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Public Perception of Biodiversity Landscape Elements and Autonomous Technologies in Small-Scale Production Systems

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Abstract

The perception and evaluation of rural landscapes resulting from human interaction with nature is highly subjective. However, understanding how the non-agricultural population views the impact of an altered landscape image is crucial. This paper explores the German population's perceptions of changes in agricultural landscapes brought about by multi-crop, small-scale field structures (strip intercropping) combined with the introduction of biodiversity landscape elements and field robotics. An online survey was conducted with German residents aged 18 and older (n = 2,022). Preferences and the importance of individual image components were analysed based on four images depicting a field with strip intercropping, featuring various combinations of tractors, robots, and flowering strips. Participants' emotional associations with key image components were also measured. The findings reveal that nearly two-thirds of respondents preferred the image featuring a flower strip and a tractor, associating it with concepts such as green, nature, and environment (flowering strip), as well as the traditional image of agriculture (tractor). Among the two images without flower strips, the tractor was preferred over the robot by more than a sixfold margin. Conversely, the image with a robot and flower strips was chosen about as frequently as the image with a tractor but without flower strips. Additionally, the study highlights how socio-demographic characteristics may influence the evaluation of agricultural landscape changes. Two logistic regression models indicate that factors such as age, gender, direct contact with farmers, and respondents' reported "green consumption value" significantly impact preferences of specific landscape components. Overall, the results suggest a preference for landscapes that are both familiar and environmentally oriented. Nevertheless, the use of autonomous technologies and the shift towards small-scale diversified production systems are not broadly rejected.

Keywords

Autonomous farming technologies; biodiversity; public acceptance; rural landscape; strip intercropping.

Presenter Profile

Andreas Gabriel is a member of the 'Digital Farming' working group at the Bavarian State Research Center for Agriculture. With extensive experience in empirical social research, his work focuses on investigating the social acceptance and adoption of digital technologies in agricultural practice.

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Introduction

The visual perception of a rural landscape ("landscape image") is an important factor for acceptance of individual features in agricultural structures among both agricultural stakeholders and the general public. This perception is influenced, e.g. by associated farming processes and environmental effects and is strongly shaped by the subjective perspective of the individual (cf. Roth et al., 2011). Therefore, interactions such as the introduction of new production systems and structural elements (e.g., agroforestry systems, flower strips, etc.) or the use of new technologies (e.g., field robots) to promote ecological sustainability must also be discussed and evaluated in terms of its impact on the landscape.

In light of current efforts to promote biodiversity-enhancing production systems (FAO, 2023; Ruggeri Laderchi et al., 2024), small-scale diversified crop production systems such as strip intercropping are gaining importance (cf. Alarcón-Segura et al., 2022; Spykman et al., 2023). Strip intercropping refers to the simultaneous cultivation of different crops on the same field in parallel strips (Vandermeer, 1989). If established on a larger scale, this production system has far-reaching impacts on the landscape image compared to conventional farming. It is assumed that the management of such small-scale diversified production systems can be made labour-efficient through automation (e.g., automatic steering systems and section control), or by using autonomous technologies such as field robots or drones (cf. Lowenberg-DeBoer, 2021; Gackstetter et al., 2023). Particularly, the introduction of autonomous technologies would further change both the aesthetic appearance of the landscape and agricultural practices.

Previous research has demonstrated the influence of user experience and knowledge about a technology's purpose on the evaluation of its visual impact on the landscape image: Dentzmann and Goldberger (2020) examined images of a biodegradable alternative to conventional polyethylene mulching foil in focus group discussions with farmers. It was found that the evaluation of this alternative was strongly dependent on the experiences of the respondents, with functional knowledge influencing the visual assessment (Dentzmann and Goldberger, 2020). The visual assessment of the landscape image within the professional group is thus also based on knowledge about farming methods, their feasibility, and economic prospects.

However, it is not easy to determine how groups that are not familiar with the operational functions of landscape-shaping farming measures will react to changes in the landscape. Positive ecological effects often occur as part of conservation measures associated with "disorder", but these measures do not necessarily diminish a certain preference for "tidy" landscapes and familiar landscape images. In this regard, farmers differ from the non-agricultural society in their perception and evaluation of the landscape (Burton, 2012). In contrast to farmers, the non-agricultural society partly evaluates linearity in landscape images as negative and "unnatural" (Laroche et al., 2018). The aesthetic perception weighs heavier than other evaluation criteria such as agricultural production or conservation. It is postulated that planting natural elements (e.g., bushes) in linear, structured cultivation forms (e.g., straight rows) can evoke feelings of "cultural dissonance" (Laroche et al., 2018). However, the type of landscape image culturally established is relevant in this context. For example, an agroforestry system within traditional orchards generates higher acceptance (e.g., measured in higher willingness to pay) if more than one crop is grown between the tree rows (Alcon et al., 2020), i.e., if more structures are present. However, not only the visual quality of the landscape was evaluated, but also the associated ecosystem services and cultural heritage, represented by manual management as opposed to a tractor (Alcon et al., 2020). This approach also points to the complex interplay of visual perception and associated processes for the non-agricultural population. Warren-Kretzschmar and Von Haaren (2014) emphasize the relevance of positive visual evaluation by society as an important aspect besides the ecological benefits of agricultural practice. This likely also generates acceptance for a change in the cultural landscape.

In addition to changes in the landscape image through new agricultural systems or structural elements, an impact from the use of technologies in the fields is expected. Although autonomous technologies such as field robots are associated with various benefits, including reduced labour costs (Lowenberg-DeBoer et al., 2021), a survey of farmers showed that concerns about a negative image of "alienated agriculture" in the population can influence the planned acquisition of field robots (Spykman et al., 2021). Previous research on the population suggests that field robots tend to be rated neutral to positive (Pfeiffer et al., 2020). However, Willmes et al. (2022) describe a negative impact on the willingness to pay for food produced with the help of digital technologies. The authors add that this negative impact can be reduced by additional ecological benefits of the technologies. These findings are reflected in a choice experiment on autonomous technologies in weed control, where the method of weed control (mechanical vs. herbicide broadcast and spot-spraying) influenced the decision more than the degree of autonomy of the technologies used (Spykman et al., 2022). However, a joint consideration of autonomous technologies and altered production systems has not yet been undertaken.

The aim of this paper is to analyse the perception of the German population regarding new small-scale diversified production systems, the integration of structural (biodiversity) elements such as flower strips, and the use of autonomous technologies such as field robots using an online survey. A special focus is on identifying and evaluating the triggers for potential preferences and the connections to individual visual components. This is done by categorizing short associations provided by survey participants in connection with their preference decisions. Furthermore, this paper also includes a segmentation analysis and illustrates how various sociodemographic characteristics of the population influence the evaluation of agricultural elements such as flower strips or the use of automated technologies.

Methods

Online survey among the German population

A nationwide online survey of the German population aged 18 and older was conducted from mid-September to mid-October 2023. Access to this consumer panel was facilitated through the engagement of a field service provider. The use of a consumer panel allows the separation of personal data and content data, so that research ethics can be assured. The panel enables a pre-stratification of the sample to ensure that participants were representative of the German population in terms of age, gender, size of residential area, and federal state. In addition to various sociodemographic data, information on leisure activities in rural areas, personal connections to agriculture, attitudes towards technology, local food production and sustainable consumption, and knowledge of agriculture, was gathered using established market research methods. After the final data validation, the survey sample comprised 2,022 usable and completed data sets.

Analysis of preferences, motives, and short associations

In a question set regarding visual evaluation, participants were asked to assess various aspects of a landscape image with strip intercropping using four photomontages. All four image variants were based on an identical strip intercropping image which shows a machine passage. The differences included the use of a field robot instead of a tractor and the presence of flower strip. All four images were photomontages that were deliberately not realistic (slightly divergent size of the machines) but were designed to increase the recognizability of the various components for participants (Table 1).

Table 1: Choice of image variants for respondents

Variants	Robot/ no flower strip	Tractor/ no flower strip	Robot/ with flower strip	Tractor/ with flower strip
Visualization of the image variants for selection				

Note: Image sources: Photomontages, Bavarian State Research Center for Agriculture, 2023.

The four images were presented simultaneously to the participants and without randomised arrangements. After selecting their preferred image variant, participants were asked to choose three out of six predetermined image components that influenced their decision, ranking them in order of importance. Four of the six selection options were 'the robot in the field', 'the tractor in the field', 'the flower strip between the fields', and 'the tidiness of the adjacent field strips' as variable image components. The latter component refers to the order and straightness of the parallel field strips as a structured form of cultivation without any interruption, e.g., by a flower strip. As a control option, participants were offered 'the beautiful row of trees in the background', which was identical in all image variants. As the sixth selection option, 'another reason' could have been chosen and provided with a text response. The selected image components were counted and weighted according to their specified rank — rank 1 received a triple weight, rank 2 double weights, and rank 3 single weights. This approach allows for the consideration of all three mentioned image components and a composite ranking.

In a follow-up question, survey participants were asked to provide up to three short associations in the form of keywords related to the decisive image component (first rank). These rather spontaneous associations to the picture components shown offer additional insights into the decisive image component and the choice of image variant. While the ranking of predetermined image components served the cognitive evaluation by the participants, the affective and thus emotion-based approach of short associations provides another dimension for determining acceptance (Busch et al., 2019; Pfeiffer et al., 2020; Langer et al., 2022). After data cleaning, a total of 4,872 usable keywords as spontaneous associations for the components of the four images were available. Most of these were related to image 4 (tractor/with flower strip), for which a total of 3,092 keywords were analysed and categorised, manually and in several iterations, into 33 categories. From these, the 16 most frequently mentioned categories (covering 2,995 keywords) were identified and prepared for this contribution.

Modelling the factors influencing preferences

Another goal of this contribution is to identify possible sociodemographic influences on the preference for one of the four image variants. Based on similar studies, it was assumed that personal factors such as age, gender, size of residential area, or living in a specific region (e.g., East Germany with large-structured landscapes) play a role, as may the respondents' direct connection to an agricultural environment (Devlin, 2005; Boogard et al., 2008; Pfeiffer et al., 2020). Additionally, the Green Consumption Value (GCV), which reflects the respondents' tendency towards environmentally friendly shopping behaviour, was used as a value- and attitude-based factor. This was measured using six items (Haws et al., 2014). These six items, presented in a Likert-type scale format, were condensed into an individual standardized factor score through factor analysis and considered as a metric predictor for the selection of the image variant. Since respondents could also choose between the use of a tractor and a field robot in the images shown, the attitude towards technology (ATT) was assessed using nine items in a Likert scale format and condensed into a standardized factor score (Edison and Geissler, 2003). For both scales, negative factor values indicate a stronger manifestation of this characteristic, while positive values indicate a lower manifestation. While the typology of survey participants regarding GCV is right-skewed, indicating that participants' purchasing behaviour is predominantly environmental-conscious according to their statements, attitude towards technology is more evenly distributed, showing a balanced ratio between technology-oriented and tech-averse respondents (Figure 1).

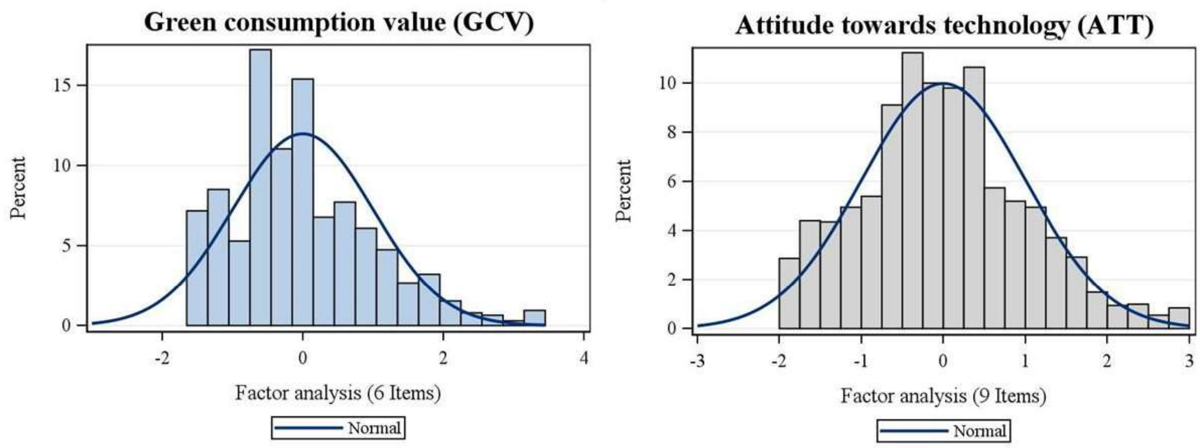

Figure 1: Distribution of the factor values for green consumption value (GCV) and the attitude towards technology (ATT) of the respondents (n = 2,022); GVC: median: -0.11; skewness: 0.774; kurtosis: 0.525; ATT: median: -0.09, skewness: 0.339; kurtosis: -0.127

Multivariate regression models determine the relationships between multiple predictor variables and a dependent variable. For binomial and categorical dependent variables, logistic procedures are used to determine the probability of the occurrence or non-occurrence of an event (e.g., selection of an image) based on the values of the included predictor variables (Backhaus et al., 2018). Logistic regression provides information about the transformation of the dependent variable logit (p):

$$logit(p) = ln\, p/(1-p) \; = \; ln\,(Odds\ Ratio) \qquad (1)$$

where p is the probability that the selection of a particular image is influenced by the measured characteristics, and 1−p is the corresponding non-selection. The odds ratio represents the ratio of these two probabilities. When incorporating k predictor variables, the model takes the following form:

$$logit(p) = \ln p/(1-p) \ = \ \beta_0 \ + \ \beta_1 x_1 \ + \ \beta_2 x_2 \ + \ \dots \ + \ \beta_k x_k \qquad (2)$$

The regression equation provides information about the importance of each predictor based on the values of the coefficients (βk), allowing for the creation of a hierarchy of the measured variables' effects on group assignment (Backhaus et al., 2018).

To capture the overall effects and explanatory contribution of the selected influencing factors on image preferences based on the specific image elements ‘image with robot’ and ‘image with flower strip’, two binomial logistic regression models were estimated. For this purpose, the image preference was dummy coded as the dependent variable (Model A: 1 = one of the two images with a robot was chosen; Model B: 1 = one of the two images with a flower strip was chosen). Sociodemographic characteristics included gender (1 = female), age (1 = < 40 years), size of residential area (1 = < 20,000 inhabitants), geographical location (1 = western German states), and educational level (1 = no general higher education entrance qualification). Respondents' statements regarding personal connection to agriculture was included in the modelling either as personal employment in the sector (1 = yes) or through personal contact with agriculture in the circle of friends or acquaintances (1 = yes) (cf. Pfeiffer et al., 2020). The metric factor scores of GCV and ATT were also integrated into the two models as additional independent characteristics.

Results

Distribution of preferences and selection motives

In a central question, participants were asked to evaluate changes in the landscape based on single images, considering both the use of robots instead of tractors and the additional use of flower strip. The overall distribution of the stated preferences indicates that the variant with flower strip in conjunction with fieldwork performed by tractors is preferred (Image 4 in Table 1: 67.6%). The image variant ‘tractor without flower strip’ (Image 2 in Table 1) is preferred by 15.3% of the 2,022 respondents, while 14.6% chose the robot in combination with flower strip (Image 3 in Table 1). Only 2.5% of the survey participants favoured image 1 (see Table 1), in which the robot was depicted on the field without flower strip.

Figure 2 shows the results of the ranking of the image components that were decisive for the participants' preference choices. For images 3 and 4, which depict the robot and the tractor respectively, the flower strip shown in both images is the primary component (41% and 43%, respectively).

This is followed by the technical aspect – robot or tractor – with 27% and 28%, respectively. The ‘beautiful row of trees in the background’, an identical component in all four images, ranks third in both variants (13% and 14%, respectively). The ‘tidiness of the adjacent field strips’ is also frequently mentioned for both images 3 and 4, with 13% each. For images 1 and 2, which depict the robot or tractor without the flower strip, the focus is primarily on the technological aspect, cited as the reason by 39% for the robot and 40% for the tractor. The second place in these variants is occupied by the ‘tidiness of the adjacent field strips’ (30% and 31%). As ‘other reasons’, respondents noted for image 2 (tractor without flower strip) that it best represents the familiar image of traditional agriculture and that the flower strip is perceived as rather disruptive to core fieldwork. Regarding image 4 (tractor with flower strip), some respondents remarked that the flower strip specifically symbolizes nature and animal conservation for them. For images 1 and 3, which show fieldwork done by a robot, innovation, potential efficiency gains, and novelty were mentioned as distinct motives for selection.

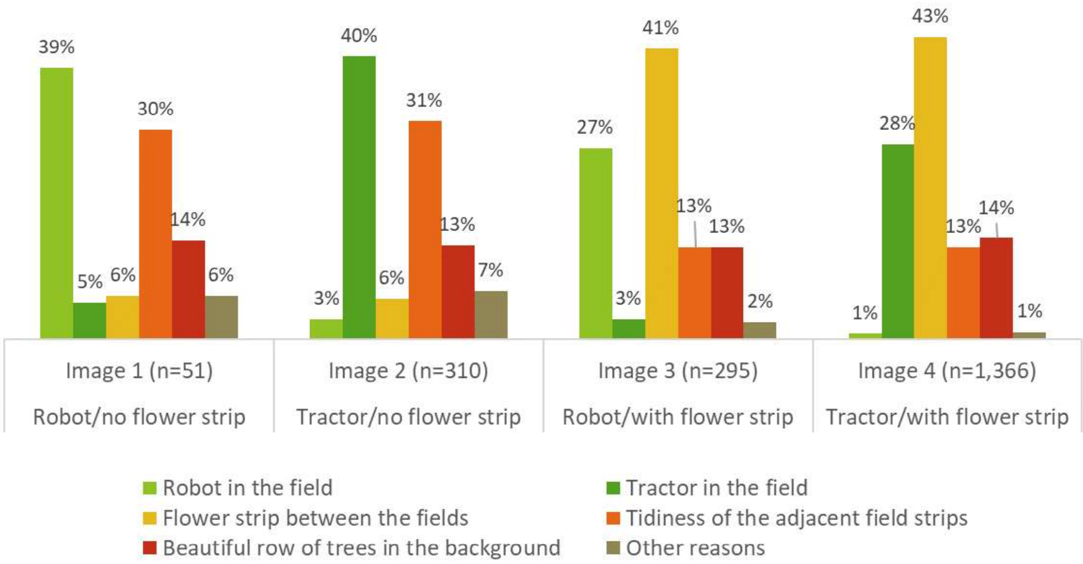

Figure 2: Distribution of preferences and selection motives

Factors influencing preferences

The two binominal logistic regression models examining the influence of sociodemographic characteristics on the selection of images with robots and images with flower strip demonstrate distinct effects. Gender influences the selection of images with the robot (Table 2) as female participants are significantly less likely to choose images with a robot compared to men (Odds Ratio = 0.434). If respondents have personal contacts with acquaintances in the agricultural sector, the likelihood of selecting the robot image is significantly lower. Interestingly, respondents with personal agricultural experience exhibit an opposite, though not statistically significant effect. No additional influence factors, such as the attitude towards technology or origin from western or eastern German states, affect the preference for a field robot compared to a tractor.

Table 2: Logistic regression model A 'Field robot'

Predictors Model A Field robot	B	*SE*	Wald	p	Odds Ratio	95% CI LL	95% CI UL
Gender (1=female)*	-0.835	*0.337*	6.137	0.013	0.434	0.224	0.840
Age (1=younger than 40 years)	0.067	*0.392*	0.029	0.864	1.069	0.496	2.304
Education (1=no A-levels and below)	0.100	*0.332*	0.090	0.764	1.105	0.576	2.118
Size of place of residence (1=less than 20k inhabitants)	-0.288	*0.342*	0.706	0.401	0.750	0.384	1.467
Region (1=Western Germany states)	-0.314	*0.367*	0.730	0.393	0.731	0.356	1.501
Own agricultural experience (1=yes)	0.405	*0.670*	0.365	0.545	1.499	0.403	5.572
Personal contact with farmers (1=yes)*	-2.088	*1.043*	4.008	0.045	0.124	0.016	0.957
Attitude towards technology (ATT) (negative factor value = higher degree)	-0.034	*0.141*	0.059	0.808	0.966	0.732	1.275
Green Consumption Value (GCV) (negative factor value = higher degree)	0.087	*0.178*	0.239	0.625	1.091	0.770	1.546
Constant***	-1.398	*0.406*	11.892	0.000	0.247		

Note: ***p<0.001, *p<0.05; $\chi^2(9) = 16.460$, p = 0.058; Nagelkerke's $R^2 = 0.076$; (Cox & Snell $R^2 = 0.036$) | Total percentage of assignment classification (contribution of predictor variables) = 90.3% | Source: own survey

In the selection or non-selection of images with flower strip, some sociodemographic factors differ from those influencing the machinery aspect in model A (Table 3). Persons younger than 40 are significantly less likely to choose the flower strip compared to older individuals (Odds Ratio = 0.381). The size of the respondent's place of residence also plays a crucial role: a person living in a village or small town (less than 20,000 inhabitants) is almost 1.6 times more likely to choose the flower strip than someone in a more urban environment. Individuals with a less pronounced sustainable purchasing behaviour (negative factor values of the GCV) are less likely to select images with flower strip (Odds Ratio = 0.652).

Table 3: Logistic regression model B 'Flower strip'

Predictors Model B Flower strip	B	*SE*	Wald	p	Odds Ratio	95% CI LL	95% CI UL
Gender (1=female)	0.272	*0.244*	1.250	0.264	1.313	0.814	2.117
Age (1=younger than 40 years)***	-0.966	*0.262*	13.602	0.000	0.381	0.228	0.636
Education (1= no A-levels and below)[a]	-0.228	*0.244*	0.876	0.069	0.796	0.493	1.284
Size of place of residence (1=less than 20k inhabitants)*	0.451	*0.248*	3.305	0.049	1.570	0.965	2.554
Region (1=Western Germany states)[a]	0.519	*0.267*	3.791	0.052	1.681	0.997	2.835
Own agricultural experience (1=yes)	-0.470	*0.431*	1.189	0.276	0.625	0.268	1.455
Personal contact with farmers (1=yes)	0.260	*0.368*	0.499	0.480	1.297	0.630	2.669
Attitude towards technology (ATT) (negative factor value = higher degree)	0.033	*0.104*	0.101	0.751	1.034	0.843	1.268
Green Consumption Value (GCV) (negative factor value = higher degree)***	-0.428	*0.141*	9.146	0.002	0.652	0.494	0.860
Constant**	0.827	*0.312*	7.044	0.008	2.287		

Note: *** $p<0.001$, ** $p<0.01$, * $p<0.05$, [a] $p<0.1$; $\chi^2(9) = 37.843$, Nagelkerke's $R^2 = 0.122$; (Cox & Snell $R^2 = 0.080$) | total percentage of assignment classification (contribution of predictor variables) = 78.7% | source: own survey.

Evaluation of short associations

For the evaluation of the short associations, the most frequently selected image 4 ('tractor / with flower strip', Table 1) was used. The mentioned keywords were assigned to a category system developed as part of the analysis, and the respective mentions were counted. Depending on which image component was decisive for the participants in choosing image 4, there were different frequencies of assignments to the categories. Table 4 shows the most frequent assignments in the category system, indicating the rank for the main components 'flower strip', 'tractor', and 'the tidiness of the adjacent field strips'. With the flower strip being the main motive for choosing image 4, it is predominantly associated with a functioning ecosystem (green/nature/environment). Within this category, numerous keywords refer to 'biodiversity', 'species diversity', and 'habitat for insects and bees'. The second most frequently mentioned keywords relate to the aesthetics of the landscape, such as 'colourful', 'idyllic', 'beautiful', or 'vibrant'. The third most frequently used category for the flower strip includes terms that express well-being, such as 'joy', 'peace', 'life', 'friendliness', 'strength', or 'harmony'. Other frequent mentions can be categorized under variation ('no monoculture'), soil and soil protection, neat and tidy ('separated'), relevance/useful, agriculture in general, season, and familiar image/tradition.

The categories agriculture in general and familiar image/tradition are most frequently associated with the image component tractor and therefore achieve a significantly higher rank than for the flower strip. These two categories include terms that describe agriculture in general and neutrally, such as 'farmer', 'sowing', 'ploughing', or the mention of specific tractor manufacturers. The category familiar image/tradition includes keywords such as 'home', ‘familiar’, ‘known’, ‘normal’, ‘original’, or ‘tradition’. Other frequent associations for the tractor fall into the categories of maintaining jobs and work in general, where the working conditions and activities of the farmers themselves are emphasized. Keywords such as ‘human work’, ‘people’, ‘workplace’, ‘craft’, and ‘good work’ indicate a positive evaluation of agricultural activity.

Table 4: Frequencies and ranking of the main categories of keywords mentioned for the three most frequent image components for the selection of image 4

	Image components					
	Flower strip		Tractor		Tidiness of the adjacent field strips	
Association category	**Mentions**	**Rank**	**Mentions**	**Rank**	**Mentions**	**Rank**
Green/Nature/Environment	1,535	1	54	5	25	2
Aesthetics	347	2	21	8	15	4
Well-being	175	3	64	4	17	3
Variation	52	4	0	26	1	9
Soil and soil protection	43	5	5	14	0	13
Neat and tidy	37	6	9	10	49	1
Relevance/Useful	25	7	3	16	1	9
Agriculture in general	23	8	175	1	12	5
Season	21	9	2	20	0	13
Familiar image/Tradition	14	10	91	2	0	13
Nostalgia	11	11	31	6	1	9
Maintaining jobs	3	20	66	3	0	13
Efficiency/Quality	3	20	14	9	5	6
Work in general	2	22	25	7	1	9
Retrograde step/Old	0	30	3	16	2	7
Modern/Trendy/Progress	8	16	2	20	2	7
Total	**2,299**		**565**		**131**	

Further in the ranking, similar frequencies of assignment are shown as for the image component flower strip. Even with the tractor, the categories well-being, green/nature/environment, and aesthetics are frequently occupied. Although the constant image component ‘beautiful row of trees in the background’ represents the third most frequent mention for image #4 (see Figure 2), frequent evaluations of the landscape image of strip cultivation are also mentioned for the component ‘tidiness of adjacent field strips’ (see Table 4). The associations with tidiness, in terms of the orderly arrangement of field strips, can mainly be assigned to the category of neat and tidy. Examples of assigned keywords include adjectives such as ‘well-kept’, ‘clean’, ‘conscientious’, ‘precise’, or ‘symmetrical’. Following in the ranking are other categories that are also frequently mentioned in connection with the flower strip, such as green/nature/environment, well-being, or aesthetics.

Discussion and Conclusions

If a small-scale diversified production system offers various ecological benefits, the question arises as to how such production systems should be technologized and designed. This is important to ensure public acceptance and, consequently, consumers’ willingness to pay for such production systems and their elements. The evaluations of the preferred images and the decisive individual components suggest overall preferences for natural or near-natural landscape images (e.g., flower strip) among the general population. Furthermore, a 'familiar' image of agriculture (tractor) is also preferred. In the image variants without flower strip, the survey participants chose the tractor more than six times as often as the robot, which may be reflected by the fact, that the use of field robots in agriculture is yet not being widespread and therefore hardly known.

However, the image variant with a robot and flower strip is chosen about as often as that with a tractor but without a flower strip. This aligns with observations from similar studies, which indicate that the use of autonomous machines in the field is not fundamentally viewed critically by society (Pfeiffer et al., 2020) or that the degree of autonomy is considered as secondary to the reduction of herbicides in food production (Spykman et al., 2022). According to the survey responses, strip intercropping, as a production system that changes the familiar landscape image, is not generally rejected. Both with and without flower strip, the visually assessed 'tidiness of the adjacent field strips' received a moderate level of approval and is associated with both an orderly structure and the categories of aesthetics and green/nature/environment. This result of the present study mitigates the conclusions of Laroche et al. (2018), which suggested that natural vegetation in linear structures causes dissonance. However, the additional increase in acceptance of the changed landscape image due to the flower strip aligns with previous findings, which indicate that consumers desire food production to be as "natural" as possible (Zander et al., 2013; Kühl et al., 2019).

The method of querying visual preference with subsequent affect-oriented key words (short associations) serves as a more in-depth source of information about the motivation behind decisions for or against rural landscape components. The mentioned keywords can mostly be assigned to categories considered positive or neutral. Due to the initial question about a preference for an image variant, it is assumed that the respondents almost exclusively mentioned positive or neutral reasons rather than negative exclusion criteria. Thus, negative associations were hardly present, so no conclusions can be drawn about which image components cause rejection and for what reasons. In other studies, on image-based evaluations of production processes in agriculture, for example, free associations without prior preference queries (Kühl et al., 2019; Pfeiffer et al., 2020) or agreement on a scale between two opposing word poles (Busch et al., 2019; Langer et al., 2022) were asked. In the present study (in reference to image 4), the mentioned keywords for the flower strip were mostly assigned to positive association categories. This may not only underscore the subjective well-being or aesthetic aspect of this element for the participants but also its functional importance for environmental and soil protection. The tractor, as another decisive selection element of this specific image, triggers more neutral associations, such as familiarity with this image of agriculture. This neutral evaluation is also reflected in the frequency of more general keywords mentioned regarding agriculture, such as tractor brands or field operations. In addition to the image causing associations with well-being, the tractor is also known to be viewed as a symbol of maintaining jobs in agriculture (Pfeiffer et al., 2020). However, the low mention of the image component 'robot' by those participants who selected an image with a tractor (Figure 2) suggests that the choice was not made due to the rejection of the robot.

A preference for autonomous field equipment based on the selection of images showing a field robot can be demonstrated for certain characteristics in the population. While age and education level do not play a role in our sample, men show a higher likelihood of agreeing to the use of robots in the field than women. Also, a lack of direct contact with agricultural practice seems to be a reason to break away from the familiar image of the tractor and prefer the use of robotics (in the context of strip intercropping). This insight is consistent with social constructivist theoretical approaches, which often postulate that knowledge and views are constructed through social processes and interactions (Gergen, 1985). For the flower strip as the most important reason for image selection, the likelihood of preference increases among older people, those living in rural regions, and respondents who consider themselves "green consumers". The latter correlation is well established in consumer research literature, which shows that a preference for sustainable consumer products can lead to the non-environmental characteristics of a product or production process also being rated more positively (Haws et al., 2014), even if these are not known in detail. This possibly explains the higher preference for the image of the robot with a flower strip compared to the robot without a flower strip, although further investigations are necessary for a reliable statement in this regard. It can still be assumed that for individuals with a high degree of GCV, the evaluation of the use of autonomous technology is positive, provided it results in more sustainable production methods. The two models explored selected variables influencing preferences for landscape components. Future studies should consider additional factors, such as the population's knowledge of farming practices, experiences, or attitudes towards ecology and nature.

In previous research on field robots, surveys of farmers have already played an important role (e.g., Spykman et al., 2021). Also, studies on the perspectives of manufacturers and stakeholders in the agricultural machinery industry show that the interests of the non-agricultural society and non-human actors such as animals, landscapes, and soil have not yet been adequately recognized as relevant stakeholders (cf. Ayris et al., 2024). Although the approach of Responsible Research and Innovation (RRI), as discussed by Rose and Chilvers (2018) and Regan (2021), primarily emphasizes the social science perspective, the broader ecological context must not be overlooked to also consider the societal perspective on changes in landscape structures. The present contribution thus addresses a crucial aspect for future research: the view of the non-agricultural society on the impacts of changed landscape images due to small-scale production systems and the use of new farming technologies.

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