

Citizens' Willingness to Pay for Sustainable Innovations: Evidence from Six European Union Member States

Consentement des citoyens à payer pour des innovations durables : observations dans six États membres de l'Union européenne

Die Bereitschaft der Bürger, für nachhaltige Innovationen zu zahlen: Erkenntnisse aus sechs EU-Mitgliedstaaten

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Previous studies on innovation have predominantly focused on aspects such as the cost-benefit analysis of implementation, factors influencing innovation adoption, and the development of business models. However, little has been done to address the impact of sustainable innovations on the generation of public goods at the pan-European level. This study aims to fill this gap by exploring the degree to which citizens are willing to pay for public goods associated with sustainable innovations in six European Union (EU) Member States: Spain, Hungary, the Netherlands, Italy, France and Poland.

Public goods and their valuation

Public goods are commodities or services that benefit all members of society. If an individual uses such commodities or services, it does not reduce its availability to others. Public goods make important contributions to societal welfare (Davis, 2018). Following the literature, we used a choice experiment to value public goods (Aanesen *et al.*, 2015; Abdullah and Mariel, 2010; Curzi *et al.*, 2022; Morris *et al.*, 2009). Valuing public goods is vital because they contribute to social welfare and to the design of policies that support public goods provision.

To the best of our knowledge, previous studies have primarily focused on innovations in agricultural products in one country (Norton and Alwang, 2020) but not at the pan-European level. In this study, we compared the willingness to pay (WTP) for public goods associated with sustainable innovations in the agri-food industry across Europe and analysed how socio-demographic factors influence citizens' preferences based on a choice experiment in tandem with cluster analysis. We adopted the choice experiment method considering its capacity to provide greater information to decision-makers regarding citizens' preferences for public goods. Additionally, we utilised cluster analysis to discern WTP patterns among different EU Member States, thus elucidating how policymakers can tailor socially inclusive public goods provision strategies and foster efficient resource allocation.

Innovations in Europe contributing to public goods

Seven innovations were implemented in six European Member States of the Horizon 2020 CO-FRESH project, of which two innovations were in Spain, as follows: *Company S1* (in the northern part of Spain) adopted

sensors to facilitate the smart use of fertilisers and reutilising water in processing, and *Company S2* (in southern Spain) adopted an innovation to reduce food waste by utilising leftover products. In the Netherlands, *Company N* adopted an innovation targeting the manufacture of products based on locally grown raw products. In Hungary, *Farm H* adopted a more sustainable packaging system to reduce the use of plastic packaging. In Italy, *Farm I* adopted a smart irrigation system to reduce the amount of water and energy used for irrigation while maintaining the same yield and quality. In France, *Farm F* adopted 100% local vegetable protein to feed animals and better integration into the local agri-food industry. In Poland, *Farm P* adopted innovation to reduce fertiliser usage through the composting process.

Although the sustainable innovations adopted by farms and companies in the six EU Member States differ, they have **common attributes** for the sake of comparison. Owing to the reduction in the use of plastic packaging and fertilisers as well as water and energy owing to locally produced raw products or vegetable proteins, implementing these innovations is expected to reduce

carbon emissions. As our food system is among the primary drivers of biodiversity loss, reducing food waste, reducing plastic pollution, and saving water and energy contribute to mitigating **biodiversity loss.** Moreover, the innovations are expected to structurally influence **local employment** because more labour may be needed in certain areas (e.g. managing smart fertiliser or irrigation systems), while less traditional labour may be needed. The price of the innovations is assumed to be paid through **environmental taxes**, which include taxes on energy, transport and pollution. Citizens are assumed to pay indirectly, such as through monthly energy bills.

“ La principale implication de nos résultats importante pour les politiques est que l'approche uniforme ne correspond pas à la perception qu'ont les citoyens de l'Union européenne de la durabilité. ”

Based on the three common attributes associated with the seven innovations studied, we conducted a choice experiment to estimate and compare the WTP of citizens living near innovation sites regarding carbon emissions, biodiversity and local employment. (See **Box 1** for details). Choice experiments were conducted using a survey. Accordingly, we provided a common framework to assess citizens' preferences that can be applied to seven pilot cases, as the attributes are identical. In the questionnaire administered after the choice experiment, we collected sociodemographic information, including age, gender, household size, household income and education. Additionally, we asked

Box 1: Discrete choice experiment's design and implementation

The determination of common attributes for the seven pilot cases and their levels was based on focus groups, expert opinions, historical data, and baseline results from the Horizon 2020 CO-FRESH project, as Figure A summarises. The choice sets were based on a D-efficient design – a type of orthogonal design. We created an efficient design by blocking using the *Ngene 1.3* software, which minimised the standard error of the parameter estimates to improve the D-efficiency of a random design. The final design included 18 cards (see Figure B for an example of a choice card). Each card contained three alternatives, one of which was the status quo. Rational choice theory assumes that people select an alternative that maximises their utility.

Figure A: Summary of attributes and their levels












Carbon emission	Biodiversity	Local employment	Environmental tax
Level 1: status quo	Level 1: status quo (scale 0)	Level 1: worsen (scale -1)	Level 1: status quo
Level 2: improve 5%	 Level 2: improve (scale 1)	Level 2: status quo (scale 0)	Level 2: increase 5%
Level 3: improve 10%	 Level 3: improve (scale 2)	Level 3: improve (scale 1)	Level 3: increase 10%

Figure B: Example of a choice set

	Choice A (status quo)	Choice B	Choice C
Carbon emissions			
Biodiversity			
Local employment			
Environmental tax per month	37 €	+ 5%	37 €

To reduce the cognitive burden on the respondents, we randomly divided the 18 cards into three blocks (i.e. six cards per block). Additionally, we added a seventh card – the consistency-checking card – to assess whether the respondents were rational and focused during the choice experiment by intentionally introducing a dominant choice (greater reduction in carbon emissions, better biodiversity, better local employment, and the same environmental tax). As a method of quality control, we filtered out all responses that did not select the dominant choice in the consistency-checking card. The WTP estimates were calculated by dividing the coefficient of the non-monetary attributes by the price coefficient. We calculated the 95% confidence intervals based on the Krinsky and Robb approach with 1,000 draws.

We commenced the choice experiment in August 2023 and ended it in November 2023. Responses were collected online from citizens living in nearby areas wherein innovations were implemented for each pilot case, with 3,500 valid responses (500 per pilot case). A quota-sampling approach was performed using the following three criteria: (1) being older than 18 years, (2) agreement with the General Data Protection Regulation, and (3) selecting the dominant choice in the consistency-checking card.

respondents questions regarding their attitudes towards climate change and their trust in the government in implementing policies that benefit public goods. An additional block of six questions was added to measure

environmental attitudes based on the New Ecological Paradigm (NEP) – a standard instrument used in the social and behavioural sciences to assess environmental awareness (Ziegler, 2021).

Heterogeneity of European citizens' WTP for public goods

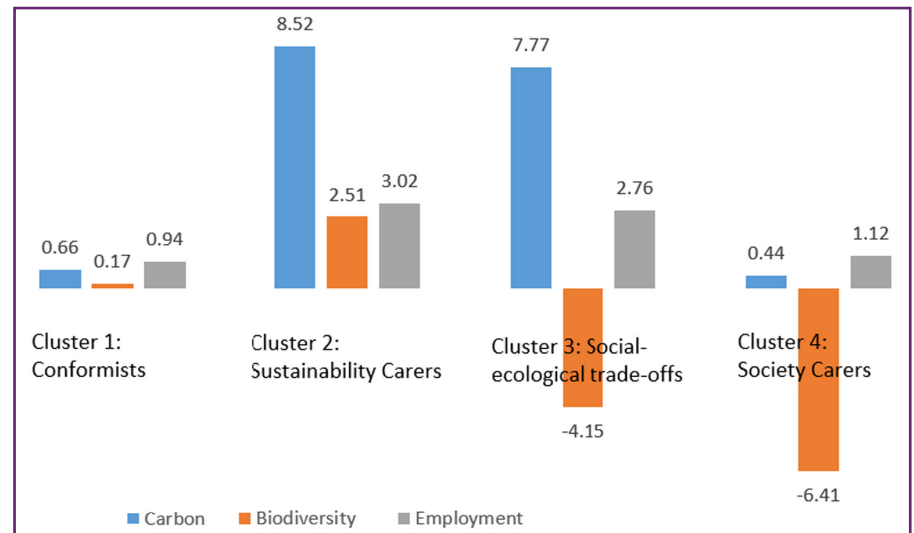
First, we estimated citizens' WTP for reducing carbon emissions, improving biodiversity, and increasing local employment, based on a choice experiment model. Further, we applied cluster analysis to identify four clusters based on WTP estimates. **Figure 1** presents the results.

Cluster 1 comprises those citizens with a relatively low WTP level for all public goods. The WTP for carbon, biodiversity and local employment were all less than one euro. As they adopted a conservative position despite having a low positive WTP, we categorised them as **conformists**. Cluster 2 comprised citizens with relatively high WTP levels for all public goods – that is, 8.52, 2.51 and 3.02 euros per month for carbon, biodiversity, and local employment, respectively. This segment was identified as **sustainability carers**. By comparison, citizens belonging to Cluster 3 exhibit a negative WTP for biodiversity (−4.15 euros), but a relatively high WTP level for others –

“ Die wichtigste politische Implikation unserer Ergebnisse ist, dass ein ‘Universal-konzept’ nicht mit den Vorstellungen der EU-Bürger und Bürgerinnen von Nachhaltigkeit übereinstimmt. ”

that is, 7.77 and 2.76 euros for carbon and local employment, respectively. The sum of carbon emissions and biodiversity (3.62) is close to that of employment (2.76). Therefore, they were identified as **social-ecological trade-offs**. Cluster 4 comprises citizens with a high negative WTP for biodiversity (−6.41 euros) and

Figure 1: Results of cluster analysis based on individual WTP for each attribute estimated by a random parameter logit model (WTP in euros)



relatively low WTP level for others – that is, 0.44 and 1.12 euros for carbon and local employment, respectively. As they exhibit more social than environmental concerns, we named them **society carers**.

To analyse the heterogeneity of European citizens' WTP for public goods associated with sustainable innovations, we performed an *F*-test and chi-squared test for continuous and categorical socio-demographics as well as attitudes towards the environment across clusters. Appendix **Table S1** in the online supplementary information

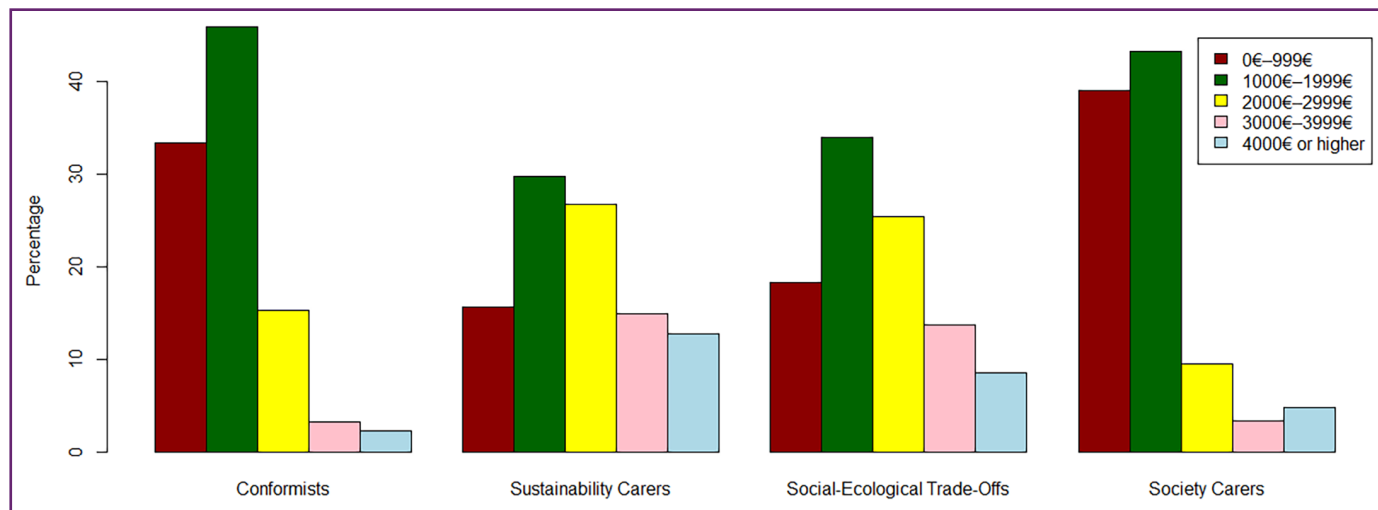
summarises the differences between the different clusters in detail.

In summary, age, years of education, household size, belief in climate change, and attitude towards the environment (NEP score) differ significantly among the clusters. Older sustainability carers and socio-ecological trade-offs are generally willing to pay more than younger conformists and society carers. However, belief in the government's implementation of environmental taxes for improving public goods is not statistically significant. Sustainability carers and social-ecological trade-offs have



Biodiversity is likely to be neglected by the citizens although it is of vital importance
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Figure 2: Net income differences among clusters



slightly shorter education years and lower beliefs in climate change as well as lower NEP scores, indicating that, on average, they care less for biodiversity – consistent with prior research (Czarnek *et al.*, 2021) that environmental attitudes contribute to the heterogeneity of WTP.

Further, the net income levels in Member States of origin significantly differ among the clusters. Figure 2 indicates that conformists and society carers include more than 70 per cent of citizens in the lowest two income categories (Categories 0 and 1) and less than 10 per cent of citizens in the highest two income categories (Categories 3 and 4), contributing to the generally low WTP attributable to income restrictions. By comparison, sustainability carers and social-ecological trade-offs comprised more than 20 per cent of citizens in the highest two income categories and less

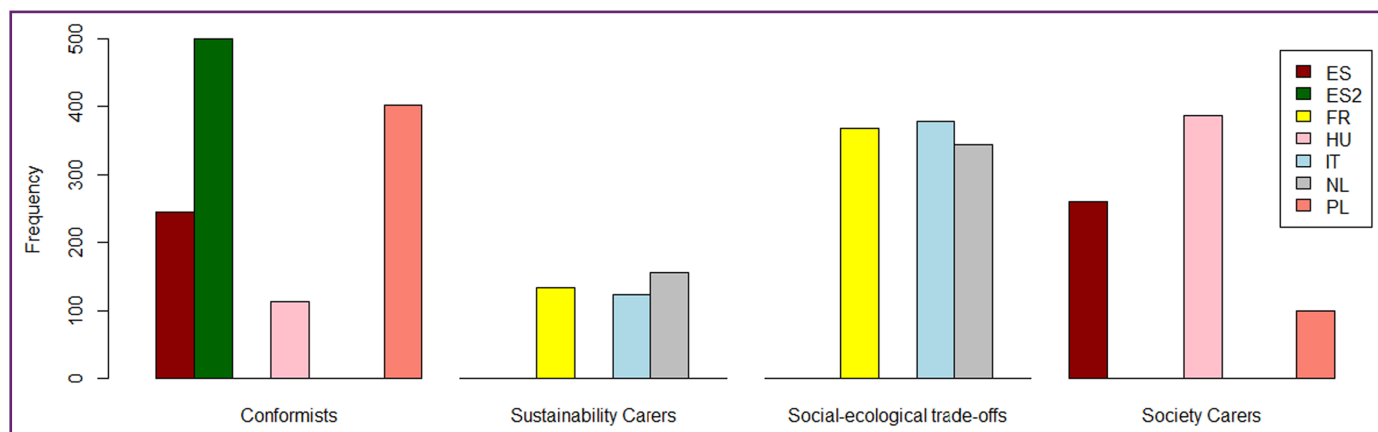
than 50 per cent of citizens in the lowest two income categories. This may explain why sustainability carers and social-ecological trade-offs are, generally, willing to pay more than the other two clusters are.

“ The primary major policy implication of our results is that the one-size-fits-all approach does not match EU citizens’ perceptions of sustainability. ”

Regarding the Member States of origin, respondents from northern and southern Spain, Poland and Hungary

were categorised as conformists and society carers with a relatively low WTP (Figure 3). Respondents from France, Italy and the Netherlands were categorised as sustainability carers and social-ecological trade-offs, with a relatively high WTP. Comparing sustainability carers and social-ecological trade-offs reveals that twice as many Italian, Dutch and French citizens exhibit a negative WTP for biodiversity than those who have a positive WTP. This indicates that biodiversity is not a major issue for numerous citizens in these three Member States. Hungary exhibits a pattern similar to that of conformists and society carers. By comparison, although citizens’ WTP for public goods from southern Spain and Poland is relatively low because of income restrictions, 80 per cent and 100 per cent of Polish citizens and citizens from southern Spain exhibit WTP for biodiversity, respectively. However,

Figure 3: Member States’ differences among clusters



Note: ES, northern Spain, ES2-southern Spain; FR, France; HU, Hungary; IT, Italy; NL, Netherlands; PL, Poland.

among citizens from northern Spain, only 48 per cent exhibit WTP for biodiversity. Interestingly, heterogeneity exists even within the same Member State.

Conclusion and policy implications

This study estimates citizens' WTP for public goods associated with sustainable innovations in the agri-food industry in six EU Member States. Sustainability is at the core of agri-food systems' transition. A successful agricultural transition must be socially inclusive. Understanding the level and heterogeneity of citizens' WTP in different Member States is important to support the design of agricultural and food policies for facilitating the effective provision of public goods at the European level.

Our results' primary major policy implication is that the one-size-fits-all

approach does not match EU citizens' perceptions of sustainability. Specifically, the heterogeneity of European citizens' preferences corroborates the need for flexible resource allocation strategies – for example, prioritising public goods initiatives based on the identified preferences in each Member State or region, like the already ongoing happenings in the EU with the Smart Specialisation Strategy and the New Delivery Model of the common agricultural policy (CAP).

The second major implication is that flexibility must be supported by maximising citizen engagement to ensure efficient and evidence-based resource use. This may occur through different means, both during the design phase (e.g. with participatory processes) and in the choice of policy instruments and measures. For the latter, a higher consideration of outcome-based payments or

market-based instruments (e.g. through certification) in the CAP can help translate more directly diversified preferences into incentives for farmers.

A notable result is the lower WTP for improving biodiversity compared to carbon and local employment, which may be explained by the indirect contribution of biodiversity and regulation of services to human well-being (Díaz *et al.*, 2018). However, this contrasts with the high relevance of biodiversity in current EU policies. One major example is the eco-schemes in the CAP – implemented since 2023 – with biodiversity protection being a key priority in 14 Member States (Runge *et al.*, 2022). Additionally, the *Biodiversity Strategy for 2030* and Nature Restoration Law under discussion present ambitious goals that seem inconsistent with the preferences identified in this study. On the contrary, the fact that citizens



Sustainable innovations were identified and introduced to stakeholders in the agri-food value chain © Yan Jin.

exhibit greater WTP for carbon and local employment can be connected to concerns regarding climate change (and related extreme events) and the economic difficulties that characterise numerous areas of the EU.

A broader understanding of the importance of biodiversity by various stakeholders, farmers, citizens and consumers may help build a collaborative environment for future policy actions, including future eco-schemes and agri-environmental-climate measures of the CAP. Considering the specific preferences and priorities of each Member State, developing tailored

campaigns related to different aspects of sustainability may be an important tool. For Member States with low NEP scores and low beliefs in climate change, targeted communication and campaigns aimed at strengthening environmental awareness are necessary, especially for those who do not care about biodiversity. However, along with communication, innovative means of engagement can be promoted, such as citizens' scientific approaches and directly involving citizens in a common learning process regarding actions to ensure sustainability in the EU.

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Supporting Information

Additional supporting information may be found in the online version of this article at <http://onlinelibrary.wiley.com/doi/10.1111/1746-692X.12433/supinfo>

Appendix Table S1. Differences among different clusters regarding socio-demographics.

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Summary

Citizens' Willingness to Pay for Sustainable Innovations: Evidence from Six European Union Member States

 Innovations in the agri-food industry targeting the strengthening of sustainability have recently increased their emphasis on compliance with the Sustainable Development Goals (SDGs). In the H2020 CO-FRESH project, seven sustainable innovations have been implemented by seven local farms and companies in six EU Member States using diversified formats, including a smart irrigation system, reutilising water in processing, and sensors for precisely applying fertilisers. Previous studies have predominantly focused on sustainable innovations in one Member State but not at a pan-European level. In this study, we adopted a choice experiment to assess citizens' Willingness-To-Pay (WTP) for public goods associated with sustainable innovations in Europe. The common attributes derived from different innovations enable a cross-country comparison of the WTP of citizens living near innovation sites for carbon emissions, biodiversity and local employment. The results indicate European citizens' different WTP for public goods and significant regional heterogeneity of socio-demographics among citizen clusters. A successful agricultural transition must be socially inclusive. This study has policy implications for various stakeholders in the agri-food value chain as well as policymakers when deciding on optimally allocating resources or implementing policy incentives to enhance sustainability and avoid 'one-size-fits-all' applications, considering the heterogeneity in Europe.

Consentement des citoyens à payer pour des innovations durables : observations dans six États membres de l'Union européenne

 Les innovations visant le renforcement de la durabilité dans l'industrie agroalimentaire ont récemment mis davantage l'accent sur le respect des objectifs de développement durable (ODD) de l'Union européenne (UE). Dans le cadre du projet H2020 CO-FRESH, sept innovations durables ont été mises en œuvre dans sept exploitations agricoles et entreprises locales de six États membres de l'UE. Elles présentent des formats diversifiés, notamment un système d'irrigation intelligent, la réutilisation de l'eau dans la transformation alimentaire et des capteurs pour une application précise des engrais. Les études précédentes portaient principalement sur les innovations durables dans un État membre, mais pas au niveau paneuropéen. Dans cette étude, nous avons adopté une expérimentation des choix pour évaluer le consentement à payer (CAP) des citoyens pour les biens d'intérêt public associés aux innovations durables en Europe. Les attributs communs dérivés de différentes innovations permettent une comparaison entre pays du CAP des citoyens vivant à proximité des sites d'innovation en termes d'émissions de carbone, de biodiversité et d'emploi local. Les résultats indiquent les différents CAP des citoyens européens pour les biens d'intérêt public et une nette hétérogénéité régionale des données sociodémographiques parmi les groupes de citoyens. Une transition agricole réussie doit être socialement inclusive. Cette étude a des implications pour les politiques pour diverses parties prenantes de la chaîne de valeur agroalimentaire ainsi que pour les décideurs de l'action publique lorsqu'ils décident de l'allocation optimale des ressources ou de la mise en œuvre d'incitations gouvernementales pour améliorer la durabilité et éviter les applications uniformes, compte tenu de l'hétérogénéité de l'Europe.

Die Bereitschaft der Bürger, für nachhaltige Innovationen zu zahlen: Erkenntnisse aus sechs EU-Mitgliedstaaten

 Innovationen in der Agrar- und Ernährungswirtschaft, die auf die Stärkung der Nachhaltigkeit abzielen, haben in letzter Zeit verstärkt den Schwerpunkt auf die EU Sustainable Development Goals (SDGs) gesetzt. Im Rahmen des H2020-Projekts CO-FRESH wurden in sechs EU-Mitgliedstaaten sieben nachhaltige Innovationen von sieben lokalen landwirtschaftlichen Betrieben und Unternehmen in verschiedenen Formaten umgesetzt. Darunter fallen ein intelligentes Bewässerungssystem, die Wiederverwendung von Wasser in der Verarbeitung und Sensoren für die präzise Ausbringung von Düngemitteln. Bisherige Studien haben sich überwiegend auf nachhaltige Innovationen in einem Mitgliedstaat konzentriert, nicht aber auf die gesamteuropäische Ebene. In unserer Studie haben wir ein Auswahlexperiment (Choice Experiment) verwendet, um die Zahlungsbereitschaft der Bürger für öffentliche Güter im Zusammenhang mit nachhaltigen Innovationen in Europa zu ermitteln. Die gemeinsamen Attribute der verschiedenen Innovationen ermöglichen einen länderübergreifenden Vergleich der Zahlungsbereitschaft von Bürgern, die in der Nähe von Innovationsstandorten leben. Die Ergebnisse, in Bezug auf Kohlenstoffemissionen, Biodiversität und lokale Beschäftigung zeigen, dass die europäischen Bürger unterschiedliche Zahlungsbereitschaften für öffentliche Güter haben und dass die soziodemografischen Merkmale der einzelnen Bürgergruppen regional sehr unterschiedlich sind. Eine erfolgreiche Agrarwende muss sozial integrativ sein. Diese Studie hat politische Auswirkungen für verschiedene Interessengruppen in der landwirtschaftlichen Wertschöpfungskette, aber auch für politische Entscheidungsträger und -trägerinnen. Dabei geht es um die optimale Zuweisung von Ressourcen oder die Umsetzung politischer Anreize zur Verbesserung der Nachhaltigkeit und – in Anbetracht der Heterogenität in Europa – die Vermeidung von ‚Universalkonzepten‘.

summary