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Consumer Behavior and Sustainability in the Construction Industry—Relevance of Sustainability-Related Criteria in Purchasing Decision

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Abstract: The construction industry significantly contributes to global greenhouse gas emissions and consumption of raw materials, and is thus under intense pressure to become more sustainable. Despite the ever-increasing availability of sustainable solutions, they do not seem to be widely adopted. As key decision makers in the early planning stage of a construction project, end consumers strongly impact sustainable development. However, their knowledge of sustainability-related criteria and their influence on purchasing decisions within the German construction industry is not yet sufficiently well established. Therefore, this study aims to determine the effects of sustainability-related aspects on the purchasing behavior of private individuals, as end consumers in the German construction industry. A quantitative online survey involving 306 participants was utilized to determine their understanding of the term "sustainability" and how they identify and measure the sustainability of a building product. Our results indicate that consumers have a fundamental interest in sustainable building products; however, they lack a holistic view of the concept of sustainability. With the focus on environmental aspects, social and economic aspects tend to be neglected. Since private individuals rarely make purchasing decisions in the building product sector, it is the task of the entire construction industry to establish a system in which consumers can quickly and easily obtain understandable information about sustainable products. Consumers need support from experts to understand and drive sustainable development in the construction industry.

Keywords: consumers; purchasing decision; sustainability; construction; survey

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1. Introduction

Globally, there is increasing concern about the state of the environment regarding climate change. Global warming, depletion of the ozone layer, destruction of natural habitats, and loss of biodiversity are often subject to worldwide discussions. In particular, the construction industry makes a considerable contribution to this [1]. The International Energy Agency states in its global Status Report for Buildings and Construction that in 2018 the building sector was responsible for 36% of the final energy use and 39% of energy-related CO_2 emissions [2]. For this reason, sustainable solutions for the construction sector are constantly under development [3–5], but fail to be adopted into contemporary practice [6,7]. Since end consumers are key decision makers in the influential early planning stage of a construction project, they have a major influence on its sustainable development [6,8,9]. Consequently, a more sustainable lifestyle cannot be achieved without significant changes in the attitudes and behavior of consumers [10]. However, there seems to be a lack of knowledge about the consumer's understanding of sustainability and the importance of sustainability-related criteria within the German construction sector [11].

This paper examines the extent to which private individuals (as consumers in the German construction industry) have an interest in buying sustainable products and how the relevance of sustainability-related criteria is represented in purchasing decisions. Particular attention is paid to how the respondents' engagement with the issue of sustainability, and

their personal understanding of this concept influence the ranking of criteria for a purchase decision. By analyzing a quantitative online survey, conclusions are drawn about how consumers recognize a product as sustainable and whether they make a purchasing decision based on this criterion. Within this framework, three hypotheses regarding the behavioral patterns of consumers in the construction industry were formulated and evaluated using descriptive and inferential statistical methods. It was expected that consumers have a certain interest in buying sustainable building products, but would not have a holistic understanding of the concept of sustainability in construction.

Finally, the study aims to collect the input from the survey and provide guidelines on the effective communication of the sustainability performance of building products to consumers.

2. Theoretical Background

2.1. State of the Art

A review of the literature on the platforms "Scopus", "ScienceDirect", and "Web of Science" was conducted for the time period of 2015 to 2022 using various combinations of the following keywords: consumer behavior; sustainability; sustainability understanding; sustainability definition; construction; building; survey. This review did not reveal a comparable study that used a quantitative survey as methodology to analyze consumer behavior and their understanding of sustainability specifically within the German construction industry. Nevertheless, quantitative analyses of general consumer behavior (without specification of a particular industry) in relation to sustainability and consumer behavior in the construction industry analyzed with other research methodologies could provide an overview of the current state of the art. Calderon-Monge et al. analyzed sustainable consumer behavior by questioning 223 Spanish consumers and found that consumers generally have an interest in incorporating the dimensions of sustainability in their purchasing behavior. The authors recommended that it is essential for manufacturers to increase transparency regarding the product manufacturing and distribution processes and to include the product traceability information on labels or through another medium [12]. Focusing on the construction industry, a study about end-consumers' interest in Australia's push toward sustainable residential housing in 2021 highlighted that, contrary to the expectations derived from the literature, people want to build sustainable houses [12,13]. However, looking at consumers' understanding of sustainability, a survey conducted by Alexander et al. in 2022 found that consumers often view the issue of sustainability from an environmental perspective. The results of 701 respondents from higher education institutions in the USA. showed that the highest rated elements examined were aligned with the environmental dimension of sustainability [14]. Shao and Ünal's study aligns this finding when surveying consumers about "green" purchasing. The results of their survey indicated that environmental impact information of products has significant influence on consumers' green purchasing while social impact does not. [15] A quantitative study from 2022 surveying 112 stakeholders in the Zambian construction industry points to a mismatch between the more environmental-centric understanding of sustainability and the sustainability practices with a focus set on social and economic issues within the industry [16]. Another survey questioning 102 consumers in construction in Kuwait elaborated on the poor awareness of sustainability and the level of knowledge of construction materials. However, this study only considered consumers awareness of the environmental dimension of sustainability [7]. The researchers Rochikashvili and Bongaerts emphasize the relevance of identifying consumer knowledge about sustainability in the construction sector and influencing decision making using a survey [11]. They point out the importance of eco-labels and environmental certificates for consumers of the German construction industry with a questionnaire with 212 respondents. Their focus again was placed only on environmental aspects and not the relevance of all three sustainability dimensions [17].

What is clear from our review of the literature is that there is a lack of detailed analysis and understanding of consumer behaviors and knowledge relating to environmentally,

socially, and economically sustainable products, specifically within the German building sector. This research is thus a major step in: (i) gaining an understanding of how relevant sustainability-related criteria are for consumers and producers in the German construction industry; and (ii) which criteria in particular these consumers use to decide if a building product is sustainable.

2.2. Sustainability in Construction

To identify whether a product is considered sustainable, a basic understanding of the term "sustainability" is essential. In the Brundtland Report published in 1987, the World Commission on Environment and Development defines sustainable development as development that "meets the needs of the present generation without compromising the ability of future generations to meet their own needs" [18]. Within the framework of this idea, the concept of sustainability encompasses three dimensions: economic, environmental, and social. The economic aspect, which is often not intuitively associated with the term sustainability, characterizes the preservation of economic capital for future generations. In this context, the economic basis of life should be preserved [19]. Environmental sustainability refers to a moderate use/consumption of our natural resources and a reduction of the environmental impacts for a permanent preservation of the natural basis of life. The focus of this aspect is on topics such as environmental protection, resource conservation, and the preservation of biodiversity [20]. The third dimension is defined in the Brundtland Report as social sustainability through the pursuit of intergenerational and intragenerational justice. Therefore, people living now and in the future should be enabled to secure their existence in the long-term [18].

When considering the aspect of sustainability in the planning of a building, a life-cycle-wide sustainability assessment should be performed in an early phase of the project. Using this method offers the opportunity to minimize burdens—be they of an economic, social, or environmental nature—over the entire life cycle of a building based on sound planning and, at the same time, ensuring its quality of usage [21]. Experts criticize that the life cycle in its entirety, at present, does not play a significant role in the planning and assessment of buildings. Currently, only the utilization phase is crucial for the energetic evaluation, while so far only the production phase is considered for the building's economic burdens [22].

However, to ensure the most sustainable alternative possible, it is particularly important to perform the analysis of a building based on its entire life cycle in the early project phase [23]. At this stage, one still has the most influence on the development of the project and the resulting effects on its environment. Accordingly, consumers are of the utmost relevance for all significant decisions during the early planning phase.

2.3. Consumer Behavior in Construction

In the construction industry, consumers as stakeholders play a unique role in the development toward increasing sustainability. Moreover, the decisions the owner of a building makes during the construction project not only impact the immediate construction process, but also largely influences the energy and resource consumption in the use phase over several decades and during disposal [9]. Folke Ölander and John Thøgersen previously observed in their research paper from 1995 that more sustainable lifestyles cannot be achieved without significant changes in consumer attitudes and behavior [10]. However, these changes in consumer attitudes and needs must then also be recognized and addressed by the industry with appropriate offerings. Especially in the building industry, this knowledge about needs and wishes of consumers or customers is of crucial relevance. According to Othman, in such a competitive business environment, achieving customer satisfaction is an important measure of success for construction projects and an effective tool for maintaining competitive advantage. This perspective stems from the crucial role that the customer plays as core of the construction industry and driving force for its improvement [8].

In general, there appears to be a lack of understanding and comprehension among consumers when it comes to the issue of sustainability. A survey conducted by the "Gesellschaft für Konsumforschung" (Society for Consumer Research) in 2016 has shown that approximately 1/3 of the participants associate aspects of "environmentally conscious action" with the term "sustainability" and 20% connect each of "resource-saving" and "renewable materials" with "sustainability" [24]. Even though the three dimensions of sustainability are defined as having equal significance, social and economic associations were not specifically mentioned.

In his book of research on sustainability at German universities, Leal Filho elaborates that the concept of sustainability—as well as the preferences of consumers when buying goods and their understanding of sustainable products—is very multifaceted [25]. The criteria for recognizing a products' sustainability are dependent on very subjective factors. This is reinforced by the fact that purchasing decisions in the building sector involve very complex processes, which are characterized by individual decisions and consultation from the personal environment [9]. Therefore, the comprehension and resulting behavior of consumers in relation to sustainability-related criteria can be highly individual and vary from one consumer to another. This increases the difficulty for companies to communicate the sustainability of their products in a correct, easily understandable, and appealing manner. Apel elaborated in his publication that raising awareness and education about sustainability is already known to exert a positive effect on sustainable development—on both sides, customer and producer [24].

In order to determine how consumers behave in the construction industry and which methods should be used to communicate the sustainability of products in the best possible way, it is initially necessary to evaluate the customers' current state of knowledge and the motivations for purchasing decisions for building products. For this purpose, we made use of a written survey.

3. Materials and Methods

The overall goal of the research was to set guidelines on how the sustainability performance of building products can effectively be communicated to consumers in order to support a more sustainable construction industry. It became evident throughout the literature review (see Section 2.3) that consumers' purchasing decisions made in an early project stage play a key role in the construction industry whereby their attitude toward sustainability has a major impact on the development of a more sustainable industry. Accordingly, the research question arose on whether private individuals as consumers in the German construction industry have an interest in buying sustainable products and how the relevance of sustainability-related criteria is represented in purchasing decisions. To answer the research question, the following hypotheses were formulated based on the challenges and questions that arose:

1. Consumers in Germany do not have a holistic understanding of the term "sustainability" in general, as well as in the context of the construction sector. They instead focus on environmental aspects, while tending to neglect the social and economic aspects.
2. Sustainability criteria that potentially lead to purchasing decision of building products are subjective and differ between different groups of consumers in Germany.
3. Criteria that drive purchasing decision are not consistent and can change with the state of consumer knowledge on different topics. The acquisition of knowledge and the confrontation with the issue of sustainability in construction leads toward a higher importance of sustainability-related criteria when making purchasing decision for building products.

When constructing a questionnaire, well-considered conception and planning is essential. This includes the determination of choice of a qualitative or quantitative approach as well as framework conditions of the survey, such as purpose, target group, and expectations that are placed on the results [26,27]. To examine the formulated hypotheses, it was determined to use the method of a quantitative online survey. This explicit method

was chosen because other approaches like observation and the literature review are not sufficient to answer the research question as to whether consumers in the construction industry consider sustainability when making purchasing decision for building products. The choice of a written format proves to be particularly advantageous as it ensures an increased structure of the survey content and is particularly cost effective. This form of interview is perceived by the respondents as very anonymous, which has a beneficial effect on the willingness to provide honest information and to deal profoundly with the problem being asked [28]. Furthermore, the online format was chosen because people can be easily reached nationwide and direct contact with many people was not possible due to the ongoing COVID-19 pandemic. This is of particular importance in order to gather information from a sufficiently large sample size. As a target group, the questionnaire was intended to address private individuals as consumers of the German construction industry.

A questionnaire needs to be as long as necessary to cover all relevant aspects, but at the same time as short as possible to minimize the effort for the respondents without the requirement of any further explanations [27,28]. The quality of a questionnaire can be determined by three central quality criteria:

- Objectivity: independent of the test user;
- Reliability: the proportion of error associated with a particular value is as small as possible;
- Validity: the questionnaire measures exactly what it is supposed to measure [28].

To measure exactly what is needed within a survey it is vital to not only carefully design the questions, but also to ensure the possible responses are formulated in such a way to allow the hypothesis to be disproven. For accurate data measurement, different scales for the particular questions can be used. The four most important types of scales are nominal scales, ordinal scales, interval scales, and ratio scales [28]. When choosing the scales for the questions of this study, attention was paid to avoid unnecessarily complex scale forms if the data collected with them did not contribute any further added value to answering the research question.

When analyzing quantitative samples, a basic distinction is made between inferential statistics and descriptive statistics. Descriptive statistics describe certain characteristics of a sample population without any entitlement to make a statement about the underlying population. Based on these descriptive statistical results, inferential statistics, also referred to as analytical statistics, can be used to draw conclusions from the sample to the overall population. [26] Inferential statistics address the problem of how to apply results obtained from a relatively small number of people to the population, and thus, make generally valid statements. For this purpose, the statistical significance of the results is tested commonly with the method of the hypothesis testing in the form of a *t*-test. With help of this technique, a decision can be made about the research hypothesis that is to be tested. [28,29] For the evaluation of the questionnaire of this study, both descriptive and inferential statistical methods are used with the help of the software SPSS.

A flow chart of the procedure for the development and implementation of the method of this research is outlined in Figure 1.

3.1. Target Group Definition and Contact

Only respondents of the age of 18 years and older were included in the evaluation of the results since minors are not of legally competent age, and therefore, not of current relevance to the construction industry. This and other demographic information for the classification of different consumer groups was determined with six demographic questions in the questionnaire. The aim was to survey as many people as possible across Germany in different demographic groups such as age, educational background, and gender. This should allow the evaluation of the hypotheses with regard to differences and similarities between various consumer groups.

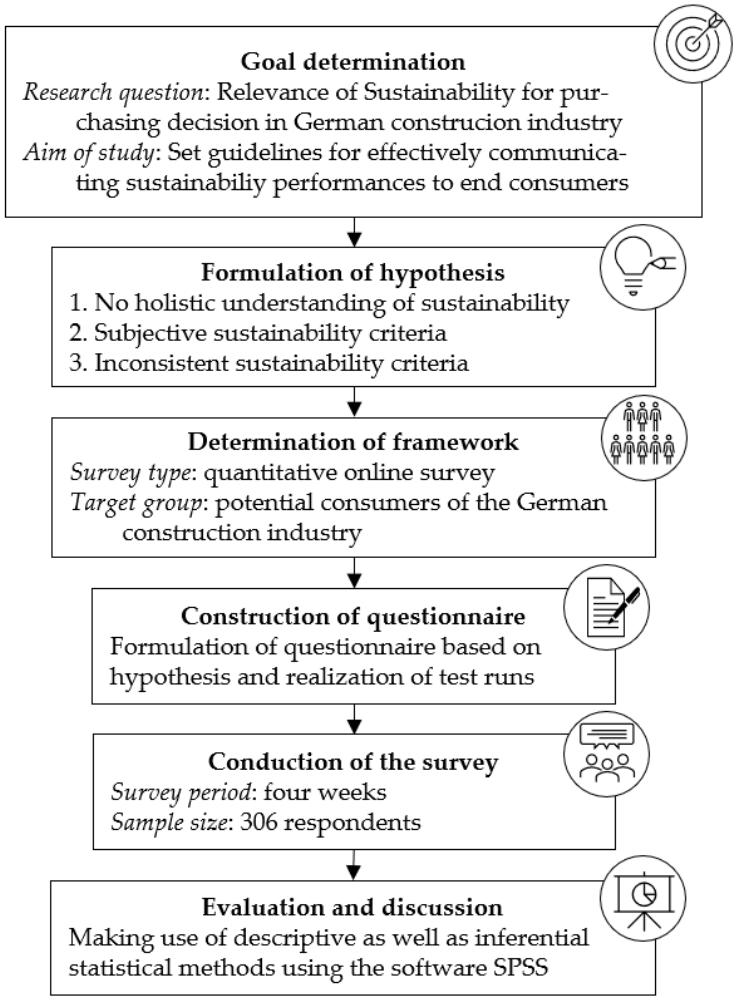


Figure 1. Survey development and implementation.

Respondents were contacted on several social media platforms as well as in the authors' network. It made use of the social media platforms Facebook, WhatsApp, and LinkedIn. A focus was set on groups for clients of construction projects as well as people who are interested in building or purchasing real estate. Care was taken to ensure that the sample was as random and diverse as possible.

All potential consumers of the German construction industry were of interest for this research and therefore defined as the basic population. The number of these is difficult to determine; however, since all German citizens over the age of 18 can potentially make a purchasing decision in the construction industry, a population of N = 69,411,087 was assumed on the basis of data from the German Federal Statistical Office for 2020 [30]. In order to define the statistically relevant sample size (n) for this research, Equation (1) was used [31]:

$$n = \frac{N}{1 + \left(\frac{(N-1)\cdot e^2}{z^2 \cdot p \cdot (1-p)}\right)} \quad (1)$$

N = Population size = 69,411,087
e = Error margin = 5%
z = z-value = 1.96
p = Standard deviation = 0.3056

The error margin, or confidence interval "e", describes the tolerated possibility that an answer by the sample group does not match the overall population. The parameter "z-value" measures the difference between an observed statistic and its hypothetical

population parameter in units of standard deviation and is derived from the chosen confidence level. For this research a tolerated error of ε = 5% = 0.05 and a confidence level of 95% = 0.95 is chosen. Using the table of the standard normal distribution, a z-value of 1.96 can be determined accordingly [32]. Based on data from the German Federal Statistical Office, an average age of 40 years is assumed as the actual mean age of all German residents over the age of 18. This results in a standard deviation p = 30.56% = 0.3056. Given these parameters applying Equation (1), a sample size (n) of 327 respondents (see Equation (2)) is aimed for.

$$n = \frac{96,411,087}{1 + \left(\frac{(96,411,087-1)\cdot 0.05^2}{1.96^2 \cdot 0.3056 \cdot (1-0.3056)}\right)} = 327 \quad (2)$$

3.2. Survey Construction and Evaluation

The questionnaire was divided into several thematically grouped sections to guide the participants through the questionnaire in the best way possible. The survey began with a brief explanation of relevant information and notes, along with contact details for questions and comments. The introduction was followed by questions inquiring about the respondents' level of knowledge of the construction industry and relevant criteria when making purchasing decisions for building products. Respondents were then asked about their level of knowledge of sustainability in general, as well as in the construction industry, and the relevance of sustainability criteria when purchasing products. Before collecting the demographic data, the question of the relevant criteria for the purchase decision of building products was repeated to check the consistency of the answers.

The questions (see Table 1) were specifically designed to answer a hypothesis or provide information about the demographic distribution of the participants. In the question about the understanding of sustainability in general and in the building sector, respondents had the option of answering in terms of the three dimensions of sustainability. The differentiation of multiple aspects within the term environmental sustainability was adopted because of the expected tendency toward the environmental dimension. Furthermore, this allows for more specific recommendations in this field that can be given to companies in the construction sector when analyzing the data. Additionally, a comparison between the frequency with which sustainability-related criteria are considered when purchasing building products is made with that of purchasing groceries, such as food. The reason for this is that purchasing decisions for groceries are usually made by consumers on a very regular basis, which is not the case in the construction industry. Concerning the analysis of hypothesis 3, such a comparison can therefore be helpful.

Table 1. Survey design.

Research Part	#	Question	Answer(s) Provided in the Questionnaire
Demographic	1	Do you have any experience in the construction industry and if so, what kind?	Yes, via an apprenticeship; Yes, via higher educational studies; Yes, via the profession; Yes, via a real estate purchase; No profound experience so far.
H3	2	Which criteria are most relevant for you when making a purchase decision for a specific building product? *	Price; Outside appearance; Durability; Holistic sustainability of raw materials; Energy efficiency; Consultation by experts.
Demographic	3	Do you have any experience in the field of sustainability and if so, what kind?	Yes, via an apprenticeship; Yes, via higher educational studies; Yes, via the profession; Yes, via regular private engagement; No profound experience so far.
H1	4	What do you understand by the term "sustainability"?	Resource preservation; Recycling; Energy efficiency; Environmental action; Economic action; Socially responsible and fair action.

Table 1. *Cont.*

Research Part	#	Question	Answer(s) Provided in the Questionnaire
Demographic	5	How important is sustainability to you in your personal life?	Important; Rather important; Neutral; Rather unimportant; Unimportant.
H1	6	What do you understand by sustainability in the construction sector?	Recyclability at the end of the product's lifetime; Durability; Cost saving construction; Optimized use of energy and resources; Low environmental footprint; Fair working conditions; Proportion of recycled material in the product.
H2	7	In your opinion, how important is a sustainability assessment in the construction sector?	Important; Rather important; Neutral; Rather unimportant; Unimportant.
	8	Which of the following sustainability certificates of the construction sector do you know?	Level(s); DGNB; BREEAM; VinylPlus; LEED; BNB; Cradle to Cradle; None.
General understanding	9	When purchasing groceries, do you consider the sustainability of the products?	Always—Never.
	10	When purchasing building products, do you consider the sustainability of the products?	Always—Never.
H2	11	What is generally important to you in terms of sustainability when purchasing products?	Regional production; Recyclability of the product; Production under fair working conditions; Low energy and CO_2 emissions in production; Proportion of recycled material in the product.
	12	Which attribute is most likely to indicate to you that these criteria are being fulfilled?	Certificates/Labels; Outer appearance and design; Detailed product information.
	13	Where do you gather your information about the sustainability of products?	Social media; Scientific articles and magazines; Product manufacturer; Friends and acquaintances, Daily newspaper; Info events and trade fairs.
H3	14	Which criteria are most relevant for you when making a purchase decision for a specific building product? *	Price; Outside appearance; Durability; Holistic sustainability of raw materials; Energy efficiency; Consultation by experts.
Demographic	15	To which age group do you belong to?	<18; 18–27; 28–40; 41–60; >60
	16	What is your gender?	Male; Female; Diverse.
	17	What is your highest educational qualification?	School leaving qualification; Apprenticeship, Higher educational studies.

* At this point, a specific building product was inquired about, which cannot be named for confidentiality reasons.

Before the questionnaire was shared with the target population, it was tested with a sample group of the author's friends and colleagues. Following this, a total of 306 people participated in the actual survey during a period of four weeks. To analyze the data, a descriptive evaluation was first performed using Excel. Based on this, the hypotheses were then tested inferentially using the statistical software SPSS 28.

4. Results

4.1. Statistics

After closing the survey in August 2021, a total of 402 people took part, of which 306 completed the survey. Within the framework of the evaluation, only the results of the questionnaires that are completed in full are included in the analysis. We accordingly proceeded with a total sample size of respondents, which is n = 306, even though this number is slightly below the aimed sample size of 327.

In total, 146 of the respondents declared as female, 159 male and 1 diverse. Of these, the majority (41%) were between the ages of 18 and 27, 19% were between the ages of 28 and 40, 29% were between the ages of 41 and 60, and 11% were over 60. Respondents

under 18 years of age were excluded from the statistics and the following evaluations, as they are not of legal age for making business decisions and thus not of direct relevance to companies in the construction industry. In total, 59% of persons considered have a university degree as their highest educational qualification, 20% have completed apprenticeship training, and 22% have a school-leaving qualification.

More than 50% of the respondents said they have no profound experience in the construction industry so far. On the other hand, 28% have prior knowledge via a real estate purchase, 10% via their profession, 14% via their higher educational studies and 3% stated they have acquired prior knowledge via apprenticeships. In the area of sustainability, the level of prior knowledge of the respondents behaves very similarly. With 48%, the largest part of the respondents stated that they have not yet acquired any profound experience in the field of sustainability. A noteworthy number of people (35%) already have prior knowledge via regular private engagement. In total, 13% gained prior knowledge via their profession, 18% via their higher educational studies, and 2% via apprenticeships.

The distribution of the relevance of sustainability in the respondents' personal lives is illustrated in Figure 2.

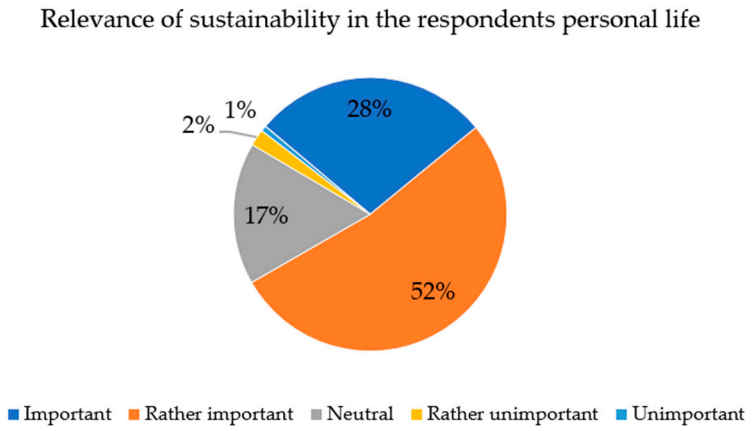


Figure 2. Relevance of sustainability in the respondents' personal lives.

There are no significant correlations between the age group, gender, or educational background and the relevance of sustainability in the private lives of the respondents. This was tested with a *Chi*2-test using the statistical software SPSS.

Within the framework of the question to what extent consumers pay attention to whether building products are sustainable when purchasing them, the respondents were asked to make an indication between "always" (= 0 points, in 100% of the cases) and "never" (= 100 points, in 0% of the cases) using a rule slider. On average, this resulted in a value of 52.62 points with a standard deviation of 24.13 points (Figure 3). On the other hand, when asked how often they pay attention to the sustainability of products when buying groceries, the participants gave an average score of 32.79 points with a standard deviation of 22.51 points. This means that on average, respondents pay attention to whether products are sustainable 47.4% of the time when buying building products and 67.2% of the time when buying groceries. The columns in Figure 3, which visualizes these results, each give the percentage of respondents making a particular point indication, clustered into groups of five points. In addition, a smoothed curve shows which indications the respondents make in the overall trend.

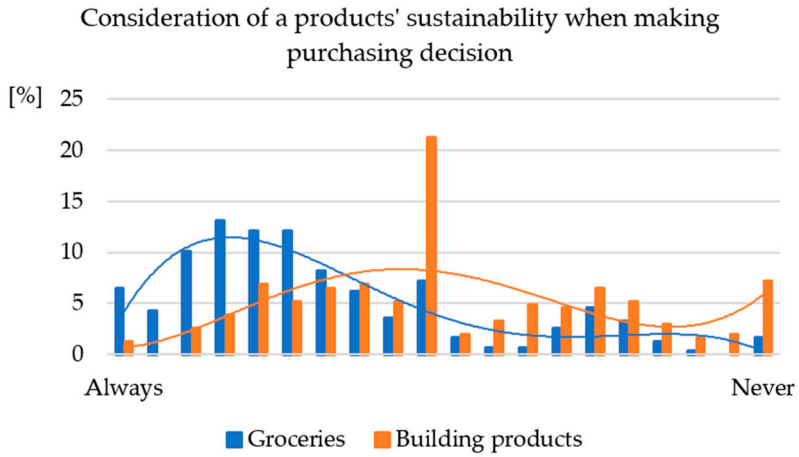


Figure 3. Consideration of a product's sustainability when making purchasing decision.

4.2. Hypothesis 1

When asked what respondents understand by the term "sustainability", 56.3% of the respondents ranked resource preservation as most applicable. On average, this answer option received a rank of 1.78 on a scale of 1 = "rather applies" to 6 = "rather does not apply". In addition, the respondents associate recycling, environmental action, and energy efficiency with the term "sustainability" in descending order. Socially responsible and fair, as well as economic action, were ranked as least applicable. When it comes to associations about sustainability in the construction sector, the findings are very similar. On average, the respondents ranked the aspects of environmental sustainability as most applicable and aspects of economic and social sustainability were ranked as less applicable. Figures 4 and 5 visualize the results of these two questions.

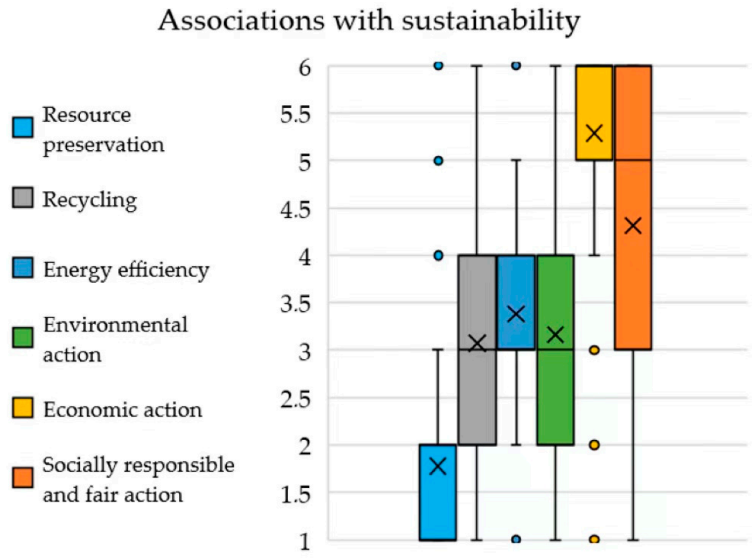


Figure 4. Respondents' associations with sustainability with 1 = maximum and 6 = minimum.

After further examination based on the *Chi*2-test, no significant correlations between the classification of sustainability aspects and the respondents' gender or educational level were found. However, it is revealed with a significance level of 5% that there is a significant dependence of the variable "Durability" and the age group. There is a weak positive correlation of these two variables with a correlation coefficient of $\rho_{Durability,Age} = 0.039$. Upon further investigation, it is noticeable that within the younger age groups the average ranks for this criterion are 2.51 and 2.46, while for respondents of the older age groups (41 to 60 and older than 60 years) this criterion is ranked 2.72 and 2.71 on average. There-

fore, it can be said that on average younger age groups find the criterion of durability as a more fitting association with sustainability in construction than older respondents, which can also be proven by the positive correlation coefficient. Furthermore, it is striking that the criterion of the products' proportion of recycled material, which was generally poorly rated, was classified by 15.3% more by the respondents aged 18 to 27 years as a relevant criterion than respondents aged 60 years and over. The difference between rating this criterion—and the criterion of the recyclability of the product as well fitting—is already 48.5% in the oldest age group. In the youngest age group, on the other hand, this difference is only 17.6%.

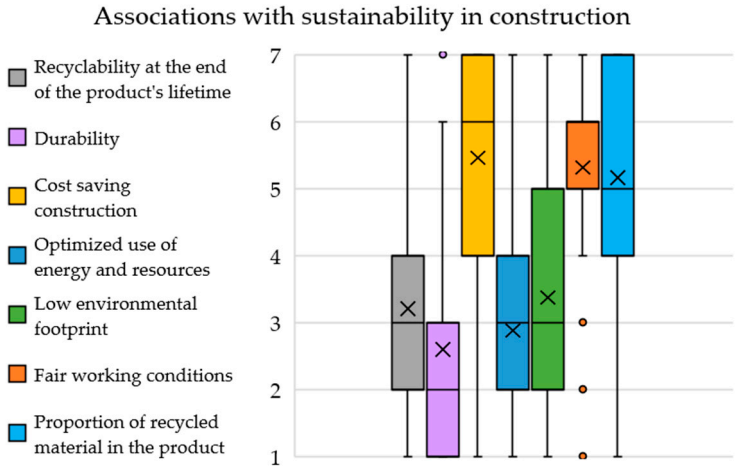


Figure 5. Respondents' associations with sustainability in construction with 1 = maximum and 7 = minimum.

The fact that all target groups on average rated the aspects of environmental sustainability as more applicable to both the general term sustainability and sustainability in the construction sector suggests that the hypothesis—that consumers generally do not have a holistic understanding of the concept of sustainability but primarily associate environmental aspect—is fulfilled. However, since these results only reflect the views of the sample population, the hypothesis still needed to be tested using an inferential statistical method to make a statement about the overall population. For this purpose, the method of a hypothesis test (*t*-test) was used.

First, it was tested whether the aspects of environmental sustainability in construction are significantly different from the aspects of social sustainability. If this hypothesis can already be rejected, then a test of the hypothesis whether aspects of environmental sustainability are significantly different from those of economic sustainability is no longer necessary. This is because the difference in the indication of social and environmental sustainability in the sample was already smaller than that of environmental and economic sustainability. For the test, a normal distribution was assumed because the criterion (n = 306) − 1 > 40 is fulfilled and therefore the sample is sufficiently large. The hypothesis was tested with a significance level of $\alpha = 5\%$.

$$H_0(\text{null hypothesis}) : \bar{x}_{1\text{st query}} = \bar{x}_{e2\text{nd query}}$$
$$H_1(\text{research hypothesis}) : \bar{x}_{1\text{st query}} \neq \bar{x}_{2\text{nd query}}$$
$$\bar{x}_{1\text{st query}} = 4.41$$
$$\hat{\sigma}_{1\text{st query}} = 1.39$$
$$\bar{x}_{2\text{nd query}} = 4.16$$
$$T_{act} = \frac{\bar{x}_{1\text{st query}} - \bar{x}_{2\text{nd query}}}{\frac{\hat{\sigma}_{1\text{st query}}}{\sqrt{n}}} = \frac{4.41 - 4.16}{\frac{1.39}{\sqrt{306}}} \approx 3.15$$
$$T_{crit} = \pm 1.96$$

Consequently, $T_{act} = 23.00 > T_{crit}$ and the null hypothesis were rejected with a significance level of 5%. $\bar{x}_{social}$ is significantly different from $\bar{x}_{environmental}$ and the research

hypothesis is fulfilled. It can therefore be concluded that with a significance level of 5%, environmental and social—and additionally, environmental and economic aspects—are not equally associated with sustainability in the construction sector by the overall population.

A closer look at the information provided by the different age groups reveals that respondents between 18 and 27 years of age rated the aspect of social sustainability as more relevant than the other age groups when asked about the importance of the general concept of sustainability. While a mean rank of 4.17 was given for this age group, a mean rank of 4.5 is given for respondents between 28 and 40 years of age, 4.33 for respondents of 41–60 years of age, and 4.56 for respondents over 60 years of age.

4.3. Hypothesis 2

For most respondents (78.8%), it was of particular importance, in terms of sustainability, when purchasing products that were produced regionally. On average, ranked second place was the the criterion of low energy and CO_2 emissions in production (65.7%), followed by the recyclability of the product (60.5%), and production under fair working conditions (56.2%). With 40.9%, the criterion of the proportion of recycled material in the product was stated by the fewest number of people as an important sustainability-related criterion. The evaluation of the sustainability criteria by the respondents is visualized in Figure 6. It shows different sustainability-related criteria and the proportion of respondents who consider them as relevant criteria when making a purchasing decision. While only 30.3% of the respondents over 60 years of age selected the proportion of recycled material in the product as an important sustainability-related criterion, 37.5% of the 41- to 60-year-olds and 43.1% of the 28- to 40-year-olds did so. In the youngest age group, 45.6% considered this criterion to be an important sustainability-related aspect. The average indication of the recyclability of the product, on the other hand, is made up as thus: 78.8% of all respondents over the age of 60 said that this criterion is relevant to their purchase decision. In the 18- to 27-year-old group, on the other hand, it was already 63.2% and in the middle-aged groups, 53.4% (28 to 40 years) and 54.5% (41 to 60 years).

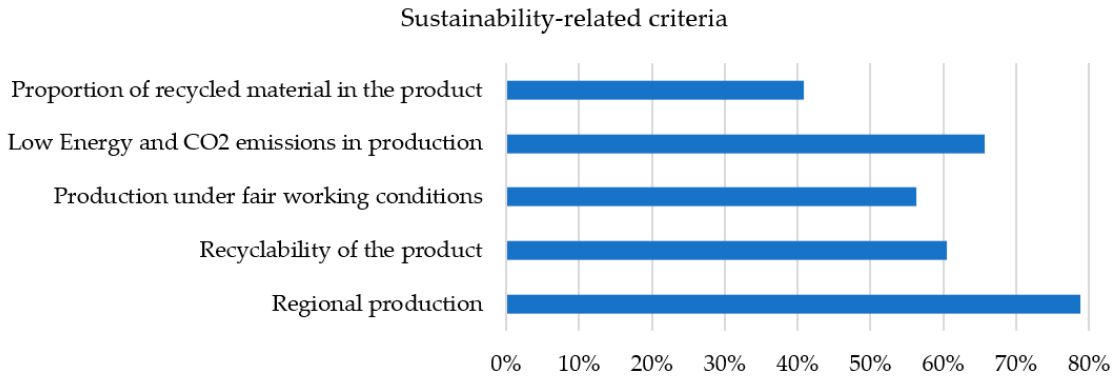


Figure 6. Relevant sustainability-related criteria when making purchasing decision.

Of those questioned, 54.3% said that when purchasing products sustainability certifications and labels mostly indicate whether they meet the sustainability criteria. In total, 42.2% said that this is done on the basis of detailed product information, and only 2.3% of those questioned are given an indication of a product's sustainability by its outer appearance and design. These results are illustrated in Figure 7. It shows different attributes, which could indicate the sustainability-related criteria to be fulfilled and once again, the proportion of respondents who considered them as applicable. In addition to selection options, responses stated in the open text field contain the respondents' own research and reviews of the product as well as the place of purchase or the familiarity of the seller of the product.

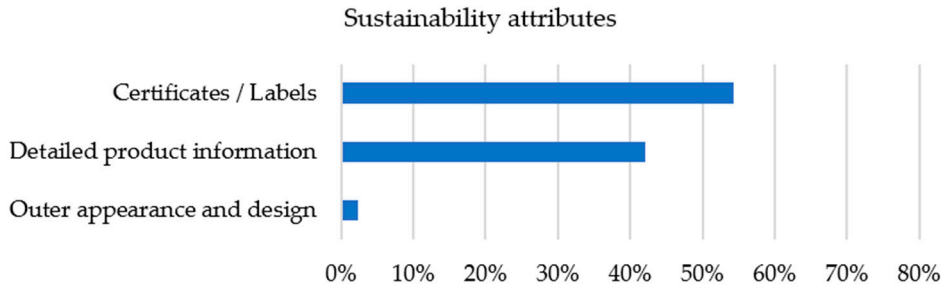


Figure 7. Sustainability attributes when making purchasing decision.

Even though the attribute of certifications and labels to recognize sustainable products was favored, few respondents actually have knowledge about sustainability certificates and labels of the construction sector. In total, 77.6% even stated that they have no awareness of any sustainability certificate in the construction sector. Nevertheless, more than 85% of the respondents stated that they still consider the sustainability rating in the building sector to be important or rather important. It is notable that the "Cradle to Cradle" certificate is indicated to be known by 15.2% of those 18–27 years of age, while only 3.0% of the respondents above the age of 60 did so. Among the age groups 28–40 and 41–60, 10.5% and 11.4% said they are aware of the certificate, respectively.

The evaluation of the information source for recognizing the sustainability of a product (see Figure 8) indicates that the majority of respondents (70.9%) obtain their information from the product manufacturer. This source of information seems to be of particular importance for respondents between 18 and 27 years of age, as 77.6% in this age group chose the product manufacturer as their source of information. This is followed by 52.3% of respondents having said that they use scientific articles and magazines, and 37.6% from friends and acquaintances to gather information. Social media (31.1%), daily newspapers (20.6%), and information events and trade fairs (10.8%) were mentioned less frequently. The people who use social media as their preferred source of information for the sustainability assessment of products are mostly either between 18 and 27 years of age or over 60 years of age. While in these age groups 36.8% and 33.3% of the respondents selected this source of information, much fewer did so in the other two age groups, with 26.8% (28 to 40 years) and 26.7% (41 to 60 years), respectively. Following this, Figure 8 contains different sources of information and the proportion of respondents that consider them as relevant for the evaluation of a products' sustainability.

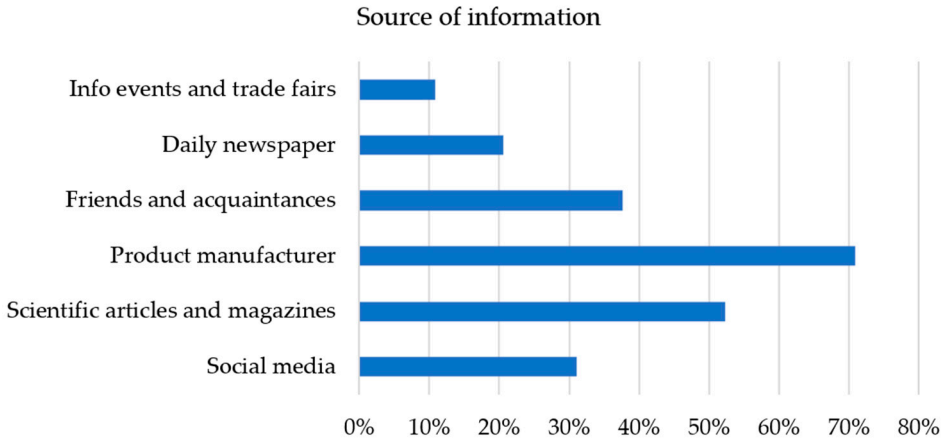


Figure 8. Source of information for sustainability assessment in purchasing decisions.

A more detailed examination of the age groups also reveals that with a proportion of 57.6%, most of the respondents above the age of 60 stated that they mostly use scientific articles or journals as a source of information about the sustainability of a product.

Furthermore, the proportion of people in this age group who indicated newspapers as a preferred source of information is with a proportion of 42.4% more than twice as large as the average proportion of all respondents. Trade fairs and information events were on average mentioned less frequently by the respondents, whereby it is noticeable that especially the older age groups have an interest in such sources of information (16.3% among those aged 41 to 60 and 15.2% among those over 60).

Distinctions also arise comparing respondents with and without further experience in the construction industry. For example, the source of trade fairs and info events is relevant for almost twice as large a proportion of respondents with experience of building or buying real estate (14.1%) than for those without prior experience (7.8%). Daily newspapers are also more popular among respondents with prior experience, with a share of 29.4%, than among those without prior experience, among whom only 18% choose this medium. The situation is different, however, when it comes to the relevance of obtaining information through friends and acquaintances. Of the respondents who already have prior experience in the construction industry through the construction or purchase of a property, 32.9% said they make use of this source, compared with 41.3% of respondents with no prior experience. Likewise, obtaining information from the product manufacturer is more relevant to respondents with no prior experience (73.1%) than respondents with prior experience, among whom 61.2% made this selection.

Other sources of information mentioned in the free text field are internet research via search engines, such as Google, documentaries or interviews with experts on YouTube, or in podcasts.

4.4. Hypothesis 3

When making a purchasing decision of a specific building product, the criteria durability and energy efficiency are most relevant to the respondents. On average, these criteria achieved a rank of 2.60 and 2.58 at first query. At second query, these results did not change significantly (2.60 and 2.59). The respondents ranked the criteria price and outside appearance as next most relevant. At the first query, the criterion of the price of the product reached on average a better rank (3.30) than the criterion of the outside appearance (3.33). At the second query, after the consumers were asked several questions about their personal understanding of sustainability in construction, this initial preference by the respondents is reversed (Price = 3.35 and outside appearance = 3.29). Meanwhile, the criteria of a holistic sustainability of raw materials and consultancy by experts at first query did not seem to have a major impact on the respondents purchasing decision. With an average rank of 4.41, the holistic sustainability of raw materials reached the penultimate rank and the criterion of consultancy by experts, the last one of which with an average rank of 4.77. Within this aspect, it is interesting to observe that the respondents did rank the criterion of a holistic sustainability of raw materials on average much better in the second query than before (4.16). The aspect of a consultancy by experts, on the other hand, was ranked as even less relevant than before (average rank: 5.00). Figure 9 illustrates the average rating of the single criteria at first and second queries by the respondents.

Since there appear to be no significant differences at the first and second query within the criteria "price", "outside appearance", "durability", and "energy-efficiency", only the consistency of the criterion "holistic sustainability of raw materials" was tested using inferential statistics. The mean value at the first query of this criterion was $\bar{x}_{1st\ query} = 4.41$ with a standard deviation of $\hat{\sigma}_{1st\ query} = 1.39$. Therefore, a hypothesis test based on the standard normal distribution with a significance level of $\alpha = 5\%$ results as follows:

$$H_0(\text{null hypothesis}) : \bar{x}_{1st\ query} = \bar{x}_{e2nd\ query}$$

$$H_1(\text{research hypothesis}) : \bar{x}_{1st\ query} \neq \bar{x}_{2nd\ query}$$

$$\bar{x}_{1st\ query} = 4.41$$

$$\hat{\sigma}_{1st\ query} = 1.39$$

$$\bar{x}_{2nd\ query} = 4.16$$

$$T_{act} = \frac{\bar{x}_{1st\ query} - \bar{x}_{2nd\ query}}{\frac{\hat{\sigma}_{1st\ query}}{\sqrt{n}}} = \frac{4.41 - 4.16}{\frac{1.39}{\sqrt{306}}} \approx 3.15$$

$$T_{crit} = \pm 1.96$$

Consequently, $T_{act} = 3.15 > 1.96 = T_{crit}$ and the null hypothesis is rejected with a significance level of 5%. $\bar{x}_{1st\ query}$ is significantly different from $\bar{x}_{2nd\ query}$ and the research hypothesis is fulfilled. It can therefore be concluded that with a significance level of 5% the criterion of a holistic sustainability of raw materials is not being ranked of consistent relevance by the overall population. After being confronted with the issue and the personal understanding of sustainability in the construction sector, this criterion is ranked as significantly more important when making purchasing decision for a specific building product than before.

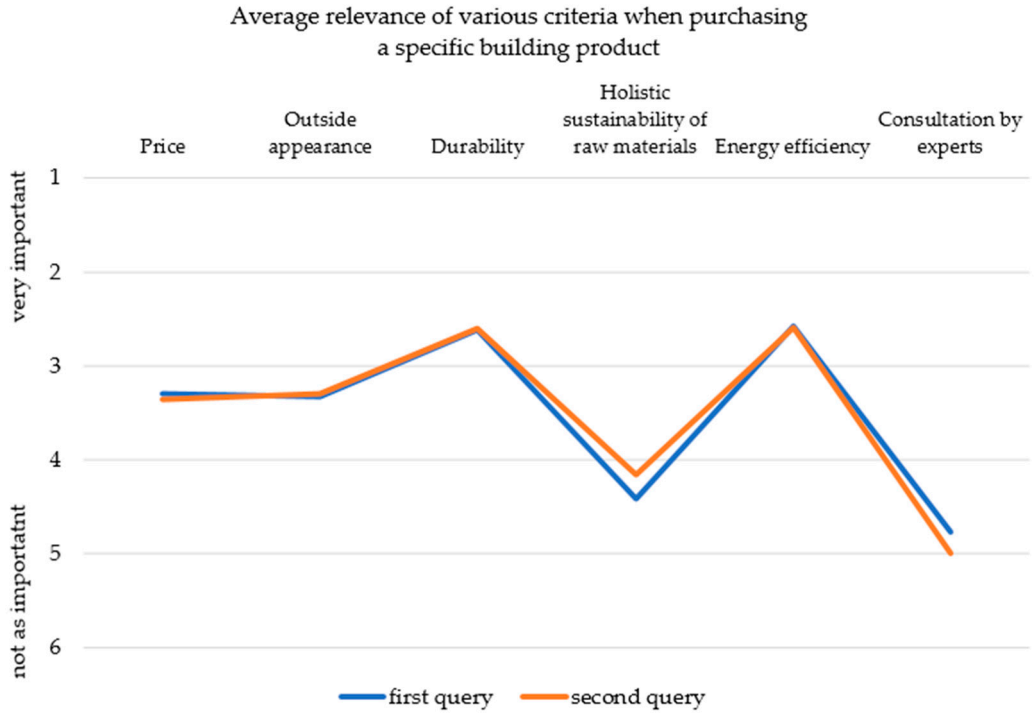


Figure 9. Relevant criteria when making a purchasing decision for a specific building product.

5. Discussion

Firstly, it must be examined whether this written survey is a representative survey. With an actual sample size of 306 respondents, the target sample size was not reached. However, since the overall population was assumed to be exceptionally large by including all German citizens aged 18 and older, this sample size is sufficient enough for the purpose of this study. The gender and age distribution are representative for potential consumers in the German construction industry. With a nearly equal distribution of male and female participants and a predominant share of young adults (18 to 40 years), the picture of people who will make a purchase decision in the German construction industry in the foreseeable future was well represented. Therefore, first analysis and evaluations about a trend of consumer behavior regarding the issue of sustainability in the construction sector and the elaboration of guidelines for the industry are possible. However, it should be critically noted that it cannot be said with absolute certainty that the respondents did not fill out the questionnaire randomly or make false statements. It should also be noted that although care has been taken to ensure that the sample population is as random and diverse as possible, it cannot be guaranteed with absolute certainty that it is representative of the overall

population. In regard to the large sample size and its broad demographical background, the results are still valid to elaborate guidelines and orientation, but are not explicit predictions for companies of the construction industry.

The results need to be critically questioned, as it is possible for respondents to more likely give sustainability-related responses when answering a questionnaire about the relevance of sustainability in the construction sector, besides the case of questionnaires that are not related to the subject. Furthermore, the indication of sustainability-related responses is a socially accepted behavior and even if the survey was anonymous, it cannot be ruled out that the respondents may have been biased by this.

An overall picture emerged from the results that consumers have a general interest in sustainable building products. The majority stated that they also find the issue of sustainability relevant in their private lives. A product-specific difference was clearly observed in the attention paid by respondents to the purchase of products, i.e., consumers seem more conditioned to consider sustainability when grocery shopping compared to purchasing building products. In the case of smaller investments that are made regularly, such as the purchase of food, more attention is paid to the sustainability of the products than in the case of more long-term but less frequent investments, such as the purchase of building products. Consumers have more opportunities to become aware of the relevance of sustainability-related criteria in the case of purchases that they make regularly and which are daily occurrences. Since the purchase of building products is not very daily and a consumer is accordingly not often in the position to think about relevant criteria of product purchase, the sustainability aspect might simply not yet be present enough in this context.

This picture is generally consistent with what already emerged from the literature review [7,17]. A similar picture was shown with results of quantitative research studies about general consumer behavior in various countries [12,14,15]. Furthermore, studies analyzing the sustainability understanding of consumers within the construction sector using focus groups as a means of data collection also obtained comparable results. In addition, studies surveying stakeholders in other countries' construction sectors also obtained similar findings [7,16]. Accordingly, although the results of this quantitative research study relate only to German consumers in the construction sector, the recommendations for action and perspective for construction companies can certainly be applied within other regions and/or sectors.

5.1. Hypothesis 1

In order to understand when and to what extent sustainability aspects play a role in purchasing decisions, this first hypothesis was used to test what consumers in Germany generally understand by the term sustainability and sustainability in the construction industry. It was assumed that the term "sustainability" is often viewed too one-dimensionally and that many people think primarily of environmental protection and forget—or are not even aware of—the other two dimensions of sustainability.

It could be seen that a particular focus by the respondents lies on the conservation of materials. Regarding the understanding of the general term of sustainability, a focus is set on resource conservation. In the construction sector, the durability of products as well as the optimized use of energy and resources play a major role for consumers. A higher importance of the products' durability to the younger group of consumers could be identified. This can be explained by the fact that younger people live even longer and therefore consume the building product for a longer period of time. With younger consumers, therefore, the criteria of quality and long durability of the product are to be particularly emphasized.

As suspected in the first hypothesis, the aspects most often associated with the concept of sustainability, both in general and in the construction industry, are environmental aspects. Therefore, the first hypothesis was proven true. The concept of sustainability indeed is often understood only in relation to environmental sustainability and that the aspects of social and economic sustainability are not equally considered. This results in

a poorer understanding of the term sustainability, which is frequently used in general language, by a significant number of people. It is worth noting that even if the overall population does not equally associate the three dimensions of sustainability, the younger age group considers aspects of social sustainability as more relevant than older age groups do. Thus, there could possibly exist a greater general understanding of the issue for future generations of builders.

However, in order to promote sustainable development, an understanding of the terms used is essential to ensure good communication about sustainable building products between companies and consumers. Therefore, it is of the highest importance to educate people in order to strengthen their understanding of such relevant terms. This can be done, for example, through school education. Although this is not directly the task of the companies in the construction sector, they also have the opportunity to draw attention to the three dimensions of sustainability. For example, in product advertisement, they can provide information on what makes their product sustainable, referring to all three dimensions.

5.2. Hypothesis 2

In the second hypothesis, the subjective recognition of sustainable building products and its source of information was examined. It was assumed that a subjective understanding of the term sustainability also leads to subjective evaluations of a product's sustainability. This leads to various target groups needing different information based on their subjective perception of sustainability in order to recognize a product as sustainable and possibly make a purchase decision for this reason. It should be noted that this hypothesis was not tested for statistical significance, due to the fact that the hypothesis is so multifaceted that it cannot be formulated into a simple hypothesis test. Nevertheless, it could be determined that various target groups do have a subjective assessment about product's sustainability, which are discussed below.

Regional production, low energy, and CO_2 consumption during production are the most important features for respondents when buying a sustainable product. Subsequently, consumers pay attention to the recyclability of the product and its manufacture under fair working conditions. Very few people state the proportion of recycled material in the product as an important sustainability-related criterion in their purchase decision. It is interesting to point out that the focus on a recyclable product should consequently include products already made of recycled material because if a product is recycled at the end of its life, in the best case scenario, it can create new products from recycled material. However, there is a difference of almost 20% among the respondents who discriminate between recyclable products and products already consists of recycled materials. If all consumers were to buy recyclable products, but no one were to buy products made of recycled materials, the problem of resource shortages would only be postponed, and the responsibility passed on to the future generation of builders. The results of the survey show that younger people are more likely to consider this aspect as relevant when making a purchasing decision. This discrepancy between the two aspects is much smaller than that for older age groups. This could lead to the conclusion that related to the fact that younger age groups, with an additionally higher rated aspect of social sustainability in general, have a more holistic view of the issue of sustainability and therefore may have a greater fundamental understanding of such interrelationships.

When asked how respondents recognize a sustainable product, there is a clear tendency toward certificates or labels and detailed product information. However, the level of knowledge about sustainability certifications in the building industry is very low, despite the high rating of these. Of the sustainability certifications questioned, the "DGNB" and "Cradle to Cradle" certificates are the best known. There were differences between the youngest age group and the oldest one for the "Cradle to Cradle" certificate. In the younger age group, this certificate was mentioned five times as often as in the oldest group. The DGNB certificate, on the other hand, is more familiar in the older age groups, especially among respondents aged 41 to 60. The proportion of people who stated that they are not

familiar with any sustainability certification in the construction industry still dominates by a wide margin. It is also noteworthy that respondents who said they were aware of certificates may only have heard of them and may in fact have no further knowledge about their meaning. Despite the clear fundamental interest in evaluating the sustainability of products on the basis of their certificates, there remains an obvious knowledge gap. This, too, must be addressed in the interest of advancing sustainable development in the construction industry. Consumers' interest in the sustainability assessment using labels should be seen as an opportunity, and therefore, companies should address this interest and apply sustainability certifications to their products more frequently and more prominently. In addition, it is important to educate people about what it means for the product to hold this certificate. Consumers can evaluate a products' sustainability by their preferred criterion and additionally gain an awareness as well as an understanding of sustainability certifications.

In order to be able to make recommendations to companies on how best to respond to this subjective image, it is also necessary to discuss where different target groups obtain information to be able to address the right target groups at the right places. In general, it can be observed that the largest proportion of respondents stated that they obtain information about a products' sustainability from scientific articles and journals, and particularly and frequently from the product manufacturer. Consumers over the age of 60 have a clear interest in obtaining information through the print media as the relevance of daily newspapers within this consumer group are twice that of the average of all respondents. In the same way, trade fairs and information events are more popular with consumers of older age groups than with younger ones. Compared to respondents with no prior knowledge, an almost twice as high proportion of respondents with prior knowledge of the construction industry through a real estate purchase state that this source of information is also relevant to them. This could be explained by people having positive experiences with such sources of information and subsequently rating it as more relevant than before. Despite this positive trend, it should be underlined that the proportion of people who classify trade fairs and information events as relevant are still smaller than the other sources of information. In this context, it should be considered that, due to the global COVID-19 pandemic, these events have not taken place for a long time and for this reason, might not have been of acute relevance to the respondents.

Although daily newspapers are more popular as sources of information for people with prior knowledge in the construction sector, obtaining information through friends and acquaintances is less popular than for those without prior knowledge. Likewise, people without prior knowledge are particularly interested in obtaining information from product manufacturers about the sustainability of various products. In general, it should be emphasized that consumers place great trust in information provided by the manufacturer. Not only do they use this source of information most often to find out what makes a product sustainable, but they also make their general sustainability assessment of when making a purchase decision based on detailed product information from the manufacturer. By presenting information well and enabling consumers to easily obtain information, companies can simplify the purchasing decision for many customers. A simplified purchase decision can then lead to a gain in customers. In particular, people who do not yet have any experience in the construction industry and who may still be about to make the decision to build or buy a house are keen to contact product manufacturers and benefit from a detailed and simplified source of information from the manufacturer.

In summary, it can be seen that depending on the target groups, there are clear differences in what defines a product as sustainable and how this product is recognized as sustainable. It is therefore necessary to pay close attention to which target group the product is aimed at and to adapt the product features accordingly or to create the possibilities for a sustainability assessment by providing detailed information.

5.3. Hypothesis 3

This section examines which criteria are of general relevance when deciding to buy a specific building product and what role sustainability-related criteria play in this context. The third hypothesis was that consumers' criteria leading to purchase decisions in Germany are not consistent regarding the issue of sustainability. It could be determined that consumers give priority to energy efficiency and durability when deciding to buy a specific building product. It should be noted that the aspect of durability was already rated very highly in the question about the definition of sustainability in the construction industry. Therefore, an aspect, which is seen as a suitable association with sustainability in construction is also of high relevance when making a purchase decision for a specific building product. It can therefore be concluded that subjective sustainability-related criteria have major impacts on purchase decision by consumers in the construction sector, as only after this do the criteria of price and outside appearance follow. Furthermore, the aspect of consultation from experts is considered to be rather unimportant. This weak rating is at odds with the fact that consumers look to the product manufacturer in particular when deciding whether a product is sustainable. Consumers may thus feel the need to inform themselves rather than seek advice to achieve a sense of control in obtaining information.

Even though the aspect of the holistic sustainability of the raw is considered to be rather unimportant as well, it has been determined that the rating of this criterion by the respondents within the questionnaire is statistically significantly inconsistent. Consequently, the engagement with the issue of sustainability and the confrontation of one's personal understanding of this topic has a significant influence on how relevant sustainability-related aspects are rated when making a purchasing decision for a building product. This means that consumers are rather willing to pay more attention to sustainability criteria when finding themselves more frequently in a position in which they must deal intensively with the topic of sustainability. Product manufacturers can contribute to this effect by actively recommending the sustainable variant of the product to the consumers. It is furthermore possible to influence the decision-making process through legal regulations, property allocation competitions or discounts for sustainable alternatives to draw attention to sustainable products. Such measures can encourage consumers to consider sustainable product variants over the standard variant. Nevertheless, in order to choose a standard variant, an active decision by the consumers would then have to be made against the sustainable one. It is plausible that in such a scenario the sustainable variant will be chosen more frequently than in the current practice, in which the standard variant is recommended by the product manufacturer and is then chosen due to a lack of engagement with the topic and a certain degree of laziness by the consumers. However, such measures alone cannot necessarily lead to an active engagement by the consumers with their personal understanding of sustainability. Once again, one possibility for reinforcing this development is through school education or education in other areas of training.

6. Conclusions

A quantitative online survey was conducted to assess the consumer behavior of private individuals as end consumers in the German construction industry. This research is a major step in drawing the link of consumers' understanding of sustainability and the relevance of sustainability-related criteria when making a purchasing decision of building products. The study aimed to set guidelines to drive sustainable development within the construction sector. Since the conducted survey only questioned German end consumers, it is important to expand research within different regions and sectors. In such work, other stakeholder groups can, for example, be further investigated making use of AHP analysis or structural equation.

The key conclusions of this study can be summarized as follows:

- An interest in purchasing sustainable building products does exist within the German construction sector;

- Consumers do not have a holistic understanding of the concept of sustainability, as the focus lies clearly on environmental aspects, with social and economic aspects tending to be neglected;
- Knowledge gaps can be explained by the fact that end consumers in Germany are rarely engaged in a construction project and therefore do not have a profound opinion about the sustainability of building products when they are faced with a corresponding purchasing decision;
- Due to the relevance and the resulting trust in the manufacturer's product information, companies have the opportunity to inform consumers comprehensively and possibly direct them toward sustainable products;
- Companies need to reach out to potential consumers and offer them the opportunity to obtain comprehensive information about the sustainability of products. The use of sustainability certificates and labels might be a helpful method of drawing attention to the sustainability of products.

Companies within the construction sector play a significant role in driving sustainable development. In the short term, they should focus on environmental aspects when advertising their products. However, in the long-term, they need to face the responsibility of providing information about all three dimensions of the sustainability of their products. This approach is the only way to ensure a long-term, mutual understanding of crucial concepts and the associated product information. Sustainable product variants must be in the foreground to clearly draw attention to them and thus to make a purchase decision in their favor as simple as possible. If sustainable products are not marketed more prominently, or if they are not available at all, consumers will continue to prioritize standard versions through lack of knowledge or even laziness. Finally, the fundamental interest of the consumers in sustainable development of the construction industry must be addressed and a framework to facilitate more sustainable purchasing decisions must be established.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee at the Medical Faculty of RWTH Aachen University (approved 26 September 2022).

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