


Research

The understanding of the agriculturally shaped environment: from the theoretical construct to an applied indicator of sustainable development

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Received: 24 May 2024 / Accepted: 28 August 2024

Published online: 05 September 2024

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Abstract

Sustainable development of the resource 'land' is increasingly being discussed with a focus on rural areas. Understanding is key to solving land use conflicts. It can lead to joint solutions and can thus enable sustainable development at a practical level. It goes beyond environmental consciousness, which is related to general issues, and instead aims to address concrete challenges in the context of sustainable development at an applicable level. 'Understanding' with regard to land use conflicts has not yet been defined in the literature. Based on this motivation, it is the aim of this study to create the construct of 'understanding' conceptually, to validate it empirically with structural equation modelling, and to demonstrate that understanding might be an important prerequisite for sustainable development. In this case, the focus is not on a general kind of understanding, but rather on specific aspects of understanding in relation to the agriculturally shaped environment in rural areas. The empirical data for the paper were collected by means of a large-scale population survey in Western Pomerania, Germany, a rural peripheral region characterized by typical land-use conflicts in predominantly rural areas. A tripartite division of the construct into cognitive, emotional, and opinion levels was derived theoretically. The construct is supported empirically and that it can be applied as an SDG indicator. Thus, the refined construct of understanding the agriculturally shaped environment can make a substantial contribution towards closing the knowledge/attitude-behavior gap.

Keywords Environmental understanding · Attitude-behavior gap · SEM · SDG indicator · Land-use conflicts · Sustainable development

1 Introduction

Sustainable development is crucial to maintain a vital life for humanity. A very suitable testfield of this transformation is the resource 'land', as agricultural land use, crops, and livestock were responsible for approximately 20% of global greenhouse gas emissions in 2018 [1]. Land-use conflicts are exacerbated by climate change. Examples include

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s43621-024-00462-5>.

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climate change-related environmental risks, such as floods and droughts [2]. In this context frequent lines of conflict occur between or within the domains of food security (large-scale vs. small-scale, conventional vs. organic) and nature conservation, but also energy use (e.g., biomass for biogas production, location for wind and solar farms). Many different viewpoints, experiences, and knowledge come together and this can lead to conflicts. Land use conflicts can hinder sustainable development, therefore resolving such conflicts is quintessential to sustainable development [3, 4]. To increase sustainable land use and overcome related conflicts it is important to achieve policy support through narratives and norms. The power to influence narratives and norms is contained in society [5]. This is, why this study focuses on the societal level and therefore on people's subjective understanding of the agriculturally shaped environment.

A focal point of research in this context lies in the contribution towards closing the attitude-behavior gap. This gap entails that knowledge or attitudes are often insufficient to result in pro-environmental behavior. Here, environmental consciousness is often seen as an important prerequisite for sustainable behavior, which typically involves general attitudes and intentions concerning pro-environmental behavior or the environment [6]. However, challenges in the context of sustainable development and climate change can only be met in concrete terms (e.g. rewetting of peatlands). Recent research follows the same line of argument, stating that it is more relevant to solve environmental problems if the starting point for deriving theories is the concrete problem that needs to be solved (inductive approach to theory development) [7, 8]. One way in which this demand can be met is with the introduction of specific geographical references into environmental psychology. This approach is followed here by the case of Western Pomerania, a predominantly rural region in the northeast of Germany, which needs to transform to sustainable land use and shows general as well as place-specific land use conflicts.

Conflict research has shown that understanding the point of view of others and the creation of mutual understanding can effectively assist in finding common solutions [9, 10]. Therefore, a central challenge in promoting sustainable development lies in bringing together the varying degrees of knowledge and skills from different (groups of) people [3, 11–13]. In this way, the different perspectives, horizons of experience, and areas of knowledge could be used to find common solutions for sustainable development. Understanding is an important prerequisite for conflict resolution [9, 10]. In this paper, it is applied to land use conflicts and takes the relevance of land use for climate change (especially greenhouse gas emissions) into account. Therefore, a broad understanding of issues related to the agriculturally shaped environment can avoid ending up in destructive land use conflicts and enables constructive sustainable development [14].

So far, understanding in the context of land use conflicts has been scarcely researched. One approach to tackle this research gap is to first derive a generalized construct of understanding and to then relate this to processes concerned with the agriculturally shaped environment as well as the actors in it. By establishing the understanding of the agriculturally shaped environment as a multifaceted construct, deeper insights with more practical relevance into regional challenges concerning sustainable development can be gained than is possible by means of environmental consciousness, which refers to general issues. We aim to demonstrate that the different facets of understanding are an important prerequisite for pro-environmental behavior and thus, sustainable development, not least because understanding goes beyond the cognitive and opinion level (attitudes) of the attitude-behavior-gap since it also has an emotional (affective) level.

Based on these goals we aim to derive the understanding of the agriculturally shaped environment as a multi-faceted construct and investigate if this structure is empirically supported by data collected in a large-scale population survey ($N = 2084$) in Western Pomerania, Germany, a prime example of a rural region with current land use conflicts.

2 Conceptual background

2.1 From environmental consciousness to the understanding of the agriculturally shaped environment

In this section, we argue that pro-environmental behavior is implemented in concrete contexts and thus understanding is more appropriate for concrete solutions and actions than environmental consciousness. Therefore, we first derive a core construct of understanding.

A well-established finding in research on pro-environmental behavior is that pro-environmental attitudes as well as knowledge regarding environmental issues often do not directly translate to pro-environmental behaviors

[15, 16]. This effect is referred to as the attitude-behavior gap and is a focal point of contention in research on pro-environmental behavior [6, 17, 18]. Several models deal with environmentally friendly behavior and the explanation of the gap between knowledge, attitude, and intention on the one hand and (sustainable) behavior on the other, e.g. the model for the explanation of sustainable actions [19] or the meta-analytic structural equation model of environmentally friendly behavior [20].

According to the model of pro-environmental behavior [6], such behavior is affected by a multitude of internal as well as external factors, including a three-dimensional environmental consciousness with a cognitive, emotional, and values/attitudes dimension, which are expected to influence the aim of achieving pro-environmental behavior. The attitude-behavior gap emerges as a result of different intermediating factors such as lack of internal and external incentives and possibilities, lack of environmental consciousness [6], or also the so-called 'Dragons of Inaction Psychological Barriers'—scale [21]. Accordingly, environmental consciousness is a crucial determinant for promoting environmentally friendly behavior.

In the literature, there are many definitions of environmental consciousness with varying scopes depending on the area of application [22–24]. While different definitions concur that environmental consciousness incorporates three components (environmental knowledge, environmental experience, and consternation and environmental value orientations, e.g., [6, 22]), the definitions differ in terms of their underlying concepts, as well as the importance attributed to the components. For instance, when compared to [22], the affective component is broader in the model by [6] (e.g. affective relationship to nature) and includes attitudes in addition to the values-component. The latter suggests that the model of pro-environmental behavior [6] does not explain comprehensively their 'environmental consciousness' using a three-part attitude concept (as in [22]), but rather see attitudes as a factor within environmental consciousness.

However, there is a gap between a general level (construct), such as environmental consciousness, and the concrete (level) land-use conflict in a specific place. Sustainable development is strongly negotiated in rural areas, which means that specific issues come into play (e.g., organic/conventional farming vs. paludiculture). These issues often manifest themselves in land-use conflicts. To meet the concrete challenges in the context of sustainable development, it makes sense to also approach the topic at the concrete level and thus follow the correspondence principle [25, 26]. This is done here by focusing on the understanding of the agriculturally shaped environment, since it does not refer to general attitudes, but is instead thematically tied to the specific land-use conflicts of a region.

Understanding itself has not yet been clearly defined in the literature. There are different approaches to conceptualizing understanding with regard to a certain object [27]: they often evolve around language understanding, textual understanding, understanding in communication, or Max Weber's understanding of social action or also understanding within psychoanalysis [27–32]. Understanding is always object-related, but it can still be traced back to concrete components. This core concept will be derived in the next sections.

The complexity of understanding is often dealt with in the literature by introducing different dimensions of understanding. This is also reflected in the literature where a cognitive and an emotional level of understanding already recur: for example, in the psychology of understanding according to Jaspers, the hermeneutic circle is repeatedly listed with aspects as opposites (e.g. rational and genetic understanding, empathic understanding) [33, 34]. In order to, on the one hand, map the complexity of the term, and, on the other, different population groups' perspectives on sustainable development in rural areas and their "accesses" to the topic, a multidimensional construct is suitable [35]. The related concept of environmental consciousness also suggests multidimensionality [e.g. 6, 22].

The concept of understanding used here goes beyond the cognitive level and also includes an emotional as well as an evaluative level (opinion). Therefore, types of knowledge do not completely encompass understanding (see

Table 1 The three-level approach to understanding

| | | |
|-------------------------|---|-----------------------|
| Cognitive Level | ➔ | Sense Acquisition |
| Emotional Level | ➔ | Affective Experiences |
| Level of Opinion | ➔ | First Assessment |

Table 1). In this context, the *cognitive level* is best described by sense acquisition or connected understanding [27, 36, 37]. The *emotional level* is best described by affective experiences which are also a basis for empathy. This affective aspect is also named by [27]. Here, understanding a person or an action is achieved by comprehending the world of experience of the person to be understood [27]. Accordingly, those who have similar worlds of experience can comprehend more easily. It is easier to comprehend the demands of farming if, for example, one has grown up on a farm or one's spouse is a farmer [38]. Here it is therefore primarily a matter of being able to understand through experiences that are associated with emotions rather than the subjective feeling that a person has of understanding or being understood by someone else. As a consequence of the concept of understanding used here the latter has an important effect on mutual accommodation, which in turn supports sustainable development [39].

We propose a *third level* of understanding, in which people reflect and evaluate for the first time based on the previous levels and form a view or an *opinion*. In conflicts, it is important to be able to understand or comprehend the point of view of others as well [40]. On the other hand, different opinions can also lead to conflicts in the first place [41]. Therefore, they are an essential part of understanding. In this context, opinions are a form of expression of attitudes, which are also described as a non-consistent part of attitudes [42].

Other theories and models support the argument that the three levels of understanding are relevant for leading sustainable action: for example, emotions play a significant mediating role in predicting the effect of knowledge on environmental behavior [43].

Likewise, the dissolution of spatial and temporal distance, e.g. by directly experiencing the effects and thereby making climate change visible, is very useful for the promotion of environmentally friendly behavior [38]. Nevertheless, emotional reactions do not necessarily lead to corresponding behavior [44].

On the cognitive level, the phenomenon of cognitive dissonance must be listed, but it also has an impact on the opinion and emotional level. This can lead to various consequences (including, for example, adapting behaviors due to knowledge). Different kinds of knowledge play a crucial role due to the complexity of the conflicts by contributing to the awareness of the actors involved [3].

In addition, this proposed tripartite division is also reflected in environmental consciousness according to [6]: there is a cognitive level ('knowledge'), an affective level ('feelings, fear, emotional involvement'), and a third level in, which 'opinion' as an expression of 'attitudes' is also included. As a meta-model, the individual internal factors cover a broad range of meanings, so that the understanding developed here represents a specified and operationizable concretization of the generally held environmental consciousness.

According to the attitude-behavior-gap, both the cognitive level and the attitude level considered alone would not be sufficient to lead to pro-environmental behavior [6]. In the concept of understanding used here, an emotional level is addressed in addition. By adding the emotional level, the understanding construct contributes more towards pro-environmental behavior and in this case closes the gap substantially more than only a cognitive or attitudinal level would. And thus, the understanding construct, at least, allows for a statement about the potential for sustainable development. Nevertheless, for a direct predictor of pro-environmental behavior, further factors would have to be fulfilled (e.g., external factors according to [6]).

It was possible to derive a three-dimensional construct of understanding from the literature. In order to apply these dimensions in the context of land-use conflicts and thus support the achievement of sustainable development, a corresponding object is required—the agriculturally shaped environment. The derivation of this object is the subject of the next chapter.

2.2 The object of understanding—the agriculturally shaped environment

Land is one of the world's most central and limited resources [45]. The resource land itself as well as its use "... are subject to a variety of conflicts worldwide" [2] (e.g. between agriculture and nature conservation, tourism and energy production, the spread of settlement areas, and preservation of space for recreation) [46].

Land-use conflicts are exacerbated by climate change, for example, due to floods and droughts [2]. On the one hand, land use is affected by climate change, but at the same time, the type of land use also affects the climate and the environment. In terms of dealing with climate change, many challenges lie ahead for agriculture, e.g. as a result of land-use changes, both to adapt to climate change and to be more climate-friendly [47]. Therefore, agricultural land use is one of the most important aspects of sustainable development due to the extent of area used, its value creation, its supply function (food, energy), and further ways nature contributes to people [2, 48]. In this context, frequent

lines of conflict occur within the domain of food security (large-scale vs. small-scale, conventional vs. organic) and between food security and nature conservation, but also energy use (e.g. biomass).

Land-use conflicts and their resolution are central to sustainable development [3]. Thus, it seems all the more important to mitigate potential conflicts to enable a common sustainable development and avoid or reduce negative impacts from conflicts that occur [14]. Conflict research has shown that understanding the point of view of others and the creation of mutual understanding can effectively promote the finding of common solutions [9, 10].

Conflict usually arises from different interests or different opinions. Conflict resolution can take place for example through consensus building, conflict transformation, or even cooperation [3]. This paper is primarily concerned with regional and local non-violent land use conflicts which are characterized by high levels of complexity. This includes multiple stakeholders with different interests, and knowledge and values associated with a variety of political and administrative contexts and levels [3]. The emergence and the resolution of conflicts both involve cognitive and emotional levels as well as an opinion level, which is why a multidimensional understanding can play a crucial role in conflict resolution [49].

The outstanding importance of agricultural land and the associated land use conflicts in the context of sustainable development and the fact that agricultural land is mostly located in rural areas, makes this a space where many land use conflicts are fought out. Therefore, the object of understanding here will be the agriculturally shaped environment.

In the following, the individual aspects of the word group 'agriculturally shaped environment' will be derived and explained.

The concept of environment is to be understood broadly here and follows three parts of the hierarchical concept in ecology. Thus, both the physical and ecological environment, as well as what is related to it and experienced internally by people (psychologically), play a role [50].

'Agriculturally shaped' opens up the association with related economic sectors such as the manufacturing industry or energy supply. Furthermore, it is an individual interpretation of what is perceived as 'agricultural', which is always accompanied by an individual horizon of understanding and experience.

In this context, the agriculturally shaped environment contains areas used for agriculture, such as pastures, fields, meadows, and kitchen gardens, but also structures used for agriculture and the processing of its products and wetlands. Settlement areas, forests, coasts, and beaches are not included here.

Thus, the theoretical multi-dimensional construct of understanding with a cognitive, emotional, and an opinion level is derived as well as its object: the agriculturally shaped environment. Nevertheless, the specification of the object serves as the content orientation of the items for the questionnaire.

Based on these theoretical results we aim to address the following empirical research question in the following parts of the paper: is the theoretically derived structure of the construct of understanding empirically supported in our data?

3 Methods

3.1 Study region

The empirical data used in this paper were collected by means of a large-scale population survey in the German region of Western Pomerania. The region exhibits typical examples of conflicts related to more sustainable land use, which is why it seems particularly suitable for the development of the construct of the understanding of the agriculturally shaped environment and therefore serves here as a study area.

Western Pomerania is located in northeastern Germany and is a part of the federal state of Mecklenburg-Western Pomerania. It shares a border with Poland. The study area consists of the two Western Pomeranian districts Vorpommern-Rügen and Vorpommern-Greifswald. Its population density is very low (65 inhabitants per km²) and it is one of the economically weakest regions in Germany [51] (see Table 2).

This paper focuses on some of the land-use conflicts that are most relevant in the region: due to the socialist past of the region, during the existence of the German Democratic Republic (GDR), a large-scale, less sustainable agricultural landscape developed there, which is now strongly oriented toward a scale economy [55, 56]. At the same time, the proportion of organically farmed land in the region is comparatively high for German standards [57]. This reflects the different land-use requirements.

Table 2 Characteristics of the population in Western Pomerania in 2019. Source: based on data from [52–54]

| | |
|-------------------------------------------|---------|
| Population | 460,325 |
| Female | 234,613 |
| Male | 225,712 |
| Population density (per km ²) | 65 |
| Net migration | 2647 |
| Natural population change | – 3481 |
| Average age (in years) | 45.6 |
| GDP per capita (in €) | 26,627 |
| Unemployment rate | 8% |
| Share of agricultural land | 63% |

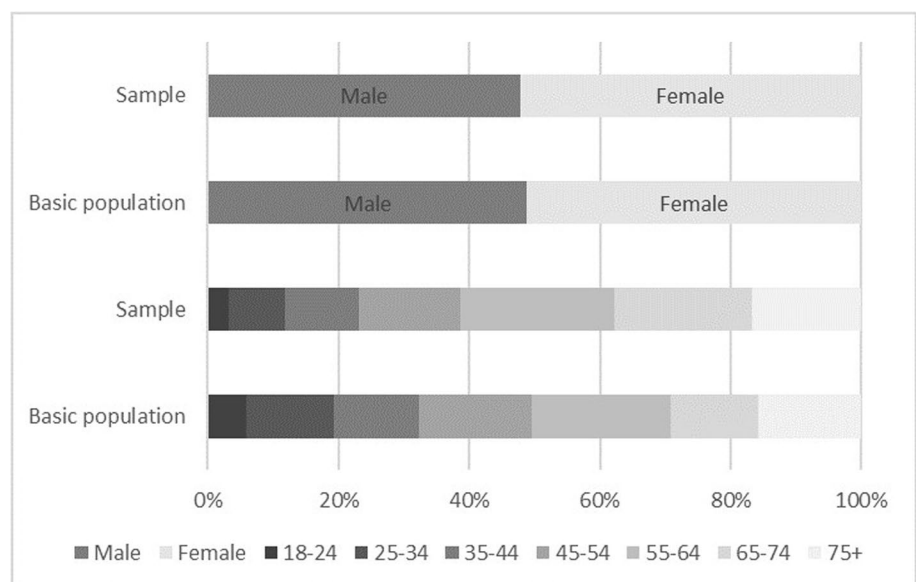
As a result of the transformation processes in agriculture in the former GDR after the German reunification, an alienation from agriculture has developed in many places, among other things due to agricultural cooperatives losing the social functions they previously fulfilled and also because of the rationalizations (loss of jobs) [56, 58]. Likewise, an overall alienation from nature can be observed [59–61].

Another very important issue for Mecklenburg-Western Pomerania is the management of drained peatlands. Drained peatlands are the largest emitters of greenhouse gases in Mecklenburg-Western Pomerania. Rewetting and using these areas for paludiculture (when peatlands that are wet or rewetted are used agriculturally for the cultivation of biomass) [62] could thus make a major contribution to preserving the climate [46]. On the other hand, for farmers, this means a conversion which is connected with financial expenditure as well as a decrease in the value of their land. Acceptance by the population is also relevant for rewetting measures. This goes hand in hand with fears of flooded cellars or insect plagues. Thus, Western Pomerania is an ideal example of typical urban–rural land-use conflicts.

3.2 Data

The data for this paper are from a population survey on the demands on the agriculturally shaped environment in Western Pomerania. It was implemented as a written postal survey. A random sample of 12,496 people was drawn from all adults whose primary residence was in the study area. This sample is stratified by municipality-level. The response rate was 16.68% (*N* = 2084 data sets collected, 2078 included in the final analyses: age: *M* = 57.40, *SD* = 16.505, age range of participants 18 to 98 years old; sex: 1074 female, 981 male). The sample is representative for the characteristic sex, and somewhat overrepresents older persons (see Fig. 1).

Fig. 1 Representativity of sex and age (Source: based on data from [53])



The questionnaire contains four thematic blocks related to the population of Western Pomerania: (1) utilization of the agriculturally shaped environment, (2) cognitive understanding of the agriculturally shaped environment, (3) demands on the agriculturally shaped environment, and (4) socio-demographic characteristics. For the construct of understanding being considered here, a selection of questions of the survey were relevant. These questions were divided into six sections (see Appendix). The questions were developed by experts in the respective domains regarding (sustainable) land use, but also based on theoretical considerations derived from the literature regarding the understanding levels. The content is oriented towards the main lines of conflict in Western Pomerania, which on the one hand concern the value chain of regional products, but on the other hand, also the climate impact of peatlands as well as the cultural ecosystem services that people can gain from their interactions with the environment. In terms of content, there are questions about the everyday use of the agriculturally shaped environment, contextual knowledge related to relevant topics in the agricultural environment of Western Pomerania, direct contact with agriculture, and opinions about specific topics in the agricultural environment.

3.3 General analytical approach

The analyses conducted in the present study were carried out within a structural equation modeling (SEM) framework. Specifically, in our analyses, we focused on identifying and extracting a reliable factor structure from the collected data, including different ordinal and dichotomous items. Further, we investigated the interrelations between the identified factors and key demographic variables (i.e., age and sex).

Our analytical approach consisted of three major parts: (1) an exploratory part that investigated the factor structure of the data, (2) a confirmatory step used to test the suitability of the identified factor structure, and (3) a final step where the factor scores obtained from the previous parts were related to demographic and further relevant variables. To account for potential issues when conducting exploratory and confirmatory analyses on the same dataset (i.e., overfitting) and to ensure a robust and stable solution [63], we randomly split our data set ($N=2078$, 6 cases were excluded due to excessive amounts of missing data) into three practically equal subsets ($n_1=692$, $n_2=693$, $n_3=693$). The first two subsets were used in the exploratory part of our analyses. The remaining subset was held back for the subsequent confirmatory analysis steps. Once a satisfactory factor structure was identified, the three subsets were recombined in the final step of the confirmatory analyses to obtain the greatest possible precision for our estimates.

Given the dichotomous and ordinal scale levels of our data, the diagonally weighted least squares (WLMSV) estimator and theta parametrization were used for all models. Following this approach, the fit indices describe the fit of the factor models to the polychoric correlation matrix of items [64, 65]. Previous research has shown that this estimator is particularly suitable for ordered data [e.g. 66].

3.3.1 Exploratory factor analyses

To identify the most suitable number of dimensions in our data, we examined scree plots and used Velicer's Minimum Average Partial (MAP) criterion [67] on the two subsets of data reserved for exploratory analyses. Subsequently, exploratory factor analyses (EFA) were conducted on the range of suitable dimensions. Given that we expected the extracted factors to be interrelated in geomin rotation, an oblique rotation method was used. The selection of factor structure used in the subsequent analysis steps was informed by theoretical consideration regarding the factor structure (e.g., the coherence of the factors obtained) and statistical recommendations for scale design and exploratory factor analyses [68, 69]. Specifically, a factor was deemed suitable if at least one item loading had a loading on this particular factor $>|0.60|$ or two or more items showing loadings $>|0.50|$ and at least three items loadings $>|0.40|$ [68]. Factors that did not meet these criteria were removed from subsequent analysis steps. Cross loadings were included if the item loaded $>|0.60|$ on the factors it was primarily loading on and if the difference in loadings between the first and the second factor it was loading on was $>|0.20|$. Items that did not sufficiently load onto any factors (i.e., all loadings $<|0.40|$) or showed cross-loadings that did not meet the outlined criteria were removed from the analyses.

The aforementioned steps were carried out on both subsets of data reserved for exploratory analyses and the results were compared. When analyses on both subsets yielded comparable results, the model was deemed sufficiently consistent for confirmatory analyses.

3.3.2 Confirmatory factor analyses

The model identified in the exploratory step was then fitted to the subset of data withheld for confirmatory analyses. Similar to previous steps the model was fitted using the WLSMV estimator. Fit measures (i.e., χ^2 statistic, root mean squared error of approximation, Tucker–Lewis Index, Confirmatory Fit Index) were extracted to assess how well the model represented data. Once a satisfactory fit was obtained the model was fitted to the full dataset and factor scores were extracted for subsequent analyses. Finally, we estimated to which extent the obtained model measuring the understanding of the agriculturally shaped environment exhibited measurement invariance across sexes by comparing three models in nested model comparisons. Specifically, a comparison was made between (1) the initial model with free factor loadings and intercepts, (2) a model with (in part) equality constraints on the loadings, and (3) a model with (partially) constrained item loadings and unstandardized item thresholds. If a comparison revealed significant differences in the equality constraints for item loadings [when comparing (1) and (2)], and thresholds [comparing (2) and (3)], the loadings were then released, stepwise, in order to obtain partial invariance [70]. Partial scalar invariance was achieved by the aforementioned stepwise release of item loading conducted based on model modification indices. We followed a systematic approach where all thresholds are constraints within a factor (except those required for identification purposes, see [71]). Subsequent analyses were based on factor scores obtained from the (partially) invariant model.

3.3.3 Further analyses

In the final modeling step, we related the obtained factors to each other, demographics, and to further relevant variables (e.g., one item of the Extended Inclusion of Nature in Self scale [72]) using correlational analyses. Further, we used analyses of variance to analyze if differences between the sexes were present in any factor in the understanding of the agriculturally shaped environment.

3.3.4 Statistical software

Analyses were conducted using R, Version 4.2.2 [73] and Mplus, Version 8 [65]. Specifically, scree plots and the MAP criterion were calculated using the ‘EFA.dimensions’ package [74]. EFA was carried out using MPLUS. CFA and tests of measurement invariance were conducted using ‘lavaan’ [75]. Lastly, correlational analyses and ANOVAs were implemented using R’s ‘base’ and ‘stats’ packages.

4 Results

4.1 Exploratory factor analyses

MAP analyses on all 52 items for the first two subsets revealed that a five-factor structure was optimal according to both the original [67] and the revised criterion [76] in both datasets. Investigations of scree plots for both subsets yielded the same result.

An exploratory factor analysis using the WLSMV estimation on the geomin rotated correlation matrix revealed a five-factor structure. Initial analyses of loadings revealed that 10 and 11 items respectively were initially removed from analyses because they did not load sufficiently on any factor (i.e., loadings $>|0.40|$ on an item level). Further, six and five items respectively were removed because they had cross-loadings that did not meet the criteria [69]. This step was conducted to ensure that an unambiguous and simple structure was retained. The removal of these items resulted in four-factor solutions in both subsets (see Fig. 2). Theoretically informed inspections comparing the factor structure in both models revealed only minor differences. Specifically, the only differences identified were caused by loadings of four and three items respectively that were slightly below the predefined threshold (loadings $\geq |0.34|$). No loadings on other factors or differences in cross-loadings were found between both solutions, indicating a stable solution (see Appendix).

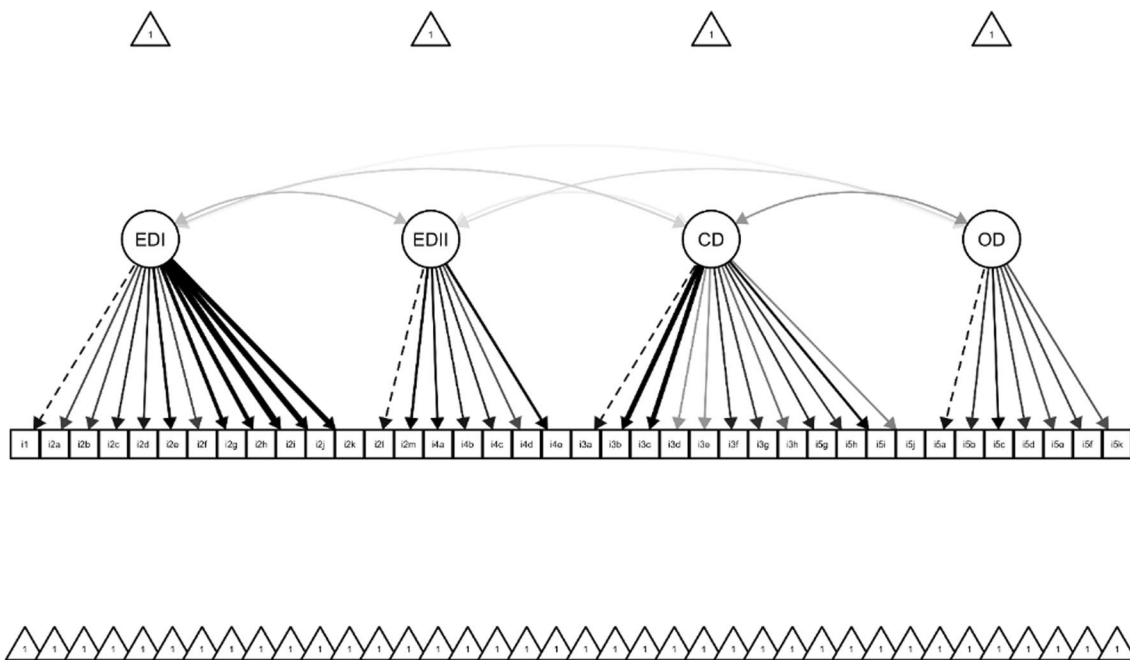


Fig. 2 SEM structure of the understanding construct

4.2 Confirmatory factor analyses

Confirmatory factor analysis applying the identified factor structure to the subset of data withheld for confirmatory analyses using the WLMSV estimator revealed satisfactory fit measures (RMSEA = 0.050, CFI = 0.898, TLI = 0.891). Results further showed that all items loaded significantly onto their factor, indicating no need for further analyses. A subsequent confirmatory factor analysis testing the model on the entire dataset revealed comparable, satisfactory fit indices (RMSEA = 0.056, CFI = 0.882, TLI = 0.874) (see Fig. 2).

Analyses of the internal consistency of the identified factors revealed that factor one had good internal consistency (Alpha = 0.86), factors three and four had sufficient internal consistency (Alpha = 0.78 and Alpha = 0.79), whereas factor four showed a lack of internal consistency (Alpha = 0.54). Based on post hoc content-driven considerations the subscales were labeled emotional dimension I (ed I), emotional dimension II (ed II), cognitive dimension (cd), and opinion dimension (od) (see Fig. 2).

For tests of measurement invariance, two further items had to be excluded because one of the ordinal-scale options was not chosen in one of the groups (items: 3a and 3g). Comparisons of a model with unconstrained and constrained item loadings across sexes revealed a significant difference in the model fit ($X(32) = 61.41, p < 0.010$). Lifting the equality constraint between sex groups for the items with the four largest differences in item loadings across sexes [items: 2e, 2f, 2g, 2i] yielded a model with partial measurement invariance (difference between the unconstrained and partially constrained model: $X(28) = 34.829, p = 0.175$). The obtained model was subsequently compared to a model with constraints to examine scalar invariance, thereby revealing a lack of scalar invariance ($X(90) = 338.34, p < 0.001$). Subsequently, items' thresholds were constrained one scale at a time to test if, partial invariance can be achieved by freeing thresholds within a specific subscale. The results showed that partial invariance was achieved through the threshold in ed I ($X(48) = 62.831, p = 0.074$). For identification purposes, all but one threshold were restrained for the entire subscale, except for five items (1, 2a, 2b, 2c, 2d), where all thresholds were restrained.

4.3 Further analyses

The correlation matrix featuring the four identified factors of the understanding and demographic variables can be found in Fig. 3.

Fig. 3 Correlation plot. Larger circles represent stronger correlations. Insignificant correlations ($p > 0.05$) are left blank

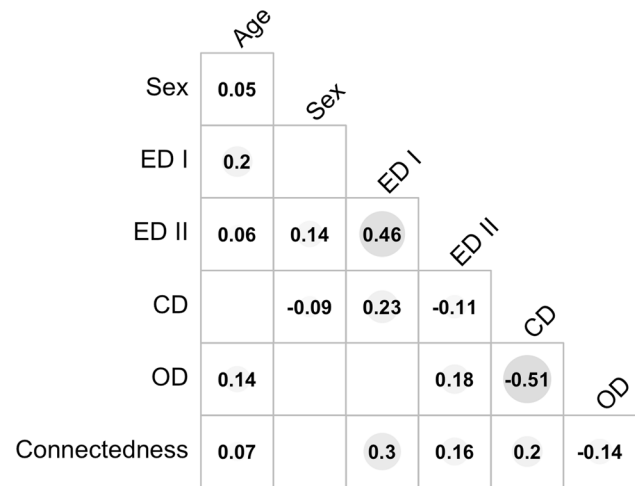


Table 3 Scale means by sex

| Sex | ed I M 95%-CI | ed II M 95%-CI | cd M 95%-CI | od M 95%-CI |
|--------|--------------------|----------------------|---------------------|---------------------|
| Female | 0.08 [0.04, 0.12] | -0.13 [-0.16, -0.11] | 0.21 [0.13, 0.29] | -0.02 [-0.07, 0.03] |
| Male | 0.04 [-0.01, 0.08] | 0.01 [-0.02, 0.04] | -0.04 [-0.13, 0.05] | 0.02 [-0.04, 0.07] |

A multivariate Analysis of Variance (MANOVA) comparing scores between the sexes for the four subscales identified in the analyses outlined above revealed differences ($F(4, 2050) = 19.907, p < 0.01, \eta^2_p = 0.04, 95\% \text{ CI } [0.02, 0.05]$). Post hoc tests using univariate ANOVAs revealed a significant sex difference in the mean subscale scores for ed II ($F(1, 2053) = 44.02, p < 0.001, \eta^2 = 0.02, 95\% \text{ CI } [0.01, 0.03]$), with women ($M = -0.130$) scoring significantly lower than men ($M = 0.010$) and cd ($F(1, 2053) = 17.01, p < 0.001, \eta^2 < 0.01, 95\% \text{ CI } [0.00, 0.02]$), with women ($M = 0.211$) scoring significantly higher than men ($M = -0.040, 95\%$) (see Table 3). For the remaining subscales, no significant differences were found ($F_s < 2.316, p_s > 0.130$).

5 Discussion

5.1 Validity and resilience of the construct of the understanding of the agriculturally shaped environment

The present study investigated how a multidimensional conceptualization of environmental understanding can provide more detailed insights into environmental conflicts and behaviors. Specifically, understanding of the agriculturally shaped environment as a construct consisting of cognitive, emotional, and opinion facets was theoretically derived and embedded into the existing literature on pro-environmental behavior as a critical prerequisite for closing the attitude-behavior gap. Further, empirical support for the proposed structure was found using data from a large-scale assessment of land use conflicts in a rural German area. Specifically, SEM indicated that the empirical data was best represented by a model of understanding with four dimensions: one cognitive, two emotional, and one opinion dimension.

With regard to emotional understanding, two subdimensions have namely emerged. One, representing general contact with the agriculturally shaped environment (ed I), which was very stable across all analyses, and one with a strong contact with agriculture (ed II), in which the internal consistency was critically low. This may be due to several reasons: First, it is the subdimension in which many dichotomous items are found. Thus, a different data level could be the decisive factor. On the other hand, the response distribution of some items (yes/no) is very one-sided (in some cases, only 2.9% of respondents answered that they had contact with agriculture to the extent indicated in the item), which also has to do with the dichotomy of the variable.

The problem can be solved in later studies by ordinal scaling of the items or by reformulating the items so that a larger part of the population feels addressed when testing the scale in other regions. This second emotional subdimension could have better internal consistency in even more rural regions (probably located in other countries rather than Germany).

At the same time, however, the response behavior also reflects the great alienation of the population from agriculture in particular (see Sect 3.1). This shows once again how important it is to promote mutual understanding, especially in the field of agriculture.

One explanation for why the emotional dimension is split into two subdimensions could be that it makes a difference both thematically and in terms of intensity whether someone has contact with the environment more generally or specifically with agriculture. Accordingly, however, it is important to address both aspects, since otherwise certain challenges (e.g., general contact with the environment but no contact with agriculture and thus potentially less understanding of agricultural issues or, conversely, many contacts with agriculture and otherwise little contact with the environment, perhaps also a lack of affective access) would not be recognized. On the other hand, the different data levels (dichotomous versus ordinal) and the problems already explained could favor this differentiation into two dimensions.

Partial invariance was established in the model. This means that measurement properties for the items and initial factors differ across the sexes. However, through constraints imposed on item loadings and thresholds, these issues were alleviated. For further research applications of the measurement of the level of the construct, a direct comparison of the sexes using sum scores to obtain factor scores is not recommended, as sex differences in ed II might be caused by differences in the functioning of items across sexes. This may indicate a sex difference in attitudes towards sustainability with women generally having more positive attitudes towards sustainability than men, which has also been documented in the literature [77, 78].

For the second sub-facet of emotional understanding, significant differences between sexes were found even after potential invariance issues were accounted for. This indicates a pronounced difference in contact with agriculture, which has been repeatedly shown in the literature: In Germany, men are predominantly employed in agricultural occupations, which means that their contact with agriculture is, on average, more intensive than that of women [79, 80]. In Mecklenburg-Western Pomerania in particular, the difference between the proportion of men and women employed in agriculture is even greater than the national average [81, 82].

There are also significant correlations between the individual dimensions of understanding and also the control variables 'age', 'sex', and the 'Inclusion of Nature in Self' scale [83] (see Fig. 3). The latter scale thereby maps the implicitly perceived connection between self and nature [83]. The initial intention was to include it as an item in the dimensions, but since the correlation with all dimensions of understanding is slightly too moderate, it is used here as a control variable. Thereby, nature connectedness correlates moderately with ed I. This reflects a well-known correlation: Those who have more contact with nature have a higher nature connectedness [e.g. 84, 85]. "Naturalist knowledge" also correlates positively with closeness to nature [85]. This could be significant in the weak correlation of cd with nature connectedness. At the same time, nature connectedness correlates slightly negatively with od. This dimension of understanding includes some rather conservative or conventional (profit-oriented) opinions related to agriculture. One consideration is that people with a generally conservative attitude and also a tendency towards materialism may also be more likely to agree with statements related to industrial agriculture in the understanding dimension. Political conservatism as well as materialism are negatively correlated with nature connectedness [85]. For people who have contact with agriculture (ed II), the aspect of nature connectedness through exposure as well as a tendency towards industrial agriculture (slightly positive correlation) probably come into play. The fact that the environment is not only regarded as "nature" per se but also as an economic basis plays an additional role so that ultimately a slightly positive correlation between ed II and nature connectedness comes about (see Fig. 3).

Within the dimensions of understanding, there is a high negative correlation ($r = -0.51$) between od and cd (see Fig. 3). On one hand, the high correlation can be explained by the partial overlap between opinion and cognition. Therefore, the cd also includes items from the opinion variable. It is important to note that the term "attitudes" is not used unambiguously in psychology. Thus, there is a multiplicity of definitions, some are one-dimensional e.g. [86, 87] or there are those with three components such as the ABC model [88]. Three-component approaches often have an affective, a behavioral, and a cognitive dimension. This may be an important indication of why the cognitive level partially overlaps with the opinion level in the construct studied here (see Fig. 3).

The opposite direction of the correlation can be explained by the content orientation of the items of the two scales, namely that the cd is more oriented towards sustainability and the od towards conventional agriculture. Thus, a further underlying structure can be suspected (see Fig. 3).

Another high correlation ($r=0.46$) exists between ed I and ed II. This seems logical since they both represent sub-dimensions of the emotional dimension of understanding: contact with the agriculturally shaped environment. And additionally, Western Pomerania is very rural, therefore contact with the agriculturally shaped environment is easy. A moderate correlation ($r=0.27$) exists between the ed I and the cd. One conjecture is that it is likely that ed I with general contact with the agriculturally shaped environment is also associated with more sustainable attitudes and cognitions. This is contrasted with a low correlation ($r=0.18$) between ed II and od, again suggesting similar attitudes. In this case, alienation towards conventional agriculture (see Fig. 3).

5.2 Limitations

The present study is limited by its reliance on a single data set for both exploratory and confirmatory analysis steps. Therefore, a robust modeling approach, designed to alleviate the potential issues of overfitting, was used. In general, a larger sample size could be better for the representativeness and robustness of the effects. However, the data used here represents the population of the region very well and the absolute number of observations (> 2000) is statistically sufficient to produce robust results. Nevertheless, it would be appropriate to further validate the proposed structure of understanding construct. Future studies could address the impact of external factors on the distribution of understanding within the population and in different spatial and regional contexts. In addition, future research could test whether the proposed structure of the understanding construct holds true in other regional contexts (e.g. dust bowl syndrome or post-mining landscapes) and populations.

5.3 Application of the understanding construct in the context of land use conflicts and sustainable development

The construct of the three-part understanding developed here in the context of land use conflicts and, thus, as a key element to advance sustainable development was based on the example of Western Pomerania, which has many typical examples of land-use conflicts. It can be transferred to other regional contexts in the future by adapting the content of the items and, ideally, a new statistical test of the construct must also be conducted.

In practice, the construct of understanding can be used as an indicator, e.g., to monitor the characteristics of the individual dimensions of understanding within a certain population group or a certain region. In this way, statements can be made about regional differences in the characteristics of the understanding dimensions. Based on this, it would be possible to find out whether there is a need to increase the understanding of a certain group of the population in a certain dimension, e.g. increasing the emotional dimension of urban inhabitants who are alienated from nature by farm visits. By establishing a concrete reference to specific socio-demographic characteristics and a corresponding spatial relation, it is possible to implement appropriate educational measures in the real world. In this manner, conflicts can be prevented or defused in the long term and common solutions for sustainable development can be found by developing mutual understanding.

The four understanding dimensions for which empirical evidence was found in this paper can help to specify policy measures to foster sustainable development. Existing research in other areas of sustainable development (e.g. green energy) has already shown that understanding emotional responses is vital for securing public acceptability, with emotions often stemming from how projects align with or violate people's core values [89]. This can be transferred to the challenge of sustainable land use change as well. Additionally, leveraging emotions like empathy and perspective-taking can influence pro-environmental behavior, with low-fear interventions potentially having a more significant positive effect on promoting sustainability [90]. Furthermore, the complexity of developing strategies for sustainable regional development necessitates a deeper cognitive understanding of the intricate causal relationships within economic, environmental, and societal systems [91]. The ability to alter narratives in the society by policy interventions relies on the ability to influence key elements such as attitudes, beliefs, or values. This refers to the opinion dimension of understanding. Narratives in turn influence policy, rules and infrastructure [5].

Especially for the Sustainable Development sub-goals 4.7 and 12.8, this construct can be used as an indicator. Such an indicator can be applied in sustainability reports at the municipal or regional level. For this purpose, only the weighted sums of the individual dimensions need to be calculated after the variables have been surveyed.

6 Conclusion

The purpose of this study was to theoretically derive and empirically test the new multidimensional construct for understanding the agriculturally shaped environment. A multidimensional theoretical understanding construct with an emotional, a cognitive, and an opinion level was successfully derived and put into an application-oriented relation—with the agriculturally shaped environment of Western Pomerania as an object, exemplary of a region with many land-use conflicts. It has been shown that resolving land use conflicts is essential for successful sustainable development. Understanding is relevant as a prerequisite for conflict resolution. The construct of understanding developed here could be located in the meta-model of [3] on environmentally friendly behavior, which clarifies the relevance of understanding for sustainable development. After the development of the theoretical construct, the empirical research question was pursued to establish whether the construct could be empirically proven. This was examined using a two-step approach: after the theory-based conceptualization of the items, an explorative factor analysis was conducted on all items to identify the general structure of the construct. To circumvent overfitting issues, this procedure was conducted on two separate subsets of the data. A confirmatory factor analysis was then implemented on a subset of data to identify the most suitable factor structure. This analysis was separate from the explorative analysis steps. Items were excluded and partial measurement invariance was identified. Thus, measurement instruments mapped the understanding of the agriculturally shaped environment. Furthermore, the construct can be applied as a regional SDG indicator in practice as a tool to detect potential conflicts, understand conflicts and challenges in a differentiated way, and then respond effectively with concrete measures to increase mutual understanding and find common solutions for sustainable development. Future research can make the developed construct transferable for regions with other conflict lines by thematic adaptation of the items and, ideally, by also re-testing statistically.

Author contributions Judith-Maria Maruschke: conceptualization, writing—original draft, data curation, methodology, software, formal analysis. Franz Wortha: methodology, software, formal analysis, writing—review & editing. Daniel Schiller: writing—review & editing, supervision, funding acquisition, conceptualization.

Funding Open Access funding enabled and organized by Projekt DEAL. The underlying research was supported by the Federal Ministry of Education and Research (BMBF), Germany, within the funding initiative ‘Stadt-Land-Plus,’ ‘Vorpommern Connect’ project (grant number 033L211A).

Data and code availability The anonymized data set and code will be available at the repository of the University of Greifswald after completion of the dissertation of Judith-Maria Maruschke: ckan.fdm.uni-greifswald.de/dataset/xx_xx_2019_population_survey_voco_ap4.

Declarations

Competing interests The authors declare no competing interests.

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