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1 **Farmers' perception of climate change: identifying types**

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4

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1 **Abstract**

2 Ambitious targets to reduce greenhouse gas (GHG) emissions from agriculture have been set by
3 both national governments and their respective livestock sectors. We hypothesise that motivation
4 based on self-identity influences assessments of climate change; therein, affecting the behavioural
5 capacity of farmers to implement measures which address the issue. Perceptions of climate change
6 were determined from 286 beef/sheep farmers and evaluated using Principal Component Analysis
7 (PCA). The analysis elicits two components which evaluate identity (productivism and
8 environmental responsibility), and two components which evaluate behavioural capacity to adopt
9 mitigation and adaptation measures (awareness and risk perception). Subsequent Cluster Analyses
10 reveal four farmer types based on the PCA scores. ‘The Productivist’ and ‘The Countryside
11 Steward’ portray low levels of awareness of climate change, but differ in their motivation to adopt
12 pro-environmental behaviour. Conversely, both ‘The Environmentalist’ and ‘The Dejected’ score
13 higher in their awareness of the issue. In addition, ‘The Dejected’ holds a high sense of perceived
14 risk; however, their awareness is not conflated with an explicit understanding of agricultural GHG
15 sources. With the exception of ‘The Environmentalist’, there is an evident disconnect between
16 perceptions of agricultural emission sources and their contribution towards GHG emissions
17 amongst all types. If such linkages are not conceptualised, it is unlikely that behavioural capacities
18 will be realised. Effective communication channels which encourage action should target farmers
19 based on the groupings depicted. Therefore, understanding farmer types through the constructs
20 used in this study can facilitate effective and tailored policy development and implementation.

21 **Keywords**

22 Environmental impact, farmer engagement, livestock, red meat, sustainable intensification

23 **Abbreviations**

24 A Awareness

25 ER Environmental responsibility

26 GHG Greenhouse gas

27 P Productivism

28 PCA Principal component analysis

29 PR Perceived risk

1

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14 **Author biographies**

15 Hyland, J.

16 I am a PhD student at Bangor University, looking at the opportunities and barriers for agriculture
17 to reduce its environmental footprint. This involves interdisciplinary research, including social
18 science, environmental sciences, and economics. Research interests include sustainable
19 intensification, food security, and how farmer's perceptions of environmental issues influence their
20 behaviour.

21

22 Jones, D.L.

23 I hold a Professorial Chair in Soil and Environmental Science at Bangor University. A major focus
24 of my research is on understanding below-ground processes with specific focus on nutrients and
25 human pathogen behavior in soil-plant-microbial systems. Current applications of my work
26 include the use of wastes for land restoration, implementation of strategies for controlling *E. coli*
27 O157 in agricultural systems, enhancing food safety, carbon sequestration in grasslands and ways
28 to improve nutrient use efficiency in cropping systems.

29 Parkhill, K.

1 My research interests span energy geographies and geographies of risk. I use qualitative methods
2 to explore how the public and stakeholders engage with/resists notions of low carbon lifestyles
3 and low carbon transitions, including examining how they themselves consume/perceive energy. I
4 am also interested in risk perception and how the public socially construct and engage with
5 environmental and technocratic risks. Such risks include: energy technologies such as civil nuclear
6 power, renewables or coal with carbon capture and storage; climate change, and;
7 geoengineering. The interaction of place, space and context underpins and flows throughout all of
8 these interests.

9 Barnes, A.

10 My research interest focuses on capturing the impacts of policy change and farmer behaviour at
11 the farm and catchment level within a modelling framework. Work has been conducted on a variety
12 of topics within this area, particularly in terms of understanding attitudes, motivations and
13 perceptions of farmers toward water pollution issues. Whereas some of this work encompasses
14 qualitative methods, such as citizen's juries, the main thrust has been towards quantitative
15 modelling. This includes traditional linear programming based methods, but also applications
16 using positive mathematical programming and agent-based modelling frameworks. A further
17 research interest lies in measuring and adjusting productivity indicators for non-economic factors,
18 such as animal welfare and environmental impact.

19 Williams, A.P.

20 I come from an agricultural background and much of the applied aspect of my research sits at the
21 interface between academia and industry. I have collaborated with the water, waste and agriculture
22 industries on a number of projects; covering soil science, pathogens, nutrient management, water
23 quality, livestock diseases, sustainable intensification, and animal by-products. As well as the
24 natural sciences, my involvement with many inter-disciplinary projects has given me valuable
25 experiences in socio-economic research.

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- 2 original version of this manuscript.

1 **Introduction**

2 Approximately 14.5% of anthropogenic global greenhouse gas (GHG) emissions can be attributed
3 to livestock production (Gerber 2013). Per kg of produce, red meat, such as beef and lamb, has a
4 higher carbon footprint in comparison to cultivated crops and alternative protein foodstuffs
5 (Lesschen et al. 2013). For industry to reduce emissions, it is important to understand how farmers
6 perceive climate change and their willingness to alter current management regimes. The aim of
7 this study is to establish different types of beef/sheep farmers, based on their sense of self-identity
8 and their perceptions of climate change. Such information can serve to improve future policy by
9 enabling the targeted transfer of climate change information.

10 In a pioneering study, Gasson (1973) suggested that farmer behaviour is driven by profit
11 maximisation. Subsequent research proposes that basing farmer behavioural types on the
12 assumption of a simple profit-maximising behaviour is inappropriate (Vanclay 2004; Pannell et al.
13 2006). Other revaluations of behaviour have unveiled that farmers do not act in ways that are
14 strictly governed by economic principles. Therefore, participation in environmental initiatives is
15 determined by more than just financial incentives (Vanclay and Lawrence 1994; Lockie et al. 1995;
16 Edwards-Jones 2006). It is therefore necessary to better understand what underpins farmer's
17 participation in environmental initiatives when developing effective policies and extension
18 programs (Vanclay et al. 2006; Pannell et al. 2006).

19 Farmers often ascribe different levels of importance to environmental and production aspects
20 of farm management (Vanclay and Lawrence 1994; Vanclay et al. 1998). However, extension
21 strategies and practices have traditionally ignored farmer diversity, presuming that adoption
22 programs are universally applicable, and thus universally adopted (Vanclay and Lawrence 1994).
23 Different epistemologies influence the mobilization and transformation of knowledge. The
24 limitations of the traditional paradigm of knowledge transfer led to the formation of non-didactic
25 'human development' approaches, which are based on social learning, participation, and
26 empowerment (Black 2000; Fleming and Vanclay 2010). Categorising farmers into groups has
27 been proposed as a means of effectively capturing this diversity (Valbuena et al. 2008). Whilst
28 perception-based farmer types are regarded by some to have limited salience – a criticism being
29 farmers do not identify themselves within pre-defined groups (Vanclay et al. 2006) – they have
30 gained prominence as a basis to effectively capture heterogeneity, and to effectively target farmers
31 for the voluntary uptake of environmental initiatives (Bidogeza et al. 2009; Voss et al. 2009;
32 Barnes and Toma 2012; Morgan-Davies et al. 2011; Nainggolan et al. 2012).

33 Few studies use typologies to characterise the perceptions of climate change from livestock
34 farmers of temperate regions. Eggers et al. (2014) found that North German grassland farmers

1 could be grouped into four types based on their perceptions of the issue. The research, which
2 focuses on adaptation measures on ley and permanent grassland, postulates that farmers consider
3 adaptation on economic factors or emotional reasoning. Elsewhere, Barnes and Toma (2012)
4 depict six distinct types of Scottish dairy farmers from perceptions of climate change and planning
5 goals. Half of the farmer types in the study believed that climate change would impact them
6 negatively in the future; signalling the likely adoption of technologies to combat such scenarios.
7 Conversely, other groupings did not perceive climate change as a significant enough threat to
8 change their future management planning. Whereas these studies have focused on farmer types in
9 other sectors, or on one aspect of adaptation or mitigation (Eggers et al. 2014; Bruce 2013), there
10 is a specific need to investigate beef and sheep farmers' perceptions of climate change in temperate
11 regions. Such analyses are important in light of the considerable attention bestowed on the red
12 meat sectors' contribution towards climate change; therein, assisting the industry's aspirations in
13 reducing emissions.

14 Farmers' perceptions of climate change differ – conceptual, practical, and information
15 barriers all act as limitations to pro-environmental behaviour (Fleming and Vanclay 2010). As
16 such, understanding farmers' self-identify, their awareness of an environmental issue and
17 perceptions of its risk, are essential in tailoring initiatives aimed at providing improvements in the
18 environmental performance of agriculture (Greiner et al. 2009; Yazdanpanah et al. 2014). These
19 constructs may influence the likelihood of farmers' voluntary uptake of climate change measures,
20 and their participation in programs that focus on reducing the sector's GHG emissions. Research
21 proposes a gap between awareness and pro-environmental behaviour. Reasons for such disconnect
22 can vary when considering climate change, and may be caused by the complexity of a problem
23 that is global in character (Kollmuss and Agyeman, 2002). However, the level and type of
24 knowledge can lessen the gap between awareness and mitigation behaviour (O'Connor et al. 2002).
25 Moreover, the appraisal of risks climate change may bring is a significant factor in influencing
26 adaptive responses (Arbuckle et al. 2015; O'Connor et al. 1999). Story and Forsyth's (2008)
27 awareness-appraisal-responsibility model asserts that individuals become increasingly likely to
28 protect and sustain the environment as awareness and responsibility of an environmental issue
29 heighten, and appraisal of its risk become elevated.

30 We therefore utilise constructs that assess farmers' self-identity and their behavioural
31 capacity to implement measures that address climate change. Two constructs determine self-
32 identity, and are based on productivism and environmental responsibility. Motivation to adopt
33 environmental behaviour is based on internal perceptions of how farming should be practiced
34 (farmer-identity). The Dual Interest Theory acknowledges that both economic and environmental

1 motivations are represented in varying strengths when individuals make environmental decisions
2 (Sheeder and Lynne, 2011). Furthermore, two additional constructs assess awareness and risk
3 perception, and hence the behavioural capacity to implement adaptation and mitigation measures.
4 Behavioural capacity can be defined as the latent potential of behavioural change to affect
5 improvements in the environment (Beretti et al. 2013).

6 Considering the limited focus on beef/sheep farmers perceptions of climate change in
7 temperate regions, the aims of this study are to: (1) determine such farmers' perceptions of the
8 issue; (2) create a typology of beef/sheep farmers based on these perceptions; (3) assess if self-
9 identity influences the behavioural capacity of farmers to implement measures which address
10 climate change. We hypothesise that farmers who align themselves with an environmental self-
11 identity are conscious of the intricacies of climate change and the risks that it may bring. The
12 opposite is foreseen for farmers who displayed productivist tendencies. In the following section,
13 we critically engage with the conceptual literature associated with the aforementioned motivational
14 and behavioural capacity constructs which are used to assess the hypotheses outlined above.

15

16 **Awareness, self-identity, and perceptions of risk**

17 Self-Identity

18 Self-identity refers to the extent to which certain behaviour is considered part of one's self (Terry
19 et al. 1999). Ascription of one's beliefs may be filtered through an individual's value system
20 (Sulemana and James Jr. 2014). The more salient an identity, the greater the probability of it being
21 activated; hence it is possible to predict desired action using self-identity (Burke and Stets 2009).

22 Pro-environmental and productivist identities are two of the most commonly examined in an
23 agricultural context (Sulemana and James Jr. 2014). Although modern-day agriculture has adapted
24 to serve multiple purposes, i.e. the provision of food and ecosystem services, research postulates
25 that a productivist identity dominates the decision-making process of farmers (Burton 2004;
26 Burton and Wilson 2006). Productivism is often legitimised by government policies advocating
27 that increasing output serves the national interest (Burton and Wilson 2006). Indeed, Rosin (2013)
28 demonstrated that despite increasing environmental concerns over intensification, the 2008 global
29 food price spike has further reinforced productivist idealisms within New Zealand farmers.

30 Environmental programs may be resisted in cases where this productivist self-identity is
31 threatened by the perceived induction of pro-environmental legislation (van der Werff et al. 2013).
32 Therefore, understanding farmers' sense of identity is important in assessing their motivation in
33 adopting environmental measures and participation in environmental programs (Sulemana and
34 James Jr. 2014). Indeed, Indiana farmers who were motivated by environmental responsibility

1 (rather than profitability) were most likely to adopt conservation practices (Reimer et al. 2012).
2 Moreover, Lokhorst et al. (2011) observed that self-identity is significantly related to farmers'
3 intention to perform non-subsidised environmental practices. Hence, self-identity can significantly
4 affect an individuals' motivation to undertake voluntary measures where financial
5 reimbursements, or awards, are not forthcoming.

6

7 Awareness

8 Awareness of environmental problems is a perceived estimate of reality that individuals formulate
9 from accumulated knowledge (Dietz et al. 2007); this construct can subsequently influence
10 behavioural decisions (McCown 2005), and willingness to adopt solutions (Prokopy et al. 2008).
11 Awareness in the context of this study refers to the degree in which individuals are aware that
12 climate change is happening, and that agriculture is a contributing factor to anthropogenic-induced
13 GHG emissions.

14 Research proposes a positive correlation between awareness of climate change and the
15 likelihood of implementing mitigation measures (Lorenzoni et al. 2007). Mitigation can be defined
16 as an anthropogenic intervention to reduce sources or enhance the sinks of GHGs (IPCC 2001).
17 Climate change awareness is therefore a relevant facet in predicting pro-environmental behaviour
18 (Bord et al. 2000; O'Connor et al. 2002; Prokopy et al. 2008; Semenza et al. 2008). Arbuckle et
19 al. (2013) postulate that mitigation action requires farmer awareness of climate change, at least
20 tacitly, and that human activity is an underlying cause of the issue.

21

22 Perceived risk

23 While awareness of climate change is a powerful predictor of behavioural intentions, it is
24 independent from the belief that climate change will have negative impacts. Risk perception
25 corresponds to the belief about adverse consequences for valued objects (Leiserowitz 2006; Dietz
26 et al. 2007; Brody et al. 2012; Arbuckle. et al. 2015); it is dependent on values and ecological
27 worldviews (Stern et al. 1999). Perceptions of the risks that climate change may bring can therefore
28 influence engagement and the support of policies that address the issue (O'Connor et al. 1999).

29 In the context of this study, perceived risk is farmers' appraisal of the negative effects of
30 climate change on agriculture. Individuals are more likely to adopt pro-environmental behaviour
31 when they understand the adverse impacts of no action (Masud et al. 2013; O'Connor et al. 1999).
32 Participation in adaptation and mitigation initiatives becomes less appealing when climate change
33 is weighed up against risks such as economic instability (Stuart et al. 2014). Subsequently, farmers
34 who perceive climate change in terms of local consequences which may negatively impact their

1 enterprise are more likely to support and participate in initiatives that aim to address the issue
2 (Haden et al. 2012; Arbuckle et al. 2015).

3 The extent to which farmers succeed in living in accordance to their identity tends to be
4 moderated by constraints such as risk (Pannell et al. 2006). Indeed, a dystopian perception of the
5 adverse effects of climate change has been found to be among the strongest predictors of support
6 for climate change policies (McCown 2005; Dietz et al. 2007). For instance, it has been observed
7 that climate change risk perceptions influence support of adaptive actions amongst US farmers
8 (Arbuckle et al. 2015; Niles et al. 2013). Adaptation can be defined as adjustments in human or
9 natural systems in response to actual or expected climatic stimuli and their effects or impacts
10 (IPCC 2001). Therefore, perceptions of the risks associated with climate change are a necessary
11 precursor for the adoption of adaptation measures (Arbuckle et al. 2013).

12

13 **Methods**

14 **Wales: a case study**

15 Little attention has focused specifically on beef/sheep farmers perceptions of climate change in
16 developed temperate regions. Moreover, factors which influence farmers' willingness to adopt
17 initiatives aimed at reducing the sector's GHG emissions have been largely unexplored. This is in
18 spite of livestock production accounting for a particularly high proportion of global GHG
19 emissions (Gerber et al. 2013). To reduce livestock emissions, countries have adopted numerous
20 approaches at the farm level, many of which are voluntary (Cooper et al. 2013).

21 Wales presents characteristics that are applicable to various nations that aim to alleviate
22 emissions from pastoral-based systems; indeed, beef and sheep enterprises represent the
23 overwhelming majority of farm holdings nationally. The topography of the country varies
24 considerably, encapsulating an array of challenges and environments faced globally by temperate
25 farmers in the sector. Wales aspires to reduce its total emissions by annual increments of 3% from
26 2011 onwards (Welsh Government 2009); the livestock industry has also initiated a strategic plan
27 outlining how the sector plans to meet such targets (HCC 2011). A better understanding of farmer
28 perceptions of climate change will help identify whether these targets are achievable, and the
29 barriers to change. Like many countries, Wales largely relies on farmers' voluntary uptake of
30 adaptation and mitigation measures. Uptake has been incentivised through initiatives such as
31 efficiency grants offered by government (Welsh Government 2014).

32 **Questionnaire design and distribution**

1 The development of a pilot questionnaire resulted from a review of relevant literature on farmer's
2 perceptions of climate change (Widcorp 2009; Farming Futures 2011; Barnes and Toma 2012;
3 Hall and Wreford 2012). This was then trialled with 30 livestock farmers, and minor amendments
4 (e.g. to the wording of some questions) were implemented thereafter. The final administered ($n =$
5 286) bilingual survey (English/Welsh) consisted of three sections (see Supplementary material).
6 Section one elicited socio-demographic information, section two consisted of 29 statements where
7 respondents were asked to express their opinion on a 5-point Likert scale, and the final section
8 captured farmers' general views on climate change sources. Farmers were recruited by
9 convenience sampling throughout Wales during 2012 at union meetings, livestock markets,
10 agricultural extension open days, as well as agricultural shows and events.

11

12 Analyses

13 Survey results were analysed statistically in a variety of ways including Principal Component
14 Analysis (PCA) and Cluster Analysis. The first part of the results section presents an overview of
15 all respondents' perceptions of climate change along with issues related to the concept; therein
16 setting the scene for subsequent analyses and discussion. Details of procedures used for PCA and
17 cluster analysis used to assess farmers' motivation and behavioural capacity are outlined in the
18 sections that follow.

19 Principal Component Analysis

20 Participants' responses to statements in section two of the questionnaire were analysed using PCA
21 to give a more detailed representation of perceptions of climate change. PCA identifies common
22 factors to account for most of the variation in data and is performed by examining the pattern of
23 correlations among independent variables (i.e. questionnaire statements). When these variables are
24 highly correlated, they are effectively 'saying the same thing' and described as components (Field
25 2009). The subsequently acquired factor loadings are merely the correlations among all
26 individuals' answers to each of the questionnaire statements with the derived component score.
27 The components extracted from the PCA are subsequently used as classification criteria to cluster
28 respondents into types (Bidogezza et al. 2009; Voss et al. 2009; Barnes and Toma 2012; Morgan-
29 Davies et al. 2011; Nainggolan et al. 2012). These groupings are internally homogenous, while
30 being externally heterogeneous from one another (Janssens et al. 2008).

31 The Kaiser-Meyer-Olkin measure of sampling adequacy was found to be greater than 0.6
32 (0.808), thereby verifying that the dataset was appropriate for PCA. Subsequently, the Bartlett's
33 test of sphericity was seen to be significant ($p < 0.05$), thus indicating that PCA could proceed

1 (Pallant, 2010). The factors selected (based on the Kaiser criterion with eigen-values ≥ 1) explained
2 55.7% of the variance.

3 A Varimax rotation was implemented to increase the interpretability of the results (Field
4 2009). Considering the sample size, a statement was only retained if the loading factor was at least
5 0.35 (Janssens et al. 2008) and the difference between the loading, and two other cross-loadings,
6 greater than 0.3 (Wang and Ahmed 2009). Interpretation of the scree plot revealed inflexions that
7 justified retaining four components; this was supported by parallel analysis (Pallant 2010). The
8 content of a component was best interpreted by examining items with factor loadings of 0.4 or
9 above, such factors are considered to be 'fair' (Costello and Osborne 2011). Subsequently, the four
10 components were named: awareness (A), environmental responsibility (ER), productivism (P), and
11 perceived risk (PR). Both environmental responsibility and productivism components can be
12 described as identity standards; whereas awareness and risk perception components specifically
13 reflect an individual's behavioural capacity to implement mitigation and adaptation measures
14 (Table 1).

15

16 <<Table 1 around here>>

17

18 Cronbach's alpha was applied to test the reliability and internal consistency of the derived
19 factor loadings (Pallant 2010). Cronbach alpha's > 0.5 are considered acceptable as evidence of a
20 common factor underlying the responses (Nunnally 1967). The reliability of each factor's
21 Cronbach's alpha was examined through the impact on alpha by the removal of each statement.
22 An alpha value higher than the final value suggested the removed statement was unnecessary (Field
23 2009). Consequently, question 28 ('I find information on climate change easy to understand') was
24 removed from the analysis.

25 Cluster analysis

26 The factor scores from PCA were subjected to both Ward's hierarchical and K-means clustering
27 methods (Burns and Burns 2008). The PCA scores were used for the Ward's hierarchical clustering
28 technique as the algorithms require continuous, rather than the categorical Likert scale data
29 collected in the survey. Hair et al. (1998) point out that the selection of the final cluster solution
30 requires substantial researcher judgement. The application of the hierarchical cluster analysis
31 suggested the presence of four clusters from interpretation of the dendrogram (Köbrich et al. 2003).
32 An elbow test verified the ideal number of clusters for the successive k-means clustering method

1 to be $n = 4$, which was consistent with the interpretation of the dendrogram (Burns and Burns
2 2008).

3 The K-means method minimises the distances within each cluster to the centre of that
4 cluster, and was carried out following hierarchical cluster analysis. K-means methods are superior
5 to the hierarchical methods when the choice is made for an initial configuration based on the results
6 of hierarchical clustering (Janssens et al. 2008). Subsequently, respondents were grouped into their
7 respective clusters. The types were labelled according to evident differences in perceptions of
8 climate change based on the cluster centres for each grouping. Cluster comparison and validation
9 was carried out by a one-way-analysis-of-variance and Bonerroni multiple comparison tests; the
10 tests verified significant differences present between groups with regard to their perception of the
11 four PCA components. Furthermore, Pearson's Chi-Squared test (X^2) was used to determine
12 whether groupings differed significantly in the frequency in which they answered questions not
13 included in PCA analysis ($p < 0.05$).

14

15 **Results**

16 Characteristics and perceptions of respondents

17 In total, 286 completed surveys were obtained, representing ca. 2.2% of livestock farmers in Wales
18 (Welsh Government 2012). Table 2 summarises the general characteristics of the respondents,
19 while Figure 1 illustrates where farmers obtained information on climate change.

20

21 <<Table 2 around here>>

22 <<Figure 1 around here>>

23

24 Farmers were uncertain as to what opportunities, if any, that climate change may bring.
25 The main opportunity that climate change may bring was thought to be that of a longer growing
26 season. Unpredictable and extreme weather was ascribed as the greatest risk from climate change
27 on their farms (42.3%) (Table 3). Whilst there was awareness that anthropogenic climate change
28 is a reality, there was some uncertainty of the contribution of livestock to the problem (Fig. 2). It
29 was interesting to observe how respondents were less hesitant in chastising other industries and
30 activities as being contributors to climate change (Fig. 3).

31

32 <<Table 3 around here>>

33 <<Figure 2 around here>>

34 <<Figure 3 around here>>

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Farmers were also asked to rank the threat to society from climate change, relative to various other pertinent environmental issues. Food security was forecast as being the greatest future threat to society, followed by energy security, water quality, climate change, waste management, and air pollution (Fig. 4).

The responses from all participants suggest an awareness that climate change is happening, but there is an evident disconnect in terms of agriculture’s perceived contribution towards the problem. We now create a typology of farmers to assess if the awareness and disconnection outlined above is influenced by farmer self-identity. We also investigate if self-identity impends famers’ behavioural capacity to implement issues that address climate change.

<<Figure 4 around here>>

A typology of farmers

<<Table 4 around here>>

Through PCA and Cluster Analyses, four types of individual farmers were identified (Table 4). Using the cluster centres from the most appropriate solution from Ward’s method (based on the four PCA components), K-means clustering was applied (Table 4). A radar diagram is constructed from these cluster centres to give a visual representation of the differences between each of the types created with respect to the components elicited from PCA (Fig. 5). Two self-identity components evaluate motivation to act in a pro-environmental manner (environmental responsibility and productivism) while two evaluate behavioural capacity to implement mitigation and adaptation measures (awareness and risk perception). Furthermore, responses to non-statement questions in Section 3 of the questionnaire, which are not included in PCA analysis, are assessed based on farmer type and used to further define the four groupings (Table 5). These relate to what/where respondents perceived to be GHG sources. Such analysis deciphers farmer explicit knowledge of agricultural emissions. Where different farmer types obtained information on climate change was also determined (Table 5).

<<Figure 5 around here>>

The Environmentalist

The defining feature of The Environmentalist was their high awareness of climate change, while they also encapsulated a high sense of environmental responsibility. Hence, both motivation to act

1 pro-environmentally and behavioural capacity to implement mitigation measures were high. The
2 Environmentalist however had a low perceived sense of the risks which climate change may bring,
3 suggesting a lower likelihood of adopting adaptation measures (Fig. 5). There was a general
4 consensus from farmers in this group that the manufacturing and use of fertilizer, along with
5 methane from ruminants and the management of their manure, contribute towards climate change
6 (Table 5). Compared to the other groupings, a higher percentage of Environmentalists believed
7 methane associated with livestock to be a cause of climate change. Indeed, only 6.7% ascribed it
8 as not being a contributing factor.

9 The Environmentalist was the highest educated of the four clusters and 50% of those
10 sampled had a university degree or higher. A significant characteristic ($p < 0.01$) in defining The
11 Environmentalist from the other groups was the time period they had been involved in farming.
12 Farmers sampled within this type had been farming for between 21 – 30 years, whereas the
13 majority of farmers in the other groups had been farming for over 31 years. Evans et al. (2011)
14 observed that the longer individuals had been farming, the more inclined they were to disagree that
15 science had considered all factors in its estimates of climate change. Essentially, such farmers did
16 not value the findings of scientists and researchers.

17

18 *The Dejected*

19 Members of this type projected a pessimistic and dejected disposition towards climate change as
20 they expect it to affect them unfavourably. The factor most prevalent in characterising this group
21 is a high sense of perceived risk, indicating an inherent high behavioural capacity to implement
22 adaptation measures. Furthermore, The Dejected scored high in terms of awareness (Fig. 5), which
23 suggests implicit willingness to consider implementing mitigation measures. Indeed, high
24 perceptions of risk, when coupled with awareness of climate change, can be strong indications of
25 adaptation and mitigation (Arbuckle 2013).

26 Although such farmers were aware that climate change is occurring and that livestock
27 farming contributes towards the problem, there was an evident lack of understanding concerning
28 how emissions are generated (Table 5). The Dejected was aware to some extent that the
29 management of livestock and their waste led to the emission of GHGs, but only 8% of those
30 sampled ascribed emissions of methane to livestock as being a major cause of climate change.
31 Indeed, 25.4% of farmers in this cluster believed that methane associated with livestock farming
32 does not contribute towards climate change (Table 5). This disconnect suggests a conspicuous lack
33 of understanding in linking agricultural emission sources with the concept of climate change.

34

1 *The Countryside Steward*

2 A high sense of environmental responsibility was evident for this particular type of farmer. The
3 Countryside Steward was deeply concerned about the environment and see themselves as
4 protectors of the countryside. Furthermore, they held a low disposition towards productivism (Fig.
5 5). The Country Steward's sense of personal attachment to the land is therefore transmuted into
6 the wider environment (Leopold 1949). Consequently, the will to adopt pro-environmental
7 behaviours is evident.

8 Although The Countryside Steward's sense of environmental responsibility was comparable
9 to The Environmentalist, the two groupings differed greatly with regards to awareness of climate
10 change. Indeed, The Countryside Steward scored lowest for this component (Fig. 5). The belief
11 that methane associated with livestock management does not contribute to climate change
12 significantly differentiated them from the other groups ($p < 0.01$). Evidently, 41.8% of Countryside
13 Stewards perceived such emissions as being unproblematic (Table 5). Furthermore, a higher
14 percentage of this farmer type perceived emissions from other industries as only a minor cause of
15 climate change (Table 5). A low behavioural capacity to implement mitigation or adaptive
16 measures is consequently borne from The Countryside Steward's low senses of awareness and
17 perceived risk. Interestingly, the proportion of university-educated members was significantly
18 lower in this cluster in comparison to the other types ($p < 0.05$).

19

20 *The Productivist*

21 Farmers within this type were defined by their lower sense of environmental responsibility, while
22 displaying a penchant for productivism (Fig. 5). The disparity observed in motivational constructs
23 suggests that production dictates management decisions. It could be argued that such farmers sees
24 their enterprise primarily as a business, where the environment provides the raw materials and
25 resources necessary to produce a profit. Such farmers focus on the quantitative outputs of land
26 management (Lowe et al. 1993; Wilson 2001). Other studies have also revealed farmers with
27 characteristics that predominantly converge on profits and efficiency maximisation (Gasson 1973;
28 Guillem et al. 2012; Barnes and Toma 2012).

29 The Productivist was not as aware of climate change as other farmer types, nor did they
30 perceived it to be a risk to their farming enterprise. Conversely, they denounced emissions from
31 other industries as being a major cause of climate change, while placing little accountability
32 towards the livestock sector (Table 5). Hence, The Productivist may not be as pro-active as other
33 groups since low motivation to act pro-environmentally was coupled with a low behavioural
34 capacity to implement both mitigation and adaptation measures.

1
2 <<Table 5 around here>>

3
4 **Discussion**

5 The purpose of this study is to establish a typology of beef/sheep farmers based on farmers self-
6 identity and their perceptions of climate change. The convenience sampling method used has been
7 shown to be representative (Luschei et al. 2009). Although bias is possible (Berk 1983), its
8 potential was considered to be negligible as every possible farmer encountered at the numerous
9 study sites was approached on sampling days. The findings are hence robust for the 286
10 respondents who gave their views on climate change and provide a sound basis for future
11 investigation. Pastoral-based livestock systems in temperate regions are ubiquitous the world over.
12 The approach used in this study is particularly relevant to researchers who aspire to determine the
13 perceptions of climate change from farmers who operate in such environs. Moreover, where
14 equivalencies in farmer identity and behavioural capacity are evident, findings may be extrapolated
15 to aid policy-makers in other temperate regions to encourage farmers in adopting measures that
16 address climate change.

17 Farmers' perceptions of environmental issues are heavily influenced by political agendas
18 (Holloway and Ilbery 1996). Topical issues are likely to be those that are colloquial, where farmers
19 have been forced to recognise issues through legislation or environmental groups. With this in
20 mind, we found that farmers ranked climate change below food security, energy security, and water
21 quality in terms of important issues confronting society in the future. This ranking is consistent
22 with the general public's perception of the issue in recent years (Ratter et al. 2012). Possible
23 explanations are issue fatigue, the impact of the global financial crisis, distrust, and the deepening
24 politicisation of the issue (Pidgeon 2012).

25 Low behavioural capacity is borne from a lack of awareness of climate change and a low
26 sense of the perceived risks that it may bring. This acts as a barrier for both The Productivist and
27 The Countryside Steward in adopting measures that help address climate change. It could be
28 hypothesised that the primary reason that The Productivist would take the climate into
29 consideration is if there are (economic) incentives in place to do so (Defra 2010; Fleming and
30 Vanclay 2010). Messages which focus on low-cost 'win-win' technologies may therefore resonate
31 (Islam et al. 2013). However, the costs of inaction can often be considerably greater than the
32 economic costs of immediate action (OECD 2012). Discourses framed in such a monetary manner
33 may gain recognition with farmers who possess productivist tendencies. Furthermore, the concept

1 of sustainable intensification could particularly appeal to such farmers as their production
2 tendencies would not be compromised (The Royal Society 2009).

3 Weber (1997) proposes a ‘finite pool of worry’, which implies that one’s regard for the
4 environment decreases as other factors gain prominence. The theory suggests that individuals have
5 a limited capacity as to how many issues they deem relevant at any one time. Farmers like the
6 Productivist may feel compelled to assert management decisions towards production as such an
7 alignment may be deemed necessary for survival. Readjusting focus towards the environment may
8 be therefore condemned as superfluous by such farmers. Given The Countryside Steward’s high
9 environmental responsibility, their low awareness of climate change may be an example of
10 ‘availability heuristic’ (Tversky and Kahneman 1973). It could be hypothesised that they do not
11 consider climate change as being the cause of adverse weather conditions.

12 It is important to recognize the complexity of climate change along with the intricacy of its
13 causes. Notably, we observe how many farmers depict agriculture as contributing little towards
14 GHG emissions, whereas emissions from other industries are generally perceived to be a major
15 cause of climate change. Furthermore, none of the farmer types perceive methane from livestock
16 as being a major cause of climate change, further illustrating a reluctance to accept responsibility
17 (Table 5). Such displacement of blame is not unique, and blame avoidance is an important barrier
18 for effective engagement (Kurz et al. 2005; Lorenzoni et al. 2007).

19 There is evidence that strongly suggests that some farmers who believe in climate change
20 have higher quantitative perceptions of associated future hazards (direct or indirect) (Menapace et
21 al. 2012). This in some way may decipher why farmers like The Dejected feel threatened by the
22 issue. However, there are often uncertainties about aspects of GHG emissions even where
23 individuals accept the overarching scientific consensus that climate change is a reality (Moser
24 2010). As such, accurate understandings of the causes of climate change is an important
25 determinant of pro-environmental behaviour and support of climate change policies (O’Connor et
26 al. 1999). With the exception of The Environmentalist, analyses of the farmer types reveal a
27 disconnection between agricultural emission sources and their contribution towards climate
28 change. This is particularly evident in The Dejected, who is aware that agriculture contributes
29 towards climate change but is unsure as to how such emissions are generated. The observed
30 disconnect suggests emotional-focused coping to lessen risk perceptions by avoidance, denial, and
31 desensitisation (Clayton and Myers 2009). Bruce (2013) demonstrates that beef/sheep farmers
32 conceptualised methane emissions associated with ruminants as a natural occurrence rather than a
33 pollutant. A perception of GHG emissions from ruminates as being environmental benign may
34 allude to why The Productivist and The Countryside Steward are not aware of agriculture’s

1 contribution to climate change. Therefore, conceptualising methane towards the paradigm of being
2 a negative externality requires specific attention, which should be facilitated by knowledge
3 transfer.

4 The literature recommends increasing attention to the role of advice and information
5 dissemination that leads to voluntary individual and collective action (Hall and Wreford 2012).
6 Understanding farmers' perceptions is therefore imperative in building effective outreach
7 strategies (Greiner et al. 2009). Both primary and secondary information sources were comparable
8 across the four farmer types (Table 5). Although limited, unilateral information sources can be
9 beneficial if used to support debate and raise awareness so that a common knowledge base is
10 attained (Bizikova et al. 2014). This would be particularly advantageous in addressing the
11 observed disconnect that farmers display between on-farm GHG emission sources and their
12 contribution towards climate change.

13 Different epistemologies influence the mobilization and transformation of knowledge. The
14 traditional knowledge-transfer approach has been criticised as it fails to adequately address
15 heterogeneity within the farming community (Klerkx et al. 2012), and may explain the variance in
16 awareness and risk perception amongst the types in this study. The limitations of the traditional
17 paradigm led to the formation of non-didactic 'human development' approaches, which are based
18 on participation and empowerment (Black 2000; Fleming and Vanclay 2010). Lankester (2013)
19 demonstrates how organised collective group learning is an effective method of fostering
20 sustainability and pro-environmental behaviour among farmers. Social learning bases its
21 philosophy on participation and integrating knowledge from different perspectives and involves
22 critical thinking, interactions, dialogue, and questioning assumptions that underline individual
23 concepts (Leeuwis et al. 2002). This approach would allow the four types to discuss views on
24 climate change with each other and experts (Carolan 2006).

25 Social learning could be propitious in shifting The Productivist's sense of what is involved
26 in being a 'good farmer' away from a production standard towards one with more environmental
27 tendencies (McGuire et al. 2013). Group discussion would provide a platform to increase
28 awareness and to deliberate the adoption of measures that are both environmentally and
29 economically beneficial. The Countryside Steward has a particularly high sense of environment
30 responsibility but is lacking in their awareness of climate change; therefore, it is reasonable to
31 assume that effective participatory approaches could encourage their participation in programs that
32 focus on climate change. Social interaction can also ease unfounded risk perceptions that farmers
33 such as The Dejected may hold (Langford 2002; Maiteny 2002). Communication of risks could

1 also inspire greater action and support of climate change initiatives in other types (Leiserowitz
2 2006).

3 Although the human development model is seen as an improvement on the knowledge-
4 transfer approach, no single model is likely to be sufficient by itself for effective knowledge
5 exchange and/or knowledge transfer. There is still therefore a need for access to reliable scientific
6 information, just as there is a need to promote communication within a social system (Black 2000).
7 Furthermore, information sources that are trusted by farmers should be utilised, irrespective of the
8 model used (Reed et al. 2014). The fact that no one paradigm suits all further illustrates the
9 importance of recognising the heterogeneity within the farming sector. Hence, carefully planned
10 communication, targeted at the different farmer types, can help encourage a positive change in
11 farm management practices that reduce GHGs for all types (Garforth et al. 2004; Maibach et al.
12 2009).

13

14 **Conclusions**

15 The farmer types elicited in this study can be used as a tool to advance the development and uptake
16 of mitigation and adaptation measures. Farmers are more likely to protect and sustain the
17 environment when they are aware of an environmental problem, consider the environmental threat
18 to be great, and feel responsible for acting (O'Connor 1999; Story and Forsyth 2008). We
19 hypothesise that farmer identity influences assessments of climate change, therein affecting their
20 behavioural capacity to implement measures that address the issue.

21 Mitigation and adaptation are determined through farmers' awareness of the issue and their
22 perceptions of risks that it may bring. The Environmentalist is therefore most likely to adopt
23 mitigation measures as their awareness is higher than the other types. The Dejected also has a high
24 implicit behavioural capacity to implement mitigation measures. Furthermore, a high inherent
25 capacity to implement adaptation measures is evident through their high perceptions of risk.
26 However, we observe that while The Dejected accepts that livestock contributes towards climate
27 change, there is evidence of avoidance, denial, and desensitisation through their lack of
28 understanding of how exactly emissions are generated from livestock farming. Therefore, their
29 capacity to implement climate change measures may be stifled. The Countryside Steward displays
30 a high sense of motivation to act pro-environmentally but is lacking in their awareness of climate
31 change, implying a low behavioural capacity to implement measures to address the issue.

32 Globally, environmental considerations are often in competition with other societal
33 outcomes such as food production. Policy-makers should be aware that farmer's adoption of
34 environmental measures depends upon the measures practicality and cost, amongst other factors

1 (Jones et al. 2013). Such factors may contribute to the concept of a ‘finite pool of worry’ as
2 individuals have a limited capacity as to how many issues are deemed relevant at any one time.
3 Farmers are also often challenged by changing market conditions whilst also being expected to
4 deliver an expanding range of ‘public goods’, such as increasing food production (Stuart and
5 Gillon 2013). Collectively, this means that farmers like The Productivist are less likely to adopt or
6 support environmental measures as motivation to produce overshadows an environmental ethos.
7 Hence, messages framed under the concept of sustainable intensification may particularly appeal
8 to their self-identity characteristics.

9 The Dejected and The Countryside Steward’s lack of knowledge of how exactly livestock
10 contributes to climate change indicates how neither high awareness, nor environmental
11 responsibility, are conflated with an explicit knowledge of the issue. Particular attention should be
12 paid to addressing the evident disconnect in perceptions of agricultural emission sources and their
13 contribution towards climate change. If such linkages are not conceptualised, it is unlikely that the
14 migration or adaptation potentials will be fully realised across the elicited farmer types. The farmer
15 types depicted can enable the effective transfer and exchange of knowledge which can encourage
16 the voluntary adoption of adaptation and mitigation measures. A variety of dissemination methods
17 should be used to facilitate farmer action which addresses climate change based on the types
18 elicited.
19

1 **References**

- 2 Arbuckle J. G., J. G., Morton, L. W., and Hobbs, J. 2013. Farmer beliefs and concerns about
3 climate change and attitudes toward adaptation and mitigation: Evidence from Iowa. *Climatic*
4 *Change* 18 (3-4): 551-563.
- 5 Arbuckle, J. G., Morton, L. W., and Hobbs, J. 2015. Understanding farmer perspectives on climate
6 change adaptation and mitigation: The roles of trust in sources of climate information, climate
7 change beliefs, and perceived risk. *Environment and Behavior* 47(2): 205-234.
- 8 Barnes, A. P., and Toma, L. 2012. A typology of dairy farmer perceptions towards climate change.
9 *Climatic Change* 112(2): 507-522.
- 10 Beretti, A., Figuières, C., and Grolleau, G. 2013. Behavioral innovations: The missing capital in
11 sustainable development? *Ecological Economics* 89: 187-195.
- 12 Berk, R.A. 1983. An introduction to sample selection bias in sociological data. *American*
13 *Sociological Review* 48: 386-398.
- 14 Bidogeza, J., Berentsen, P. B. M., De Graaff, J., and Oude Lansink, A. G. J. M. 2009. A type of
15 farm households for the Umutara province in Rwanda. *Food Security* 1(3): 321-335.
- 16 Bizikova, L., Crawford, E., Nijnik, M., and Swart, R. 2014. Climate change adaptation planning
17 in agriculture: Processes, experiences and lessons learned from early adapters. *Mitigation and*
18 *Adaptation Strategies for Global Change* 19(4): 411-430.
- 19 Black, A. 2000. Extension theory and practice: a review. *Animal Production Science*, 40(4), 493-
20 502.
- 21 Bord, R. J., O'Connor, R. E., and Fisher, A. 2000. In what sense does the public need to understand
22 global climate change? *Public Understanding of Science* 9(3): 205-218.
- 23 Burns, R., and Burns, R. P. 2008. *Business research methods and statistics using SPSS*. London:
24 Sage Publications Limited.
- 25 Brody, S., Grover, H., and Vedlitz, A. 2012. Examining the willingness of Americans to alter
26 behaviour to mitigate climate change. *Climate Policy* 12(1): 1-22.
- 27 Bruce, A. 2013. The lore of low methane livestock: Co-producing technology and animals for
28 reduced climate change impact. *Life Sciences Society and Policy* 9(10).
- 29 Burke, P. J., and Stets, J. E. 2009. *Identity theory*. Oxford University Press.
- 30 Burton, R. J. 2004. Seeing through the 'good farmer's' eyes: Towards developing an understanding
31 of the social symbolic value of 'productivist' behaviour. *Sociologia Ruralis* 44(2): 195-215.
- 32 Burton, R. J., and Wilson, G. A. 2006. Injecting social psychology theory into conceptualisations
33 of agricultural agency: Towards a post-productivist farmer self-identity? *Journal of Rural*
34 *Studies* 22(1): 95-115.

- 1 Carolan, M. S. 2006. Sustainable agriculture, science and the co-production of ‘expert’ knowledge:
2 The value of interactional expertise. *Local Environment* 11(4): 421-431.
- 3 Clayton, S., and Myers, O. G. 2009. *Conservation psychology: Understanding and promoting*
4 *human care for nature*. Cambridge: Cambridge University Press.
- 5 Cooper, M. H., Boston, J., and Bright, J. 2013. Policy challenges for livestock emissions
6 abatement: Lessons from New Zealand. *Climate Policy* 13(1): 110-133.
- 7 Costello, A., and Osborne, J. 2011. Best practices in exploratory factor analysis: Four
8 recommendations for getting the most from your analysis. *Practical Assessment, Research*
9 *and Evaluation* 10(7), Retrieved from <http://pareonline.net/pdf/v10n7.pdf>. Accessed 13
10 December 2014.
- 11 Defra. 2010. *Low carbon farming: The benefits and opportunities*. London: Department for
12 Environment, Food and Rural Affairs.
- 13 Dietz, T., Dan, A., and Shwom, R. 2007. Support for climate change policy: Social psychological
14 and social structural influences. *Rural Sociology* 72(2): 185-214.
- 15 Edwards-Jones, G. 2006. Modelling farmer decision-making: Concepts, progress and challenges.
16 *Animal Science* 82(6): 783-790.
- 17 Eggers, M., Kayser, M., and Isselstein, J. 2014. Grassland farmers’ attitudes toward climate change
18 in the North German plain. *Regional Environmental Change*, 14(4), 1-11.
- 19 Evans, C., Storer, C., and Wardell-Johnson, A. 2011. Rural farming community climate change
20 acceptance: Impact of science and government credibility. *International Journal of Sociology*
21 *of Agriculture and Food* 18(3): 217-235.
- 22 Farming Futures. 2011. *Climate change survey stage five report*. Cambridge: Farming Futures.
- 23 Fleming, A., & Vanclay, F. 2011. Farmer responses to climate change and sustainable agriculture.
24 *Agriculture for Sustainable Development* 30(1): 11-19.
- 25 Field, A. 2009. *Discovering statistics using SPSS*. London: Sage Publications Limited.
- 26 Garforth, C., Rehman, T., McKemey, K., Tranter, R., Cooke, R., Yates, C., Park, J., Dorward, P.
27 2004. Improving the design of knowledge transfer strategies by understanding farmer attitudes
28 and behaviour. *Journal of Farm Management* 12(1): 17-32.
- 29 Gasson, R. 1973. Goals and values of farmers. *Journal of Agricultural Economics* 24(3): 521-542.
- 30 Greiner, R., Patterson, L., and Miller, O. 2009. Motivations, risk perceptions and adoption of
31 conservation practices by farmers. *Agricultural Systems* 99: 86-104.
- 32 Guillem, E., Barnes, A., Rounsevell, M., and Renwick, A. 2012. Refining perception-based farmer
33 typologies with the analysis of past census data. *Journal of Environmental Management* 110:
34 226-235.

- 1 Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Tempio, G. 2013.
2 *Tackling climate change through livestock: A global assessment of emissions and mitigation*
3 *opportunities*. Rome: Food and Agriculture Organization of the United Nations FAO.
- 4 Haden, V. R., Niles, M. T., Lubell, M., Perlman, J., and Jackson, L. E. 2012. Global and local
5 concerns: What attitudes and beliefs motivate farmers to mitigate and adapt to climate
6 change? *PLoS One* 7(12): e52882.
- 7 Hair, J. F., Anderson, R. E., Tatham, R. L., and Black, W. C. 1998. *Multivariate data analysis* (5th
8 ed.). Upper Saddle River, NJ: Prentice Hall International.
- 9 Hall, C., and Wreford, A. 2012. Adaptation to climate change: The attitudes of stakeholders in the
10 livestock industry. *Mitigation and Adaptation Strategies for Global Change* 17(2): 207-222.
- 11 HCC. 2011. *A sustainable future: The Welsh red meat roadmap*. Aberystwyth: Hybu Cig Cymru.
- 12 Holloway, L., and Ilbery, B. 1996. Farmers' attitudes towards environmental change, particularly
13 global warming, and the adjustment of crop mix and farm management. *Applied Geography*
14 16(2): 159-171.
- 15 IPCC. 2001. *Climate change 2001: Impacts, adaptation, and vulnerability: Contribution of*
16 *working group II to the third assessment report of the intergovernmental panel on climate*
17 *change*. Cambridge: Cambridge University Press.
- 18 Islam, M. M., Barnes, A., and Toma, L. 2013. An investigation into climate change scepticism
19 among farmers. *Journal of Environmental Psychology* 34: 137-150.
- 20 Janssens, W., De Pelsmacker, P., Wijnen, K., and Van Kenhove, P. 2008. *Marketing research with*
21 *SPSS*. Upper Saddle River, NJ: Prentice Hall.
- 22 Jones, A., Jones, D., Edwards-Jones, G., and Cross, P. 2013. Informing decision making in
23 agricultural greenhouse gas mitigation policy: A Best–Worst scaling survey of expert and
24 farmer opinion in the sheep industry. *Environmental Science and Policy* 29: 46-56.
- 25 Klerkx, L., Schut, M., Leeuwis, C., and Kilelu, C. 2012. Advances in knowledge brokering in the
26 agricultural sector: Towards innovation system facilitation. *IDS Bulletin* 43(5): 53-60.
- 27 Köbrich, C., Rehman, T., and Khan, M. 2003. Typification of farming systems for constructing
28 representative farm models: Two illustrations of the application of multi-variate analyses in
29 Chile and Pakistan. *Agricultural Systems* 76(1): 141-157.
- 30 Kollmuss, A., and Agyeman, J. 2002. Mind the gap: Why do people act environmentally and what
31 are the barriers to pro-environmental behavior? *Environmental Education Research* 8(3): 239-
32 260.

- 1 Kurz, T., Donaghue, N., Rapley, M., and Walker, I. 2005. The ways that people talk about natural
2 resources: Discursive strategies as barriers to environmentally sustainable practices. *British*
3 *Journal of Social Psychology* 44(4): 603-620.
- 4 Langford, I. H. 2002. An existential approach to risk perception. *Risk analysis* 22(1): 101-120.
- 5 Lankester, A. J. 2013. Conceptual and operational understanding of learning for sustainability: A
6 case study of the beef industry in north-eastern Australia. *Journal of Environmental*
7 *Management* 119: 182-193.
- 8 Leeuwis, C., Pyburn, R., and Röling, N. 2002. Wheelbarrows full of frogs: Social learning in rural
9 resource management: International research and reflections. The Netherlands: Koninklijke
10 Van Gorcum.
- 11 Leiserowitz, A. 2006. Climate change risk perception and policy preferences: The role of affect,
12 imagery, and values. *Climatic Change* 77: 45-72.
- 13 Leopold, A. 1949. *A Sand County Almanac*. New York: Oxford University Press.
- 14 Lesschen, J. P., van den Berg, M., Westhoek, H. J., Witzke, H. P., and Oenema, O. 2011.
15 Greenhouse gas emission profiles of European livestock sectors. *Animal Feed Science and*
16 *Technology* 166: 16-28.
- 17 Lockie, S., Mead, A., Vanclay, F., and Butler, B. 1995. Factors encouraging the adoption of more
18 sustainable crop rotations in South-East Australia: Profit, sustainability, risk and stability.
19 *Journal of Sustainable Agriculture* 6(1): 61-79.
- 20 Lokhorst, A. M., Staats, H., van Dijk, J., van Dijk, E., and de Snoo, G. 2011. What's in it for me?
21 Motivational differences between farmers' subsidised and non-subsidised conservation
22 practices. *Applied Psychology* 60(3): 337-353.
- 23 Lorenzoni, I., Nicholson-Cole, S., and Whitmarsh, L. 2007. Barriers perceived to engaging with
24 climate change among the UK public and their policy implications. *Global Environmental*
25 *Change*, 17(3-4): 445-459.
- 26 Luschei, E. C., Hammond, C. M., Boerboom, C. M., and Nowak, P. J. 2009. Convenience sample
27 of on-farm research cooperators representative of Wisconsin farmers. *Weed Technology* 23(2):
28 300-307.
- 29 Lowe, P., Murdoch, J., Marsden, T., Munton, R., and Flynn, A. 1993. Regulating the new rural
30 spaces: The uneven development of land. *Journal of Rural Studies* 9(3): 205-222.
- 31 Maibach, E., Roser-Renouf, C., and Leiserowitz, A. 2009. Global Warming's Six Americas 2009:
32 An Audience Segmentation Analysis. Yale project on climate change, Yale University and
33 George Mason University, New Haven.

- 1 Maiteny, P. T. 2002. Mind in the gap: Summary of research exploring 'inner' influences on pro-
2 sustainability learning and behaviour. *Environmental Education Research* 8(3): 209-306.
- 3 Masud, M. M., Akhtar, R., Afroz, R., Al-Amin, A. Q., and Kari, F. B. 2013. Pro-environmental
4 behavior and public understanding of climate change. *Mitigation and Adaptation Strategies*
5 *for Global Change* 18(7): 1-10.
- 6 McCown, R.L. 2005. New thinking about farmer decision makers. In: Hatfield J.L. (Ed.). *The*
7 *Farmers' decision: Balancing Economic Successful Agriculture Production with*
8 *Environmental Quality*. Soil and Water Conservation Society. Ankeny, Iowa, USA. 11-44.
- 9 McGuire, J., Morton, L. W., and Cast, A. D. 2013. Reconstructing the good farmer identity: Shifts
10 in farmer identities and farm management practices to improve water quality. *Agriculture and*
11 *Human Values* 30(1): 57-69.
- 12 Menapace, L., Colson, G., and Raffaelli, R. 2012. Cognitive heuristics and farmers' perceptions
13 of risks related to climate change. *2012 Annual Meeting, August 12-14, 2012, Seattle,*
14 *Washington, (124770) 12/08/12.*
- 15 Morgan-Davies, C., Waterhouse, T., and Wilson, R. 2011. Characterisation of farmers' responses
16 to policy reforms in Scottish hill farming areas. *Small Ruminant Research* 102 (2-3): 96-107.
- 17 Moser, S.C. 2010. Communicating climate change: history, challenges, process and future
18 directions. *Climate Change* 1(1): 31-53.
- 19 Nainggolan, D., Termansen, M., Reed, M. S., Cebollero, E. D., and Hubacek, K. 2012. Farmer
20 typology, future scenarios and the implications for ecosystem service provision: A case study
21 from south-eastern Spain. *Regional Environmental Change* 13(3): 601-614.
- 22 Niles, M. T., Lubell, M., and Haden, V. R. 2013. Perceptions and responses to climate policy risks
23 among California farmers. *Global Environmental Change* 23(6): 1752-1760.
- 24 Nunnally, J. 1967. *Psychometric theory*. New York: McGraw-Hill.
- 25 OECD 2012. *OECD Environmental Outlook to 2050: The Consequences of Inaction*. Paris:
26 Organization for Economic Co-Operation and Development.
- 27 O'Connor, R. E., Bord, R. J., and Fisher, A. 1999. Risk perceptions, general environmental beliefs,
28 and willingness to address climate change. *Risk Analysis* 19(3): 461-471.
- 29 O'Connor, R. E., Bord, R. J., Yarnal, B., and Wiefek, N. 2002. Who wants to reduce greenhouse
30 gas emissions? *Social Science Quarterly* 83(1): 1-17.
- 31 Pallant, J. 2010. *SPSS survival manual: A step by step guide to data analysis using SPSS*. London:
32 Open University Press.

- 1 Pannell, D. J., Marshall, G. R., Barr, N., Curtis, A., Vanclay, F., and Wilkinson, R. 2006.
2 Understanding and promoting adoption of conservation practices by rural landholders.
3 *Australian Journal of Experimental Agriculture* 46(11): 1407-1424.
- 4 Pidgeon, N. 2012. Public understanding of, and attitudes to, climate change: UK and international
5 perspectives and policy. *Climate Policy* 12(1): 85-106.
- 6 Prokopy, L., Floress, K., Klotthor-Weinkauff, D., and Baumgart-Getz, A. 2008. Determinants of
7 agricultural best management practice adoption: Evidence from the literature. *Journal of Soil
8 and Water Conservation* 63(5): 300-311.
- 9 Ratter, B. M. W., Philipp, K. H. I., and von Storch, H. 2012. Between hype and decline: Recent
10 trends in public perception of climate change. *Environmental Science and Policy* 18: 3-8.
- 11 Reed, M.S., Stringer, L.C., Fazey, I., Evely, A.C., Kruijssen, J.H.J. 2014. Five principles for the
12 practical knowledge exchange in environmental management. *Journal of Environmental
13 Management* 146: 337-345.
- 14 Reimer, A. P., Thompson, A. W., and Prokopy, L. S. 2012. The multi-dimensional nature of
15 environmental attitudes among farmers in Indiana: Implications for conservation adoption.
16 *Agriculture and Human Values* 29(1): 29-40.
- 17 Rosin, C. 2013. Food security and the justification of productivism in New Zealand. *Journal of
18 Rural Studies* 29: 50-58.
- 19 Semenza, J. C., Hall, D. E., Wilson, D. J., Bontempo, B. D., Sailor, D. J., and George, L. A. 2008.
20 Public perception of climate change: Voluntary mitigation and barriers to behavior change.
21 *American Journal of Preventive Medicine* 35(5): 479-487.
- 22 Sheeder, R. J., and Lynne, G. D. 2011. Empathy-conditioned conservation: “Walking in the shoes
23 of others” as a conservation farmer. *Land Economics* 87(3): 433-452.
- 24 Stern, P. C., Dietz, T., Abel, T., Guagnano, G. A., and Kalof, L. 1999. A value-belief-norm theory
25 of support for social movements: The case of environmentalism. *Human Ecology Review* 6(2):
26 81-98.
- 27 Stets, J. E., and Burke, P. J. 2003. A sociological approach to self and identity. *Handbook of self
28 and identity*, 128-152. New York: The Guilford Press.
- 29 Story, P. A., and Forsyth, D.R. 2008. Watershed conservation and preservation: Environmental
30 engagement as helping behavior. *Journal of Environmental Psychology* 28(4): 305-317.
- 31 Stuart, D., and Gillon, S. 2013. Scaling up to address new challenges to conservation on US
32 farmland. *Land Use Policy* 31: 223-236.

- 1 Stuart, D., Schewe, R. L., and McDermott, M. 2014. Reducing nitrogen fertilizer application as a
2 climate change mitigation strategy: Understanding farmer decision-making and potential
3 barriers to change in the US. *Land Use Policy* 36: 210-218.
- 4 Sulemana, I., and James Jr., H. S. 2014. Farmer identity, ethical attitudes and environmental
5 practices. *Ecological Economics* 98: 49-61.
- 6 Terry, D. J., Hogg, M. A., and White, K. M. 1999. The theory of planned behaviour: Self-identity,
7 social identity and group norms. *British Journal of Social Psychology* 38(3): 225-244.
- 8 The Royal Society 2009. *Reaping the benefits: science and the sustainable intensification of global*
9 *agriculture*. London: The Royal Society.
- 10 Tversky, A., and Kahneman, D. 1973. Availability: A heuristic for judging frequency and
11 probability. *Cognitive Psychology* 5(2): 207-232.
- 12 Valbuena, D., Verburg, P.F., and Bregt, K.B. 2008. A method to define a typology for agent-based
13 analysis in regional land use. *Agriculture, Ecosystems and Environment* 128(1-2): 27-36.
- 14 Vanclay, F., and Lawrence, G. 1994. Farmer rationality and the adoption of environmentally sound
15 practices; a critique of the assumptions of traditional agricultural extension. *European Journal*
16 *of Agricultural Education and Extension* 1(1): 59-90.
- 17 Vanclay, F., Mesiti, L., and Howden, P. 1998. Styles of farming and farming subcultures:
18 Appropriate concepts for Australian rural sociology? *Rural Society* 8(2): 85-107.
- 19 Vanclay, F. 2004. Social principles for agricultural extension to assist in the promotion of natural
20 resource management. *Animal Production Science* 44(3): 213-222.
- 21 Vanclay, F., Howden, P., Mesiti, L., and Glyde, S. 2006. The social and intellectual construction
22 of farming styles: Testing Dutch ideas in Australian agriculture. *Sociologia Ruralis* 46(1): 61-
23 82.
- 24 Voss, A. G. J., Spiller, A., and Enneking, U. 2009. Farmer acceptance of genetically modified
25 seeds in Germany: Results of a cluster analysis. *International Food and Agribusiness*
26 *Management Review* 12(4): 61-80.
- 27 Wang, Y., and Ahmed, P. K. 2009. The moderating effect of the business strategic orientation on
28 eCommerce adoption: Evidence from UK family run SMEs. *The Journal of Strategic*
29 *Information Systems* 18(1): 16-30.
- 30 Weber, E. U. 1997. Perception and expectation of climate change: precondition for economic and
31 technological adaptation. *Environment, Ethics, and Behavior: The Psychology of*
32 *Environmental Valuation and Degradation*. San Francisco: The New Lexington Press.
- 33 Welsh Government. 2009. *One Wales: One planet*. Cardiff: Welsh Government.
- 34 Welsh Government. 2012. *Farming facts and figures, Wales 2012*. Cardiff: Welsh Government.

- 1 Welsh Government. 2014. *An introduction to Glastir and other UK agri-environment schemes*.
2 Cardiff: Welsh Government.
- 3 Widcorp. 2009. *Understanding farmer knowledge and attitudes to climate change, climate*
4 *variability, and greenhouse gas emissions*. Melbourne: Water in Dry-lands Collaborative
5 Research Program.
- 6 Wilson, G. A. 2001. From productivism to post-productivism... and back again? Exploring the
7 (un)changed natural and mental landscapes of European agriculture. *Transactions of the*
8 *Institute of British Geographers* 26(1): 77-102.
- 9 Yazdanpanah, M., Hayati, D., Hochrainer-Stigler, S., and Zamani, G. H. 2014. Understanding
10 farmers' intention and behavior regarding water conservation in the middle-east and North
11 Africa: A case study in Iran. *Journal of Environmental Management* 135: 63-72.

1 Table 1. **Factor loadings of attitudinal statement (prior to varimax rotation). Factor loadings**
 2 **are derived from principal component analysis. The content of a component is best**
 3 **interpreted by examining items with factor loadings of .4 or above**

	A	ER	P	PR
Livestock farming contributes to climate change	.701			
Climate change will affect Welsh farming in the next 10 years	.669			
I accept that man-made climate change is happening	.633			
Livestock farmers should share responsibility towards the industry's impact on climate change	.612			
Climate change is an important global issue	.612			
It is possible to reduce GHG emissions from my farm without lowering production levels	.461			
Environmental regulations are important for the future of farming	.451			
Others in my family think that I should farm as environmentally friendly as possible		.686		
I want to farm as environmentally friendly as possible		.665		
Switching to a more environmentally friendly farming methods would not require much change from my current operation		.592		
As a farmer I have an obligation to maintain or improve the environment for future generations		.553		
I am interested in trying different technologies and/or systems to reduce my farms' GHG emissions		.534		
The way farming colleagues think about my farm is important to me		.449		
The government should encourage food production in the UK to reduce reliance on imports			.722	
The government should financially support farmers in adapting to climate change			.640	
Other industries pollute more than livestock farmers and should therefore be penalised more			.510	
Any climate change reduction strategies must make economic sense to the individual farmer			.475	
Being seen as primarily as a food producer is important to me			.426	
The best climate change mitigation strategies are too costly to adopt				.639
Climate change poses more of a threat to farming in the next 10 years than that of a general recession				.607
Climate change will lead to lower productivity on my farm due to disease and pests				.579
Uncertainty due to variable weather patterns caused by climate change will negatively influence my ability to farm in the future				.381
Beef or lamb produced with low emissions should be sold at a higher price				.351
<i>Cronbach's alpha</i>	.774	.700	.533	.512

4 * **Factor codes: A = Awareness, ER = Environmental Responsibility, P = Productivism, PR = Perceived risk**

5

1 **Table 2. Profile of survey participants**

		%
Farmer type	Full-time farmer	68.5
	Part-time farmer	31.1
Gender	Male	90.6
	Female	9.4
Age	18-25	18.1
	26-35	12.2
	36-45	13.3
	46-55	19.9
	56-65	19.2
	>66	17.1
Highest level of education	Primary school	8.7
	GCSE/O-Levels	26.2
	A-Levels/NVQ	18.5
	HNC/HND	19.2
	University undergraduate degree or higher	27.3
Farm size (acres)	<100 (<40.47 ha)	35.3
	101-300 (40.5-121.41 ha)	33.9
	301-500 (121.81-202.3 ha)	14.3
	>501 (>202.75 ha)	16.1
Livestock sector?	Beef only	16.8
	Sheep only	18.5
	Mixed (sheep and cattle)	64.7
Farming experience (years)	0-10	15.7
	11-20	16.1
	21-30	23.8
	>31	44.1

2 * In cases where percentages do not add up to 100, the respective question was not answered on all
 3 questionnaires or due to rounding

4

5

1 **Table 3. The main opportunities and risks respondents anticipate climate change may bring**

Main opportunity that climate change may bring (%)		Main risk that climate change may bring (%)	
Don't know	25.6	Unpredictable/extreme weather	42.3
Longer growing season	24.9	Don't know	13.2
No opportunities	10.3	Increased taxes/regulations	9.6
Generating energy	8.9	Increased costs	8.9
Better prices for produce	8.9	Crop failure/reduced yields	6.8
Diversification	6.4	Animal husbandry issues (e.g. heat stress, disease)	5.3
Reduced costs	5.7	No risks	4.6
New markets	4.6	Price/Profit volatility	2.8
Increased biodiversity	1.4	Lower price for products	2.5
Other	1.4	Other	1.4
Carbon capture and storage	1.1	Soil erosion	1.4
Better conditions for livestock	0.7	Nutrient loss through run-off	1.1

2

3

1 Table 4. Scores of the final centres of farmer clusters, derived from K-means method. Types
 2 are labelled according to differences between groupings

Type (% of respondents)	Awareness	Environmental responsibility	Productivism	Perceived risk
The Environmentalist (28)	0.742	0.500	0.063	-0.789
The Dejected (26)	0.317	0.143	0.333	1.111
The Countryside Steward (23)	-0.888	0.284	-0.973	-0.100
The Productivist (23)	-0.342	-1.048	0.538	-0.199

3

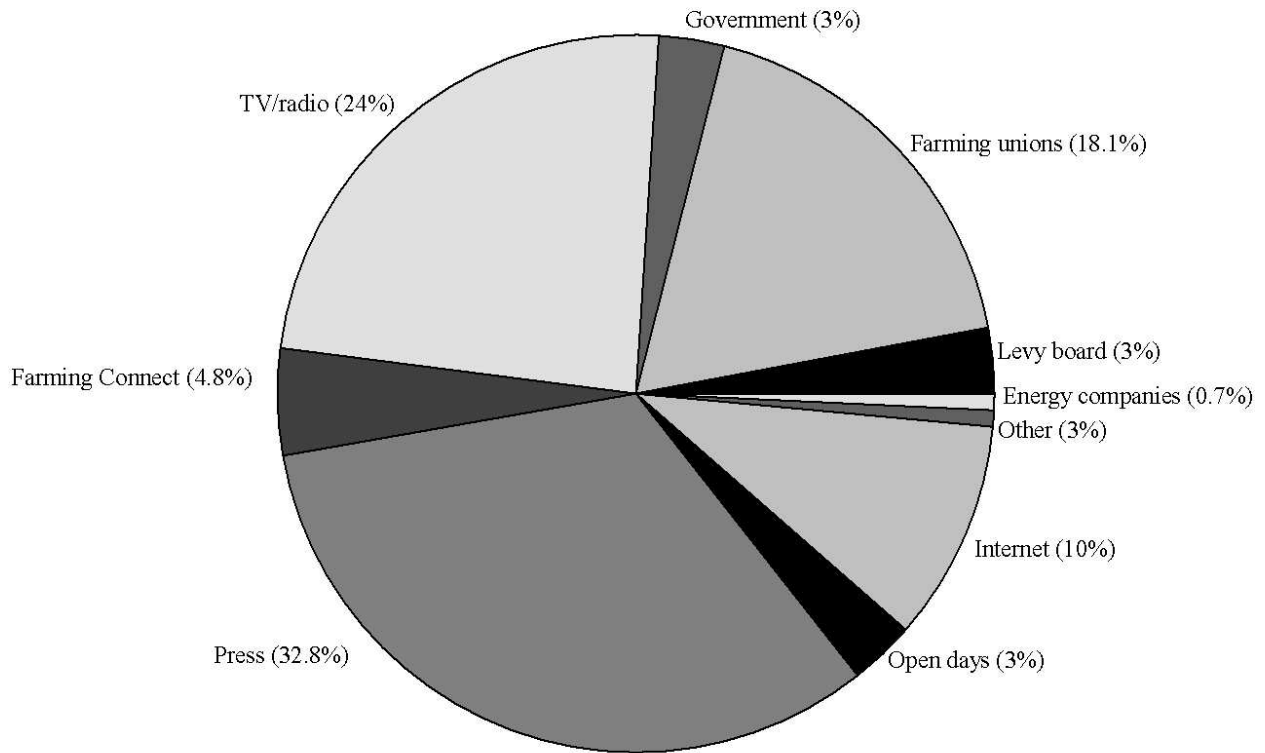
1 Table 5. **Perceptions of emission sources, climate change contributors, and sources of climate**
 2 **change information based on farmer type**

	The Productivist	The Countryside Steward	The Environmentalist	The Dejected
Perceptions of emissions associated with the management of livestock and their waste on their respective farms (%)				
Emits	42.1	33.3	56.0	47.1
Neutral	56.3	63.5	42.7	52.9
Stores	1.6	3.2	1.3	0
Perceptions of emissions associated with fertilizer use on their respective farms (%)				
Emits	34.4	22.6	45.3	33.8
Neutral	62.5	66.1	48.0	58.8
Stores	3.1	11.3	6.7	27.9
Perceived contribution of methane from livestock towards climate change (%)				
Major cause	3.1	9.0	13.3	8.5
Minor cause	70.8	49.3	80	66.2
Not a cause	26.2	41.8	6.7	25.4
Perceived contribution of the manufacture and use of fertilizers towards climate change (%)				
Major cause	13.9	23.9	39.5	22.5
Minor cause	67.7	59.7	56.9	63.4
Not a cause	18.5	16.4	6.7	14.1
Perceived contribution of 'other industries' towards climate change (%)				
Major cause	90.8	72.7	92.1	91.6
Minor cause	9.2	27.3	7.9	8.5
Not a cause	0	0	0	0
Information sources on climate change (%)				
Primary source	Press (42.3)	Press (27.0)	Press (30.7)	Press (31.9)
Secondary source	TV/Radio (20.3)	TV/Radio (25.4)	TV/Radio (24)	TV/Radio (26.2)

3

4

1 Figure 1. Respondents' main source of information on climate change

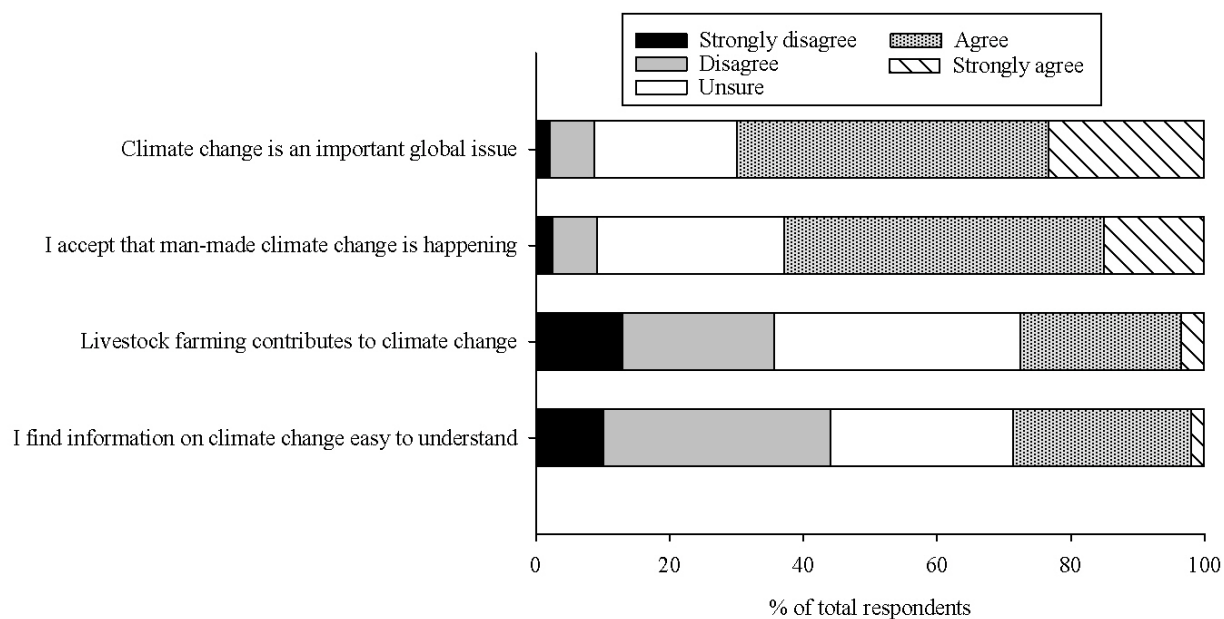


2

3 **Farming Connect is a service financed by the European Agricultural Fund and Welsh Government, offering**
4 **one-to-one support, knowledge, expertise, training, and advisory services, tailored to farmers' needs**

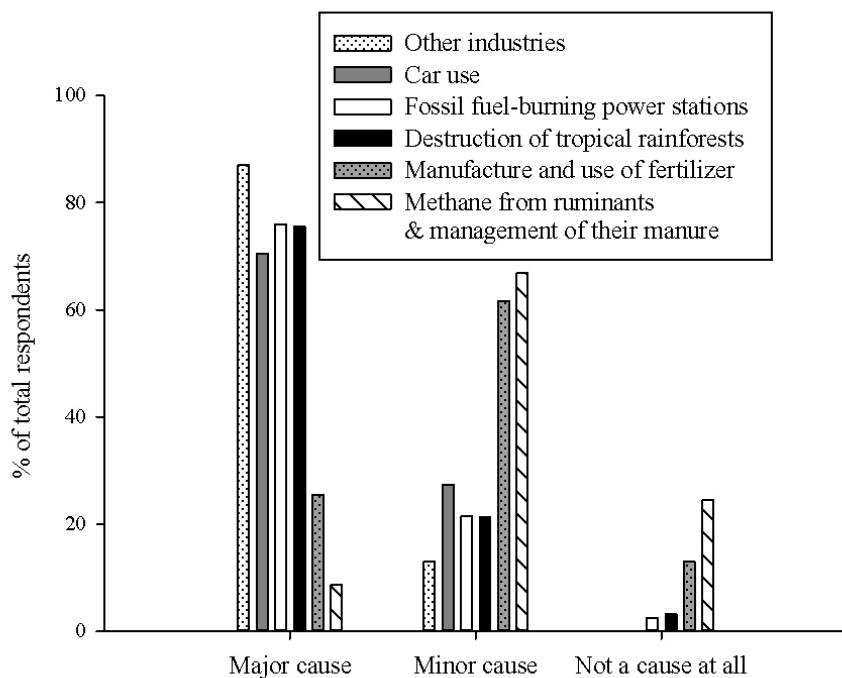
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1 **Figure 2. Respondents' attitude towards climate change statements (%)**



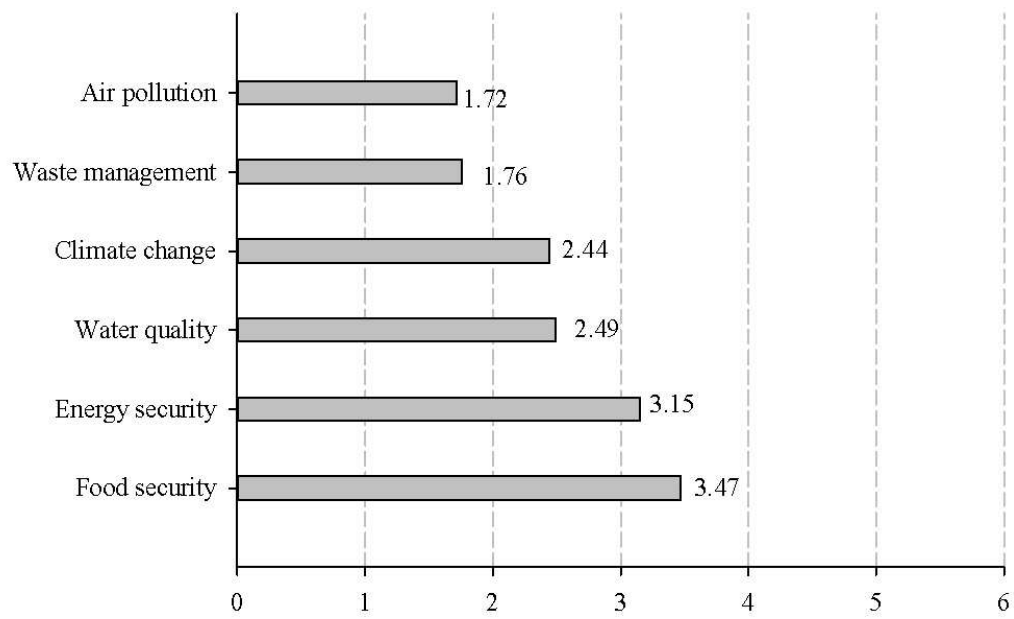
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3 **Figure 3. Respondents' perceived anthropogenic causes of climate change**



4

Figure 4. Respondents' median scores of the risk posed to society by environmental issues



*** Options ranked 1 – 6 (1 being the least risk, 6 being the greatest)**

Figure 5. Radar diagrams showing the scores of the four identified types for the four PCA components. Derived from cluster centres from Table 4 ($n = 286$)

