

## Increasing climate change resilience in agriculture: who is responsible?

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### ABSTRACT

Achieving climate change (CC) resilience in a timely and efficient fashion is becoming a major priority across multiple sectors. Agricultural CC adaptation has become an integrated part of agricultural development policy throughout the EU and further. Without the timely implementation of appropriate measures, the vulnerability of highly exposed and sensitive agricultural landscapes with low adaptive capacity will increase. This paper focuses on the Vipava Valley, a sub-Mediterranean agricultural area highly vulnerable to CC, describing the stakeholder landscape approach undertaken to define stakeholder responsibility level in terms of implementing adaptation measures; and it identifies the key challenges facing stakeholder networks at individual measure levels. The strategy for agricultural CC adaptation follows the structure proposed by the European Commission and clearly defines the necessary stakeholder landscape for implementing agricultural CC adaptation measures and indicators for adaptation strategy monitoring and evaluation. The challenges identified in relation to stakeholder interaction cannot be solved by strategy alone; a facilitated approach to policy implementation is necessary, its success being dependent on the ability of the social landscape to develop a firm implementation of a monitoring programme for adaptation to CC at the local municipality level.

**Key words** | agriculture, climate change adaptation, stakeholder responsibility

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### INTRODUCTION

Achieving climate change (CC) resilience in a timely and efficient manner is becoming a major priority across multiple sectors (Douxchamps *et al.* 2017). In this context, the limited resilience of agricultural and food systems, and of rural communities (Ashkenazy *et al.* 2018) has been the main driver for agricultural climate change adaptation (ACCA) becoming an integrated part of agricultural development policy throughout the EU and further. In 2009, the European Commission (EC) adopted the White Paper *Adapting to Climate Change: Towards a European Framework for Action* (EC 2009). In 2013, the EC adopted a Green Paper on *Insurance in the Context of Natural and*

*Man-Made Disasters* (EC 2013a), this being followed by adoption of the EU's *Strategy on Adaptation to Climate Change* (EC 2013b) that sets out a framework and mechanisms for taking EU preparedness for current and future CC impact to a new, higher level. The three aforementioned documents are the baseline framework for EU member states to prepare their own national strategies and action plans for adapting to CC. To support them, the *Guidelines for Developing Adaptation Strategies* (EC 2013c) and the platform CLIMATE-ADAPT (2017) were established, whereby member states are able to exchange data and information regarding the expected impact of and possible measures

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taken to battle CC. The platform offers accessible studies regarding CC vulnerability and adaptation levels utilising various scales, from EU to transnational, national and regional levels, to vulnerability at sector level. By 2017, several EU and other states, including Austria, Belgium, Denmark, Finland, France, Germany, Greece, Lithuania, Malta, the Netherlands, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and Slovenia had already prepared national strategies and action plans for adapting to CC. The first adaptation strategies and action plans were mainly prepared for individual sectors, e.g. water, agriculture, and industry, and did not take an integrated, pan-sector approach (Kompare & Klančnik 2017). The initial documents will have to be further developed to integrate cross-sectors to better assist policy-makers in their planning of activities related to achieving desired levels of CC resilience (Abid *et al.* 2017; Masud *et al.* 2017).

Political support for ACCA is especially important in the water-scarce Mediterranean, sub-Mediterranean and arid agricultural regions highly vulnerable to CC, for instance, the latest CC projections for the 21st century for the sub-Mediterranean Vipava Valley, Slovenia, the focus of this research paper, indicate high exposure to CC and further degradation of existing agricultural conditions. EURO-CORDEX climate simulations (Jacob *et al.* 2014), for the moderately optimistic scenario RCP4.5, assuming significant mitigating action regarding the future releases of greenhouse gases, have shown an increase in average annual temperature (+1.8 °C), a decrease in summer precipitation (−4%), and an increase of summer evapotranspiration (+6%) (Honzak *et al.* 2017). Drought, flooding and strong winds caused over €15 m damage on over 12,000 ha of agricultural land in 2012–2014 alone. Local agriculture is therefore highly sensitive to CC (Cvejić & Pintar 2017). ACCA adaptation and mitigation is increasingly and widely addressed in various national strategic documents. In reviewing the existing CC documents, 93 measures refer to ACCA, accounting for nearly 60% of all CC adaptation measures. The number of measures intended for direct and/or indirect ACCA in 2014–2020 are increasing when compared with the previous periods of 1991–2006 and 2007–2013 (Kompare & Klančnik 2017).

Numerous good-practice examples of ACCA measures can be identified in terms of reducing wind erosion potential, such as green windbreaks and late ploughing;

construction of large and small water reservoirs for improved water availability during dry periods; precise irrigation using micro-irrigation and drip-irrigation, and cover crop management in orchards for improved soil–water management; adaptation to heat, cold, and hail, incorporating experimental field introduction of heat-tolerant plants, plant production in greenhouses, and anti-hail nets, as well as monitoring of agro-meteorological variables for better informed agricultural production. Some of the measures applied in the 1970s, such as large-scale irrigation and extensive green windbreaks, did not live up to their full potential because of poor land quality stemming from a lack of maintenance, deterioration, and the reduced scope of measures, as this hindered their efficacy (Tratnik & Papež 2017a, 2017b). This indicates CC resilience is affected by both changing climate and inadequate agricultural management (Wurl *et al.* 2018). Furthermore, policy implementation analysis reveals that as much as a third of planned ACCA measures have not been implemented as yet, pointing not only to considerable policy implementation-deficit, but also to low adaptive capacity to CC (Kompare & Klančnik 2017). A lack of stakeholder coordination hampers ACCA (Islam & Nursey-Bray 2017). Especially challenging are ACCA measures whose successful implementation requires the simultaneous and coordinated operation of several stakeholder groups at different levels. Farmers, decision-makers, and regulators might not share understanding of the transformation necessary for adaptation (Saxena *et al.* 2018).

Agricultural CC vulnerability will increase without the timely implementation of appropriate ACCA measures in highly exposed and sensitive agricultural landscapes with low adaptive capacity. Consequently, the present study is focused on this particular agricultural region with the objective of determining the stakeholder landscape (SL) necessary for increasing CC resilience in agriculture for a more informed and effective future implementation of ACCA measures. The aim is to analyse who is responsible for increasing CC resilience, and how this responsibility is devolved amongst stakeholders, the underlying assumption being that policy implementation success is influenced by the mechanism used to measure implementation. In this context, a distinction is made between measures requiring the activation of a few stakeholders at one or two levels, that is measures relatively simple to implement and more

likely to be implemented, and measures requiring the activation of a larger number of stakeholders at various levels, and their coordinated operation, these being complex measures with higher risk in terms of implementation failure.

## METHODS

To complete the above research objective the initial ACCA measures for this case study area were defined based on analysis of the key national and local development documents related to ACCA, these being: (1) Rural Development Programme of the Republic of Slovenia 2020 (RDP RS 2014–2020); (2) River Basin Management Plan for the Danube and Adriatic Sea River Basins (NUV II); (3) Regional Development Programme of the Northern Primorska (Gorška) Region 2014–2020 (RDP NP 2014–2020); (4) Long-Term National Strategic Framework for Climate Change Adaptation with Guidelines for Measures over the Medium-Term Period; (5) Strategic Framework for Climate Change Adaptation; (6) Plan for Development of Irrigation and Agricultural Water Use by 2020; and (7) Programme of Measures for the Implementation of the Plan for Development of Irrigation and Agricultural Water Use by 2020. Then a CC vulnerability assessment was performed (details in Klančnik *et al.* 2017). Based on the CC vulnerability assessment, the local importance of measures in the context of ACCA was rated separately by each participating researcher in terms of expert opinion. A multi-disciplinary team of six experts (two agronomists, a meteorologist, a biologist, an expert for environmental protection, and a sociologist) employed at the Biotechnical faculty (University of Ljubljana) and Institute for Water of the Republic of Slovenia participated in the assessment. Each used a Likert-type scale from 1, not important, to 5, very important; final importance being based on an average of all individual measure ratings. In this way, an environment-specific range of measures was created from the initial range.

Several tools and frameworks exist for resilience measurement (Albiac *et al.* 2017; Douchamps *et al.* 2017) and stakeholder mapping in the context of their potential contribution to societal change (Ginige *et al.* 2018) with a focus on stakeholder roles and responsibilities. We used

the approach delineated by van der Jagt *et al.* (2019) where the SL for each ACCA measure was developed by determining stakeholder (i) prevailing level of operation, (ii) level of involvement and (iii) level of interaction with other stakeholders (Table 1), by utilising measure description from the aforementioned key national and local development documents. Each of the participating researchers made a qualitative assessment and discussion took place for unanimity in terms of rating. Based on such ratings, the SL was visualised for each of the measures making use of Programme R. Pursuant to stakeholder involvement and interaction, and prevailing level of stakeholder operational difference in relation to measures, it was possible to compare the prioritised list of measures using the SL approach (Table 1). A bundle of 46 ACCA measures and SLs was then evaluated by farmers, local and regional decision-makers, national and governmental experts, for relevance and level of stakeholder operation, involvement, and interaction. Primarily, discussion involved municipality experts and decision-makers (11 April 2017), followed by discussion at a second workshop with farmers (20 April 2017). The priorities of ACCA measures and SLs were reviewed against and aligned with stakeholder opinion.

By following the described approach, a local climate change adaptation strategy (CCAS) for the area was developed and presented for public consultation, together with an evaluation questionnaire on the municipality website.

**Table 1** | Parameters for determining the stakeholder landscape for agricultural climate change adaptation measures in Vipava Valley, Slovenia

Rank	Involvement	Stakeholder	Operation
0	Not involved in measure	/	/
1	Low involvement level, very important for implementation, but only occasionally involved in implementation	Least-frequent	Micro-local
2	Medium involvement level, regularly involved in implementation and key current measures	Frequent	Local
3	High involvement level, very important for implementation pursuant to having a key role in terms of the financing measure and measure implementation	Most-frequent	State

Additionally an invitation for public consultation was emailed to several national-level experts for CC, agriculture, and water management with a request for written review and critical opinion. The final document was approved as official CCAS for ACCA at the municipality of Ajdovščina, one of the six municipalities in the Vipava Valley (Cvejić *et al.* 2017), and is the first example of local CCAS stakeholder responsibility focusing in Slovenia.

## RESULTS AND DISCUSSION

The 18 ACCA measures classified as top-priority measures by the engaged stakeholders are explained below, and each measure's policy origination is indicated, as is its objective and implementation measurement, and how it contributes to decreasing CC vulnerability (Supplements 1 and 2, available with the online version of this paper). The collection of measures targets several areas (Table 2).

All top-priority measures were visualised by means of the SL Approach (see Figure 1 for example and Supplement 2 for details). Measure 1 from RDP 2014–2020 is directed towards increasing irrigation water availability for agriculture through irrigation development at catchment, watershed and municipality level, this being large-scale irrigation and larger water reservoirs. The measure targets irrigation system modernisation for increased irrigation efficiency and reduced water consumption in agriculture by using drip irrigation instead of sprinkler irrigation. Several active stakeholder groups at different levels are required to measure implementation, these being agricultural holdings, private companies, the farmer extension service, municipalities, research institutions, and the Ministry of Agriculture, Forestry and Food. Between 2014 and 2017, this measure was the source of high implementation-policy deficit in terms of RDP RS pursuant to its organisational and financial complexity (Cvejić & Pintar 2017). This supports the discussion of Islam & Nursey-Bray (2017) in which a shortfall in coordination amongst different stakeholders was emphasised as ACCA's main challenge. A major limitation is evidenced in terms of the limited power of the farmer extension service vis-à-vis connecting farmers into a viable project group. Municipalities are increasingly seen as the key stakeholder, the one able to

take on projects and farmers' financial burden, and this would enable large-scale irrigation development at the watershed level. However, many of the municipalities do not recognise their role in terms of irrigation development, thus leading to low measure-implementation success. Unless stakeholders realise their common role in relation to CC adaptation (Saxena *et al.* 2018), said measure faces a high possibility of not being implemented, regardless of the positive financial incentives that exist. It indicates that stakeholders lack the organisational ability necessary for appointing process facilitators to better facilitate farmer engagement at the demanding project level (Ginige *et al.* 2018).

Measure 1 is strikingly different when compared with Measure 4: relatively good measure-implementation success was evidenced in the period 2007–2014 in terms of RDP RS (Tratnik & Papež 2017b). The measure is directed towards improving on-farm water availability by constructing individual irrigation systems, purchasing new irrigation equipment and building small water reservoirs, the purchase of nurseries, anti-hail nets, anti-crack-fruit-blight protective foil, protective anti-bird netting, effective energy use investment, and agromelioration. Farmers need to individually respond, with the assistance of the farmer extension service, to a public call for funds provided by the Ministry of Agriculture, Forestry and Food and services therein. This relatively simple measure to implement only requires small-group collaboration, mostly one-to-one, and this is the reason for it being more successful in the past, and why it is also more likely to be so in the future. Policy implementation success is influenced by the mechanism used for measure implementation. Smaller stakeholder groups provide for stronger interrelation, and this results in more effective stakeholder networks (Abid *et al.* 2017).

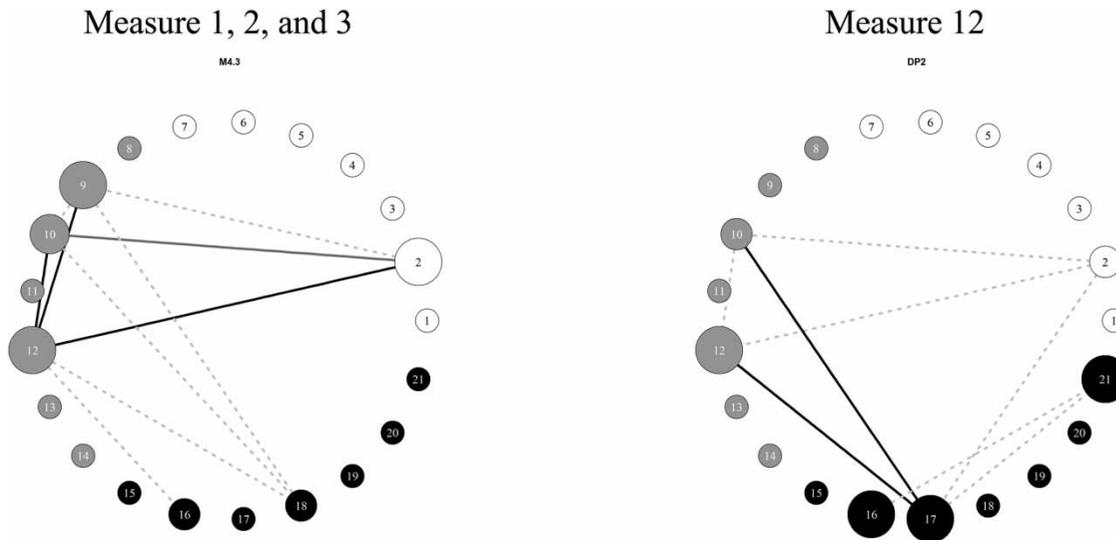
Measure 5 was recognised as important for ACCA in the area, it being directed towards courses, workshops and demonstrations to increase farmer knowledge at several levels, including irrigation scheduling and irrigation equipment use. It is included in RDP 2007–2014 in a similar form, but was never processed and public funds were not made available for measure execution. The implementation of the measure is highly dependent on public and private farmer extension services. Its measure implementation type is similar to Measure 4's, which indicates successful measure implementation. However, a concern has been raised during public

**Table 2** | The collection of top-priority measures for agricultural climate change adaptation in Vipava Valley, Slovenia

M no.	Measure (M)	Target area
Measure 1	Support for Investment in Infrastructure Related to Development, Modernisation and Adaptation of Agriculture and Forestry	technological development with respect to cross-farm advancement in relation to minimising weathering and other outdoor impacts
Measure 2	Development of Irrigation in the Vipava Valley and Goriška Brda	
Measure 3	Promotion of Effective and Sustainable Water Use	
Measure 4	Support for Agricultural Holding Investment	
Measure 5	Support for Demonstration and Information Activity	knowledge enhancement with respect to CC resilience
Measure 6	Support for Investment in the Establishment and Development of Non-Agricultural Activities	an increase in on-farm renewable energy production and use
Measure 7	Support for Investment in Processing/Marketing and Development of Agricultural Products	
Measure 8	Agri-Environment-Climate Measure Payment Obligations	disseminating on-farm practice for sustainable environmental, water management and biodiversity contributing to increased CC resilience
Measure 9	Support for Agricultural Genetic Resource Preservation, Its Sustainable Use and Development	preserving genetic resources in situ and ex situ
Measure 10	Cultivation Testing of New Plant Species and Agricultural Varieties	
Measure 11	Establishment of Agricultural and Forestry Groups and Organisations	increasing networking ability amongst farmers for joint market venture
Measure 12	Comprehensive Renovation of Windbreaks in the Vipava Valley	renovating and further developing wind erosion protection
Measure 13	Better Activation of Funds from the Climate Change Fund for the Implementation of Flood-Prevention Measures	increasing flood resilience
Measure 14	Better Activation of Funds from the EU Cohesion Fund, Regional Fund, Cross-Border Cooperation and Other Programmes in the 2014–2020 Financial Perspective for the Implementation of Flood-Prevention Measures, including the Activation of Funds	
Measure 15	Better Activation of Funds from the Rural Development Programme in the 2014–2020 Financial Perspective for the Implementation of Flood Prevention Measures	
Measure 16	Flood Safety on the Banks of the Vipava River	
Measure 17	Preparation of a Range of Indicators for the Announcement of Drought/Water Shortage Strength and Threshold Levels	increasing early preparedness for drought and water shortage
Measure 18	Support for Joint Action Aimed at Climate Change Mitigation and Adaptation, and Joint Approaches for Inclusion in Environmental Projects and Permanent Environmental Practices	

consultations as to whether the farmer extension service does in fact possess the necessary high level of knowledge to be transferred to farmers. It is possible that this measure will also require the engagement of experts from academia to provide fundamental knowledge with regard to irrigation and

ACCA. Micro-entities and agricultural holdings are entitled to funds for developing the non-agricultural activity of farms that might help support ACCA through green tourism, organic waste management and the generation of renewable sources of energy (Measures 6 and 7). Responsibility for



**Figure 1** | Stakeholder landscape for agricultural climate change adaptation measures. STAKEHOLDER: 1 individual farmers; 2 agricultural holdings; 3 producer groups: legal entities, cooperatives, social enterprise, and the like; 4 micro-entities; 5 forest ownership (public); 6 forest co-ownership, agrarian communities; 7 forest ownership (private); 8 other public bodies; 9 other private entities; 10 Agricultural Advisory Service (specialised public body); 11 private partners in public–private partnership with municipalities; 12 municipality (territorial public body); 13 other legal entities engaged in non-profit activity in the area of health care and the social inclusion of vulnerable social groups; 14 local action group partnerships (LAS); 15 legal entities in the field of education, health care education, health care and social assistance; 16 Ministry of Agriculture, Forestry and Food and bodies therein; 17 Slovenian Forest Service (specialised public body); 18 research institutions (public bodies); 19 research institutions (private bodies); 20 Ministry of the Environment and Spatial Planning and bodies therein; and 21 Farmland and Forest Fund of the Republic of Slovenia. OPERATION LEVEL: micro-locally (white circle); locally (grey circle); state level (black circle). INVOLVEMENT REQUIRED: high (largest circle); medium (medium-size circle); and low (small circle). INTERACTION REQUIRED: most frequent (black line); frequent (grey line); and least frequent (dashed grey line).

measure implementation is shared amongst the farms and micro-companies, and driven by Ministry of Agriculture, Forestry and Food incentive. Once again, farmer extension services act as help points for fund application.

The most basic measure in terms of ACCA is concerned with agri–environment–climate payment obligations. It is most popular amongst farmers, and has high implementation success. This mechanism for measure implementation is fairly simple as it revolves around a triangle made up of farmers, farmer extension services and the Ministry of Agriculture, Forestry and Food and its agencies. In this measure, all other micro-local, local and state stakeholders are afforded low importance and responsibility, contrasting with Measure 9, where the main roles vis-à-vis genetic biodiversity protection and enhancement in situ are played by public and private research bodies, and entirely independent from on-farm activities. Although municipalities only partially recognise their role in ACCA, Vipava Valley evidences that some municipalities have developed their own *ex situ* programmes to help farmers in selecting new species and varieties better adapted to high temperature and lower levels of precipitation (Measure 10).

Strengthening local food supply chains through better organisation of farmers' appearance on the markets (Measure 11) is dedicated to promoting the development of farmer groups and organisations able to enter markets in a more organised way, thus achieving better product placement and distribution, as well as sales maximisation. This measure is entirely dependent on the ability of farmers to self-organise, which has been evidenced as being their greatest challenge. The measure is of high risk in terms of implementation failure. Measure 12 promotes the comprehensive renovation of Vipava Valley's green windbreaks pursuant to the area suffering from considerable wind erosion. This measure is not financially supported by RDP RS or other programmes. It is also a very complex measure to implement as it requires implementation cross-farm and cross-land-ownership, and similar stakeholder activation to Measure 1. To better enable a higher implementation possibility, the measure should be included in the RDP RS 2021–2026. Additionally stronger local stakeholders and expert stakeholders are greatly needed to define facilitators for stakeholder measure implementation (Saxena *et al.* 2018).

Measures 13 to 15 relate to increasing flood resilience in relation to Vipava Valley. In terms of stakeholder responsibility, their implementation relies on local stakeholders, municipalities, private companies and expert stakeholders, and their ability to work with formal institutions at the state level. Micro-local stakeholder responsibility is very low with regard to this. A completely different SL landscape to other measures is given for Measures 17 and 18. These measures rely entirely on the activities of experts and the Ministry of Agriculture, Forestry and Food Ministry of the Environment and Spatial Planning at the state level. Micro-local and local stakeholders have no power in terms of measure implementation.

The CCAS for the Vipava Valley (Cvejić et al. 2017) follows the structure proposed by the EC (2013c) in the *Guidelines on Developing Adaptation Strategies*. It analyses CC risk and vulnerability, and how past weather events have affected the area. Further it explores good practice and existing measures, and describes adaptation options in detail. The ACCA measures offer the basic input for developing an action plan for ACCA for the Vipava Valley. They clearly define the SL necessary for implementing the ACCA's measures and define the indicators for the monitoring and evaluation of ACCA strategy. Nevertheless, the fear is that challenges identified in terms of stakeholder interaction cannot be solved by ACCA strategy alone unless a facilitated approach to ACCA implementation is taken on board. This step will require more from stakeholders and its success will be dependent on the ability of society to impose a strong implementation monitoring programme at the local municipality level.

## CONCLUSIONS

A novel approach to assessing SL with respect to ACCA was applied to define who is responsible for increasing CC resilience and how this responsibility is shared amongst stakeholders. Policy implementation success is significantly influenced by the mechanism used for measure implementation. A limitation of this study is that it remains unclear whether the identified and visualised interaction amongst stakeholders will develop in practice. Previous studies focusing on policy implementation success indicate that a

shortfall in terms of coordination amongst different stakeholders and their low capacity for self-organising are the main obstacles facing ACCA. A more facilitated approach to policy implementation is recommended. Nevertheless, it remains unclear as to who should lead this process at the local level; despite this, the study provides stakeholders, such as the farmer extension service, local government, ministries, and experts, with detailed information as to which measures require activation and of which stakeholders. The future success of ACCA depends on the capacity of the SL to impose a strong implementation monitoring programme at the local level. Future research should therefore focus on developing facilitation procedures and mechanisms for implementing ACCA.

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