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Farmers' perception of climate change: identifying types

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Abstract

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

Keywords

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

Abbreviations

A	Awareness
ER	Environmental responsibility
GHG	Greenhouse gas
P	Productivism
PCA	Principal component analysis
PR	Perceived risk

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Author biographies

Hyland, J.

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

Jones, D.L.

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

Parkhill, K.

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

Barnes, A.

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

Williams, A.P.

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

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Introduction

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

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

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

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

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

We therefore utilise constructs that assess farmers' self-identity and their behavioural capacity to implement measures that address climate change. Two constructs determine self-identity, and are based on productivism and environmental responsibility. Motivation to adopt environmental behaviour is based on internal perceptions of how farming should be practiced (farmer-identity). The Dual Interest Theory acknowledges that both economic and environmental motivations are represented in varying strengths when individuals make environmental decisions (Sheeder and Lynne, 2011). Furthermore, two additional constructs assess awareness and risk perception, and hence the behavioural capacity to implement adaptation and mitigation measures. Behavioural capacity can be defined as the latent potential of behavioural change to affect improvements in the environment (Beretti et al. 2013).

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

Awareness, self-identity, and perceptions of risk

Self-Identity

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

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

Environmental programs may be resisted in cases where this productivist self-identity is threatened by the perceived induction of pro-environmental legislation (van der Werff et al. 2013). Therefore, understanding farmers' sense of identity is important in assessing their motivation in adopting environmental measures and participation in environmental programs (Sulemana and James Jr. 2014). Indeed, Indiana farmers who were motivated by environmental responsibility (rather than profitability) were most likely to adopt conservation practices (Reimer et al. 2012). Moreover, Lokhorst et al. (2011) observed that self-identity is significantly related to farmers' intention to perform non-subsidised environmental practices. Hence, self-identity can significantly affect an individuals' motivation to undertake voluntary measures where financial reimbursements, or awards, are not forthcoming.

Awareness

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

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

Perceived risk

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

In the context of this study, perceived risk is farmers' appraisal of the negative effects of climate change on agriculture. Individuals are more likely to adopt pro-environmental behaviour when they understand the adverse impacts of no action (Masud et al. 2013; O'Connor et al. 1999). Participation in adaptation and mitigation initiatives becomes less appealing when climate change is weighed up against risks such as economic instability (Stuart et al. 2014). Subsequently, farmers who perceive climate change in terms of local consequences which may negatively impact their enterprise are more likely to support and participate in initiatives that aim to address the issue (Haden et al. 2012; Arbuckle et al. 2015).

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

Methods

Wales: a case study

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

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

Questionnaire design and distribution

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

Analyses

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

Principal Component Analysis

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

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

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

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

<<Table 1 around here>>

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

Cluster analysis

The factor scores from PCA were subjected to both Ward's hierarchical and K-means clustering methods (Burns and Burns 2008). The PCA scores were used for the Ward's hierarchical clustering technique as the algorithms require continuous, rather than the categorical Likert scale data collected in the survey. Hair et al. (1998) point out that the selection of the final cluster solution requires substantial researcher judgement. The application of the hierarchical cluster analysis suggested the presence of four clusters from interpretation of the dendrogram (Köbrich et al. 2003). An elbow test verified the ideal number of clusters for the successive k-means clustering method to be n = 4, which was consistent with the interpretation of the dendrogram (Burns and Burns 2008).

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

Results

Characteristics and perceptions of respondents

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

<<Table 2 around here>>

<<Figure 1 around here>>

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

<<Table 3 around here>>

<<Figure 2 around here>>

<<Figure 3 around here>>

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

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

The Dejected

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

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

The Countryside Steward

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

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

The Productivist

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

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

<<Table 5 around here>>

Discussion

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

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

Low behavioural capacity is borne from a lack of awareness of climate change and a low sense of the perceived risks that it may bring. This acts as a barrier for both The Productivist and The Countryside Steward in adopting measures that help address climate change. It could be hypothesised that the primary reason that The Productivist would take the climate into consideration is if there are (economic) incentives in place to do so (Defra 2010; Fleming and Vanclay 2010). Messages which focus on low-cost 'win-win' technologies may therefore resonate (Islam et al. 2013). However, the costs of inaction can often be considerably greater than the economic costs of immediate action (OECD 2012). Discourses framed in such a monetary manner may gain recognition with farmers who possess productivist tendencies. Furthermore, the concept of sustainable intensification could particularly appeal to such farmers as their production tendencies would not be compromised (The Royal Society 2009).

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

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

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

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

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

Social learning could be propitious in shifting The Productivist's sense of what is involved in being a 'good farmer' away from a production standard towards one with more environmental tendencies (McGuire et al. 2013). Group discussion would provide a platform to increase awareness and to deliberate the adoption of measures that are both environmentally and economically beneficial. The Countryside Steward has a particularly high sense of environment responsibility but is lacking in their awareness of climate change; therefore, it is reasonable to assume that effective participatory approaches could encourage their participation in programs that focus on climate change. Social interaction can also ease unfounded risk perceptions that farmers such as The Dejected may hold (Langford 2002; Maiteny 2002). Communication of risks could also inspire greater action and support of climate change initiatives in other types (Leiserowitz 2006).

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

Conclusions

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

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

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

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

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

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Table 1. **Factor loadings of attitudinal statement (prior to varimax rotation). Factor loadings are derived from principal component analysis. The content of a component is best 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 seem 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**
Cronbach's alpha	*.774*	*.700*	*.533*	*.512*

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

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

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

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

Main opportunity that climate change may bring (%)	
Don't know	25.6
Longer growing season	24.9
No opportunities	10.3
Generating energy	8.9
Better prices for produce	8.9
Diversification	6.4
Reduced costs	5.7
New markets	4.6
Increased biodiversity	1.4
Other	1.4
Carbon capture and storage	1.1
Better conditions for livestock	0.7

Main risk that climate change may bring (%)	
Unpredictable/extreme weather	42.3
Don't know	13.2
Increased taxes/regulations	9.6
Increased costs	8.9
Crop failure/reduced yields	6.8
Animal husbandry issues (e.g. heat stress, disease)	5.3
No risks	4.6
Price/Profit volatility	2.8
Lower price for products	2.5
Other	1.4
Soil erosion	1.4
Nutrient loss through run-off	1.1

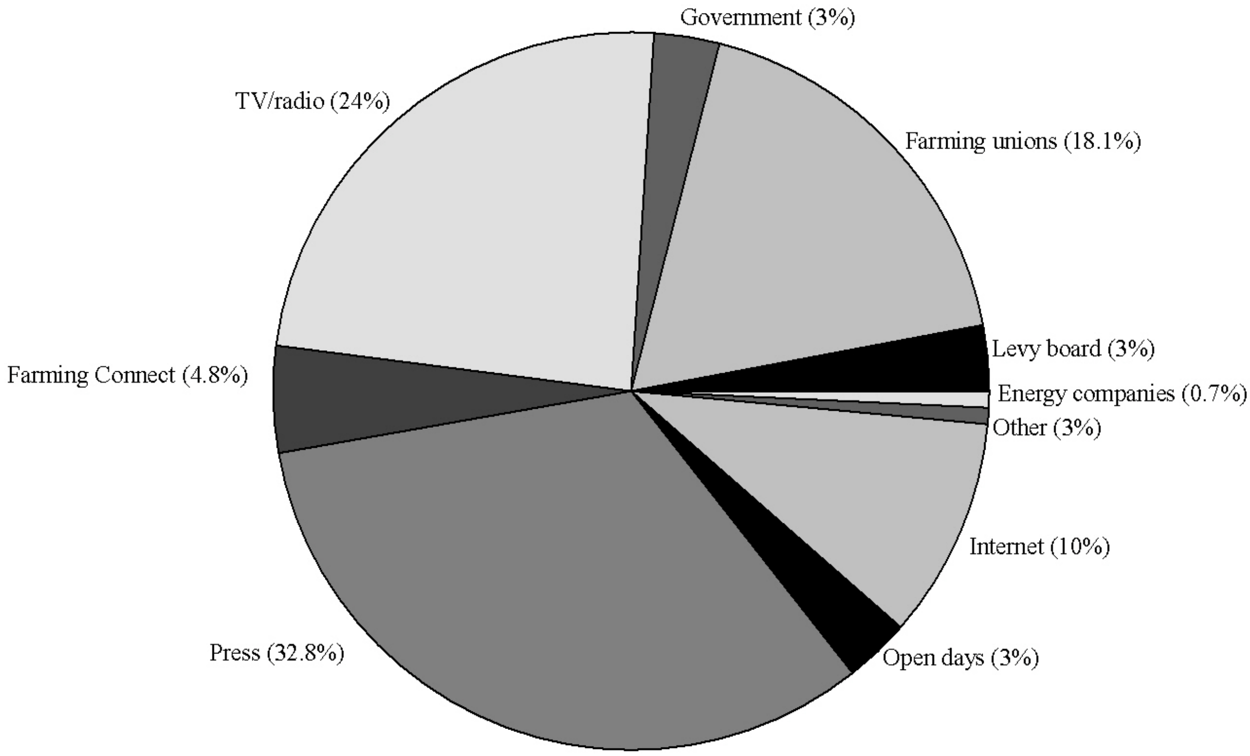
Table 4. **Scores of the final centres of farmer clusters, derived from K-means method. Types are labelled according to differences between groupings**

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

Table 5. **Perceptions of emission sources, climate change contributors, and sources of climate 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)

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



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

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

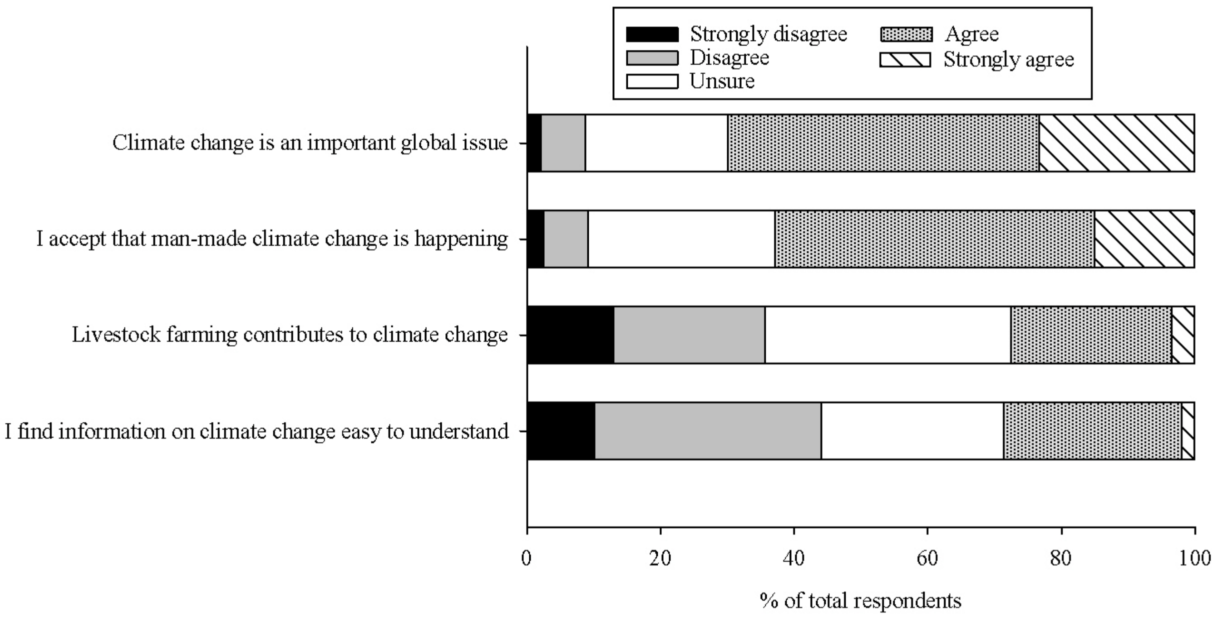


Figure 3. **Respondents' perceived anthropogenic causes of climate change**

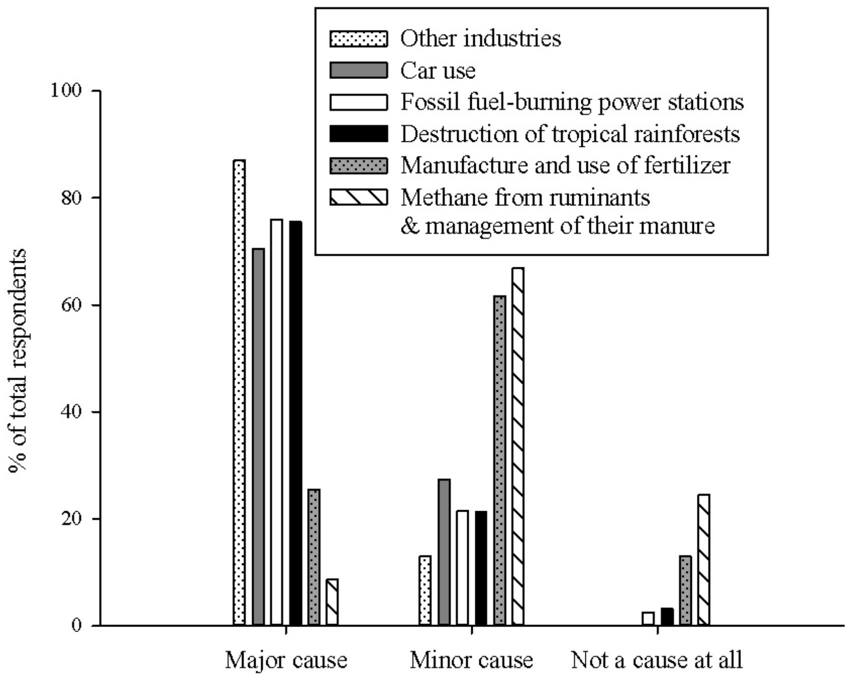
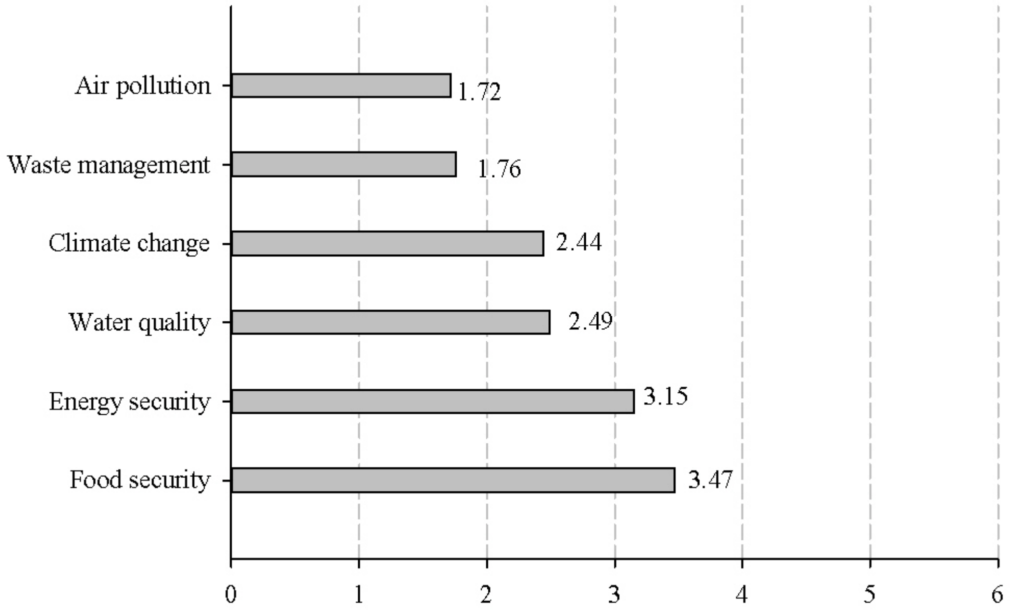
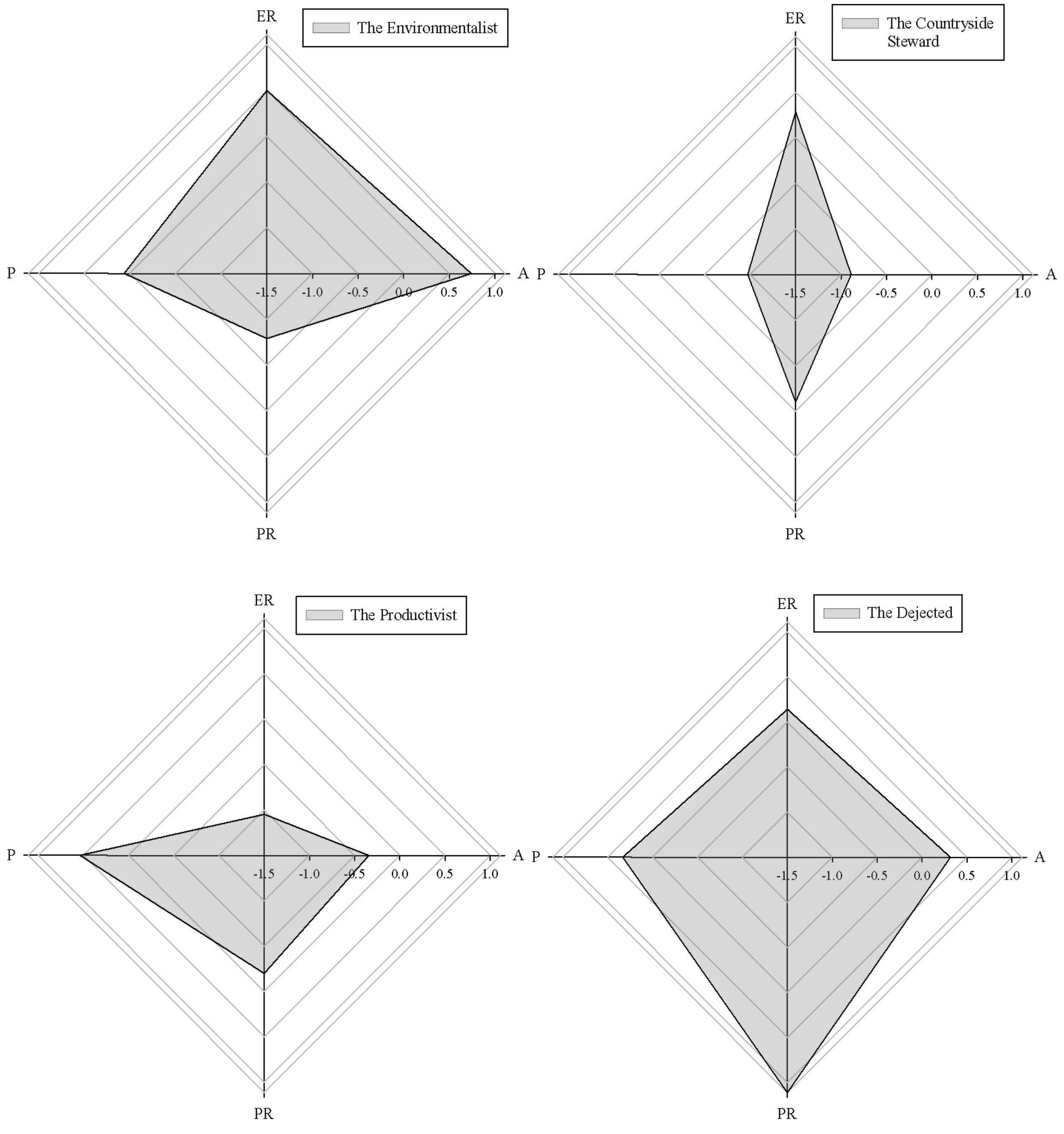


Figure 4. **Respondents' median scores of the risk posed to society by environmental issues**



*** 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)**



A = awareness, ER = environmental responsibility, P = Productivism, PR = Perceived Risk