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Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: evidence from the Netherlands, France, Switzerland and Italy

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ABSTRACT

Climate-smart agriculture (CSA) is one response to the challenges faced by agriculture due to climate change. As with other sustainability transitions, technological innovation is highlighted as playing a critical role, however, the adoption and diffusion of technological innovations in OECD countries is slow. The aim of this paper is to identify key socio-economic barriers, in terms of supply and demand, that inhibit the adoption and diffusion of CSA technological innovations in Europe. To achieve this aim, a theoretical framework is constructed based on a literature review of socio-economic barriers effecting adoption and diffusion. This framework is explored with data from semi-structured interviews with CSA technology providers and members of agricultural supply chains, such as farmers associations and consumer goods producers (the end-users of the technology). Data was collected on the barriers they experienced, with interviews conducted in the Netherlands, France, Switzerland and Italy. This data was thematically coded and categorised to identify key barrier typologies. The results demonstrate that barriers exist on both the demand (user) and supply (technology provider) sides. The paper provides recommendations for increasing the adoption and diffusion of CSA technological innovations, as well as implications for the CSA and innovation literature.

1. Introduction

Climate change has been the focus of action for over two decades by governments, since the signing of the United Nations Framework Convention on Climate Change in 1992, and increasingly since the late 1990's by business (Kolk et al., 2008). Agriculture in particular will be subjected to profound challenges due to climate change, having to adapt to changing weather patterns, contribute towards greenhouse-gas (GHG) emission reductions. Whilst facing these challenges, an increasing world population will require feeding. Climate-smart agriculture (CSA) is highlighted as key response to these challenges, seeking to enhance agricultural productivity, promote adaptation and enable GHG emission reductions.

Technological innovation has been a key response to sustainability challenges, including climate change (EIT, 2014; European Commission, 2014a; Morand and Barzman, 2006). As such, technological innovation, through the concept of CSA, represents one response to the challenges faced by agriculture.

As highlighted above, agriculture will be profoundly affected by climate change. Agriculture is a significant sector in terms of GHG emissions, and so will face pressure to mitigate climate change through GHG emission reductions. The 2014 Fifth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) estimated current emissions from agriculture, forestry and other land use is responsible for around a quarter of anthropogenic GHG emissions (Smith et al., 2014). Agriculture contributes around 11% according to the United National Environment Programme (UNEP) (2013). If pre-and post-process emissions are included, global food systems contribute between 19% and 29% of global GHG emissions (Vermeulen et al., 2012). The potential for GHG emission reductions from agriculture up to 2030, through reductions in GHG emissions and increases in soil sequestration are estimated to be between 4500 and 6000 Mt CO_2e/year (Branca et al., 2013; Smith et al., 2008). This mitigation will present multiple constraints for agriculture, as methane, N_2O and CO_2 are linked to fuel and electricity

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use, but are also produced through fertiliser production, ruminants and land-use changes.

Further, under current projections, in order to feed the global population in 2050, food production must increase by 70%; previous yield increases have often been gained through the use of fossils fuels, creating further urgency with regards to GHG emission levels due to agriculture. This implies that future increases must find climate-smart methods and inputs (Bogdanski, 2012). Whilst facing these challenges, agriculture must also deal with increasing weather variability and unpredictability, affecting the resilience of our food production systems (Bogdanski, 2012; Nelson et al., 2009). Climate change is expected to lead to greater variability in weather patterns, with increases in the occurrence and severity of extreme weather such as flood, storms, droughts or heat waves, which can all negatively impact on agriculture (Coumou et al., 2014; Trnka et al., 2014); whilst many impacts are expected to be negative, some areas will experience positive side-effects from climate change (European Commission, 2015). Local through to continental production patterns and methods are likely to change due to such impacts.

Developing counties in particular are vulnerable to climate change impacts. This is due to the relative importance of the agricultural sector and generally greater vulnerability to climate change impacts within these contexts. The impacts of climate change on agriculture threatens the economic development of such countries, and the welfare of their populations (FAO and EU, 2014). Due to these reasons, much research is evident on agriculture and climate change within developing nation contexts, and specifically in terms of CSA (Arslan et al., 2013; Bogdanski, 2012; Branca et al., 2011; Eidt et al., 2012).

CSA is one response to these challenges, which seeks to achieve sustainable agricultural development for food security under climate change impacts (FAO, 2013). CSA strives for three objectives. These include sustainable increases of agricultural productivity and incomes, the adaptation and building of resilience to climate change impacts and the reduction of GHG emissions where possible. This creates three distinct 'pillars', and potentially a 'triple-win' (FAO, 2014). CSA can be considered a programmatic concept, acting between knowledge and policy. CSAs overarching aim is to orientate and 'ground' the correct technical, policy and investment conditions required for agriculture to respond to climate change and future food demands (Ren, 2015). A key reason for the emergence of the concept was the recognition that agriculture, and related food security issues, require a synthesised approach which may not be achieved by tackling climate mitigation and adaptation objectives separately.

In the European Union climate change is high on the agricultural policy agenda, due to expectations that climate change will affect the main resources of farmers, including for example water resources and soil quality (Commission of the European Communities, 2009). Given the economic and social importance of the agricultural sector, the European Commission has developed strategies to urge member states towards (concerted) action, including 'climate-proofing' at the EU level as well as better informed decision-making (European Commission, 2014b). Preventive actions are encouraged, with the Common Agricultural Policy (CAP) being at the core of the agricultural transition, encouraging member states to embed climate change in their regional rural development programs (Commission of the European Communities, 2009). To enable changes on the ground, these policies will assist European farmers in the modernisation of farms and to adapt management practices by offering training, compensations, advisory services and technological and management innovations (European Commission, 2015).

Technological innovations, often originating from 'start-ups' or established technology companies, have been highlighted as playing a central role in transitions to a sustainable future, including within the context of CSA. Indeed, CSA technological innovations are already on the market in many cases, as illustrated within Fig. 1 and Table 2. However, diffusion curves predict that initial adoption rates of CSA technological innovations will be slow (Kemp and Volpi, 2008), as is the case with technological innovations more generally in countries of the Organisation for Economic Cooperation and Development (OECD) (del Río González, 2005).

Slow adoption and diffusion rates pose a problem, due to the time imperatives inherent with climate change and associated policy goals. As such, increasing our understanding of specific barriers to adoption is required. This understanding will aid the design and implementation of interventions that can overcome barriers. Subsequently, a key issue requiring attention at the policy, research and practice levels, is the successful adoption and diffusion of CSA technological innovations.

Several studies have considered the adoption of pro-environmental innovations within agriculture in developed country settings, such as in the wine and sheep industries in the USA and Australia (Cullen et al., 2013; Sneddon et al., 2011; Tey and Brindal, 2012). However, these examples lack the contextual specificities of Europe, such as the impact of the European CAP and typical production systems, and the drive by EU policy makers to establish CSA adoption as a strategic priority. Though the field of pro-environmental innovation adoption in general is well formed, there is a lack of previous research concerning hampering factors related to technological innovation in agriculture in EU settings, and to a greater extent specifically in terms of CSA. Indeed, much previous research on CSA within developed country contexts has focused on technical and policy areas, whereas this paper considers more socio-economic factors in relation to CSA technological innovation adoption. Further, this area of pro-environmental innovation illustrates an imbalance, where a transition towards CSA provides societal benefits, but delivers limited short-term benefits to the actors that must enact the changes, namely farmers. As such, understanding barriers in this context could highlight solutions that are applicable to other examples that also involve these imbalances.

This paper seeks to identify barriers that prevent the successful adoption of CSA technological innovations in the European Union. To achieve this objective, the paper takes an explorative approach using qualitative data collected from key informants in France, the Netherlands, Italy and Switzerland. In order to achieve this aim, a review of the relevant literature will be performed, before outlining a conceptual framework that will be used to explore the data that was collected through the interviews; following the presentation of the results, a discussion and conclusion are provided.

2. Literature review and conceptual framework

CSA can involve the implementation of a wide array of technologies, practices or actions, including for example water management, intercropping, agroforestry, integrated crop-livestock management approaches or the integration of renewable energy systems (Taneja et al., 2014). Although CSA includes a multiplicity of technological, policy and institutional approaches, the focus of this research concerns CSA technological innovations. In this paper we define these as hardware, software and org-ware that help solve climate induced problems in agriculture, including increased agricultural productivity, reduced vulnerability of agro-food systems to climate impacts and the reduction of GHG emissions (or enhanced GHG emission storage) (McCarthy, 2001).