the age range for the participants in this paper is set higher as those people might be to a greater extent responsible for their own food purchases and consumption patterns than younger ones who might still live at home (Hansmann et al., 2001). Therefore, the rationale of this data collection was, people aged 17 to 30 are directly affected by the topic of purchasing food for themselves and show an individually independent consumption pattern. The upper age limit is set at the age of 30 based on the legal and sociological considerations of the term “young adults” mentioned above.

The convenience sampling technique, a non-probability sampling strategy, was chosen due to time limitations (Etikan et al., 2016). This technique gives the researcher the possibility to include people from the target population who are easily accessible, geographically proximate, available at a given time and are willing to participate in the survey (Etikan et al., 2016). Possible participants were asked to take part in the simulation game and the survey via the Regional Center of Expertise (RCE) to implement ESD in Munich (*BeNE München e. V.*[8]), cooperation partners of the *Working Group Sustainable Nutrition e. V.* and students of the *University of Kassel* and the *Technical University of Munich.*

Using the open-source tool *G*Power*, an a priori power analysis was conducted to compute the required sample size for the present survey given the significance level (α = .05), the desired power level (1-β = .95) and the estimated effect size (*d* = .65). The effect size

[8] *BenE München e.V.* - Education for Sustainable Development - supports the Bavarian state capital as Regional Center of Expertise (RCE) in the implementation, establishment and further development of Education for Sustainable Development (ESD). The non-profit organization acts as a platform for ESD in Munich.

was generated based on the paired sample t-test results by Gatti et al. (2018) whose survey is used as a framework for the questionnaire development in the following chapter. The minimal sample size for the survey was calculated to be $n$ = 28 participants (see annex 2.1).

### *3.3.2 Survey Design*

The questionnaire used in this study was mainly based on Gatti's et al. (2018) survey on sustainability gamification and its effect on students' learning outcomes in business education using the simulation game *napuro* (see extended annex). The objective of the study was to assess "[…] how the napuro experience influenced the students' cognitive and affective learning of sustainability" (Gatti et al., 2018, p. 671). Furthermore, the participants were asked to give feedback on the game experience including the overall opinion on the game and several components of it. The mixed-method survey design including quantitative and qualitative analysis methods was chosen (Etikan et al., 2016).

The original study by Gatti et al. (2018) was conducted in a sample of business students participating in a sustainability class over the course of one semester. The students filled out the used pre-questionnaire before the first teaching lesson and the post-questionnaire after the game experience played at the end of the semester. The questions consisted of quantitative and qualitative questions. Quantitative questions such as "What is your overall expertise in sustainability?" (asked before playing the game napuro) or "How well do you think you understand the concept of sustainability" using Likert-scales ranging from 1 to 4 and 1 to 5. The authors adopted the items in the pre- and post-questionnaires based on the survey by Sharma and Kelly (2014) who evaluated

students' perceptions of sustainable development in the accounting and business field (Sharma and Kelly, 2014).

Due to the similarity of the research question and objective of the survey, the pre- and post-questionnaire was used as a framework for the questionnaire development in the present paper even though the reliability of the questionnaire was not assessed in previous studies and it was used on students in business education. The use and adaption of the questionnaire by Gatti et al. (2018) was done in agreement with the authors. The questions were translated to German and adjusted with a special focus put on the SDGs and sustainable diets. Like the questionnaire by Gatti et al. (2018), all questions in the pre- and post-game questionnaire are built according to the same scheme to analyse whether the game has an effect on the learning outcomes of test players. Furthermore, in the post-questionnaire, the test players were asked to give feedback using the same questions as Gatti et al. (2018).

### *3.3.3 Survey Piloting*

To assess whether the game structure and course of play is understandable and feasible, a pilot test with an 8$^{th}$ grade school class (students aged 14 years) of the game was conducted before the first test without using pre- and post-game questionnaires. No further adjustments were made in the game structure and course of play after the pilot test.

For the questionnaire, two separate pilot tests with students aged 26 and 27 years were conducted. Adjustments in the developed questionnaire were implemented (see annex 2.2). In general, piloting gives important information about several dimensions, like for example the comprehensibility, the order of the questions or context effects (Porst, 2013). A central issue in the wake of the pilot was the comprehensibility and the order of the questions. Firstly, the

front page was adapted giving background information about the SDGs as an informational basis for the questionnaire. Secondly, the indication of age, profession and the topic of profession was included to achieve more information about the test players for possible data analysis. Thirdly, the order of the questions was changed to achieve a better reading flow for the testimonial. Furthermore, the descriptive questions on the specific understanding of the principles of sustainable nutrition and the global impact of diets on the SDGs was changed to 6-point-scale questions, so the average sum of differences in the pre- and post-game scores are assessable. Also, the scale for the questions in the post-game questionnaire asking for the general opinion about the game and several components of the game were standardized with the other questions to a 5-point-scale. Lastly, a sentence for introducing the open-ended questions was added.

### *3.3.4 Pre- and Post-Game Questionnaires*

The final pre- and post-game questionnaire was answered by the participants before the preparation phase and after the evaluation phase of the arranged test games (see annex 2.3). Aligning with the description of learning outcomes in educational theory (see chapter 2.4.1), the developed questionnaire assessed the test players' understanding and expertise (cognitive dimension) about SDGs and sustainable diets as well as their perception of the importance and relevance (affective dimension) of the topic. The integrated Likert-scales range from 1 to 4, 1 to 5 and 1 to 6 with a scale direction from left to right (e.g. from 1 "I don't agree" to 5 "I agree").

First of all, the players are asked to indicate their age, sex and profession in the pre-game questionnaire. Afterwards, the cognitive learning outcomes in form of expertise and understanding of the

topic is assessed. A 4-point response scale serves the test players to self-rate their general expertise (novice, competent, proficient, expert) in the field of sustainable diets and their impact on the SDGs. An additional question in the post-questionnaire assesses whether the overall expertise in the topics covered in the game increased with a yes/no/don't know answering scale.

To measure the self-assessed understanding of the test players in the field of SDGs, sustainable diets and their impact on the SDGs, four different statements were designed and added to the data analysis to an average sum of scores for the overall understanding. Firstly, the statements „Ich verstehe bereits vor dem Spiel das Konzept der UN-Ziele für nachhaltige Entwicklung (SDGs)." and „Ein nachhaltiger Ernährungsstil hat einen starken Einfluss auf die Erreichung der UN-Ziele für nachhaltige Entwicklung (SDGs)." assessed the general understanding of the SDGs and the impact of sustainable diets on the SDGs with a Likert-scale from 1 („I don't agree") to 5 („I agree"). Two further questions measuring the specific understanding of the value of sustainable diets and the contribution of diets to each of the 17 SDGs were developed aside the questions on the cognitive dimension by Gatti et al (2018). The question "Bitte bewerten Sie die Bedeutung der folgenden Elemente für eine Nachhaltige Ernährung" includes five elements based on the *7 principles of a sustainable nutrition* which shall be answered on a Likert-scale from 1 to 6 (1:"not at all"; 5: "very much"; 6: "I prefer not to answer"). The question "Bitte bewerten Sie, wie viel Ernährung Ihrer Meinung nach zu jedem der 17 SDGs global beiträgt" includes all seventeen SDGs which shall again be rated on a Likert-scale from 1 to 6. These questions are rather subjective and not built up on existing literature. However, these are helpful to receive descriptive scores on the subjective understanding of the test players.

To assess how the game influences the affective dimension of learning, the questionnaire included two statements with a Likert-scale ranging from 1 to 5 to measure the importance and relevance and therefore the attitude of test players towards the topic of sustainable diets and their impact on the SDGs: „Es ist WICHTIG für mich zu lernen, welchen Einfluss Ernährung auf die Erreichung der UN-Zielen für nachhaltige Entwicklung (SDGs) hat.“ and „Es ist NÜTZLICH für mich zu lernen, welchen Einfluss Ernährung auf die Erreichung der UN-Zielen für nachhaltige Entwicklung (SDGs) hat.“ Gatti et al. (2018) included the questions “Do you think that the event with the game changed your approach on how to conduct a business? If yes, how? If no, why not?” into their questionnaire. However, this question was not taken on in this paper because there was less time between the pre- and post-game questionnaire than Gatti et al. (2018) had. Their students attended a course about sustainability in the business field for the course of one semester.

Furthermore, at the end of the post-game questionnaire three open questions were designed to gather feedback about the test players' learning experience. The players were asked to state their most important take-away from the game (associated with the cognitive dimension). Also, they were requested to answer what they would do differently in the future as a result of the game (affective dimension). Lastly, the test players were asked to give further comments including proposals for improvements.

In addition to the questions about cognitive and affective learning outcomes regarding sustainable diets and their impact on the SDGs, the post-game questionnaire included questions to evaluate the simulation game and its components. Firstly, the general level of satisfaction was asked on a Likert-scale ranging from 1 (“poor”) to 5 (“excellent”). This was followed by an assessment of various

components of the simulation game including the introduction to the game, the course of play, the discussion during the game and the debriefing of the game again using a Likert-scale from 1 (“poor”) to 5 (“excellent”).

## 3.4 Data Preparation and Analysis

The main research hypothesis for the data analysis assumes that the simulation game influences test players’ learning outcomes. This hypothesis was analysed using the pre- and post-game questionnaire applying the above described quantitative and qualitative analysis methods.

Before running the data analysis, the data set was adjusted on several dimensions. Firstly, seven answers stating “I prefer not to answer” were excluded from the analysis by characterizing them as missing values represented by the symbol *NA* (not available) in the data set. Secondly, seven outliers were identified using the visualization option with boxplots. The data set was adjusted using the “winsorizing”-method (Dixon and Yuen, 1974; Tukey, 1962). This method includes the modification of the outliers by replacing values above the ninety-fifth percentile of the data by the ninety-fifth percentile as well as values below the fifth percentile with the fifth percentile. Therefore, the value is replaced by a more plausible value compared to the initial one (Ghosh and Vogt, 2012). This method was chosen to retain the high-value answers but to not too strongly take these into account. Lastly, because of the different scales within the questionnaire (Likert-scales ranging from 1 to 4, 1 to 5 and 1 to 6), all measurements were transformed into a uniform minimum-maximum scale using the “min max normalization”-method to linearly transform the responses (Al Shalabi et al., 2006) ranging from the lowest value 0 to the highest value 1. The purpose of this normalization was to have a uniform scale to conduct the

statistical analysis and compare the results. Furthermore, the min-max-scaled answers of the four questions on the understanding dimension were assembled to one score of the overall understanding to make an appropriate analysis for the cognitive learning outcomes. Therefore, the average sum of scores of the pre- and post-understanding was calculated ranging again from 0 (lowest value) to 1 (highest value).

To conduct the analysis', the normal distribution needed to be verified. Shapiro-Wilk tests were conducted and did reveal normal distribution in five from nine components (Fields, 2009). However, normal distribution was considered for all components as the sample size is above $n = 30$ which aligns with the central limit theorem (von der Lippe, 2015).

The quantitative analysis was conducted using the open-source statistical analysis tool R studio. The mean before and after game on the test players' self-reported overall understanding, expertise, importance and usefulness were compared to analyse the differences between the cognitive and affective learning outcomes. Therefore, paired sample t-tests were conducted on the 0.05 significance level with the Cohen's d effect size to analyse the mean differences between the pre- and post-game scores on the self-reported dimensions. The effect size is interpreted by Cohen (1988), so a value of 0.2 corresponds to a small, 0.5 to a moderate and ≥ 0.8 to a strong effect. Furthermore, participants' percentages of their reported opinion about the simulation game and selected game components were calculated to reveal what was appreciated most during the game and whether aspects should be improved or changed.

The qualitative analysis of the open questions was conducted using a content analysis (Roberts, 1997). In general, the content analysis

is a systematic and objective research method to analyse written documents. The text is stepwise classified into content-related categories, so replicable and valid inferences from the data to the context can be made. An inductive approach was used as the test players were asked for their personal perception and comments on the game experience. Therefore, the answers were coded and then classified into categories to interpret the results systematically (Elo and Kyngäs, 2008).

# 4 Results

This chapter illustrates the findings. First, the sample description of the conducted trials is presented. Then, the simulation performance of the groups is outlined followed by the quantitative and qualitative analysis of the pre- and post-game questionnaires. Detailed descriptions of the results are attached in annex 3.

## 4.1 Sample Description

In total, five trials took place in August 2019. Each run proceeded in the same pattern following the game structure and course of play and lasted 120 minutes in total (15' pre-questionnaire; 95' game phases; 10' post-questionnaire; see chapter 3.2). To obtain comparable result, no adjustments were made between the runs. The first test run took place at *BeNE München e. V*. (N°1). The second (N°2) was conducted with students of the University of Kassel. The third game took place with young employees at the *Ökoring GmbH*[9] (N°3). The fourth game (N°4) was run with students at the Technical University of Munich. Lastly, the fifth run was conducted with young leaders of the *Kreisjugendring Dachau*[10] (N°5; see table 8).

[9] The *Ökoring GmbH* is a Bavarian wholesale company supplying organic products to inter alia health food shops, catering and canteens in Bavaria, Austria and South Tyrol. (more information on the website: https://www.oekoring.com/home/)

[10] The *Kreisjugendring Dachau* is formed by the youth organizations of the Dachau district. Its main tasks include supporting the activities of its affiliates and advocacy for the interests and interests of all children and young people in the district of Dachau. (more information on the website: https://www.kjr-dachau.de)

*Table 8: Test run descriptions including sample size, proportion of sex and average age (author's elaboration based on own data)*

| | **N° 1** | **N° 2** | **N° 3** | **N° 4** | **N° 5** | **Total** |
|---|---|---|---|---|---|---|
| Sample size | *n* = 7 | *n* = 6 | *n* = 6 | *n* = 7 | *n* = 5 | ***n* = 31** |
| Sex | *w* = 6<br>*m* = 1 | *w* = 3<br>*m* = 3 | *w* = 2<br>*m* = 4 | *w* = 2<br>*m* = 5 | *w* = 2<br>*m* = 3 | ***w* = 15**<br>***m* = 16** |
| Age | *M* = 24.1<br>*SD* = 4.4 | *M* = 27.2<br>*SD* = 1.2 | *M* = 27.2<br>*SD* = 4.0 | *M* = 25.0<br>*SD* = 1.2 | *M* = 23.8<br>*SD* = 5.8 | ***M* = 25.5**<br>***SD* = 3.7** |

The sample size amounted *n* = 31. Thereof, 15 participants were female, 16 were male. They were all aged between 16 and 32 (*M* = 25.5 years). Even though the target group was aimed to be aged between 17 and 30, one test player was aged 16 and two were older than 30. They were kept included to obtain five test runs with five to seven test players per game. 14 testimonials were students with backgrounds in health (*n* = 5), agriculture (*n* = 3), food economy (*n* = 1), sustainability (*n* = 1) and 4 with miscellaneous studies. 14 testimonials were employed in the food sector (*n* = 4), in agriculture (*n* = 2) or in other sectors (*n* = 6). Furthermore, two scholars attended the game as well as one who stated a different profession. All participants completed the pre- and the post-game questionnaire.

## 4.2 Simulation Performance

The overall performance of sustainability increased in four of the five groups (see figure 11). The initial value of 72.53 % increased in average up to 75.63 %. However, each test group used different intervention combinations to reach the respective performances. Test run N°2 and N°3 only performed four game rounds because the budget was depleted after round four, so no further round could be played.

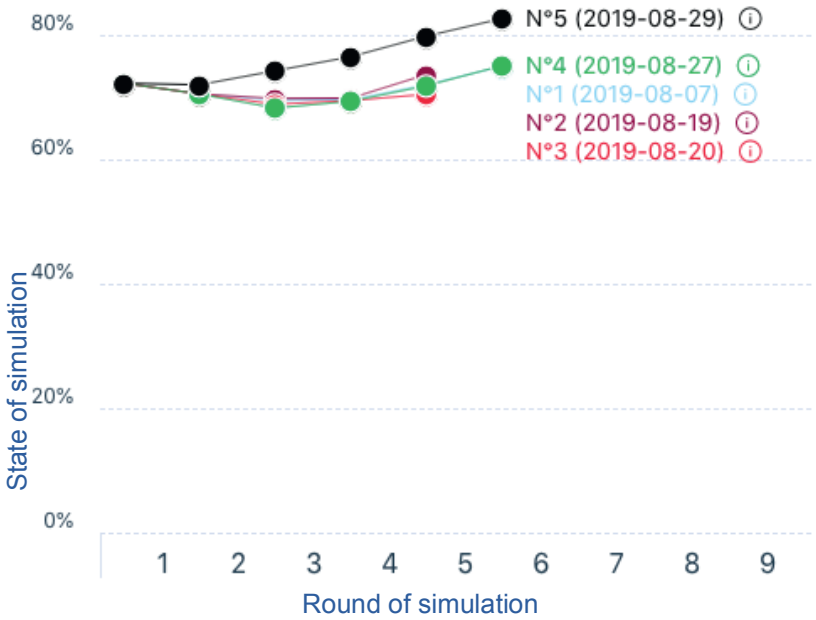


*Figure 11: Overall performance of the five test runs (author's elaboration based on own data).*

Looking at the results of each trial, the most chosen interventions which also had the most positive impact on the system consisted of a high amount of vegetables, regional and seasonal organic vegetables and meat bought at the local farmer (including the offer to support community supported agriculture) reducing processed foods as well as food waste in households (see annex 3.1). In table 9 the final status quo of each SDG was summed up according to the "wedding cake" layers environment (SDG 6, 13, 14, 15), society (SDG 1, 2, 3, 4, 5, 7, 11, 16), economy (8, 9, 10, 12) and partnerships (SDG 17). The change of performance compared to the initial situation in percentage is presented. Trials N°1, 2, 4 and 5 increased their performance in all sustainability dimensions. Trial N°3 performed less compared to the initial situation.

*Table 9: Trial performances summed up on sustainability dimensions (in %) compared to the initial situation (author's elaboration based on own data)*

| **Test group / Dimensions** | **Initial (%)** | **N°1 (%)** | **N°2 (%)** | **N°3 (%)** | **N°4 (%)** | **N°5 (%)** | **Mean (%)** |
|---|---|---|---|---|---|---|---|
| **Environment** | 100 | 16.60 | 14.11 | -3.73 | 13.69 | 33.61 | 14.85 |
| **Society** | 100 | 0.17 | -2.03 | -2.03 | 0.84 | 8.45 | 1.08 |
| **Economy** | 100 | 1.28 | 1.28 | -2.88 | 3.19 | 15.02 | 3.58 |
| **Partnerships** | 100 | 0.00 | 0.00 | 0.00 | 0.00 | 1.15 | 0.23 |
| **Total** | 100 | 3.65 | 2.11 | -2.43 | 3.89 | 14.52 | 4.35 |

In the first test run, positive effects were obtained on SDG 2, 11, 12, 13, 14 and 15 and negative ones on SDG 1, 6 and 9. Test run N°2 only shows positive contributions to SDG 12, 13, 14 and 15 by the

chosen interventions. Negative impacts can be seen on SDG 1 and 6. Test run N°3 had the lowest overall performance after four game rounds. Positive contributions are seen on SDG 6, 12 and 14. Negative impacts were reached on SDG 3, 8, 9 and 13. Test run N°4 performed only positive results on SDG 6, 8, 11, 12, 13, 14 and 15. Round N°5 had the best performance compared to other test runs. Positive impacts are seen on SDG 2, 3, 4, 5, 6, 7, 11, 12, 13, 14 and 15 and negative impact on SDG 1. In all of the test runs, no effects were seen on SDG 5, 10, 16 and 17 (see annex 3.1).

Furthermore, the SDG performances of each test run over the time horizon of five rounds are presented in annex 3.1. These performance graphs provided the basis for the evaluation phase of the game as each SDG can be chosen and evaluated separately. This helped the test players to reflect on the chosen interventions in each round and their respective effect.

## 4.3 Quantitative Analysis

To analyse differences between the cognitive and affective dimensions on sustainable diets and their contribution to the SDGs before and after the game, the means before and after scores of the questions were compared in paired sample t-tests (see annex 3.2). The overall effect size (Cohen's *d*) was calculated to be $d = .72$, which is higher compared to the overall effect size $d = .65$ by Gatti et al. (2018).

As a result of the game, 26 participants (83.9 %) reported that their general expertise on the topic of sustainable diets as well as their contribution to the SDGs increased. Two participants (6.5 %) stated that their general expertise did not increase, followed by three participants (9.7 %) who could not tell whether their general expertise increased. The high percentage of participants stating that their general expertise increased after the game aligns with the means of the pre-game expertise scores ($M = .15$; $SD = .2$) and post-game expertise scores ($M = .35$; $SD = .17$). The associated paired sample t-test revealed a significant difference on the 0.05 level with a *p*-value of $p < .001$ and an effect size of $d = 1.29$ between the pre- and post-game expertise scores. The overall understanding increased after the game ($M = .61$; $SD = .05$) compared to the pre-scores ($M = .49$; $SD = .11$). The paired sample t-tests on the pre- and post-game overall understanding revealed a significant difference ($p < .001$; $d = 1.15$) (see figure 12).

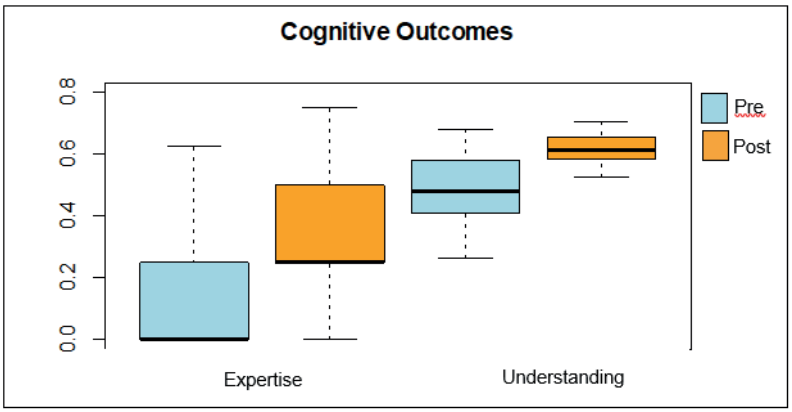


*Figure 12: Boxplot illustration of cognitive outcomes (expertise and understanding) before and after the game with standard deviations (author's elaboration based on own data).*

Considering all four answers of the understanding dimension, the paired sample t-tests show as well significant changes from the pre- to the post-game-scores (see figure 13). The understanding of the general concept of the SDGs (A) shows the most significant difference ($p < 0.001$; $d = 1.74$) comparing the pre-scores ($M = .32$; $SD = .27$) to the post-scores ($M = .66$; $SD = .12$). The understanding of the general contribution of sustainable diets to achieve the SDGs (B) shows a $p$-value of $p < .001$ and an effect size of $d = .51$ comparing pre-scores ($M = .66$; $SD = .14$) and post-scores ($M = .72$; $SD = .1$). The specific understanding of the value of sustainable diets (C) achieves a $p$-value of $p = .02$ and an effect size of $d = .42$ with pre-scores ($M = .56$; $SD = .08$) and post-scores ($M = .59$; $SD = .06$). Lastly, the specific contribution of nutrition to each of the 17 SDGs (D) reveals a $p$-value of $p < .001$ with an effect

size of *d* = .6 comparing pre-scores (*M* = .42; *SD* = .1) and post-scores (*M* = .48; *SD* = .06).

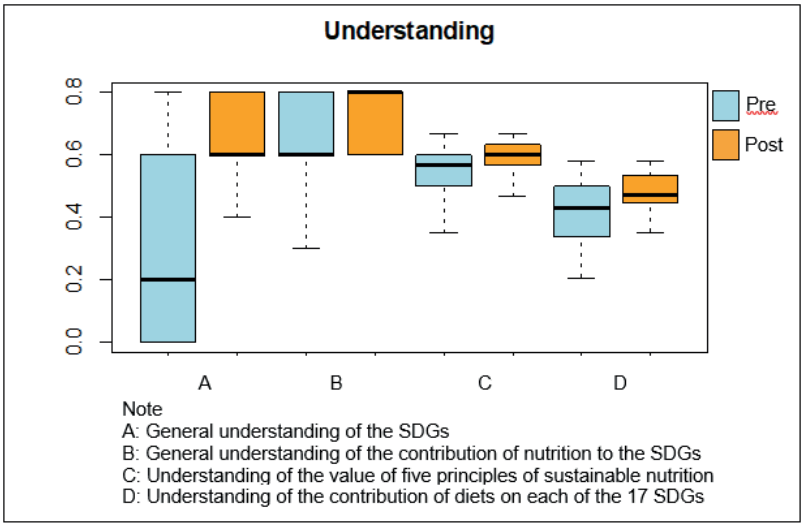


*Figure 13: Boxplot illustration of items A to D of understanding before and after the game with standard deviations (author's elaboration based on own data).*

The data analysis on the perceived importance and usefulness (affective learning outcomes) shows that although both increased, the means in the scores before and after the game are not significantly different on the 0.05 level. The scores on the pre-importance (*M* = .65; *SD* = .16) and post-importance (*M* = .71; *SD* = .14) show a *p*-value of *p* = .08 and an effect size of *d* = .32. The ones from the pre-usefulness (*M* = .7; *SD* = .14) and the related post-game scores (*M* = .73; *SD* = .14) present a p-value of *p* = .43 and an effect size of *d* = .14 (see figure 14).

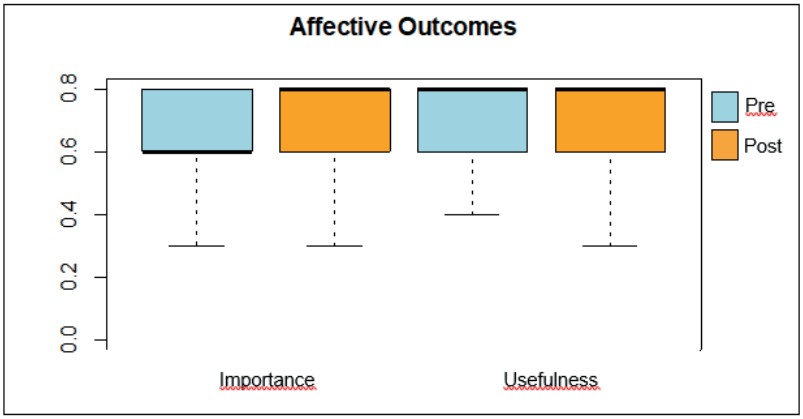


*Figure 14: Boxplot illustration of affective outcomes (importance and usefulness) before and after the game (author's elaboration based on own data).*

Table 10 provides the p-values and the respective effect size of the paired sample t-tests for each test group. The expertise increased significantly in the groups N°1 ($p$ = .02; $d$ = 1.27), N°3 ($p$ = .01; $d$ = 1.8) and N°4 ($p$ = .02; $d$ = 1.24). Means of N°2 are not significantly different ($p$ = .17; $d$ = .65) and for N°5, the data analysis tool R summarized that the data are essentially constant. The overall understanding changes significantly in trials N°3 ($p$ < .001; $d$ = 2.18), N°4 ($p$ < .001; $d$ = 1.67) and N°5 ($p$ < .001; $d$ = 1.97). N°1 ($p$ = .08; $d$ = .78) and N°2 ($p$ = .16; $d$ = .68) are not significant on the 0.05 significance level. The affective dimensions, importance and usefulness, revealed no significant changes in all groups. Data for the pre- and post-importance of trial N°4 was again stated as essentially constant.

*Table 10: Test groups' paired t-test results including p-values and effect size d (author's elaboration based on own data)*

| Test group / Components | N°1 | N°2 | N°3 | N°4 | N°5 |
|---|---|---|---|---|---|
| pre- & post-expertise | *p*=.02 *d*=1.27 | *p*=.17 *d*=.65 | *p*=.01 *d*=1.8 | *p*=.02 *d*=1.24 | NA |
| pre- & post-understanding | *p*=.08 *d*=.78 | *p*=.16 *d*=.68 | *p*<.001 *d*=2.18 | *p*<.001 *d*=1.67 | *p*=.01 *d*=1.97 |
| pre- & post-importance | *p*=.83 *d*=.09 | *p*=.47 *d*=.32 | *p*=.52 *d*=.29 | NA | *p*=.10 *d*=.96 |
| pre- & post-usefulness | *p*=.36 *d*=.38 | *p*=.74 *d*=.14 | *p*=.36 *d*=.41 | *p*=.36 *d*=.38 | *p*=1 *d*=0 |

The evaluation of the simulation game was performed using the data of the self-reported overall opinion and opinion on selected game components (see figure 15). The overall opinion of the simulation game was rated by 12.9 % of the participants as neutral, 58.1 % as satisfactory and 29 % as excellent. No participant rated the game as poor or unsatisfactory. The evaluation of selected game components was mainly stated as satisfactory or excellent. No game component was rated poor. 93.5 % of the participants evaluated the introduction as satisfactory or excellent, 6.4 % as neutral or unsatisfactory. The course of play was evaluated as satisfactory or excellent by 80.6 %, as neutral by 16.1 % and as unsatisfactory by 3.2 %. The discussion during the game was also evaluated as satisfactory or excellent by 80.6 %, as neutral by 12.6 % and as unsatisfactory by 6.5 %. The debriefing and evaluation were rated as satisfactory or excellent by 100 % of the participants.

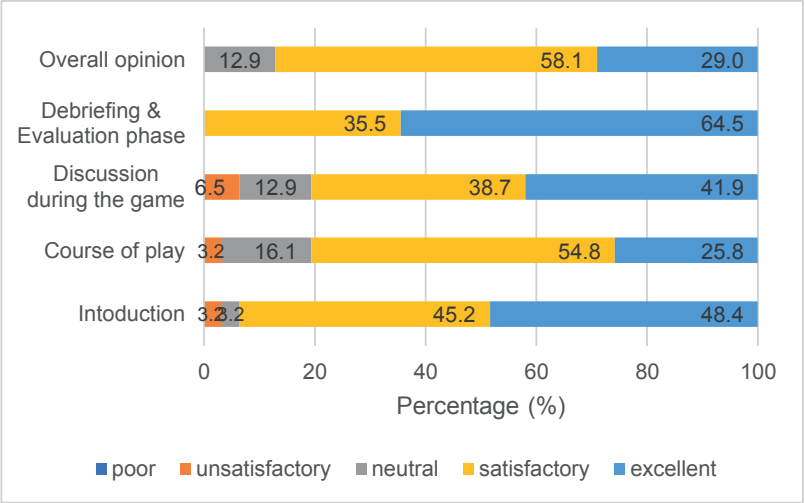


*Figure 15: Percentages of participants' evaluation of the overall opinion and selected game components (author's elaboration based on own data).*

## 4.4 Qualitative Analysis

28 of 31 participants provided an answer for the first open-question dealing with the most important take-away of the game. The second question asking what the participants will do differently in the future, was answered by 25 participants. Feedback and comments were given by 18 participants in the third question. The content analysis of the open-ended questions revealed ten codes which were then categorized into seven categories (see table 11 and annex 3.3).

*Table 11: Codes and categories based on the qualitative analysis (author's elaboration based on own data)*

| Questions | Codes | Categories |
|---|---|---|
| What was your most important take-away from the game?<br><br>Based on the participation, what will you do differently? | Diets, vegetables, organic, regional and seasonal, meat, processed foods, food waste | Impact of diets/diet components on sustainable development |
| | Connections, cross-linking, interrelation, complexity, big picture | Connections - System |
| | Actor, observation point, mutual adaptation | Stakeholder perspective |
| | Change, act, reflect, inform, engage, demonstrate, ask for, consciousness, support, cook | Communication – Change of attitude |

| | | |
|---|---|---|
| Feedback and comments | Global impact<br>Open/more roles, personal behavior<br>Events<br>Budget, money | Course of play<br>Global aspects<br>Roles<br>Events<br>Budget |
| | Target group | Target group |
| | Beamer | Material |

Stating the most important take-away, 13 testimonials mentioned the impact of sustainable diets or diet components (vegetables, organic, regional and seasonal, meat, processed foods, food waste) as important factors on sustainable development or parts of it (e. g. health, water, life under water, life on land and gender). 12 participants stated that insights of the many connections between sustainable diets and their contribution to achieve the SDGs were their most important take-away of the game. One statement comprising both categories is:

> *"The impact of nutrition is far greater than I thought and the networking is very interesting, also how big the whole thing is."*

Three testimonials recognized that different stakeholders have different perspectives on the complex topic:

> *"The big picture is very point-dependent"*.

Furthermore, five participants referred to the importance of communication and behavioural change to more sustainable diets, like for example:

*"One should continue to try both, to act sustainably individually as well as to try to convince others."*

In the latter case, the answers correspond as well to the answers of the second question participants stating what they will do differently in the future. Mainly sustainable dietary components like organic, regional and seasonal, reducing food waste as well as reducing meat consumption were recognized as important factors for the future. These were combined by the participants with words like *"change", "act", "reflect", "inform", "engage", "demonstrate", "ask for", "consciousness", "support"*. These were categorized into "change of attitude".

The feedback and comments of the third question mainly correspond to different components of the course of play (initial situation, roles, events and budget), followed by a comment on the target group and the used material. Three participants stated that a more global system perspective would be more realistic compared to the included system perspective of Germany. In addition, five comments were given about the game roles. On the one hand, four of them stated that it would be more interesting to play the game individually, so each player can visualize the impact of their own dietary habits on the system. On the other hand, one stated that more roles would be helpful to include even more stakeholder perspectives. Also, the distribution of budget was mentioned by two participants. Besides, it was said that it would be interesting to include more events like the rotten-meat scandal. Furthermore, one other participant gave the feedback to give more precise information about the target group of the game. Finally, one participant mentioned that it was difficult to follow the system changes as the software was not well displayed by the beamer.

# 5 Discussion

The developed simulation game about sustainable diets and their contribution to the achievement of the SDGs served as a tool to address the *research hypothesis* and *research questions* outlined in chapter 1. The results of the evaluation will now be discussed to examine the research hypothesis and research questions as a basis to ultimately answer the main research question.

Considering the results of the simulation performances, the research question "*How do (sustainable) diets contribute to achieve the SDGs?"* is discussed in the following. As described by the FAO (2016) and Hawkes and Fanzo (2017), nutrition is related to all 17 SDGs. This was visualized in the system construction based on existing relations by *Sustain2030* and added relations referring to relevant literature in the need field of nutrition. While the first simulation of the status quo consumption in Germany revealed a negative impact on the system, the interventions in the interaction phase of the game which were decided by the groups, showed positive contributions to the achievement of the SDGs. As intended in the simulation game development, the interventions are related to the five principles of sustainable nutrition by Koerber et al. (2012). Most positive impacts were shown to be generated by consuming a high amount of vegetables, regional and seasonal organic vegetables and meat bought by the local farmer (including the offer to support community-supported agriculture) and reducing processed foods as well as food waste in households. The respectively chosen interventions in the trials revealed positive contributions to the overall sustainability performance and also separately to the environmental, social and economic dimensions of sustainability. This result aligns with the statement of the concept by Koerber et al. (2012) that says that the principles shall help to

overcome obstacles on all sustainability dimensions at the same time.

Though, it is important to consider that the simulation game does not act as a scientific tool to forecast the contribution of (sustainable) diets to the achievement of the SDGs (cf. Hansmann et al., 2001). Rather, the game shall make sustainable and non-sustainable behaviour more tangible which aligns with Petrik (2017) on the objective of sustainability-based simulation games. Furthermore, it has to be pointed out that the applied system construction is based on the German food system. Therefore, the impact on the system can only be visualized on a national level even though the SDGs should be observed from a global perspective, especially considering today's globalized food system.

The research hypothesis "*The simulation game has an effect on test players' learning outcomes and therefore supports ESD"* and the respective research question "*What effects does the simulation game have on test players' learning outcomes about sustainable diets and their contribution to achieve the SDGs?"* is examined in the following based on the self-reported cognitive and affective learning outcomes stated by the pre- and post-game questionnaires.

The cognitive learning outcomes with the associated terms of expertise and understanding increased significantly due to the game experience (expertise: $p < .001$; $d = 1.29$ | understanding: $p < .01$; $d = 1.15$). Shephard (2008) and Gatti et al. (2018) point out that the acquisition of understanding and expertise in sustainability is acknowledged as an important component in ESD. Therefore, the results indicate that the simulation game is useful to acquire cognitive learning outcomes related to the SDGs, sustainable diets

and the contribution of sustainable diets to the achievement of the SDGs.

Even though the means of the importance and usefulness (affective learning outcomes) increase after the game compared to the means before the game, the paired t-tests do not reveal significant results (importance: $p$ = .08; $d$ = 0.32 | usefulness: $p$ = .43; $d$ = 0.14). This may be explained by the fact, that the average pre-scores of both components were already relatively high in the survey which was conducted before (pre-importance: $M$ = .65; $SD$ = .16 | pre-usefulness: $M$ = .7; $SD$ = .14) compared to the average post-scores (post-importance: $M$ = .71; $SD$ = .14 | post-usefulness: $M$ = .73; $SD$ = .13). It shows that the participants already had a positive attitude towards the usefulness and importance to learn about how sustainable diets contribute to the achievement of the SDGs before the game. These findings align with the results of Gatti et al. (2018).

As part of the affective dimension, de Haan (2008) and UNESCO (2014) point out that ESD shall support people to acquire competences (e.g. Gestaltungskompetenz) such as system thinking, collaborative decision-making or critical thinking skills. However, due to its complexity, empirically assessing these competences is difficult (Schneider, 2018) and was not part of this analysis. Still, it is feasible to recognize possible effects of the simulation game on these affective learning outcomes assessing the answers given to the open-ended questions.

Twelve participants state that their most important take-away from the game were the many connections between sustainable diets and how they contribute to achieving the SDGs. This may influence the participants' competence of system thinking and decision-making in complex systems. This supports Ballin's (2012) view that the core function of simulation games is the visualization of

interdependency networks to support decision-making in complex systems and holistic systemic thinking. The acquisition of this competence is fostered by the game experience including the interdependency network of the SDGs in the developed simulation game.

Two third of the participants ($n$ = 20) mentioned keywords of the category “attitude change” such as “more organic and regional/seasonal purchases”, “reduce meat consumption” and “ensure less household food waste”. These answers may be associated with the personal engagement of the participants towards attitude changes. The results of the qualitative feedback on the affective dimension and the results showing a statistically significant improvement of the cognitive dimension, might indicate a moderate change of future sustainable consumption patterns including more organic, regional and seasonal products, reducing food waste or meat consumption. However, this association, which was similarly drawn by Hansmann (2001) in terms of environmental knowledge and environmental behaviour, needs to be made carefully, as the connection between attitude and behavioural changes towards sustainability is weak. It is also known as the attitude-behaviour-gap (e.g. Caruana et al., 2016; Terlau and Hirsch, 2015).

In overall, the conducted analysis comparing the paired t-tests of the test groups is in accordance with the results of the quantitative analysis. However, test group N°1 and N°2 show different results on the cognitive dimension. No significant results were found in the understanding of test group N°1 ($p$ = .08; $d$ = .78) as well as expertise and understanding of test group N°2 (expertise: $p$ = .17; $d$ = .65 | understanding: $p$ = .16; $d$ = .68). Comparing the means before and after the game, both groups stated that their understanding already was relatively high before the game. This might be

explained by the fact that group N°2 presented mainly students with a background in adjoining studies like agricultural sciences and international food business. Contrary to group N°2, four of seven participants in group N°1 stated that they do not have a profession in a related field. However, two participants reported a very good understanding before the game which might have had a strong impact on the overall result of the group. The results suggest that the game did not provide new knowledge to these participants. According to Hansmann (2001, p. 9), a deeper understanding of the system connections is not solely achieved by visualizing the effect in numerical feedback within the software. Moreover, it is important to provide the players with explanations in the broader context. In this study, no pursuing information material was provided. This might also have increased the participants' understanding based on previous knowledge.

To answer the research question "*How does the simulation game support ESD to achieve more sustainable diets?",* it is important to refer to literature about simulation games. As stated by Ulrich (1997), the simulation game is an action and experiential learning method which provides a promising potential in learning about sustainability-related issues in theory. It aligns with the teaching methods in ESD which shall be designed "[…] in an interactive, learner-centred way that enables exploratory, action-oriented and transformative learning" (UNESCO, 2014, p. 12). The developed simulation game meets these requirements. It is exploratory and action oriented as it includes a group of people interacting in specific roles in a simulated decision-making environment (cf. Ballin, 2012). Furthermore, the game structure follows the general framework of a simulation game including a preparation, an interaction and an evaluation phase.

An important component of the game is the discussion between the different stakeholders during the interaction phase supported by the software-based visualization of the SDG-network. In this phase, the group observes and reflects on the impact of the chosen interventions which supports them to plan and discuss the decisions for the next game round during the game. Furthermore, the evaluation of the overall performance in the last game phase gives the players the opportunity to reflect on what they have learned during the game for their everyday reality. According to Kolb (2014), this generates so-called feedback-loops and shall enhance problem-solving competences and collaborative decision-making in a complex system (see figure 16).

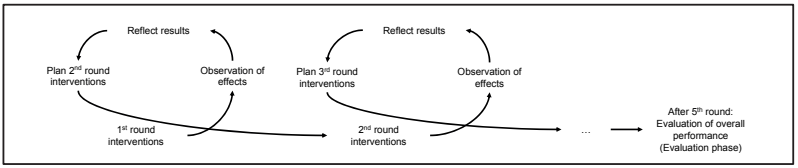


*Figure 16: Feedback loops performed in the simulation game on sustainable diets (adapted, based on Müller-Christ et al., 2017)*

As the participants act in the interaction phase of the game (Ulrich, 2002), their cognitive engagement to acquire knowledge and understanding is supported (Figueiró and Raufflet, 2015; Gatti et al., 2018). But contrary to Gatti et al. (2018), who state in their experiential study that several participants "[…] felt personally involved […]" (Gatti et al., 2018, p. 674) in the simulated environment, no emotional involvement of this kind was observed as an affective engagement in this study. The reason might be the use of a computer-based software for simulation. On the one hand, computer-based simulation games enable to demonstrate detailed

interactions and effects in interconnected systems. On the other hand, this can cause players to only concentrate on bargaining for decisions rather than searching for innovative solution. Therefore, board simulation games are often more effective when it comes to engagement (Ulrich, 2003).

Chosing young adults as target group for this survey in the context of non-formal and informal education, emphasizes the objective of the GAP ESD to "[…] support youth in their role as change agents for sustainable development through ESD" (UNESCO, 2014, p. 36). It was not assessed whether the game could also be applied to younger participants. It may be assumed that younger players might have problems in understanding the systemic view on the connections of sustainable diets and their contribution to the achievement of the SDGs (cf. Hansmann et al., 2001).

Considering these factors on how the simulation can support ESD, it is important to find out "*whether the simulation game supports ESD"*. As described above, the simulation game with its framework and the three game phases seems to be a promising method to support ESD. The interaction phase with the included game roles, the visualization of the interdependency network, the generation of feedback loops and cognitive engagement especially contributes to enhancing learning outcomes of young adults. According to the participants' self-reported opinion, 87.1 % of the participants rated the game as satisfactory or excellent. In addition, more than 90 % were satisfied by the different game components. This proves that the game using an internet-based software is both executable and reproducible. Participants between the age of 16 and 32 years accepted it as an innovative learning and teaching method in ESD (cf. Hansmann et al., 2001).

Based on the game experience and the conducted analysis, table 12 shows the observed advantages and disadvantages of the simulation game.

*Table 12: Advantages and disadvantages of the developed simulation game on sustainable diets and their contribution to the SDGs (adapted, based on Blötz, 2008)*

| **Advantages** | **Disadvantages** |
|---|---|
| • Learning outcomes with feedback loops<br>  - Significant cognitive learning outcomes<br>  - Possible affective learning outcomes<br>• Change of perspective using game roles<br>• Accelerated and safe learning environment<br>• In-depth awareness-rising to system connections<br>• Impact of diet interventions on system recognizable<br>• Playful handling of complexity | • Software-based simulation lacks emotional involvement<br>• Simulation inevitably based on assumptions whose accuracy cannot directly be verified<br>• Lack of global connections between diet interventions and the SDGs |

Conclusively, the question "*Does the simulation game on sustainable diets and their contribution to achieve the SDGs have an effect on test players' learning outcomes to support ESD to achieve more sustainable diets?"* will be answered. The quantitative analysis reveals that especially the cognitive learning outcomes significantly increased as a result of the game experience, whereas

the affective learning outcomes did not show significant results. Though, possible connections to support competences as affective learning outcomes such as system thinking, collaborative decision-making or changing perspective can be carefully drawn based on the qualitative results. Therefore, it seems possible to confirm that the simulation game as an experiential teaching method supports ESD by increasing the generation of learning outcomes that may contribute to the development of participants' critical thinking skills. Therefore, it favours the attitudes towards a change of consumption patterns to more sustainable diets. However, the sub-question "*Whether the simulation game leads to actual changes of participants' future behaviour to achieve more sustainable diets"* cannot be answered by the conducted survey. Achieving this knowledge would require a longer lasting survey assessing the testimonials' actual consumption behaviour.

Several *limitations* need to be outlined concerning the methodological framework of the survey design and the simulation game development. As the developed simulation game represents the first of its kind, no benchmark questionnaire was found which focused on pre- and post-game scores on sustainable diets and its impact on the SDGs. The questionnaire by Gatti et al. (2018) assessing the learning outcomes of a business game on sustainability in higher education was adapted to be used in the conducted trials. However, the reliability and validity of the developed questionnaire cannot be confirmed. Thus, the significance of the survey is restricted.

Furthermore, the questionnaire did not test behavioural changes. As already mentioned above, the time frame between the pre- and post-questionnaire was too short to assess whether the game had

a longer lasting effect on learning outcomes and behavioural changes.

Even though the method is likely to be biased (Etikan et al., 2016), a convenience sample strategy was used to receive an appropriate number of participants between the age of 17 and 30 years. However, the acquired testimonials did not entirely represent the core target group of young adults aged between 17 and 30.

No control group was applied to compare the results of the simulation game experience to a controlled teaching method. Hence, the conducted analysis has a pilot case study character, lacking the ability to compare whether the simulation game players' learning outcomes are stronger than in a controlled condition.

Regarding the simulation game development, it has to be pointed out that it is based on the subjective literature decisions of the game developer. Therefore, objectivity with respect to the system construction, system dynamics and the chosen impact of the interventions is not given. Overall, no claim to completeness is made about the system model. It should also be noted that the used eight-step-methodology to build the SDG-system in the field of nutrition and the resulting simulation game, are an attempt to depict a section of reality. The reproduction of reality in its entirety is not possible.

# 6 Conclusion

Global environmental, social and economic challenges suggest that the SDGs will not be reached without changing nutrition (Teitscheid et al., 2018). The developed simulation game emphasizes this complex problem. The learning goals shall engage test players to understand the interrelations of the SDGs in the field of nutrition. Besides, it shall train people to get a better understanding about which diets and dietary components contribute to the achievement of the SDGs by seeing the existing challenges from different stakeholder perspectives. Besides, the game aims to achieve cognitive and affective learning outcomes. The players are provided with a holistic approach of sustainable diets as stated by Eberle (2007). The interventions are based on the five principles of sustainable nutrition in form of purchase questions which were similarly used in the simulation game *SIMULME*. These interventions have positive impacts on the SDG-network visualized by using the software *simcision.* As for results of the trials, the players successfully increased the overall performance of the SDG-network as well as in each of the sustainability dimensions by choosing sustainable diet interventions.

The questionnaire results give a better understanding of the potential the developed simulation game can have as a teaching method in ESD in the field of sustainable development and nutrition. It was shown that cognitive learning outcomes increased with the game experience. Based on the reflections on how the simulation game supports ESD together with the participants' self-reported answers about their most important take-away, it can be assumed that affective learning outcomes like system thinking, collaborative decision-making and critical thinking skills might have improved as well. However, as the empirical assessment of the affective

dimension is difficult and the reliability and validity of the used pre- and post-game questionnaires is not given, this conclusion needs to be drawn carefully. Furthermore, it is questionable whether the participants change their consumption behaviour to more sustainable diets in the future because of the game. Shifting nutrition also means a change of culture as nutrition does not only have an important role in nourishing people, but also in cultural practices (Teitscheid et al., 2018).

Taking a closer look on the survey design, future trials of the developed simulation game would benefit from a control group to better understand the potential of the simulation game and to acquire learning outcomes in ESD. Additionally, a long-term monitoring of the participants would be interesting to see whether the game experience leads to more sustainable consumption patterns as well as to investigate on the attitude-behaviour-gap. Future research needs to develop reliable and valid benchmark questionnaires to generalize results on learning outcomes acquired by surveys on simulation games and the respective learning outcomes. Besides, these should assess how the cognitive and affective learning outcomes are related to each other. In addition, it could be interesting to assess whether the game could be appropriate for other target groups such as pupils in formal education as well as multipliers in professional education. Core target groups would need to be accordingly addressed in future trials.

For the course of play, it was suggested to transform the course of play into an individual setting and to preclude the existing game roles. The advantage would be that the players could visualize the impact of their own dietary habits on the SDGs. Besides, they could be individually adapted and the different interventions on the system could be compared. However, an important component of the game

is the discussion during the interaction phase which supports key competences in ESD. A compromise could be to develop an online version similar to the Ecological Footprint Calculator[11] to assess individual diet patterns and their impact on the SDGs. Providing each player with a computer before or after the interaction phase to experience the impact of their own dietary pattern using this application could help reflecting the game experience on their personal everyday reality and take it as a basis for future attitude changes. Also, future studies should develop appropriate information material about the topic to give the players explanations about system connections in a broader context and to increase the extent of knowledge gains. Furthermore, the included food prices need to be revised.

Furthermore, the developed system construction and the system thinking methodology of the eight-step-model could serve as a basis for the analysis of system interventions of other stakeholders to compare different decision-making opportunities for implementing the SDGs. However, for this the system construction needs to be reviewed using a methodological framework including e. g. expert interviews for each of the respective SDGs as performed by Weitz et al. (2018).

In conclusion, the developed simulation game and the conducted analysis revealed interesting insights on how consumer decisions towards more sustainable diet interventions can have a promising impact on the SDG-system. The game has the potential to be used as a tool in ESD in the field of sustainable development and nutrition

[11] e. g. from WWF Germany: https://www.wwf.de/themen-projekte/klima-energie/wwf-klimarechner/

as learning outcomes of young adults increased as a result of the game experience. However, it should be mentioned that consumers are not solely responsible for achieving more sustainable diets. To change dietary behaviour, appropriate offering structures, the inclusion of whole food systems and nutrition-related sustainable policies are needed (Brunner and Schönberger, 2005).

# 7 Summary

The aim of this master thesis was to develop a simulation to visualize the contribution of sustainable diets to the achievement of the SDGs and to use it as a tool to evaluate the effect on the test players' learning outcomes to support ESD to achieve more sustainable diets. Therefore, a simulation game based on the *Sustain2030* software called *simcision*, was developed to highlight the connection between diets and the achievement of the SDGs in Germany. Pre- and post-questionnaires were developed and used in game trials to assess cognitive and affective learning outcomes and opinions on the game of young adults between the age of 17 and 30 years.

In total, the conducted survey revealed significant cognitive outcomes of test players. No significant affective outcomes were observed. However, the simulation game as a method in ESD is discussed in terms of acquired key competences of ESD which can be drawn from the qualitative analysis. Conclusively, it seems to be possible to confirm that the simulation game as an experiential teaching method supports ESD. It increases the generation of learning outcomes which may contribute to the development of the participants' competences regarding sustainable diets and their contribution to achieving the SDGs.

# 8 Glossary

**Education for Sustainable Development**

"ESD empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity. It is about lifelong learning and is an integral part of quality education. ESD is holistic and transformational education which addresses learning content and outcomes, pedagogy and the learning environment. It achieves its purpose by transforming society" (UNESCO, 2014).

**Gestaltungskompetenz**

"*Gestaltungskompetenz* means the specific capacity to act and solve problems. Those who possess this competence can help, by active participation to modify and shape the future of society and to guide its social, economic, technological and ecological changes along the lines of sustainable development" (De Haan, 2010, p. 320).

**Life-Cycle Assessment**

"A compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO, 2006a, 2006b, p. 3).

**Sustainable Development**

"Sustainable is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Hurlem, 1987, p. 43).

**Sustainable Diets**

“Those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources” (Burlingame and Dernini, 2012, p. 264).

“Needs-oriented/appropriate and suitable for everyday use, socially differentiated and health-promoting, low-risk and environmentally friendly” (Eberle et al., 2004, p. 1).

**System Thinking**

“[…] to present the effect structure of a system manageable, better understand the dynamics of the system and to make the consequences of interventions more controllable to avoid unexpected side effects, long-distance reactions and repercussions or to identify starting points in order to counteract them in an appropriate way” (Ballin, 2012, p. 3).

## Acknowledgments

I thank my supervisors Prof. Dr. Christine Küster and Lilliana Stefanovic for their priceless suggestions. I gratefully acknowledge the exchange with the iCONDU GmbH and BeNE München to support me in my search for trial participants.

## References

Al Shalabi, L., Shaaban, Z., Kasasbeh, B. (2006): Data mining: A Preprocessing Engine. In: Journal of Computer Science. Vol. 2, No. 9, p. 735-739.

Alarcon, B., Gerritsen, E. (2014): On our plate today: healthy, sustainable food choices. Brussels: LiveWell LIFE.

Aleksandrowicz, L., Green, R., Joy, E.J.M., Smith, P., Haines, A. (2016): The Impacts of Dietary Change on Greenhouse Gas Emissions, Land Use, Water Use, and Health: A Systematic Review. In: Plos One. Vol. 11, No. 11, p. e0165797.

Ballin, D. (2012): Wirkungsnetze als Basis für die Entwicklung von Planspielen und Strategiesimulationen von Planspielen und Strategiesimulationen. In: Wilms, E.P. (ed.): Wirkungsgefüge Einsatzmöglichkeiten und Grenzen in der Unternehmensführung. Bern, Stuttgart, Wien: Haupt Verlag, p. 21-38.

Barth, B., Flaig, B.B., Schäuble, N., Tautscher, M. (2017): Praxis der Sinus-Milieus®: Gegenwart und Zukunft eines modernen Gesellschafts-und Zielgruppenmodells. Wien, Heidelberg: Springer Verlag.

Berger, V., Schrader, U. (2016): Fostering sustainable nutrition behavior through gamification. In: Sustainability. Vol. 8, No. 8, p. 67.

Bilali, H.E., Callenius, C., Strassner, C., Probst, L. (2019): Food and nutrition security and sustainability transitions in food systems. In: Food Energy Security. Vol. 8, No. 2, p. e00154.

Blanc, D.L. (2015): Towards Integration at Last? The Sustainable Development Goals as a Network of Targets. In: Sustainable Development. Vol. 23, No. 3, p. 176-187.

Blötz, U. (2008): Planspiele in der beruflichen Bildung: Auswahl, Konzepte, Lernarrangements, Erfahrungen; aktueller Planspielkatalog 2008. Bielefeld: Bertelsmann Verlag.

BMEL (2012): Ermittlung der Mengen weggeworfener Lebensmittel und Hauptursachen für die Entstehung von Lebensmittelabfällen in Deutschland: Zusammenfassung einer Studie der Universität Stuttgart (März 2012). Berlin: Bundesministerium für Ernährung und Landwirtschaft.

Bormann, I., de Haan, G. (2008): Kompetenzen der Bildung für nachhaltige Entwicklung. Wiesbaden: Springer Verlag.

Brunner, K.-M., Geyer, S., Jelenko, M., Weiss, W., Astleithner, F. (2007): Ernährungsalltag im Wandel: Chancen für Nachhaltigkeit. Wien: Springer Verlag.

Brunner, K.-M., Schönberger, G.U. (2005): Nachhaltigkeit und Ernährung: Produktion, Handel, Konsum. Frankfurt am Main: Campus Verlag.

BMJV (1990): Sozialgesetzbuch (SGB) – Achtes Buch (VIII) – Kinder- und Jugendhilfe. Berlin: Bundesministerium der Justiz und für Verbraucherschutz.

Burlingame, B., Dernini, S. (2012): Sustainable Diets and Biodiversity: Directions and Solutions for Policy, Research and Action. Rome: Food and Agriculture Organization of the United Nations.

Caruana, R., Carrington, M.J., Chatzidakis, A. (2016): Beyond the Attitude-Behaviour Gap: Novel Perspectives in Consumer Ethics: Introduction to the Thematic Symposium. In: Journal of Business Ethics. Vol. 136, No. 2, p. 215-218.

Chen, C., Chaudhary, A., Mathys, A. (2019): Dietary Change Scenarios and Implications for Environmental, Nutrition, Human Health and Economic Dimensions of Food Sustainability. In: Nutrients. Vol. 11, No. 4, p. 856.

Cohen, J. (1988): Statistical power analysis for the behavioral sciences. Abingdon: Taylor and Francis Ltd.

Coopman, A., Osborn, D., Ullah, F., Auckland, E., Long, G. (2016): Seeing the whole: implementing the SDGs in an integrated and coherent way. London: Stakeholder Forum.

De Haan, G. (2010): The development of ESD-related competencies in supportive institutional frameworks. In: International Review of Education. Vol. 56, p. 315-328.

DGE (2019): Vollwertige Ernährung nach den Empfehlungen der DGE ist auch ökologisch nachhaltig. In: Ernährungs Umschau. Vol. 6, p. 82-87

Die Bundesregierung (2016): Deutsche Nachhaltigkeitsstrategie - Neuauflage 2016. Berlin: Die Bundesregierung.

Dierßen, B., Rappenglück, S. (2015): Europabezogene Planspiele und ihre Wirkungen. In: Oberle, M. (ed.): Die Europäische Union erfolgreich vermitteln. Wiesbaden, Springer Verlag. p. 223-234.

Dixon, W.J., Yuen, K.K. (1974): Trimming and winsorization: A review. In: Statistische Hefte. Vol. 15, p. 157-170.

Donini, L.M., Dernini, S., Lairon, D., Serra-Majem, L., Amiot, M.-J., Del Balzo, V., Giusti, A.-M., Burlingame, B., Belahsen, R., Maiani, G., Polito A., Turrini, A., Intorre, F., Trichopoulou A., Berry E.M.A. (2016): A consensus proposal for nutritional indicators to assess the sustainability of a healthy diet: the Mediterranean diet as a case study. In: Frontiers in Nutrition. Vol. 3, p. 37.

EAT Lancet Commission (2019): Healthy Diets From Sustainable Food Systems – Food Planet Health: Summary Report of the EAT-Lancet Commission. Oslo: EAT Foundation.

Eberle, U., Hayn, D. (2007): Ernährungswende: Eine Herausforderung für Politik, Unternehmen und Gesellschaft. Freiburg, Frankfurt am Main: Öko-Institut e. V. und Institut für sozial-ökologische Forschung.

Eberle, U., Fritsche, U.R., Hayn, D., Empacher, C., Simshäuser, U., Rehaag, R., Waskow, F. (2004): Ernährungswende: Umwelt-

Ernährung-Gesundheit – Beschreibung der Dynamiken eines gesellschaftlichen Handlungsfeldes – Diskussionspapier Nr. 1. Freiburg, Hamburg, Darmstadt, Frankfurt Heidelberg, Köln: Öko-Institut e.V.

Ellington, H., Addinall E., Percival, F. (1981): Games and Simulations in Science Education. London: Kogan Page Ltd.

Elo, S., Kyngäs, H. (2008): The qualitative content analysis process. In: Journal of advanced nursing. Vol. 62, No. 2, p. 107-115.

Etikan, I., Musa, S.A., Alkassim, R.S. (2016): Comparison of convenience sampling and purposive sampling. In: American journal of theoretical and applied statistics. Vol. 5, No. 1, p. 1-4.

FAO (2016): Food and Agriculture: Key to achieving the 2030 agenda for sustainable development. Rome: Food and Agriculture Organization of the United Nations.

FAO (2011): Global food losses and food waste: Extent, causes and prevention. Rome: Food and Agriculture Organization of the United Nations.

Fares, J., Gauri, V., Jimenez, E.Y., Lundberg, M.K., McKenzie, D., Murthi, M., Ridao-Cano, C., Sinha, N. (2007). World development report 2007: Development and the Next Generation. Washington: The World Bank.

Fields, A. (2009): Discovering statistics using SPSS. London: Sage Publications.

Figueiró, P.S., Raufflet, E. (2015): Sustainability in higher education: a systematic review with focus on management education. In: Journal of cleaner production. Vol. 106, p. 22-33.

Garnett, T., Mathewson, S., Angelides, P., Borthwick, F. (2015): Policies and actions to shift eating patterns: What works? A review of the evidence of the effectiveness of interventions aimed at shifting

diets in more sustainable and healthy directions. Oxford: Food Climate Research Network.

Gatti, L., Ulrich, M., Seele, P. (2018): Education for sustainable development through business simulation games: An exploratory study of sustainability gamification and its effects on students' learning outcomes. In: Journal of Cleaner Production. Vol. 207, p. 667-678.

Ghosh, D., Vogt, A. (2012): Outliers: An evaluation of methodologies. In: Joint Statistical Meetings. Vol. 2012, p. 3455-3460.

Glavič, P., Lukman, R. (2007): Review of sustainability terms and their definitions. In: Journal of Cleaner Production. Vol. 15, No. 18, p. 1875-1885.

Griggs, D., Stafford Smith, M., Rockström, J., Öhman, M.C., Gaffney, O., Glaser, G., Kanie, N., Noble, I., Steffen, W., Shyamsundar, P. (2014): An integrated framework for sustainable development goals. In: Ecology and Society. Vol. 19, No. 4, p. 49.

Griggs, D.J., Nilsson, M., Stevance, A., McCollum, D. (2017): A guide to SDG interactions: from science to implementation. Paris: International Council for Science.

Gussow, J.D., Clancy, K.L. (1986): Dietary guidelines for sustainability. In: Journal of nutrition education. Vol. 18, No. 1, p. 1-5.

Hallström, E., Carlsson-Kanyama, A., Börjesson, P. (2015): Environmental impact of dietary change: a systematic review. In: Journal of Cleaner Producation. Vol. 91, p. 1-11.

Hansmann, R., Hesske, S., Tietje, O., Scholz, R.W. (2001): Internet-unterstützte Hansmann, R., Hesske, S., Tietje, O., Scholz, R.W. (2001): Internet-unterstützte Umweltbildung: Eine experimentelle Studie zur Anwendung des Online-Simulationsspiels Sim Ulme im Schulunterricht. Zürich: Umweltnatur- und Umweltsozialwissenschaften.

Hansmann, R., Scholz, R.W., Francke, C.-J.A.C., Weymann, M. (2005): Enhancing environmental awareness: Ecological and economic effects of food consumption. In: Simulation and Gaming. Vol. 36, No. 3, p. 364-382.

Hawkes, C., Fanzo, J. (2017): Nourishing the SDGs: Global nutrition report 2017. Bristol: Development Initiatives Poverty Research Ltd.

Hoffmann, I., Schneider, K., Leitzmann, C. (2011): Ernährungsökologie: Komplexen Herausforderungen im Bereich Ernährung integrativ begegnen. Munich: oekom Verlag.

Hollenberg, S. (2016): Fragebögen: Fundierte Konstruktion, sachgerechte Anwendung und aussagekräftige Auswertung. Wiesbaden: Springer Verlag.

Hurlem, B.G. (1987): Our Common Future: World Commission on Environment and Development. Oxford: University Press.

iCONDU GmbH (2018): Sustain2030 co-creative SDG modelling: SDG simulation game Deutschland – Begleitbroschüre. Ingolstadt: iCONDU GmbH.

ISO (2006a): ISO 14040:2006: Environmental Management – Life Cycle Assessment – Principles and Framework. Geneva: International Organization for Standardization.

ISO (2006b): ISO 14044:2006: Environmental Management – Life Cycle Assessment – Requirements and Regulations. Geneva: International Organization for Standardization.

Jäggi, C.J. (2018): Ernährung, Nahrungsmittelmärkte und Landwirtschaft: Ökonomische Fragestellungen vor dem Hintergrund der Globalisierung. Wiesbaden: Springer Gabler.

Johnston, P., Everard, M., Santillo, D., Robèrt, K.-H. (2007): Reclaiming the definition of sustainability. In: Environmental science and pollution research international. Vol. 14, No. 1, p. 60-66.

Jones, A.D., Hoey, L., Blesh, J., Miller, L., Green, A., Shapiro, L.F. (2016): A Systematic Review of the Measurement of Sustainable Diets. In: Advances in Nutrition. Vol. 7, No. 4, p. 641-664.

Jungbluth, N. (2000): Umweltfolgen des Nahrungsmittelkonsums: Beurteilung von Produktmerkmalen auf Grundlage einer modularen Ökobilanz. Berlin: dissertation.de.

Kidd, C.V. (1992): The evolution of sustainability. In: Journal of Agricultural and Environmental Ethics. Vol. 5, p. 1-26.

Koerber, K.v. (2018): Nachhaltigkeit in der Ernährung: Bezugsrahmen und Programme der Vereinten Nationen, in Europa und Deutschland – UN-Ziele für nachhaltige Entwicklung. In: Teitscheid, P., Langen, N., Speck, M., Rohn, H. (2018): Nachhaltig außer Haus essen. Von der Idee bis auf den Teller. Munich: oekom Verlag. p. 68-80.

Koerber, K.v. (2015): Nachhaltige Ernährung und ihre fünf Dimensionen: Umwelt, Wirtschaft, Gesellschaft, Gesundheit und Kultur. In: Schockemöhle, J., Stein M. (eds.): Nachhaltige Ernährung lernen in verschiedenen Ernährungssituationen. Bad Heilbrunn: Klinkhardt, p. 16-45.

Koerber K.v., Bader, N., Waldenmaier, J., Leitzmann, C., Lintzmeyer, A., Schwab, T. (2018): Concept of Sustainable Nutrition – Implementation via ESD in Munich. In: Payyappallimana, U., Fadeeva, Z. (ed.): Ensure Healthy Lives and Promote Well-being for All: Experiences of community health, hygiene, sanitation and nutrition. Tokyo: United Nations University Institute for the Advanced Study of Sustainability.

Koerber, K.v., Bader, N., Leitzmann, C. (2017): Wholesome Nutrition: an example for a sustainable diet. In: Proceedings of the Nutrition Society. Vol. 76, No. 1, p. 34-41.

Koerber, K.v., Leitzmann C. (2011): Empfehlungen für eine nachhaltige Ernährung: vom Wissen zum Handeln. In: Ernährungsökologie. Komplexen Herausforderungen integrativ begegnen. Munich: oekom Verlag, p. 148-154.

Koerber, K.v., Männle, T., Leitzmann, C. (2012): Vollwert-Ernährung – Konzeption einer zeitgemäßen und nachhaltigen Ernährung. 11. ed., Stuttgart: Haug Verlag.

Kolb, D.A. (2014): Experiential learning: Experience as the source of learning and development. 2. ed., Upper Saddle River: FT press.

Kranert, M., Hafner, G., Barabosz, J., Schuller, H., Leverenz, D., Kölbig, A., Schneider, F., Lebersorger, S., Scherhaufer, S. (2012): Ermittlung der weggeworfenen Lebensmittelmengen und Vorschläge zur Verminderung der Wegwerfrate bei Lebensmitteln in Deutschland. Stuttgart: Institut für Siedlungswasserbau, Wassergüte- und Abfallwirtschaft.

Lang, T., Barling, D. (2013): Nutrition and sustainability: an emerging food policy discourse. In: Proceedings of the Nutrition Society. Vol. 72, p. 1-12.

Leicht, A., Heiss, J., Byun, W.J. (2018): Issues and trends in Education for Sustainable Development. Paris: United Nations Educational, Scientific and Cultural Organization.

Macdiarmid, J.I., Kyle, J., Horgan, G.W., Loe, J., Fyfe, C., Johnstone, A., McNeill, G. (2012): Sustainable diets for the future: Can we contribute to reducing greenhouse gas emissions by eating a healthy diet? In: American Journal of Clinical Nutrition. Vol. 96, No. 3, p. 632-639.

Masset, G., Vieux, F., Darmon, N. (2015): Which functional unit to identify sustainable foods? In: Public Health Nutrition. Vol. 18, No. 13, p. 2488-2497.

Massing, P. (2004): Planspiele und Entscheidungsspiele. In: Frech, S., Kuhn, H.W., Massing, P. (eds.): Methodentraining für den Politikunterricht. Bonn: Bundeszentrale für politische Bildung.

Meier, T. (2015): Sustainable nutrition between the poles of health and environment. Potentials of altered diets and avoidable food losses. In: Ernährungs Umschau. Vol. 62, No. 2, p. 22-33.

Meier, T. (2013): Umweltschutz mit Messer und Gabel: Der ökologische Rucksack der Ernährung in Deutschland. Munich: oekom Verlag.

Meier, T., Christen, O. (2013): Environmental Impacts of Dietary Recommendations and Dietary Styles: Germany as an Example. In: Environmental Science and Technology. Vol. 47, No. 2, p. 877-888.

Meybeck, A., Gitz, V. (2017): Sustainable diets within sustainable food systems. In: Proceedings of the Nutrition Society. Vol. 76, No. 1, p. 1-11.

Müller-Christ, G., Giesenbauer, B., Tegeler, M.K. (2017): Studie zur Umsetzung der SDG im deutschen Bildungssystem. Bremen: Rat für Nachhaltige Entwicklung.

Nagel, U., Affolter, C. (2004): Umweltbildung und Bildung für eine nachhaltige Entwicklung – Von der Wissensvermittlung zur Kompetenzförderung. In: Beiträge zur Lehrerinnen- und Lehrerbildung. Vol. 22, No. 1, p. 95-105.

Nelson, M.E., Hamm, M.W., Hu, F.B., Abrams, S.A., Griffin, T.S. (2016): Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review. In: Advances in Nutrition. Vol. 7, No. 6, p. 1005-1025.

Nilsson, M., Lucas, P., Yoshida, T. (2013): Towards an integrated framework for SDGs: Ultimate and enabling goals for the case of energy. In: Sustainability. Vol. 5, No. 10, p. 4124-4151.

Pasin, F., Giroux, H. (2011): The impact of a simulation game on operations management education. In: Computers and Education. Vol. 57, No. 1, p. 1240-1254.

Perignon, M., Vieux, F., Soler, L.-G., Masset, G., Darmon, N. (2017): Improving diet sustainability through evolution of food choices: review of epidemiological studies on the environmental impact of diets. In: Nutrition Reviews. Vol. 75, No. 1, p. 2-17.

Petrik, A., Rappenglück, S. (2017): Handbuch Planspiele in der politischen Bildung. Bonn: Bundeszentrale für politische Bildung.

Pfeiffer, S., Treske, E. (2008): Planspiele: Wissenschaftliches Forschungslabor oder Trainingstool? In: Adami, W., Lang, C., Pfeiffer, S., Rehberg, F. (eds.): Montage braucht Erfahrung, Erfahrungsbasierte Wissensarbeit in der Montage. Munich, Mering: Rainer Hampp Verlag, p. 208-227.

Ploeger, A., Hirschfelder, G., Schönberger, G. (2011): Die Zukunft auf dem Tisch: Analysen, Trends und Perspektiven der Ernährung von morgen. Wiesbaden: Springer Verlag.

Porst, R. (2013): Fragebogen: Ein Arbeitsbuch. Wiesbaden: Springer Verlag.

Porst, R. (1996): Fragebogenerstellung. In: Goebl, H., Nelde, P.H., Stary, Z., Wöck, W. (eds.): Kontaktlinguistik – Contact Linguistics – Linguistique de contact. Ein internationals Handbuch zeitgenössischer Forschung. Berlin, New York: De Gruyter, p. 737-744.

Rieckmann, M. (2017): Education for Sustainable Development Goals: learning objectives. Paris: United Nations Educational, Scientific and Cultural Organization.

Rieckmann, M. (2012): Future-oriented higher education: Which key competencies should be fostered through university teaching and learning? In: Futures. Vol. 44, No. 2, p. 127-135.

Roberts, C.W. (1997): Text analysis for the social sciences: Methods for drawing statistical inferences from texts and transcripts. New Jersey: Lawrence Erlbaum Associates.

Rose, G., Ryan, K., Desha, C. (2015): Implementing a holistic process for embedding sustainability: a case study in first year engineering. In: Journal of Cleaner Production. Vol. 106, p. 229-238.

Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G. (2019): Sustainable Development Report 2019. New York: Bertelsmann Stiftung and Sustainable Development Solutions Network.

Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., Fuller, G. (2018): SDG Index and Dashboards Report 2018. New York: Bertelsmann Stiftung and Sustainable Development Solutions Network.

Schneider, J. (2018): Ortsbezogene Spiele in der BNE–Empirische Untersuchung zur Bewertungskompetenz und zur Veränderung der Naturverbundenheit. Ludwigsburg: Dissertation.

Sharma, U., Kelly, M. (2014): Students' perceptions of education for sustainable development in the accounting and business curriculum at a business school in New Zealand. In: Meditari Accountancy Research. Vol. 22, No. 2, p. 130-148.

Shephard, K. (2008): Higher education for sustainability: seeking affective learning outcomes. In: International Journal of Sustainability in Higher Education. Vol.9, No. 1, p. 87-98.

SinusSociovision (2002): Strategische Zielgruppenanalyse für den Öko-Ernährungs-Markt. Untersuchung für die CMA. Heidelberg: unveröffentlichte Studie.

Springmann, M., Godfray, H.C.J., Rayner, M., Scarborough, P. (2016): Analysis and valuation of the health and climate change cobenefits of dietary change. In: Proceedings of the National Academy of Sciences of the United States of America. Vol. 113, No. 15, p. 4146-4151.

Stieß, I., Hayn, D. (2005): Ernährungswende: Ernährungsstile im Alltag Ergebnisse einer repräsentativen Untersuchung – Diskussionspapier Nr. 5. Frankfurt am Main: Öko-Institut e.V.

Stockholm Resilience Center (2016): How food connects all the SDGs. Azote images for Stockholm Resilience Centre. URL:

https://www.stockholmresilience.org/research/research-news/2016-06-14-how-food-connects-all-the-sdgs.html [date of access 14/8/19].

Teitscheid, P., Langen, N., Speck, M., Rohn, H. (2018): Nachhaltig außer Haus essen. Von der Idee bis auf den Teller. Munich: oekom Verlag.

Terlau, W., Hirsch, D. (2015): Sustainable consumption and the Attitude-Behaviour-Gap Phenomenon – Causes and Measurements towards a Sustainable Development. In: International Journal of Food System Dynamics. Vol.6, No. 3, p. 159-174.

Tilman, D., Clark, M. (2014): Global diets link environmental sustainability and human health. In: Nature. Vol. 515, No. 7528, p. 518.

Tukey, J.W. (1962): The future of data analysis. In: The annals of mathematical statistics. Vol. 33, No. 1, p. 1-67.

Ulaszewska, M.M., Luzzani, G., Pignatelli, S., Capri, E. (2017): Assessment of diet-related GHG emissions using the environmental hourglass approach for the Mediterranean and new Nordic diets. In: Science of the Total Environment. Vol. 574, p. 829-836.

Ulrich, M. (2003): Mit Planspielen Nachhaltige Entwicklung erleben! Der Beitrag der Planspielmethodik zur Bildung über Nachhaltigkeit. In: DGU Nachrichten, Heft 27/2003.

Ulrich, M. (2002): Sind Planspiele langwierig und kompliziert? Eine Abhandlung über die Planspielmethodik und die Ausbildung von Planspiel-Fachleuten. In: Blötz, U. (ed.): Planspiele in der beruflichen Bildung. Abriss zur Auswahl, Konzeptionierung und Anwendung von Planspielen. Bonn: Bundesinstitut für Berufsbildung.

Ulrich, M. (1997): Games/simulations about environmental issues: Existing tools and underlying concepts. In: Geurts, J., Joldersma, C., Roelofs, E. (eds.): Gaming/Simulation for Policy Devleopment and Organizational Change. Tilburg: Proceedings of the 28th Annual

International Conference of the International Simulation and Gaming Association. p. 301-311.

UN (2019): Sustainable Development Goals – Communications materials. URL: https://www.un.org/sustainabledevelopment/news/communications-material/ [date of access 28/10/19].

UN (2015): Transforming our world: The 2030 Agenda for Sustainable Development. New York: United Nations General Assembly.

UN (2012): A 10-year framework of programmes on sustainable consumption and production patterns. Rio de Janeiro: United Nations Conference on Sustainable Development.

UNESCO (2019): Education for Sustainable Development beyond 2019. Paris: United Nations Educational, Scientific and Cultural Organization – Executive Board.

UNESCO (2018): UNESCO Global Action Programme on Education for Sustainable Development - Information Folder. Paris: United Nations Educational, Scientific and Cultural Organization.

UNESCO (2014): UNESCO Roadmap for Implementing the Global Action Programme on Education for Sustainable Development. Paris: United Nations Educational, Scientific and Cultural Organization.

UNS Commission (2017): Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. Resolution 68/261. New York: United Nations General Assembly.

Vester, F. (2002): Die Kunst vernetzt zu denken: Ideen und Werkzeuge für einen neuen Umgang mit Komplexität. Ein Bericht an den Club of Rome. Munich: Deutscher Taschenbuch-Verlag.

von Carlowitz, H.-C. (1732): Sylvicultura Oeconomica Oder Haußwirthliche Nachricht und Naturmäßige Anweisung zur Wilden Baum-Zucht. Remagen-Oberwinter: Kessel

von der Lippe, P.M. (2015): Grenzwertsätze, Gesetze der großen Zahl(en). Begleitlektüre zu: von der Lippe (ed.): Induktive Statistik, Formeln, Aufgaben, Klausurtraining. München, Wien: Oldenbourg Verlag.

Weitz, N., Carlsen, H., Nilsson, M., Skånberg, K. (2018): Towards systemic and contextual priority setting for implementing the 2030 Agenda. In: Sustainability Science. Vol.13, No. 2, p. 531-548.

Wiek, A., Bernstein, M., Foley, R., Cohen, M., Forrest, N., Kuzdas, C., Kay, B., Withycombe Keeler, L. (2015): Operationalising competencies in higher education for sustainable development. In: Barth, M., Michelsen, G., Rieckmann, M., Thomas, I. (eds.): Handbook of Higher Education for Sustainable Development. London: Routledge, p. 241-260.

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L.J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J.A., Vries, W.D., Sibanda, L.M., Afshin, A., Chaudhary, A., Herrero, M., Agustina, R., Branca, F., Lartey, A., Fan, S., Crona, B., Fox, E., Bignet, V., Troell, M., Lindahl, T., Singh, S., Cornell, S.E., Reddy, K.S., Narain, S., Nishtar, S., Murray, C.J.L. (2019): Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. In: The Lancet. Vol. 393, No. 10170, p. 447-492.

Witzke, S. (2016): Jugendliche und junge Erwachsene – eine Begriffsdefinition. In: Witzke, S. (ed.): Carsharing und die Gesellschaft von Morgen. Wiesbaden: Springer Gabler, p. 17-18.

**Series / Reihe** **Sustainable Food Systems - Nachhaltige Lebensmittel-und Ernährungssysteme**

Edited by / Herausgegeben vom

Department of Organic Food Quality and Food Culture, University of Kassel

http://www.upress.uni-kassel.de/

Vol. 1 Organic Food System Cases Around The World – A Documentation Project, Kassel 2021, 381 S., ISBN 978-3-7376-0938-8
Jamil, Tooba / Stefanovic, Lilliana / Kretschmer, Sebastian (eds.)

Vol. 2 Basis for monitoring the performance of Sustainable Development Goals in Organic Food Systems, Kassel 2021, 365 S., ISBN 978-3-7376-0981-4
Stefanovic, Lilliana:

Vol. 3 Quality of Life: Application of the Concept and the Questionnaire for Evaluations in Food Systems, Kassel 2022, 115 S., ISBN 978-3-7376-1010-0
Rednak, Tjaša

Vol. 4 A Simulation Game on Sustainable Diets and their Contribution to the Sustainable Development Goals (SDGs) – its Effect on Learning Outcomes to Support Education for Sustainable Development (ESD), Kassel 2022, 117 S., ISBN 978-3-7376-1011-7
Meuser, Maike

The interest in sustainable diets gained importance as it has been recognized that a change in consumption patterns, especially in industrialized countries, is urgently needed to overcome global environmental, social, and economic challenges. Nutrition is acknowledged to be linked to all seventeen United Nations' Sustainable Development Goals (SDGs). Therefore, a change of nutrition can have major contributions to achieve the SDGs. A promising method in Education for Sustainable Development (ESD) is offered by a simulation game as an action and experiential teaching method, to make systemic connections in sustainable development more tangible. Using an internet-based software, a simulation game on sustainable diets and their contribution to the SDGs was developed and applied as a tool in five test runs, to assess its effect on young adults' learning outcomes to support ESD and achieve more sustainable diets.

ISBN 978-3-7376-1011-7