Journal of Rural Studies 100 (2023) 103001

Contents lists available at ScienceDirect

Journal of Rural Studies

journal homepage: www.elsevier.com/locate/jrurstud

Perceived effects of climate policy on rural areas and agriculture: A rural-urban- divide

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ARTICLE INFO

Keywords:
Climate policy
Rural-urban polarisation
Agriculture
Centrality

ABSTRACT

Climate policies may have adverse geographically unequal socio-economic impacts that, if left unaddressed, may hamper their implementation. This paper examines factors explaining rural-urban perceptions of the effects of climate policy on agriculture and rural areas. The paper adds to current knowledge by jointly analysing socio-economic factors and factors describing the distinct role geographical locations play in shaping these perceptions. We conduct a novel statistical analysis utilising a large preference survey of the Norwegian adult population spatially matched at the municipality level with indexes capturing centrality and the relative importance, and, hence, vulnerability of agriculture to effects of climate change. Our analysis does not identify a principal conflict between the goals of climate policy, rural policy, and agricultural policy across geographical locations. Conflicts along the rural-urban gradient arise around the priority given to the three policy areas, and the concrete impact of climate mitigation measures on rural areas. Centrality more than agricultural properties explains the formation of resistance to policies. The policy process should therefore acknowledge rural concerns, and climate mitigation options should be more carefully designed to avoid further rural-urban polarisation.

1. Introduction

Combating climate change is one of the most important challenges of our time. Research indicates that for most countries the private and social costs of climate measures are unevenly distributed both along socio-economic gradients and in space (Ohlendorf et al., 2021; Peñasco et al., 2021; Burke, 2020; Goulder et al., 2019). Rural areas are particularly vulnerable to climate change. Economic activities depend in rural areas more commonly on exhaustible natural resources (oil, gas, minerals) or non-exhaustible natural resources (fisheries, aquaculture, agriculture, and forestry) (Mueller and Tickamayr 2020). Their dependence on agriculture and natural resources makes them more exposed to climate change and extreme weather events (Dasgupta et al., 2014). Climate change challenges and the need to reduce greenhouse gas (GHG) emissions, will seriously challenge many of these activities. Also, the uneven distribution of economic opportunities and living standards is increasingly challenging in many parts of the world, including in the US (Monnat and Brown 2017; Scala and Johnson 2017; McKee 2008), in Europe (Kenny and Luca 2021) and in Norway (Vik, Fuglestad and Øversveen, 2022). In the most agriculturally dependent areas, there is a real danger of depopulation when farms are closed down (Bjørkhaug and Rønningen 2014). Ultimately, increasing rural-urban inequalities are disadvantageous to all members of society (Pellow 2016) and potentially fuel existing rural-urban political tensions even further. Rural communities are therefore recognised as one of the most vulnerable to climate change (Austin et al. 2020).

The actual consequences and vulnerabilities associated with climate measures will in turn affect how people *perceive* climate measures and policies, and whether they are deemed fair and acceptable (Douenne and Fabre 2020). An extensive literature has investigated why it is often difficult to achieve the necessary acceptance among the public for the implementation of climate policies (see e.g., reviews by Köppl and

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https://doi.org/10.1016/j.jrurstud.2023.03.009
Received 25 October 2022; Received in revised form 19 January 2023; Accepted 16 March 2023
Available online 3 April 2023
0743-0167/

Schratzenstaller 2022; Maestre-Andrés et al., 2019; Klenert et al., 2018, Drews and JeroenVan den Bergh, 2016). This literature has shown that issues of (real and perceived) fairness and uneven distribution of the burden imposed by the policy may be important. However, the research to date has mostly focused on carbon pricing instruments (especially taxes), rather than specific climate measures, and the challenges of specific sectors, such as agriculture, or communities (such as rural community) having received limited attention. The literature related to climate change and agriculture often focuses on adaptation to the physical effects of climate change (Meierová & Chvatalová 2022; Ibrahim and Johansson; Soubry et al. 2020; Bjørkhaug and Rønningen 2014), resilient farming (LeGouff et al. 2022), or farmers' perceptions of climate change (Soubry et al. 2020; Brobakk 2018; Flemsæther et al., 2017), but does not consider the effects of climate mitigation policies on rural, and agricultural communities and the livelihoods of farmers. There is, therefore, a need for a better understanding of both the actual impacts of climate measures and people's perceptions of them.

There are only a few examples in the literature of studies of the different perceptions of climate policies with an explicit rural-urban dimension (Sivonen 2022; Ewald et al., 2021; Bonnie et al., 2020; Douenne and Fabre 2020; Umit and Schaffer 2020; Grimsrud et al., 2020; Devine-Wright et al., 2015). This literature indicates that, in general, rural citizens are less likely to be in favour of climate policies. In Norway, acceptance of and willingness to pay a carbon tax on fossil fuel have been found to be greater for urban than for rural residents (Grimsrud et al., 2020). Using data from Finland, Sivonen (2022) did not find major polarisation between urban and rural citizens. Nevertheless, urban residents were more in favour of climate measures affecting beef production and forestry, which typically take place in rural areas. Umit and Schaffer (2020) find significantly lower support for carbon taxes among European citizens who live in rural areas. A Swedish study by Ewald et al. (2021) found that the rural population is much more opposed to carbon taxes as well as more negative regarding climate policy generally. Douenne and Fabre (2020) found that the urban French population is more in favour of towards climate policies. Bonnie et al. (2020) found that US rural voters are more sceptical of the governmental response to climate change. They found that rural voters often acknowledge the need for regulations related to the environment but tend to be more sceptical of government policies.

The focus of this paper is on how rural factors can explain people's perceptions of possible adverse effects of climate policy and subsequent climate mitigation measures on rural areas and agriculture. Hence the key research questions are 1) Are the effects of climate policy perceived differently by the rural and urban populations and if yes, 2) which factors can explain these differences? To explore these questions, we conduct a novel analysis utilising a large preference survey based on a representative sample of the Norwegian adult population.

We hypothesize that the rural-urban polarisation becomes more pronounced the more the effects of climate policy and climate mitigation measures conflict with rural policy and agricultural policy objectives. That is, we expect that people living in rural areas are more likely to disagree with climate mitigation measures that negatively affect the economic conditions for agriculture and the living conditions in rural areas. Moreover, connecting respondents' perceptions data with both centrality and importance and vulnerability of agriculture to climate policies, allows us to explore whether variation in perceptions along the rural-urban divide links more strongly to centrality or to the role agriculture plays at the municipality level. To our knowledge, this is the first study that investigates perceived exposure to climate policy along the rural-urban gradient by combining survey data that capture spatial and municipal distance and agricultural properties. This paper improves upon the literature by applying a more sophisticated measure of rurality.

The next section describes this conceptual framework further, while section 3 introduces the survey data and the additional data for measuring rurality in terms of centrality and agriculture. The regression model used is briefly explained in section 4. Section 5 presents the results from the estimated model. Finally, the last section contains a discussion and conclusion.

2. Conceptual framework

We extend the approach of Kenny and Luca (2021) to explain rural-urban polarisation through the composition effect and the contextual effect. The former relates to the hypothesis that individuals with different characteristics are heterogeneously distributed spatially. Gender, age, education, and income have been identified as important factors for dividing supporters and opponents of the current political system (Dijkstra et al., 2020; Essletzbichler et al., 2018; Ford and Goodwin 2014; Goodwin and Heath 2016). Bishop (2009) shows that these effects can be reinforced through self-selection, e.g., by younger, more liberal, and more educated individuals settling in urban areas. At the same time, such out-migration may leave rural areas in a situation where they face adverse economic development (Barca, 2012; Crescenzi et al., 2016; Lee et al., 2018). The contextual effect focuses on the characteristics of a distinct place and the role they play in shaping the perceptions of individuals. It assumes that the social, cultural, and institutional characteristics of that place are important for explaining people's perceptions.

We follow Kenny and Luca (2021) by understanding the rural-urban divide as a continuum rather than a dichotomy. Therefore, we do not apply binary or discrete variables that would only broadly distinguish rural areas from urban areas. The term 'rural areas' does not have consistent, commonly accepted definition (Dasgupta et al., 2014). An often-used indicator is the size of the population in administrative units (Dasgupta et al., 2014). Such a definition is not helpful for Norway where, as will be shown below, a large share of agricultural activity is located in semi-urban areas. Zahl-Thanem et al. (2021) provide a definition of rurality in a Norwegian context which combines the share of employment in agriculture with centrality and the share of the municipalities' population living in sparsely populated areas. However, applying the binary index of Zahl-Thanem et al. (2021) in the statistical model would leave us with very little variation along the rural-urban dimension.

Expanding on the existing literature, we use not only a continuous index of the degree of centrality, but also continuous variables describing the relative importance of agriculture at the municipality level. In this way, we acknowledge that 'rurality' is a question not only of distance to the nearest labour market, but also of the role agriculture plays at the community level.

The agricultural sector has multifaceted impacts on society and to reflect this we develop the agricultural index around four subindexes. These subindexes measure the potential climate policy exposure to agriculture in terms of value-added (economic sustainability), GHG emissions (environmental sustainability), employment (social sustainability), and food production.

The inclusion of the centrality index and the agricultural index (described in detail below) makes it possible to provide precise explanations of differences in perceptions through the contextual effect, i.e., the intrinsic characteristics of places. We also include potential compositional effects through variables for age, marital status, gender, income, children, education, and employment (i.e., working in agriculture or not). Our hypothesis is that both compositional and contextual effects explain differences in perceptions of the risk associated with the introduction of new climate policies.

We go beyond Kenny and Luca (2021) by introducing six statements to account for the complex relationship between climate policy, agricultural policy and rural policy. These statements range from goal conflicts between the three policy areas at the more general level to concrete, adverse effects of climate change mitigation measures on the conditions for agriculture and the living conditions in rural areas.

3. Survey data and variables

3.1. Survey design and core preference statements

Data on people's perceptions are taken from a large population survey on individuals' preferences for and degree of acceptance of Norwegian climate policy in general, and carbon taxation in particular (see Dugstad et al., 2022). The survey was informed by a previous pilot study investigating heterogenous preferences and factors that may help increase support for climate policy across different socio-economic groups and geographical areas of the country (Lindhjem et al., 2021). The survey was pre-tested before data collection and carried out as an internet panel survey conducted by TNS Kantar in June 2021 in a period during which Norway was relatively little impacted by the Covid situation. The survey was distributed to TNS Kantar's high quality ISO certified panel and took a median of 23 min to answer. A total of 5336 invitations were distributed, 2248 surveys were opened by individuals, and 1832 completed them in full, resulting in a response rate of 34%. This is considered a high response rate for internet surveys. The survey was considered to be representative of the Norwegian adult population, except for the level of education, which is somewhat higher in the sample. There may be two reasons for this as pointed out by the survey company: people tend to overreport their education level and it is harder to reach respondents who have only completed compulsory education.

The survey contained a block of six statements related to climate policy, agricultural policy, and rural policy.

- S1 There is no contradiction between climate policy and rural policy.
- S2 There is no contradiction between climate policy and agricultural policy.
- S3 Climate mitigation measures must not weaken the opportunity for rural settlement.
- S4 Reduced emissions from agriculture must not lead to reduced food production.
- S5 I am worried that climate mitigation measures will negatively affect the inhabitants in rural areas.
- S6 I am worried that climate mitigation measures will cause farms to close down.

The six statements aim to address different aspects of the relationship between climate policy on the one hand and agricultural policy and rural policy on the other. S1 and S2 are broad statements about the relationships between climate policy and agricultural policy and climate policy and rural policy, respectively. We ask whether the respondents see a possible contradiction between these policy areas without going into detail about policy measures or policy objectives. S3 and S4 aim to elicit attitudes about the prioritisation of climate policy goals versus agricultural - and rural policy goals. We ask fairly normative questions about food production, the primary goal of agricultural policy, and maintaining settlement in rural areas, a major objective of rural policy, should be sacrificed to achieve GHG emission cuts, the main goal of climate policy. S5 and S6 present two very concrete and adverse effects of climate mitigation measures on agriculture and on rural areas.

Finally, the survey included questions about personal characteristics and socio-economic variables like age, gender, marital status, children, education, municipality of residence, profession or employment sector, and income.

3.2. Centrality

The centrality index was introduced by Statistics Norway in 2017 and is a measure of the centrality of each municipality in Norway. The index was updated in 2020 (Statistics Norway, 2022) after several municipalities were merged, and we use the most recent version. The index is based on people's access to workplaces and services for each of the country's more than 13 500 basic geographical units ("*grunnkrets*"), the statistical unit at the lowest administrative level in Norway. Access is defined as the number of workplaces and services a resident in a given *grunnkrets* can reach within 90 min commuting. The argument for the 90 min cut-off was that less than 1% of the Norwegian population commute more than 90 min to work and is willing to travel for an even shorter time for services (Institute of Transport Economics 2014 as cited in Statistics Norway, 2022). Moreover, both workplaces and services are weighted according to the commuting distance with closer workplaces and services given higher weights. Data on workplaces and services are collected from the national business register, which contains information about the number of employees in each business and its NACE code (Nomenclature of Economic Activities). The data are then aggregated at the municipality level using the *grunnkrets* population level as a weight. Finally, the index is normalized and assigns each municipality a value between 0 and 1000, where 1000 is the highest degree of centrality. This value is assigned to Oslo, the municipality of Norway's capital. The remaining municipalities are ranked relative to Oslo.

Statistics Norway, 2022 divides the municipalities into six centrality classes. The four rural classes (class 3–6) comprise municipalities with a centrality index of 775 or lower. The two most rural classes (class 5–6) are characterised by a centrality index of 565 or lower.

3.3. Agriculture

The survey dataset was also spatially matched with four variables describing the role of the agricultural sector at the municipality level of the respondents. An agricultural index based on four subindexes was developed that describe important aspects of agriculture's delivery of private and public goods: value-added, level of GHG emissions, contribution to employment, and food production measured in energy terms – food security (see Annex 1 for details of the definition of the subindexes). The subindexes capture the relative importance of the respective aspect within the municipality and the potential vulnerability of the municipality to the effects of climate policies.

Value added is an indicator of the economic sustainability of agriculture. The index is defined as the standard gross margin (SGM) of total agriculture in a municipality (Snellingen Bye et al., 2003) viewed in relation to the gross domestic product (GDP) of goods and services produced in that municipality. The index thus measures the variation in the mix of the different production activities among the municipalities and in relation to the total economic outcome at municipality level. Due to differences in the definitions of SGM and GDP, the subindex may take values above 100 per cent. Fig. 1 visualises the relationship between the centrality index and the subindex for value added in agriculture.

GHG emissions are a core issue of the environmental sustainability of agriculture, although they only relate to some of the many different aspects within environmental sustainability in agriculture. The subindex is defined as agriculture's share of the total GHG emissions related to the municipality's territory (Norwegian Environment Agency 2022). The relationship between the centrality index and the subindex for GHG emissions in agriculture is plotted in Fig. 2.

Employment relates to the social sustainability of agriculture as the number of farmers and workers employed in agriculture can be seen as a first approximation of the social conditions in the agricultural sector. The employment subindex is defined as agriculture's share of total employment at the municipality level. The index can take values above 100 per cent since employment in agriculture is computed using standardized workload for animals and crops. The relationship between the centrality index and the subindex for employment in agriculture is shown in Fig. 3.

Food is a private good, but its constant production is an important part of Norway's strategy for achieving food security. As food production depends on land, the subindex for food production is defined as the energy content of food per square km of the municipality's land area. It thus measures the intensity of the combined food production from animal husbandry and crops in relation to the size of the municipality. The

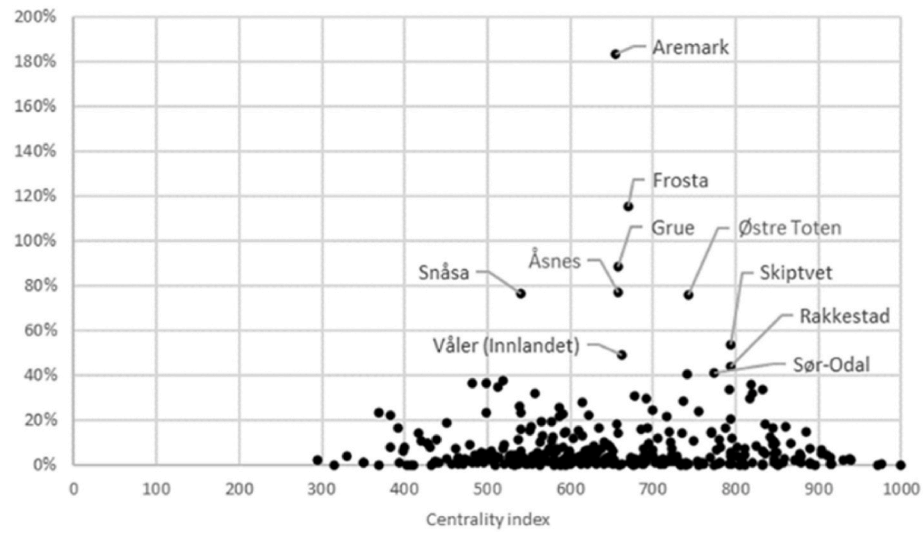

Fig. 1. Relationship between the centrality index and the subindex for value added in agriculture. The ten municipalities with the highest values are labelled.

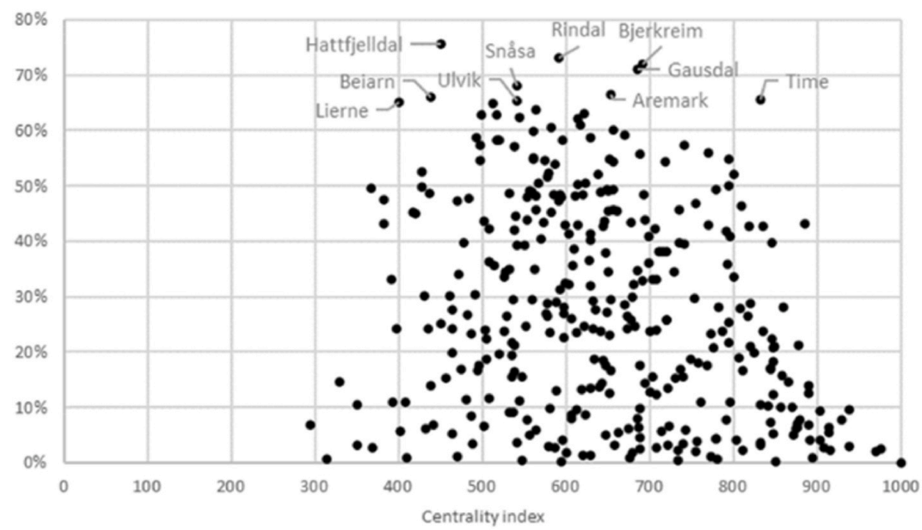

Fig. 2. Relationship between the centrality index and the subindex for greenhouse gas emissions in agriculture. The ten municipalities with the highest values are labelled.

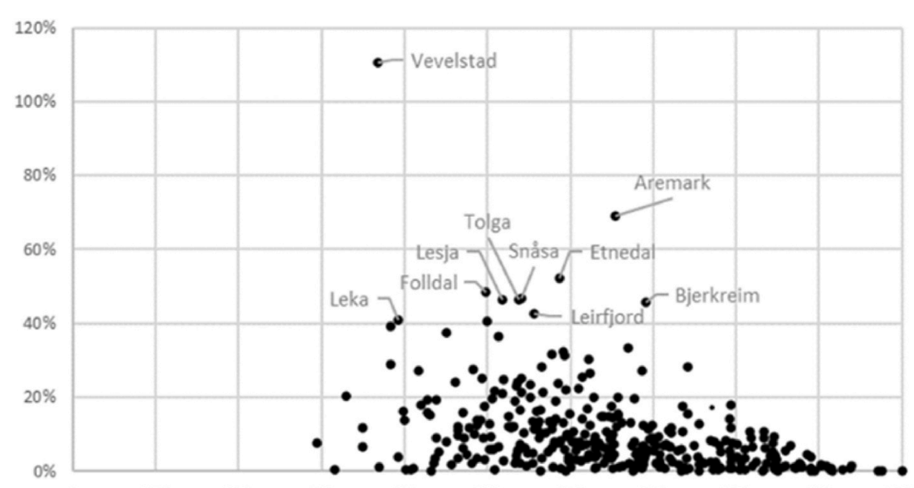

Fig. 3. Relationship between the centrality index and the subindex for employment in agriculture. The ten municipalities with the highest values are labelled.

relationship between the centrality index and the food production subindex is shown in Fig. 4.

There is a general pattern that the least central municipalities have low agricultural index-values. This is most evident for food production as soils in the least central areas are often characterized by poorer quality. This does not mean, however, that agriculture in these regions is not important neither for the inhabitants nor from a political point of view. It is an outspoken objective of Norwegian agricultural policy to maintain agricultural production all over the country. The major towns like Oslo, Bergen, and Trondheim are located at the opposite end of the centrality index. Their contribution to national agriculture is also relatively small. Within these two extreme cases, the figure shows large variations in the four agricultural subindexes for municipalities with similar centrality index. This pattern is most evident for GHG emission where no clear relationship between centrality and agriculture's share of total GHG emissions can be identified. The least central municipalities such as Lierne and Beiarn may have the same high share as semi-urban municipalities like Time and Gausdal.

To illustrate the difference between the four subindexes, we have labelled the top ten municipalities with the highest values for each subindex. Two municipalities, Aremark and Snåså, rank in the top ten of three of the four subindexes. Fig. 5 shows the top ten municipalities for the four subindexes for agriculture.

Most of the top ten municipalities for food production and value added are located in the Eastern lowlands in the proximity of the capital Oslo. The remaining top ten municipalities for food production are found in Jæren, a highly productive region in South-West Norway close to Stavanger. The top ten municipalities for greenhouse gas emissions and employment are more spread across Southern and Central Norway. In particular, the top ten municipalities with the highest share of employment, are located in less central regions.

Fig. 6 shows the distribution of GHG emissions, employment, value added, and food production in agriculture in absolute terms by the six centrality classes. GHG emissions and employment are closely related. This is because products with a high carbon footprint such as milk and meat from ruminants are also labour-intensive. More than 60% of both GHG emissions from and employment in agriculture originate from municipalities in less central regions (centrality classes 4–6). The opposite is true for value added and food production. Almost 60% of food production and value-added takes place in central municipalities (centrality classes 1–3).

Fig. 6 provides a clearer picture of the relationship, and complexity thereof, between centrality and agriculture. Norway's so-called 'production channelling policy' (i.e., high grain prices, regionally differentiated payments, transport subsidies, and a quota system for milk production) has resulted in a strong regional differentiation of agricultural production (OECD 2021). Grain production is mainly located in central areas with good agricultural conditions, while animal husbandry takes place in less central regions (e.g., valleys and mountainous areas). This explains the positive relationship between the centrality index, food production, and value added on the one hand, and the negative relationship between the centrality index, GHG emissions, and agricultural employment on the other.

We used Principal Component Analysis (Factor Analysis) to construct a single latent variable reflecting the role of agriculture in each municipality. Principal Component Analysis is a technique which maximizes the variance of the correlation matrix of the variables in focus and hereby allows us to reduce the dimension of the covariates. We chose the first principal component (dimension) which explains 58 per cent of the total variance of the four agricultural subindexes. Our final composed agricultural index may be interpreted as the overall importance of agriculture in each municipality.

4. Statistical model

We apply a statistical model to investigate whether variation in the respondents' perceptions on climate policies on the six statements can be explained by variation in the respondents' characteristics as described by the independent sociodemographic and spatial variables. Since the statements can only be translated to categorical variables, models designed for analysing continuous variables, like linear regression, are inappropriate in this context (Train 2009). The statements are ordinal, as they can be sorted in a specific order. Our point of departure is an ordered probability model. Since we have six closely related statements, we obtain more precise parameter estimates by estimating the six equations together. More specifically, we apply a random effect ordered logistic regression model to estimate the conditional probability distribution of the six statements.

The ordered logistic regression model is described in Agresti (2002). If y is the outcome variable, c is a category, x is a vector of covariates, β is a vector of parameters, α_c is the cut point between category c and category $c+1$, and C is the total number of categories, then the probability that the outcome is in category c is:

$$\Pr(y=c|x) = \begin{cases} G(\alpha_c - x^{'}\beta) c = 1 \\ G(\alpha_c - x^{'}\beta) - G(\alpha_{c-1} - x^{'}\beta) 1 < c \leq C-1 \\ 1 - G(\alpha_{c-1} - x^{'}\beta) c = C \end{cases} \tag{1}$$

where G is the cumulative distribution function.

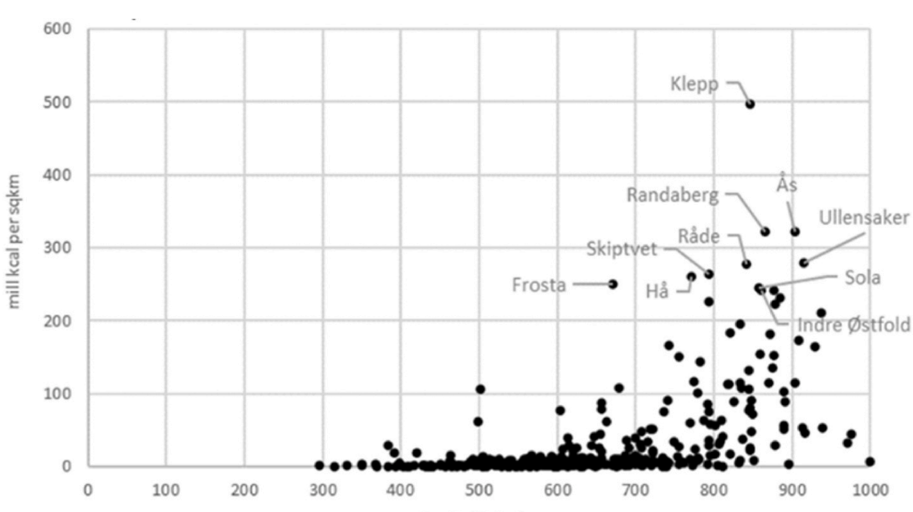

Fig. 4. Relationship between the centrality index and the food production subindex. The ten municipalities with the highest values are labelled.

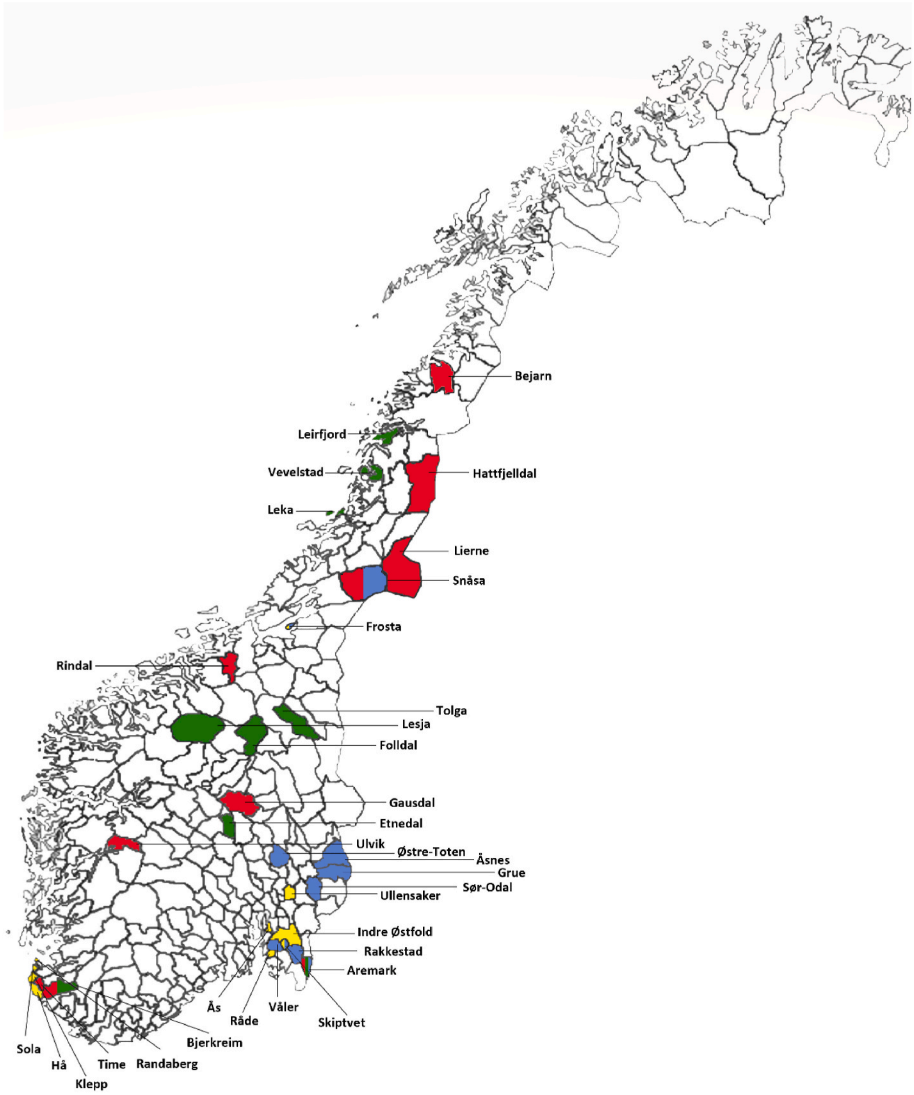

Fig. 5. Top ten municipalities with regard to the four subindices for agriculture (red: greenhouse gas emissions, blue: value added, green: employment, yellow: food production). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

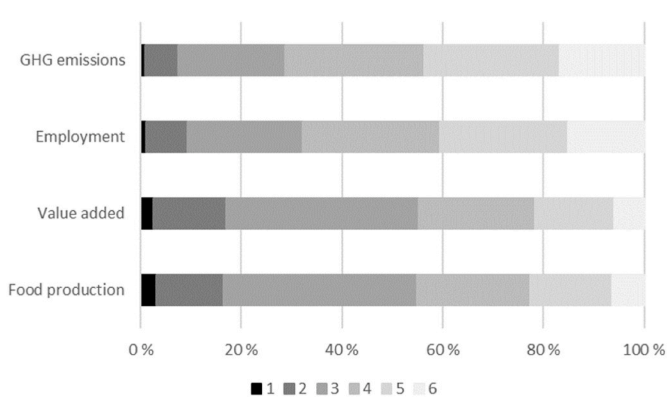

Fig. 6. Distribution of four agricultural subindexes by the six centrality classes (%).

If y_{ic} is an indicator taking the value 1 if respondent I is in category c, and 0 otherwise, the likelihood function is then given by

$$L = \prod_{i=1}^{N} \left[\prod_{c=1}^{C} \left(G(\alpha_c - x'\beta) - G(\alpha_{c-1} - x'\beta) \right)^{y_{ic}} \right] \tag{2}$$

in our case, G is the logistic distribution function with the categories completely disagree (c = 1), somewhat disagree (c = 2), neither disagree nor agree (c = 3), somewhat agree (c = 4), and completely agree (c = 5).

The continuous variables are age, income, the centrality index and the agricultural index. These continuous variables were standardised with expectation zero and unity standard deviation. The model further includes dummy variables for gender, marital status, the presence of children in the household, and education level. Finally, we include a variable indicating whether the respondent is a farmer or a farm worker ("working in agriculture").

Table 1 presents the descriptive statistics of the variables used in the regression analysis. Apart from the centrality index and the agricultural index, the analysis includes standard sociodemographic variables which are assumed to be exogenous or predetermined. The centrality index and the agricultural index are exogenous, hence there should be no problem with endogeneity bias in the model. The sample consists of 56% men, 66% of the respondents are married or living with a registered partner

Table 1
Descriptive statistics for variables used in the regression analyses.

Variable	Explanation	N	Mean	Standard deviation
Male	= 1 if male, 0 otherwise	1951	0.56	0.50
Married	= 1 if married or cohabiting, 0 otherwise	1951	0.66	0.47
Children	= 1 one or more children in the household, 0 otherwise	1951	0.38	0.47
University	= 1 if upper secondary education, 0 otherwise	1951	0.61	0.49
Age	Age of the individual	1832	49.70	16.62
Agriculture	= 1 if work in agriculture, 0 otherwise	1951	0.03	0.17
Income	= household income per consumer unit	1533	569 816	233 184
Centrality index	= index	1949	817.70	140.19
Agriculture index	= index	1949	0.00	1.52

1) Mean and standard deviation of the continuous variables are shown before standardisation.

and one or more children are present in 38% of the households. Average household income per consumer unit is NOK 570 000, where a consumer unit is defined by the square root of the number of family members (OECD 2008). The average respondent is about 50 years old, and 61% have upper secondary education. About 3% of the respondents are farmers or farm workers.[1)]

The ordered logistic regression model (equation (1)) does not explicitly contain an outcome variable but is dependent upon the response categories for the estimation of probabilities. We therefore sorted the six statements into different categories as follows: "Completely agree" = 5, Somewhat agree = 4, "Neither agree nor disagree" = 3, "Somewhat disagree" = 2, and "Completely disagree" = 1. "Don't know" was included in the "Neither agree nor disagree" and coded as 3, while no answers were deleted. The distribution of the responses is presented in Fig. 7 below.

We then constructed a latent agricultural index with Principal Component Analysis using the four agricultural subindexes. We chose the first principal component (dimension) which explains 58 per cent of the total variance of the four individual agricultural subindexes. The final composed agricultural index may be interpreted as the overall importance of agriculture in each municipality.

All covariates in Table 1 were used with equation (1) and the cumulative logistic distribution function to estimate the conditional probability that each specific individual is in each specific category for each statement. The model was estimated with maximum likelihood and the likelihood function (equation (2)).

A Likelihood-Ratio (LR)-test indicated that a random effect ordered logistic model, where all statements are estimated simultaneously, is preferred to estimating six models one by one. Since we have six statements with potentially high correlation between the responses, we transformed the data into a panel structure and estimated the model by means of the xtologit procedure in Stata (StataCorp 2017). This procedure took account of the covariance between the error terms in the six equations.

The probability of observing outcome c for statement k and individual I is then given by

$$P(y = c|x,k) = \left(\prod_{c=1}^{c=6}(G(\alpha_c - I_k x'\beta - v_i) - G(\alpha_{c-1} - I_k x'\beta - v_i)\right)^{y_{ic}} \quad (3)$$

where the indicator variable $I_k = 1$ if statement k is the focus and 0 otherwise, and v_i is individual specific random variation that is assumed *iid* $N(0, \sigma_v^2)$.

We used equation (3) to predict the probability of totally/somewhat agree on the six statements at the 90th quantile of the centrality index, at the 10th quantile of the centrality index, and their differences. Except in the case of the centrality index, the mean of the variables, shown in Table 1, is inserted into the logistic distribution function together with the estimated parameters. The 90th quantile and the 10th quantile are used for the centrality index.

The 10th quantile of the index has a value of 600, which is well below average. In the 10th quantile, 10% of the individuals in the sample live in less central regions and 90% in more central municipalities. The 90th quantile of the centrality index has a value of 1000, meaning that an individual in the 90th quantile is living in Oslo.

We apply a non-parametric bootstrap, estimating the model using 500 repetitions, and for each iteration we predict the probability of answering "Totally agree and Somewhat agree" to the six statements in Oslo and in non-central areas, keeping each of the other variables fixed at their means. Then we use the t-test for differences in probabilities for individuals living in the 10% least central areas and individuals living in Oslo.

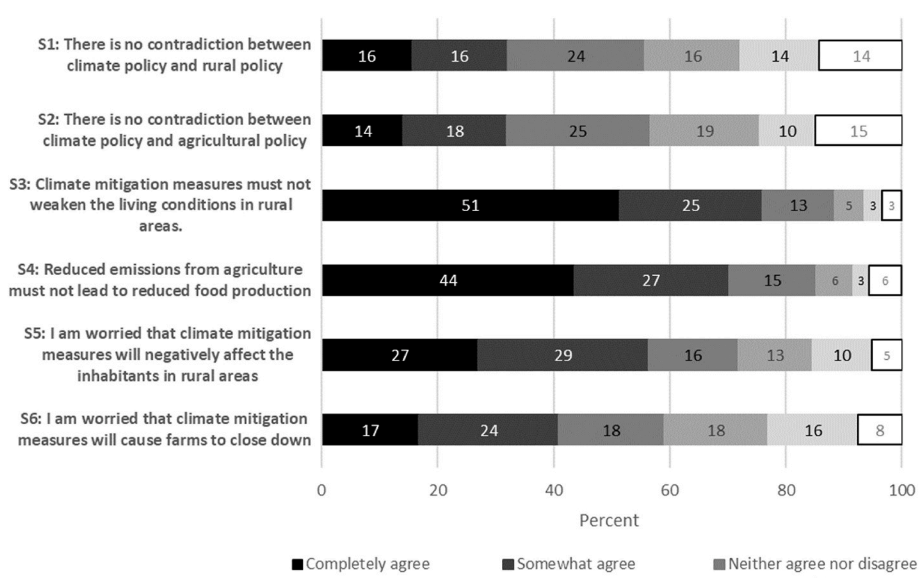

Fig. 7. Distribution of responses of the six statements about climate policy, rural policy, and agricultural policy.

5. Results

We start by presenting the responses to the six statements in Fig. 7. Responses were more or less evenly distributed across the scale for statements S1 and S2 – the two general statements about contradiction between climate policy and rural policy on the one hand (S1) and agricultural policy on the other (S2). These two statements also had the highest share of respondents with no clear opinion on the issue (Don't know/No answer). The median value for both these policy statements is 'Neither agree/nor disagree'.

For statements S3 and S4 – that climate mitigation measures should not harm rural policy (S3) or agricultural (S4) goals the median values are 'Completely agree' and 'Somewhat agree', respectively. More than 70% of respondents agreed to some extent that climate measures must not weaken opportunities for settlement in rural areas or lead to reduced food production. Only 10% disagreed, and the proportion who were neutral or did not answer was amongst the lowest for all six statements.

A small majority (52%) of respondents agreed that climate mitigation measures will negatively affect settlement in rural areas (S5), while 23% disagreed. In comparison, approximately 40% of the respondents were concerned that climate measures will cause farms to close down, while 34% disagreed and 18% were indecisive/neutral. The median values for the two policy statements were 'Somewhat agree' for rural aspects (S5) and 'Neither agree/nor disagree' for agricultural aspects (S6). Hence, respondents from urban areas seem to be less concerned about the adverse effects of climate mitigation measures on agriculture than respondents from rural areas. The lower concern about farms being closed down may be explained by the fact that farm exits and structural change has been ongoing for many decades (Forbord et al., 2014). The respondents may therefore regard the closing down of farms a natural process that happens independent of climate, agricultural, or rural policies.

While the first two statements (S1, S2) show little differences with respect to rural and agricultural policies, the responses to policy priorities (S3, S4) and the adverse effects of climate mitigation measures on agriculture and rural areas (S5, S6) differ. Although most respondents were concerned that climate mitigation measures must not be given priority over rural and agricultural policy objectives, they do not necessarily see climate policy as being contradictory to agricultural policy and rural policy. This hints at a contradiction: If climate mitigation measures must not weaken opportunities for rural settlement in rural areas or the production of food, one can regard this as a typical conflict of policy goals (VikFuglestad and Øversveen, 2022). However, the fact that many respondents had no firm opinion on this potential issue may have several explanations. Firstly, food is essential and demand for food cannot easily be reduced to mitigate climate change. Since agriculture is a biological production, GHG emissions are therefore unavoidable to satisfy essential human needs. Secondly, respondents may think that climate mitigation, food production, and the utilization of natural resources in rural areas justifying rural settlements must not be compromised in Norway. Therefore, goal conflicts may be of no purpose as climate, agricultural, and rural policy objectives need to be achieved at the same time. Thirdly, the two statements may have simply been difficult to understand. Expressing a strong attitude requires knowledge or interest in the policy areas and the answers indicate that a significant proportion of the population probably does not have it. The second explanation may indicate respondents' support for a policy-mix with climate measures that reduce greenhouse gas emissions without harming vial rural and agricultural policy objectives.

The results generated by the statistical model are presented in Table 2 and Table 3. Table 2 focuses on the three statements on rural areas and policy (S1, S3, S5), while the results concerning statements on agriculture and agricultural policy are shown in Table 3 (S2, S4, S6). Since our focus is also on the relationship between the statements and the place of residence, we used the model to analyse differences between individuals living in the least central areas and individuals living in the capital.

Table 2
Coefficients of the statistical model for the three statements concerning rural areas and rural policy (standard errors in parenthesis)[11].

	S1: There is no contradiction between climate policy and rural policy.	S3: Climate mitigation measures must not weaken the opportunity for rural settlement.	S5: I am worried that climate mitigation measures will negatively affect the population in rural areas.
Male	−0.411 (0.094) ***	0.058 (0.099)	−0.002 (0.095)
Married	−0.516 (0.112) ***	0.956 (0.118) ***	0.206 (0.113) *
Children	−0.145 (0.115)	0.081 (0.121)	0.019 (0.116)
University	−0.091 (0.098)	0.364 (0.103) ***	−0.352 (0.098) ***
Farmer/farm worker	−0.056 (0.289)	0.544 (0.351)	0.702 (0.297) **
Age	−0.024 (0.055)	0.501 (0.059) ***	0.221 (0.055) ***
Income	0.118 (0.053) **	−0.276 (0.056) ***	−0.126 (0.054) **
Centrality index	0.271 (0.066) ***	−0.591 (0.076) ***	−0.587 (0.068) ***
Agriculture index	−0.160 (0.066) **	0.134 (0.075) *	0.172 (0.067) **
Cut off parameters: $\alpha_1 = -2.76$ (0.08), $\alpha_2 = -1.61$ (0.07), $\alpha_3 = -0.22$ (0.07) $\alpha_4 = 1.05$ (0.07)			

1) *** significant at 1 per cent level, ** significant at 5 per cent level, * significant at 10 per cent level.

Table 3
Coefficients of the statistical model for the three statements concerning agriculture and agricultural policy (standard errors in parentheses)[1].

	S2: There is no contradiction between climate policy and agricultural policy.	S4: Reduced emissions from agriculture must not lead to reduced food production.	S6: I am worried that climate mitigation measures will cause farms to close down.
Male	−0.387 (0.093) ***	−0.056 (0.096)	−0.605 (0.094) ***
Married	−0.458 (0.109) ***	0.644 (0.114) ***	−0.037 (0.112)
Children	−0.088 (0.112)	0.319 (0.117) **	0.014 (0.114)
University	−0.111 (0.095)	0.276 (0.099) **	−0.566 (0.097) ***
Farmer/farm worker	0.447 (0.289)	0.746 (0.336) **	1.157 (0.301) ***
Age	0.057 (0.053)	0.418 (0.056) ***	0.157 (0.055) **
Income	0.169 (0.052) ***	−0.109 (0.054) **	−0.046 (0.053)
Centrality index	0.132 (0.065) **	−0.430 (0.070) ***	−0.386 (0.066) ***
Agriculture index	−0.107 (0.063) *	0.080 (0.069)	0.065 (0.066)
Cut off parameters: $\alpha_1 = -2.76$ (0.08), $\alpha_2 = -1.61$ (0.07), $\alpha_3 = -0.22$ (0.07) $\alpha_4 = 1.05$ (0.07)			

Note: *** significant at 1 per cent level, ** significant at 5 per cent level, * significant at 10 per cent level.

Table 2 shows that variation among inhabitants' opinions are better captured by the more specific statements than the general statements. Further, the centrality index is the single most important variable in all three statements followed by income, marital status, and the agriculture index. The socio-economic variables that are significant have, in general, a high level of significance. The agriculture index is significant in all three statements, but at a lower level. Among the socio-demographic variables, marital status, education, age, and income seem to best explain differences in respondents' perceptions about the relationship between climate policies and rural policies.

Couples, older people, people with lower incomes, individuals in less central areas, and individuals living in municipalities where agriculture is more important, are more likely to agree that climate measures must not weaken living conditions in rural areas (S3) and are concerned that climate measures will have adverse effects on rural populations (S5). This may be due to the fact that people envision negative consequences of climate measures are also more likely to be directly affected by climate measures and have less opportunity to adjust their lives so to reduce or avoid adverse effects of climate measures. Farmers and farm workers are more likely to be concerned that climate measures will negatively affect rural populations (S3).

The sign of the coefficients, or the direction of the relationship, for all significant variables remains the same for all the statements besides education. While people with higher formal education are more likely to agree that climate measures must not weaken the living conditions in rural areas (S3), these same people are less likely to agree that climate measures will negatively affect the rural population (S5). Although more educated people agree on average that rural policies should be given priority over climate policies, they are less concerned that mitigation measures will become a problem.

There are clear differences between the three statements with regard to the significance of the variables. The first statement about possible conflicts between climate policy and rural policy has the least number of significant variables. This is in line with the descriptive statistics that showed that respondents are indecisive/neutral about this question. Likewise, the highest number of variables with the highest significance level occurs for statement S3, that climate measures must not weaken the living conditions in rural areas. This reflects the high level of consensus regarding this statement as revealed in the descriptive statistics.

Turning to the results of the three statements on agricultural policy, Table 3 reveals both similarities and differences between these responses and those of the statements on rural policy. The number of significant variables decreases slightly, and so does the significance level of the variables themselves. The centrality index is left as the only variable that is significant in all three statements.

The coefficients retain the same signs as the coefficients in Table 2. This includes the change in sign of the education variable. As for rural policies, although those with higher levels of formal education are more likely to prioritize agricultural policies over climate policies, they do not seem to believe mitigation policies as causing significant problems.

Interestingly, the agriculture index contributes less to the explanation of variations in people's perceptions when it comes to statements regarding agriculture than to statements regarding rural areas. The agriculture index is only significant in S2 for possible goal conflicts between climate policy and agricultural policy.

Women, single people, people with higher incomes, people living in central areas, and also people living in municipalities where agriculture is less important, remain less likely to consider that climate policy conflicts with agricultural policy (S2). This pattern changes slightly when it comes to the prioritisation of climate policy objectives and agricultural policy objectives (S4). Singles, people with higher incomes, and people living in more central areas are still less likely to prioritize agricultural policy objectives over climate policy objectives, but when it comes to adverse effects of climate mitigation measures on agriculture, the agriculture index is not significant (S6). The importance of agriculture at the municipality level does not explain why respondents have different perceptions in this case. More important are gender, education, whether the respondent is a farmer or farm worker, age, and the centrality index. Women, people with lower levels of formal education, farmers and farm workers, older people, and people living in less central areas are more likely to be concerned that climate mitigation measures may cause farms to close down.

Table 4 and Table 5 show predicted probabilities of agreement to the six statements for individuals at the extreme parts of the centrality index

[1] Dairy cows, suckler cows, other cattle, adult sheep, adult goat, sows, slaughter pigs, laying hens, slaughter chicken, potato, oilseeds, cereals, vegetables on arable land, vegetables in greenhouses, fruits, and berries.

Table 4
Predicted probabilities to totally/somewhat agree to the six statements for the 90th quantile (Oslo, most urban) and 10th quantile (centrality class 5, most rural) and their differences.

	90th quantile (Oslo)	10th quantile (centrality class 5)	Difference	t-value
S1: There is no contradiction between climate policy and rural policy.	0.481 (0.223)	0.301 (0.027)	0.180*** (0.045)	4.037
S2: There is no contradiction between climate policy and agricultural policy.	0.453 (0.021)	0.363 (0.028)	0.089** (0.043)	2.061
S3: Climate mitigation measures must not weaken the opportunity for rural settlement.	0.582 (0.025)	0.884 (0.015)	−0.302*** (0.036)	−8.398
S4: Reduced emissions from agriculture must not lead to reduced food production.	0.582 (0.023)	0.826 (0.019)	−0.245*** (0.038)	−6.416
S5: I am worried that climate mitigation measures will negatively affect the population in rural areas.	0.356 (0.023)	0.749 (0.024)	−0.393*** (0.043)	−9.183
S6: I am worried that climate mitigation measures will cause farms to close down.	0.283 (0.021)	0.543 (0.031)	−0.259*** (0.046)	−5.628

Note: Standard deviations in parentheses. The t-value refer to the Difference.

Table 5
Predicted probabilities to totally/somewhat agree to the six statements in municipalities where agriculture plays a major role and municipalities where agriculture plays a minor role.

	Agriculture plays major role	Agriculture plays minor role	Difference	t-value
S1: There is no contradiction between climate policy and rural policy.	0.348 (0.023)	0.423 (0.017)	−0.075** (0.033)	−2.299
S2: There is no contradiction between climate policy and agricultural policy.	0.379 (0.021)	0.430 (0.016)	−0.051* (0.029)	−1.773
S3: Climate mitigation measures must not weaken the opportunity for rural settlement.	0.782 (0.018)	0.733 (0.015)	0.049** (0.026)	1.953
S4: Reduced emissions from agriculture must not lead to reduced food production.	0.730 (0.019)	0.696 (0.016)	0.034 (0.028)	1.192
S5: I am worried that climate mitigation measures will negatively affect the population in rural areas.	0.598 (0.024)	0.512 (0.018)	0.086** (0.033)	2.628
S6: I am worried that climate mitigation measures will cause farms to close down.	0.415 (0.026)	0.384 (0.017)	0.031 (0.034)	0.909

and the agricultural index respectively, when all the other variables are fixed at their means. The predicted probabilities are a measure of the divide between the respondents in these two areas.

Table 4 presents the predicted probabilities of completely or somewhat agreeing on the six statements at the 90th quantile of the centrality index (index value = 1000, centrality class 1, Oslo), at the 10th quantile of the centrality index (index value = 600, centrality class 5), and the differences between these two.

There is a large and significant difference in the probabilities of agreement between respondents in the 10th quantile (living in Oslo) and respondents in the 90th quantile (living in centrality class 5). The largest difference can be found in S5 ("Concern that climate mitigation measures will negatively affect the rural population"). For individuals in non-central areas, the probability of agreeing with S5 is 77%, but just 33% for individuals living in Oslo – a difference of 44 per centage points. The statements for which respondents expressed highest concern both in Oslo and in centrality class 5 are S2 ("Reduced emissions from agriculture must not lead to reduced food production") and S5 ("Climate mitigation measures must not weaken the living conditions in rural areas"). The probability of agreement with those statements was 84% and 90% respectively for individuals living in non-central areas and 58% and 57% for individuals living in Oslo.

The statements that show the least difference in responses are S1 ("There is no contradiction between climate policy and regional policy") and S2 ("There is no contradiction between climate policy and agricultural policy"). Among all six statements, respondents are most likely to agree on these two statements regardless of their place of residence.

Table 5 presents the predicted probabilities of completely or somewhat agreeing on the six statements at the 90th quantile of the agricultural index (i.e., respondents living in a municipality where agriculture plays a major role), at the 10th quantile of the agricultural index (i.e., respondents living in a municipality where agriculture plays a minor role), the differences between these two, and a *t*-test for the difference.

Table 5 illustrates that respondents in municipalities where agriculture plays a major role are more likely to agree on the existence of goal conflicts between climate, rural, and agricultural policy than respondents in municipalities where agriculture plays a minor role (S1, S2). Moreover, respondents in these municipalities differ significantly with respect to their prioritisation of climate policy over rural policy and the effect of climate mitigation measures on rural population. Respondents in municipalities where agriculture plays a major role are more in favour of giving priority to rural policy (S3) and are more concerned that climate mitigation measures will negatively affect the population in rural areas (S5). On the other hand, the role or importance of agriculture in a municipality does not seem to lead to significant differences in respondents' views of the two statements on climate mitigation measures and agriculture (S4, S6). For instance, respondents showed concern that climate mitigation measures would cause farms to close down (S6) irrespective of the role agriculture played in their municipality.

Looking only at respondents who agreed with the six statements, differences with regard to the centrality index were much more pronounced than the differences with regard to agriculture's importance at the municipality level. Interestingly, differences of agreement to the three statements concerning agriculture (S2, S4, S6) were much larger with regard to the centrality index compared to the degree of agriculture's importance.

6. Discussion and conclusion

A central result of our study is that climate policy contributes to the rural-urban polarisation of the Norwegian population. This was evident from respondents' perceptions about the negative effects of climate measures on agriculture and rural areas. Our main result confirms earlier research that studies perceptions of climate policies in a rural-urban context (Sivonen 2022; Ewald et al., 2021; Bonnie et al., 2020; Douenne and Fabre 2020; Devine-Wright et al., 2015).

The novel and comprehensive operationalization of the rural-urban dimension in this paper deepens our understanding of this issue. A key finding is the more pronounced significance of the centrality index compared to the variables capturing personal characteristics of respondents. According to our study, 'places' are more important than 'people'. The centrality index is highly significant in all models and for all six statements. Socio-economic variables are also important, but and not all of them and those that are, are significant to a lesser extent. Our study supports Kenny and Luca (2021) that find that both places and people matter in the context of attitudes towards policy issues and the political system, but, in addition, addresses the relative importance of places versus people which enables better targeting of policy.

A major implication is that the rural-urban divide on climate policies cannot be easily reconciled by general policy measures such as improved formal education, simply because place matters – at least as far as the dimensions we capture through the centrality index are concerned. Addressing this issue may thus require policies that take greater account of places and the way it shapes perceptions and greater engagement in places that experience 'not to matter' (Cf. Rodríguez-Pose, 2017).

When interpreting the results of the study, it is important to have in mind that the survey represents a snapshot of respondents' preferences at the time it was undertaken. It would be fruitful to repeat the survey in the near future to build a dataset with time series, so that potential changes in preferences could be identified and linked to changes in policies as well as the development of rural areas and the agricultural sector.

With regard to the rural-urban dimension, the centrality index explains perceptions along the rural-urban divide much better than the agricultural index. To some extent, the results support our hypothesis that the rural-urban divide within climate policy follows the centre-periphery dimension rather than the agricultural dimension. This suggests that distance to workplaces and (public) services matters more than the role agriculture plays in respondents' municipalities. More generally, the definition and operationalization of the concept 'places' is important. The decomposition of the rural-urban dimension into centrality and agriculture may help to disentangle its multi-dimensionality. As our study is the first to propose and empirically analyse this decomposition, more work is needed to consolidate or refute the usefulness of this approach.

The influence of the rural-urban divide is least present when it comes to potential goal conflicts between climate policy, agricultural policy, and rural policy. We interpret this as an expression of a common understanding that climate policies, agricultural policies, and rural policies in Norway are not mutually exclusive. Agriculture cannot provide goods and services without a functioning climate. There is no doubt that climate policies are vital to face today's challenges. Inhabitants in rural and less central areas appear to believe that climate policies should be given a higher priority than other policy fields, and that these policies may negatively impact the results of agricultural and rural policies. An alternative interpretation of this observation is that individuals believe that the reduction of GHG emissions can be achieved without harming neither agriculture nor rural areas. We find some support for this among people with higher levels of formal education who, on the whole, prioritize climate policy objectives over agricultural and rural policy objectives but are less concerned that this may harm agriculture and rural areas. This interpretation would reflect the view of the Norwegian Farmers' Union that it is better to reduce GHG emissions per unit of food produced than to reduce food (or meat) production. The distinction between a general acceptance of the need for and implementation of climate policies (including their spatial and socio-economic effects), already an important research field, may become even more important in the future as the urgency of taking action to stem climate change increases.

Author statement

Klaus Mittenzwei: Conceptualization, investigation, data curation, writing – original draft, writing – review and editing, Geir Wæhler Gustavsen: Data curation, formal analysis, writing – original draft, Kristine Grimsrud: Funding acquisition, investigation – original draft, Henrik Lindhjem: Funding acquisition, conceptualisation, writing – original draft, Hilde Bjørkhaug: Writing – original draft

Data availability

The authors do not have permission to share data.

Acknowledgements

The research reported in this study was financed by the Research Council of Norway under grant no. 295789 "PLATON - a PLATform for Open and Nationally accessible climate policy knowledge" (Mittenzwei, Gustavsen, Grimsrud, Lindhjem) and grant no. 315990 «LANDWELL: Climate-induced welfare impacts of ecosystem goods and services from agricultural and seminatural landscapes in Norway" (Mittenzwei, Grimsrud, Lindhjem).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jrurstud.2023.03.009.

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