Climate Change Adaptation in Agriculture – Insights from the Czech Republic

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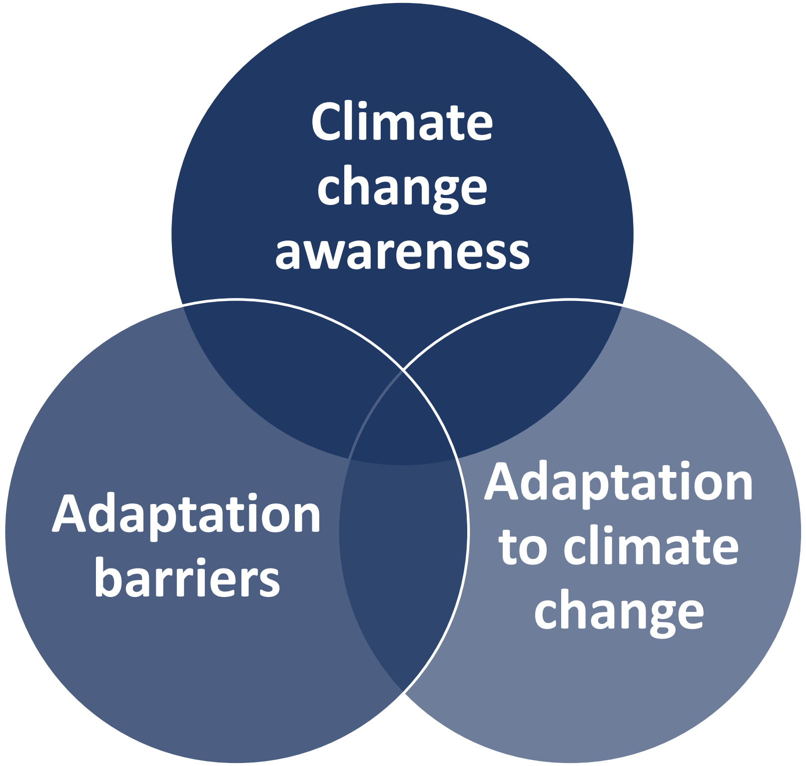
Background

- Climate change adaptation is essential for a sustainable future of agriculture (Ewert et al. 2005; Haden et al. 2012; Woods et al. 2017; Trinh et al. 2018; Rosenzweig and Tubiello 2007).
- CSA in Czech Republic has not been a research focus while farmers are particularly encouraged to apply CSA concepts in Central and Eastern Europe (EIT Climate-KIC 2021).
- Climate change impacts are not only influenced by biophysical aspects but also by characteristics of the farm and farmers themselves (Reidsma et al. 2010).
- Large fields and usage of heavy machinery contribute to increased risks of soil erosion from wind and water (particularly in Central and Eastern Europe) (EIT Climate-KIC, 2021).
- Crop production is not sufficiently diversified and is based on high input application rates + intensive tillage (EIT Climate-KIC, 2021).

Objectives



Do Czech farmers agree on the existence of climate change and which effects are they experiencing?

Which climate change adaptation measures are commonly used among Czech farmers?

What factors are influencing the degree of adaptation?

Key Concepts: Climate Smart Agriculture and Diffusion of Innovations (in CC adaptation)

CSA

- Increased Productivity
- Enhanced resilience
- Reduced Emissions

- **Relative advantage:** Is it better than the status quo?
- **Compatibility:** Consistent with values and experiences?
- **Complexity:** Is it difficult to apply?
- **Trialability:** Can the effect be proven before application?
- **Observability:** Tangible results from application?
- **Goal:** Shift stages of adoption to a possibly early stage

Climate change in Czech agriculture

- Climate predictions: higher variability in precipitation and temperature in CZ (Papadimitriou et al. 2018).
- CZ is on par with other European economies in terms of climate change adaptation planning (Papadimitriou et al. 2018).
- Decreasing availability of arable land in CZ is stressing domestic agriculture (Lorencová et al. 2013; Papadimitriou et al. 2018).
- Lack of applying CSA principles is a key driver for soil erosion in CZ (Vavra et al. 2019).

Climate change in Czech agriculture

- Czech cash crops (e.g. hops, wine) are particularly vulnerable to climate change (Mozny et al. 2009).
- Higher variability of growing seasons and crop cycles is expected in CZ, potentially leading to increased harvest losses (Potopová et al. 2015).
- Need for regional and international alignment of policies is crucial (e.g. within CAP-"The European Green Deal") (Pullens et al. 2019).

Adaptation strategies to climate change (CSA concepts)

Crop diversification (Ghahramani et al. 2020; Menike & Arachchi 2016; De Sousa et al. 2018; Fahad and Wang 2018, Shi-yan et al. 2018)

Water conservation (Nguyen and Mitsumasu 2016; Fahad and Wang 2018, Shi-yan et al. 2018; Iglesias and Garrote 2015)

Soil conservation (De Sousa et al. 2018; Biggs et al. 2018a; Muench et al. 2021; Kipling et al. 2019; Makuvaro et al. 2018)

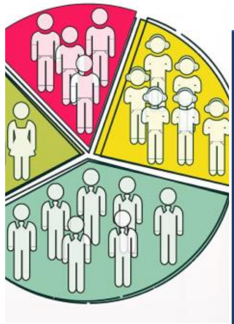
Climate resilient species (Biggs et al. 2018a; Fahad and Wang 2018)

Agroforestry (Bedeke et al. 2018; Amadu et al. 2020a)

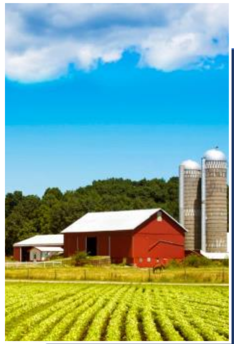
Crop rotation (Piedra-Bonilla et al. 2020; Roesch-McNally 2018; Labeyrie et al. 2021)

Factors influencing climate change adaptation

Institutional characteristics: access to credit, cooperative membership (Trinh et al. 2018;Menike & Arachchi 2016;De Sousa et al. 2018)



Socio-demographic aspects: age, gender, education, experience (Arbuckle et al. 2013; De Sousa et al. 2018; Shi-yan et al. 2018; Zhang et al. 2020)



Farm characteristics: size, legal form, specialization, rented land (Sahu and Mishra 2013;Ali and Erenstein 2017;Bedeke et al. 2018;Gunathilaka et al. 2018)

Information access: media sources, extension services (Mahmood et al. 2021; Trinh et al. 2018;Shi-yan et al. 2018;Ali & Erenstein 2017;Gunathilaka et al. 2018)

Data collection

Method: Structured questionnaire in electronic form based on random sampling via database from research institutions and associations

Selection quota: Categories of small (up to 50 hectares), middle (51 – 500 hectares) and large farms (more than 500 hectares)

Collection: 358 completed questionnaires between March-April 2020 through external provider FOCUS (prior pilot survey)

Basic BLR equation (Greene 2003)

$p(y = 1) = \frac{e\beta_0+\beta x}{1+e\beta_0+\beta x}$

Data analysis

Descriptive statistics: Respondent characteristics, climate change awareness

Binary logit regression (BLR): Factors influencing the degree of applying specified adaptation strategies

Basic BLR equation (Greene 2003)

$$\boldsymbol{p(y = 1) = \frac{e\beta_0+\beta x}{1+e\beta_0+\beta x}}$$

Marginal Effects (Cramer 2003)

$$\boldsymbol{ME = \frac{\partial \Lambda(x\beta)}{\partial x} = \Lambda(x\beta)[1 - \Lambda(x\beta)]\beta}$$

Selected variables

Dependent variables
Minimal soil cultivation
Mixed crops
Climate resilient varieties
New crops
Ever-present soil cover
Crop rotation

Independent variables
Respondent variables
Climate change awareness; Gender, Age; Education
Farm-level variables
Land area; OSVC; Rented Land (Ratio); Farm targets – profit, Rural employment, Soil protection; Wheat production
Information source variables
Agricultural associations; Ministry of agriculture; Research institutions; Other farmers; Commercial companies; Agricultural journals; Mass Media (TV,radio); Internet; Field days; Training

Descriptive results

Variables (Categories)	Mean	St. Dev	Median
Gender	1,11	0,31	1
Male (1); Female (2)	-	-	-
	-	-	-
Age	3,34	1,2	3
less than 30 (1); 30-40 (2); 41-50 (3); 51-60 (4); 60+ (5)	-	-	-
	-	-	-
Education	3,13	0,79	3
Elementary (1); Secondary/no leaving exam (2); Secondary/ leaving exam (3); University (4)	-	-	-
	-	-	-
Legal form	3,76	0,71	4
Cooperative (1); Limited liability company (2); Joint stock company (3); OSVČ (4); Other (5)	-	-	-
	-	-	-
Specialization	1,26	0,73	1
Crop production (1); Animal production (2); Mixed production (3); Other (4)	-	-	-

Table 1: Descriptive statistics of respondents

Do Czech farmers agree with the existence of climate change?

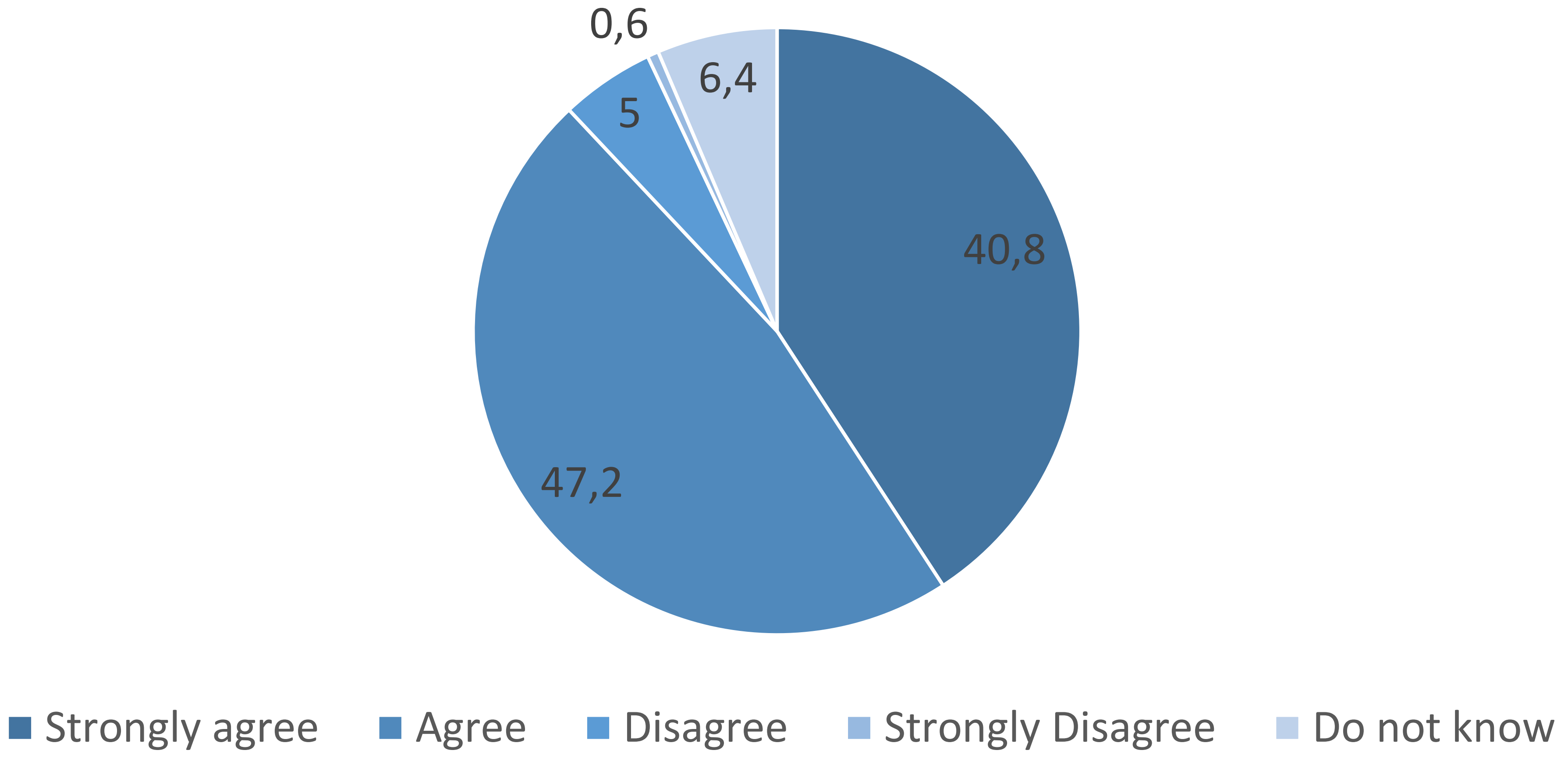


Figure 1: Degree of agreement on climate change among Czech farmers

Perceived severity of climate change effects

Climate change effects	Perceived severity (share of respondents in %)					
	No severity	Low severity	Moderate severity	High severity	Very high severity	Not experienced
Increasing temperature (vegetation period)	4,19	12,57	23,18	31,56	27,37	0
Changes in precipitation (vegetation period)	0	2,79	12,29	31,84	52,79	0
Increasing variability in temperatures and precipitation	0,28	4,47	26,54	37,99	29,61	0
Frequent extreme events (e.g. droughts)	0,28	2,23	9,78	32,4	54,47	0
Lower water accesibility	0,84	4,47	16,48	32,96	43,85	0
Shorter vegetation period	12,29	24,02	34,36	22,63	3,91	0
Change in seeding date	16,48	30,17	37,43	12,01	2,23	0
Change in harvesting date	16,2	28,21	36,31	15,92	1,96	0

Table 2: Perceived severity of climate change effects among respondents

Application rates of adaptation strategies

Adaptation strategies	Applying this strategy? (share of respondents in %)		
	Yes (already using it)	No (planning to use within 3 years)	No (no concrete intention to use)
Minimal soil cultivation	48,3	8,38	43,30
No-tillage	4,47	5,31	90,22
Mulch	38,83	9,22	51,96
Mixed crops	38,27	15,36	46,37
Inter-cropping	5,03	12,57	82,40
Cover crops	67,04	9,78	23,18
Legumes cropping	23,18	10,06	66,76
Irrigation	8,10	4,75	87,15
Climate resilient varieties	56,15	20,95	22,91
New crops	24,02	28,77	47,21
Timber on arable land (agroforestry)	2,79	3,35	93,85
Timber on pastures (agroforestry)	2,51	3,91	93,58
Permanent soil cover	34,64	21,23	44,13
Crop rotation	91,62	3,63	4,75
Precision agriculture	26,54	31,28	42,18

Table 3: Application of adaptation strategies

Factors influencing adaptation behaviour

Minimal soil cultivation	Mixed crops	Climate-resilient varieties	New crops	Permanent soil cover	Crop rotation
Awareness* (-) Age* (+) Mass media** (-) Internet* (+) Importance for profitability*** (+)	Wheat production** (-) Comm. Companies** (-) Agricultural journals* (-) Importance for profitability*** (+)	Awareness* (-) Rural employ.** (-) Wheat prod.* (+) Research inst.*** (+) Mass media*** (-) Field days** (+) Importance for profitability*** (+)	Age** (-) Rented land** (-) Research inst.* (+) Importance for profitability*** (+)	Soil protection* (+) Agricultural journals* (+)	OSVC** (+) Wheat prod.*** (+) Other farmers* (-) Field days* (+) Importance for profitability** (+)

Note: *=p≤0.1; **=p≤0.05; ***=p≤0.01

Table 4: Statistically significant factors influencing the application of specified adaptation strategies

Discussion

- 88% of the sample were acknowledging climate change. (Findlater et al. 2018; Menike and Arachi 2016; Sahu and Mishra 2013).
- Profitability is an important driver, showing a positive effect on all adaptation measures.
- CSA strategies as described by the CGIAR (2021), FAO (2021), or the World Bank (2020) are applied by Czech farmers but not all to a full potential (Vavra et al. 2019).
- Potential reason for deviance between awareness and adaptation: cognitive isolation and no perceived benefits (Findlater et al. 2018).
- Privatization of extension services in the EU was causing smaller agricultural businesses to struggle with knowledge access (Labarthe and Laurent 2013).

Discussion

- High perceived severity of droughts and reduced water accessibility while application rate of irrigation adaptations is low.
- Low dissemination rate in agriculture could explain a delay of DOI concerning CSA principles (Fichter and Clausen 2021): focus on information provision.
- Research institutions, agricultural journals, internet and training attendance increased the likeliness to apply a higher number of adaptation strategies.
- Mass media and commercial companies decreased the likeliness to use specified adaptation strategies.
- Information provision through appropriate channels is a key focus point to increase the application of adaptation strategies (Makate et al. 2019; Mahmood et al. 2021; Shi-yan et al. 2018; Trinh et al. 2018).

Recommendations

- Closer collaboration between policy makers, research institutions, topic-specific journals and training to efficiently support Czech farmers in climate change adaptation.
- Focus on communicating connectivity between profitability and climate change adaptation/provision of financial incentives for adapters.
- Further analysis on how farmers could benefit from applying measures with a currently low application rate (e.g. irrigation, intercropping, no tillage, agroforestry).
- Organisation/planning of field days with particular emphasise on adaptation.
- Regional specifications have to be taken into consideration in international policy planning.

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Thank you for your attention