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REVIEW ARTICLE

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A systematic scoping review and content analysis of policy recommendations for climate-resilient agriculture

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ABSTRACT

Climate-resilient agriculture (CRA) is among the top policy priorities for the Association of Southeast Asian Nations (ASEAN) in their food, agriculture, and forestry sectors. However, the strategies that have been adopted to date have failed to produce positive changes or alter climate change trajectories. Scientific evidence is crucial for evidence-based policy making in this arena and elsewhere. We undertake a scoping review to explore what is known from the existing scientific literature about the policy recommendations for CRA in ASEAN. We follow the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for new systematic reviews. Furthermore, we conduct a content analysis to classify the policy recommendations into eight CRA policy categories and to investigate how the policies identified in the reviewed articles reinforce the climate resilience capacities (CRC) needed for CRA. The synthesis review is based on 47 papers. This research contributes to climate resilience literature, and explains how the results of this study could be applied in policy analysis to build CRC within the agricultural sector. The knowledge generated by this study can support policy design, and therefore support the building of an enabling environment for CRA for ASEAN and elsewhere.

Key policy insights

- Scientific literature on CRA typically recommends policies that support *communication and knowledge sharing* and advance *research and technology development*, often in combination with *risk management*- and/or *environmental/climate support*.
- There is insufficient evidence on actual policies enabling CRA. This result may also reflect a lack of research on some of the identified CRA policy categories, such as *agricultural production support*, *investment support*, *infrastructural support*, *land use regulation and certification*.
- This synthesis review identifies literature addressing policy capacity to achieve CRA goals. Adaptability and transformability are key dimensions of policy capacity enabling responsive actions to climate change, mainly via social learning, in-depth learning and research and technology development. Literature pays little attention to anticipation and robustness, facilitating proactive ex-ante initiatives and coping for climate change; we argue that these

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dimensions of capacity merit further research.
- This synthesis demonstrates key gaps in research and understanding of CRA and related policies targeting capacity building, followed by a need to raise awareness of the importance of such policies. It also points to the need to enable preparation for climate-related crisis planning, through use of anticipatory policies and tools, such as climate predictions to inform planning of robust prevention measures.
- Last but not least, the synthesis identifies that representation across the ASEAN countries and the type of agricultural systems in is unbalanced; research from Vietnam and Malesia and research on rice production or rice in combination with other crops or shrimp are over-represented. We argue that research on climate change adaptation for other important agricultural production systems, covering the remaining ASEAN countries, is needed to fill this gap.

1. Introduction

Human activities linked to agricultural production, forestry, and land use are responsible for a quarter of the total amount of greenhouse gas (GHG) emissions and therefore contribute significantly to climate change (Jia et al., 2019). The Association of Southeast Asian Nations (ASEAN), in particular, is ranked fourth in terms of GHG emissions from agriculture (8.6%), immediately below Southern Asia (17.7%), Eastern Asia (14.8%), and South America (14.0%) (FAO, 2016). ASEAN is also one of the regions that is the most vulnerable to climate change, including droughts, heavy rains, tropical cyclones, rises in sea level, and salinity intrusion (ASEAN Secretariat, 2015).

Climate resilience (CR) is crucial for ASEAN agriculture, where food security, economic and ecological stability, and sustainable development are seriously threatened by climate irregularities (FAO, 2016). Climate-resilient agriculture (CRA) involves the incorporation of adaptation practices (Wassmann et al., 2019), including behavioural adjustments made by organizations and individuals to reduce the vulnerability of food, agricultural, and forestry sectors to climate change (Pielke, 1998). CRA requires adjustments by decision-makers from the farm to the global level (Lipper et al., 2014). At the farm level, a wide range of climate change adaptation practices in agriculture have been adopted by farmers worldwide (Acevedo et al., 2020; Enriquez et al., 2021). However, the involvement of farmers is necessary but insufficient. It is the key role of governments – as providers of the public good – to solve climate concerns through the design and implementation of CR policies. Policy measures are a set of techniques by which governmental authorities use their power to facilitate behavioural change (in values, beliefs, actions, etc.) among a particular target group of society to improve climate resilience capacity (CRC) (Mickwitz, 2003). Here, CRC refers to an ability of the sector to anticipate, cope with, and respond to the effects of climate stimuli (Engle, 2011; Mathijs & Wauters, 2020; Meuwissen et al., 2019).

CR and policies that enhance CRC of food, agricultural, and forestry sectors are ranked as a top policy priority for ASEAN, as stipulated in ASEAN's 2025 declaration (ASEAN Secretariat, 2015). The declaration emphasizes that a 'resilient ASEAN is able to anticipate, cope with, and respond to disasters, including climate change disasters' (ASEAN Secretariat, 2015, p. 113). The priority for building CRC is grounded on the common concern that the agricultural sector should be better supported in climate change responses in order to accelerate the sector's contribution to the achievement of the 1.5°C target of the Paris Agreement. The literature on actions taken towards attaining the 1.5°C goal emphasize the necessity of policies that target both the anticipation of future change and responses to a changing climate (Travis et al., 2018). ASEAN governments have committed to incorporating CR into their national policies, as well as design measures that increase the CRC of the agricultural sector (ASEAN Secretariat, 2015). Nevertheless, strategies undertaken to date have failed to produce positive changes or alter the trajectory of climate change (on e.g. food security vulnerability) (Islam & Kieu, 2020).

Scientific evidence supports climate change adaptation planning, and expectations that the scientific community will translate research into practical assessment to assist evidence-based policy making is high (Fujisawa & Kanamaru, 2019). We refer to 'scientific evidence' as an assertion based on information gathered systematically by using recognized scientific methods (Cairney, 2016), such as reviews intended to address policy

implications. Scientific evidence is necessary to identify viable options for CR-enabling activities, which makes the CRA studies a basis to inform policies on CR adaptation, both for the design of new interventions and for the reorientation of policy in response to climate change (EBPC, 2016; Lipper et al., 2014). Still, the literature shows that evidence-based policy making in ASEAN is limited (Dany et al., 2016, 2017; Lebel, 2014). A common understanding of the low use of research findings by policy makers is that policy makers do not understand and do not act on available evidence (Cairney, 2016). Moreover, research from low- and middle-low-income countries shows that evidence is inadequate and inaccessible to policy makers at both local and national levels (Lipper et al., 2014). Building and compiling scientific evidence in usable ways for policy makers and practitioners is an important principle in empowering evidence-based policy making (Cairney, 2016). Reducing the gap between science and the policy is especially important in climate change adaptation, due to the high uncertainties involved in climate change planning (Dany et al., 2016).

To provide practical answers and a sound background for policies supporting climate change adaptation in ASEAN, scholars have conducted empirical studies to: (i) predict climate change effects on the agricultural sector (Hayashi et al., 2019); (ii) estimate vulnerability to climate change (Pleerux, 2013); (iii) explain determinants of climate change adaptation like socioeconomic factors (Bosma et al., 2012; Huynh et al., 2020; Masud et al., 2017; Rondhi et al., 2019) and psychological factors (Dang et al., 2013; Hein et al., 2019; Hoan et al., 2019; Hoang et al., 2014; Huynh et al., 2020; Masud et al., 2017; Thoai et al., 2018); and (iv) evaluate existing climate policy programmes/initiatives (e.g. Islam & Kieu, 2020; Renaud et al., 2015). In addition, it is widely acknowledged in the literature that public policies can enable or hinder the CR of the agricultural sector (Buitenhuis et al., 2020; Darnhofer, 2014; Mathijs & Wauters, 2020). A recent review related to CRA in low- and middle-income countries, including ASEAN, focuses solely on determinants for the adoption of climate-resilient crops by small-scale producers (Acevedo et al., 2020). However, to the best of our knowledge, there are no synthesis articles that seek to integrate the existing scientific literature, or to identify and present the available findings on policies for CRA in ASEAN. Policy recommendations identified in research are required to ensure that public interventions are directed at supporting CRA (Hyysalo et al., 2019). Moreover, how policies suggested in scientific literature reinforce the CRC needed to achieve CRA is unknown.

Given this background, the aim of this article is twofold. First, to explore what is known in existing scientific literature about the policy recommendations for CRA in ASEAN. Second, to evaluate how these policies reinforce the CRC needed to achieve CRA. The study brings together evidence from research and provides valuable input to the policy-making process. This study identifies policy recommendations concerning research for climate adaptation in ASEAN, and then links them to CRC. The research contributes to the resilience literature as a concept and explains how the results of this study could be applied in the analysis of policies for building CRC within the agricultural sector. The knowledge generated by this study can support policy design while also formulating priorities and targets for climate actions, therefore promoting the enabling environment of CRA for ASEAN.

The paper is structured as follows. Section 2 presents the method and the analytical approach and Section 3 provides the results and discussion of these. Conclusions are presented in Section 4.

2. Method and analytical approach

Here we combine a scoping review (Arksey & O'Malley, 2005; Peters et al., 2015) to explore current knowledge in existing scientific literature of policy recommendations for CRA in ASEAN with a content analysis (Elo & Kyngäs, 2008; Manevska-Tasevska et al., 2021). The aim is to identify and classify policy recommendations into policy categories to better understand and explain how these policies reinforce CRC.

2.1. Scoping literature review

Scoping reviews have become a common methodological approach that systematically searches and thematically characterizes the extent, range, and nature of existing research evidence (Acevedo et al., 2020). Scoping reviews are designed to summarize and provide evidence synthesis (Arksey & O'Malley, 2005; Xiao & Watson, 2019) in order to inform the wider scientific community and policy makers about relevant research and

evidence (Acevedo et al., 2020; Arksey & O'Malley, 2005; Peters et al., 2015). Moreover, through scoping reviews, knowledge gaps and limitations of previous studies can be revealed, which can inform new studies (Lasserson et al., 2021). Scoping reviews, with evidence synthesis from studies using various methodologies, allows both qualitative and quantitative interpretations (Arksey & O'Malley, 2005; Xiao & Watson, 2019). This type of review is especially important, as the research conducted in the highly climate-vulnerable ASEAN region is understudied; mainly due to resource constraints like a lack of technology, support, and/or data availability (Raghavan et al., 2019). In our scoping review, we followed the guidance and the steps recommended by Arksey and O'Malley (2005) and Peters et al. (2015). These steps are presented in Sections 2.1.1 and 2.1.2.

2.1.1. Study selection and inclusion criteria and review protocol

We follow the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guide for new systematic reviews of databases and registers (Page et al., 2021). Figure 1 shows the steps for conducting the review.

The search criteria considered studies that were: (1) published in peer-reviewed and non-peer-reviewed journals, conference papers, or book chapters; (2) written in English and listed in Web of Science and Scopus; (3) focused on climate change, agriculture, food, and policy, in a combination with the adoption of practices for climate change, adaptive capacity resilience, resilience capacity; and (4) originated from ASEAN countries. The search strings used for the two databases are given in Textbox S1, Supplementary Material.

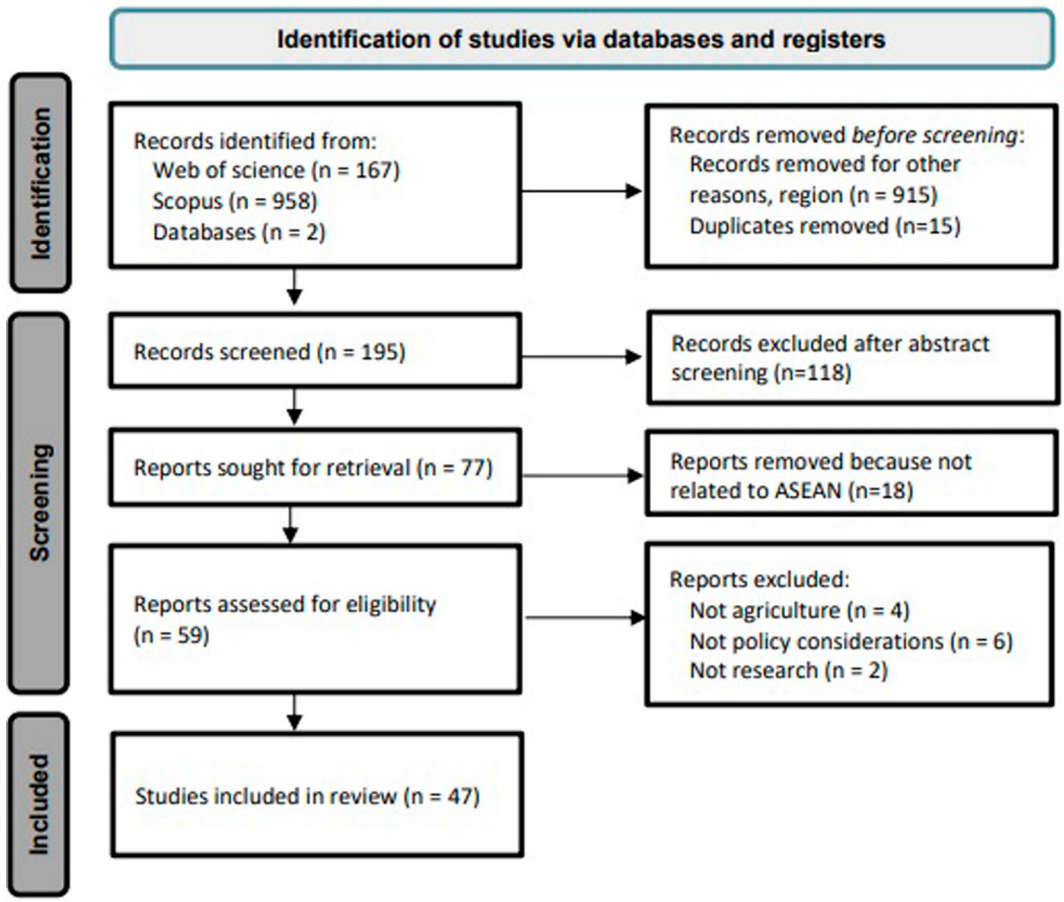

Figure 1. Steps of new systematic reviews via databases and registers, adapted from Page et al. (2021).
Source: PRISMA (prisma-statement.org).

The initial search identified 1125 articles, out of which 913 were excluded before the abstract screening after being evaluated against the predefined inclusion criteria. Of these, 898 articles did not belong to the region, and 15 articles were duplicates. The research team performed a double-blind title and abstract screening on 195 articles that were related to resilience and to climate change adaptation and provided a policy relevance. Papers focusing on agricultural production and water resource management in agriculture were taken into consideration. Although different, the two sectors above are connected to each other and highly sensitive to climate change, given the fact that most of the agriculture in ASEAN is rain-fed, and water resource management infrastructure in the region is underdeveloped (Dany et al., 2017). Papers with a clear focus on water management in general were excluded from the analysis. In total, 78 papers with selected abstracts were further considered for full paper review, out of which 31 papers were excluded from analysis. This round of exclusion was due to deviations from the inclusion criteria, such as not belonging to ASEAN, not being related to agriculture, containing no policy considerations, or not counting as research. A total of 47 remaining papers were then subjected to data extraction. The full list of articles considered for abstract and full-text screening is illustrated in Supplementary Material, References S1 and S2, respectively. Following the guidance for conducting scoping reviews, an assessment of study quality was not carried out (Arksey & O'Malley, 2005; Peters et al., 2015).

2.1.2. Data extraction

The full list of 47 articles included in this assessment, coupled with the extracted data are presented in the Supplementary Material, Table S2. Data were extracted in a Microsoft Excel spreadsheet and tested with selected articles from the scoping review search, including Akhtar et al. (2019); Dang et al. (2013); Enriquez et al. (2021); Hoang et al. (2014); Islam and Kieu (2020); and Renaud et al. (2015). Studies used for defining policy categories and developing the analytical framework were also considered, including Anbumozhi et al. (2019); Buitenhuis et al. (2020); Duchek (2020); Mathijs and Wauters (2020); and Termeer et al. (2018). Extracted data contain information on authors, type of publication, location of study, level of assessment (e.g. local, regional), type of agricultural production (e.g. crops, livestock, food sector in general), data source (e.g. primary, secondary, literature review), analytical method (e.g. qualitative, quantitative), study focus, and the identified policy recommendations.

2.2. Content analysis

A content analysis of the selected 47 articles was conducted in two steps. In the first step, inductive codes representing policy categories supporting the adoption of CRA were created from the policy recommendations identified in the reviewed articles (Denzin & Lincoln, 2011). These inductive codes were triangulated with literature on CRA (Anbumozhi et al., 2019; Buitenhuis et al., 2020; Duchek, 2020; Termeer et al., 2018). Checking the codes with what is found in the literature was instructive, allowing us to fulfil the requirement for 'triangulation' (Denzin & Lincoln, 2011), and to verify that the selected policy categories are relevant for both the literature and for practice (Coopmans et al., 2021). See Table 1 for specific examples of how policy categories were assigned.

In the second step, a deductive approach (Elo & Kyngäs, 2008; Manevska-Tasevska et al., 2021) was conducted on the reviewed articles to investigate how policy categories identified from the policy recommendations (in Step 1) contribute to building the CRC, which is needed for CRA. A deductive content analysis approach implies that the structure of coding is operationalized on the basis of previous knowledge (Elo & Kyngäs, 2008). Qualitative studies are considered largely subjective, as different researchers can come up with different conclusions. To reduce subjectivity, the coding process was followed by several discussions on coding issues and a double-blinded coding was conducted by three researchers. In order to minimize the researchers' bias, two researchers cross-checked the coding, and together came up with a common understanding and interpretation of the data.

In our analysis, the deductive coding was derived from the Resilience Assessment Tool (ResAT), developed by Buitenhuis et al. (2020). ResAT is based on an extensive review of resilience literature (Folke et al., 2010; Meuwissen et al., 2019) and policy design (Daedlow, Beckmann, Schlüter, & Arlinghaus, 2013; Howlett, 2019) to conceptualize the relationship between policies and the resilience of the agricultural systems. ResAT explains

Table 1. CRA policy categories and selected examples identified in the scoping review.

Policy category	Examples of policy support/actions that have been recommended in the review articles
Communication and knowledge sharing	Building collaboration networks in the value chain (producers, consumers, extension services); dissemination of information (media, agencies) to improve awareness; public investments in communication infrastructure (institutions, facilities, equipment) connecting villages with neighbouring cities, etc.
Research and development, including participatory technology development	Support research on climate change and involvement of stakeholders in research (drought-resistant plants, salt-tolerant rice varietals); develop research-based climate forecasting models or 'Decision Support Systems' to support practitioners' decision making; rural innovations, etc.
Risk measures	Crop insurance schemes to reduce the risk of crop failure due to climate change; loans/ access to finance coping with adverse events such as floods; support for monitoring, measuring, registration of climate data, and forcasting climate change*
Environmental/ climate support	To manage adaptation costs for reactive adaptation to climate change; incentive mechanisms that compensate private costs for public gain.
Investment support	Investments in new technology, new farming systems, increase the scale of farming, facility support, etc.
Infrastructure support	Funding for investments in e.g. infrastructure for irrigation, improved manure management, strengthening institutional setups such as creation of formal financial institutions, cooperative establishments, institutionalized reporting systems for climate change
Agricultural production support	Compensate farmers for cost of farm investments to enable continuation of production
Land use and market regulations and certification	Regulations and incentive-based approaches to adjust e.g. household decision-making

Note: *Other than finances for building infrastructure, communication, and institutions, funding research to build models for monitoring, and building.

whether and how policies enable the resilience of agricultural systems along three dimensions, namely robustness, adaptability, and transformability (Buitenhuis et al., 2020; Manevska-Tasevska et al., 2021). Following the resilience literature robustness enables the sector to cope – i.e. to absorb disturbances from existing challenges – whereas adaptability and transformability are required to enable necessary responses, including adjustments and transformations into something new (Mathijs & Wauters, 2020; Meuwissen et al., 2019). In ResAT, policies enabling robustness are characterized by (i) a short-term focus; (ii) supporting the status quo; (iii) enabling buffer resources; and (iv) offering other modes of short-term risk management support. Policies enabling adaptability: (i) have a mid- to long-term focus; and enable (ii) flexibility; (iii) variety; and (iv) social learning. Policies enabling transformability: (i) have a long-term focus; (ii) dismantle incentives that prevent changes to the status quo; (iii) enable in-depth learning; and (iv) support research and technology development (see Table 2 and Figure 2).

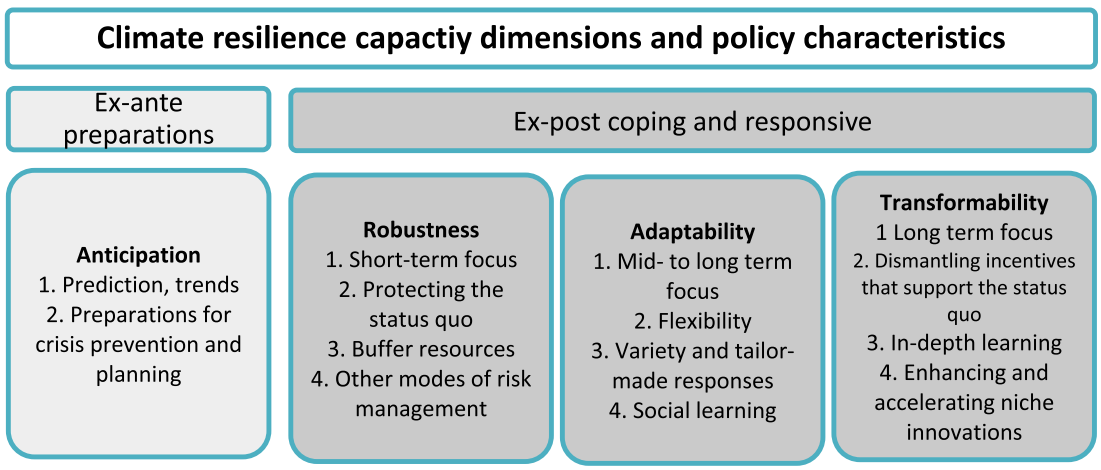

Figure 2. CRC dimensions and their respective policy characteristics. Adapted from the Resilience Assessment Tool by Buitenhuis et al. (2020) and (DeLeo, 2017; Duchek, 2020).

Table 2. CRC dimensions, key characteristics of policies enabling CRC dimensions, and examples of policy solutions enhancing CRC.

Type of CRC dimension Axial codes	Key policy characteristics Thematic codes	Examples of policy solutions
Anticipation	1. Predictions, trends 2. Crisis prevention and planning	Support for building infrastructure (institutions, facilities, equipment) to register climate data Support for building infrastructure (institutions, facilities, equipment) to identify long-term climate change risks, develop forecasting models, communicate climate projections, and disseminate knowledge
Robustness	1. Short-term focus	Ad-hoc payments and programming cycles of one year or less that focus on recovery of the system with marginal adjustments
	2. Protecting the status quo	Subsidies for quick adjustments to maintain the existing system
	3. Buffer resources	Policies provide buffer resources for recovery (emergency schemes), including compensation funds, mobilization of labour, water reservoirs, food aid
	4. Other modes of short-term risk management	Accessibility of data to individuals; subsidized private risk management; policies supporting market crisis
Adaptability	1. Middle to long-term	Programming cycles of one to five years, aiming at adjustments to the existing structure
	2. Flexibility	Dynamic, means-oriented regulatory norms; binding formal agreements are reduced
	3. Variety and tailor-made responses	Policy instruments that support diversification; policies for building infrastructure (institutions, facilities, equipment) for decentralized decisions and local autonomy
	4. Social learning	Policy supporting actors in developing, exchanging, and preserving knowledge in networks; learning across institutional boundaries
Transformability	1. Long-term	Long-term planning and strategies
	2. Dismantling incentives that support the status quo	Abolishment of instruments that support developments which hinder transformation;
	3. In-depth learning	Broad consultations; organized and consequential policy dialogues; learning communities
	4. Enhancing and accelerating niche innovations	Resources for experimentation and niche innovations, often connecting actors encouraging to them experiment

Source: Adapted from Termeer et al. (2018). D 4.1: Assessing How Policies Enable or Constrain the Resilience of Farming Systems in the European Union: The Resilience Assessment Tool (ResAT). Towards SUstainable and REsilient EU FARMing Systems, SURE-Farm Project no.: 727520.

Moreover, extending the work by Buitenhuis et al. (2020), we added another CRC dimension, namely 'anticipation' (DeLeo, 2017; Duchek, 2020) into our analytical framework. According to DeLeo (2017), climate governance is anticipatory by design, as climate change requires long-term time horizons. This additional dimension makes our study tailored to the ASEAN context, since anticipation is one of policy foci of the region. Anticipation is a capacity to predict and prevent potential risks (in the long-term) before 'the damage has taken place' (Duchek, 2020). Hence, policies enabling anticipation have two key characteristics: (i) enabling the prediction of trends and (ii) supporting the sector to prepare for crisis planning and prevention. Table 2 shows the axial codes, including various types of CRC dimensions, the thematic codes representing the key characteristics of the CRC policies, and examples of how these characteristics are related to policies.

Figure 2 presents the framework used for analysing CRC dimensions, and their respective policy characteristics. In our framework, anticipation is the first CRC dimension, mainly representing proactive ex-ante preparations (DeLeo, 2017; Duchek, 2020). The remaining CRC dimensions and their accompanying characteristics are categorized as ex-post coping (robustness) and other policies more responsive to climate change itself or experience with policy over time (adaptability and transformability).

The framework used in our study allows replication analysis across time and geographical units (Elo & Kyngäs, 2008). Although the text of any specific policy may not necessarily use the specific terms 'anticipation', 'robustness', 'adaptability', or 'transformability', characteristics that reflect these CRC dimensions were identified, and therefore coded under the relevant theme. In some cases, the CRC dimensions discussed in the articles did not correspond to the definitions applied in our framework. For example, a study may discuss policy actions aiming to enable adaptability, but the actual activities implied anticipation, robustness, or transformability. In such a case, these CRCs were assigned with thematic codes for CRC relevant to the applied framework (as presented in Figure 2 and summarized in Table 1). We allowed a single policy category to be coded for

multiple CRC dimensions (see Textbox S2 in Supplementary Material). The content analysis allows for such frequencies to be presented in the analysis (Vaismoradi & Snelgrove, 2019).

3. Results and discussion

3.1. Case study country and thematic coverage and analytical approaches

Of the 47 papers included in the analysis, 83% are published in peer-reviewed journals, 13% are book chapters, and 4% are conference papers. Across the countries, 32% of the case studies are for Vietnam, followed by 19% for Malaysia, and 13% for Indonesia. Brunei, Laos, and Myanmar have less than 5% of the total number of case studies each. Figure 3 shows the number of studies included in the scoping review, per country. Limiting the search string to Web of Science and Scopus might have affected the scope of the available articles.

Regarding production systems, rice production, or rice in combination with palm oil, coconut, other crops or shrimp, and crop production in general are the most represented agricultural systems, comprising 51% and 17% of the total, respectively. The high research interest in studying rice production has been motivated by the strong link between climate change on one side, and water management, GHG emission management, and the trade-off for the water needs for agriculture and human consumption on the other (Enriquez et al., 2021). These are followed by studies on food security, and agroforestry and forestry, accounting for 15% and 9% of the studies, respectively. Livestock systems (mainly cattle production) are under-represented, accounting for only 4% of the total number of studies included in the analysis. With respect to research topics, studies that identify factors relevant for increased use of CR practices are the most common (Al-Amin et al., 2020; Bosma et al., 2012; Brown et al., 2018; Dumrongrojwatthana et al., 2020; Thoai et al., 2018; Vo et al., 2021). Other studies observe climate and weather conditions, and use climate scenarios to project vulnerability and changes to production and economic outcomes (Al-Amin & Ahmed, 2016; Jabin et al., 2015; Panturat

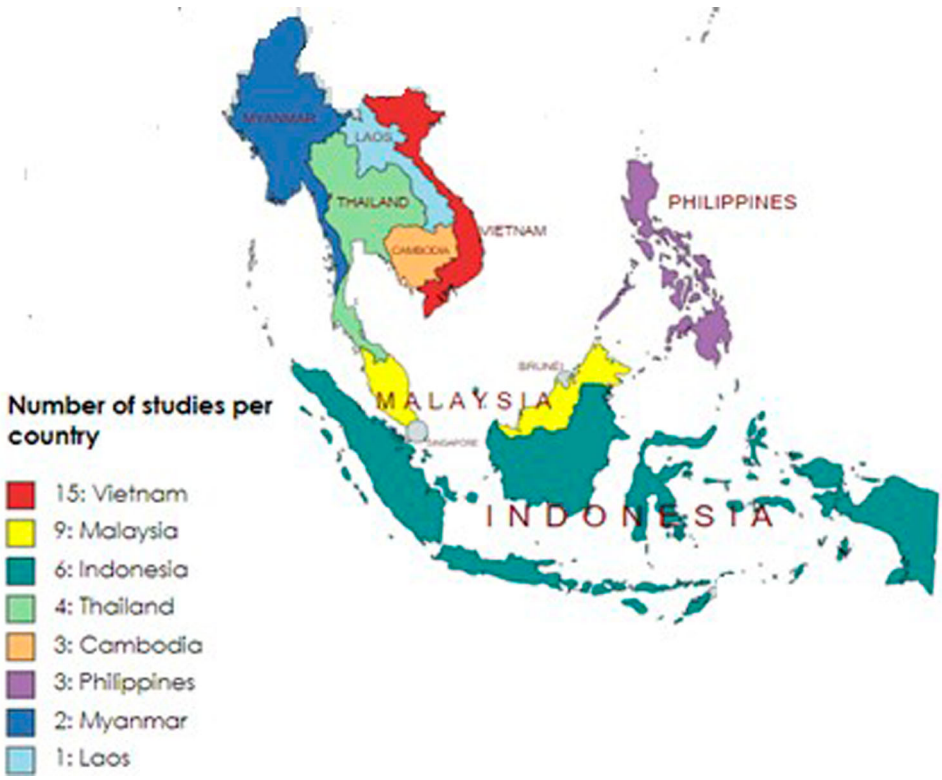

Figure 3. Number of studies included in the scoping review, per country.

& Eddy, 1991). In terms of data and methods, the analytical approach varies, with primary data, or primary data complemented with secondary data and/or a literature review being the most often used datasets, i.e. present in almost 70% of the studies. Exclusively secondary data, or data complemented by a literature review, are used in 20% of the studies. A total of 60% of the studies used quantitative methods, and 40% used mixed or qualitative methods.

3.2. Policy recommendations and corresponding CRC dimensions

The policy recommendations identified from the review are organized into eight CRA policy type categories, and then by each of the four CRC dimension. We show that among policy types, *communication and knowledge sharing* is the most represented, appearing in 36% of the identified policy categories. *Research and technology development* and *risk management* are the second- and third-most common CRA policy categories, identified in 29% and 11% of cases, respectively. The remaining policy categories relate to *environmental or climate support*, at 9%; *investment support*, at 8%; infrastructural support, at 5%; and *agricultural production support* and *land use/market regulation and certification*, at 1% (data are provided in Table S1 in Supplementary Material). Examples of policy support related to the policy categories identified with the scoping review are given in Table 2.

Similarly, previous reviewed studies on the determinants of CRA adoption in low- and middle-income countries mainly recommended interventions pertaining to education, extension services, and outreach to support CRA adoption, which fall into the *communication and knowledge sharing* and *research and technology development* categories (Acevedo et al., 2020). As expected in our scoping review, research that identifies factors influencing adaptation responses to CRA is the most common (cf. study focus in Table S2 in Supplementary Material).

This review shows that representation across the four CRC dimensions is unbalanced. Adaptability and transformability are the most often targeted, at 43% and 35% respectively. Few studies consider policy recommendations targeting anticipation and robustness, which were present in 12% and 10% of identified policies, respectively. Figures 4 and 5 provide an overview for the cases assigned to a specific policy category, and the corresponding CRC dimensions based on our analysis (data available in Table S1 in Supplementary Material).

Our results might indicate the perceived importance of adaptability and transformability in responding to climate change in the ASEAN. These two dimensions above might be perceived as important not only by researchers but also by the stakeholders involved in existing research or research activities, like surveys, interviews, or participatory workshops. These findings may signal that researchers do not see the most 'globally'

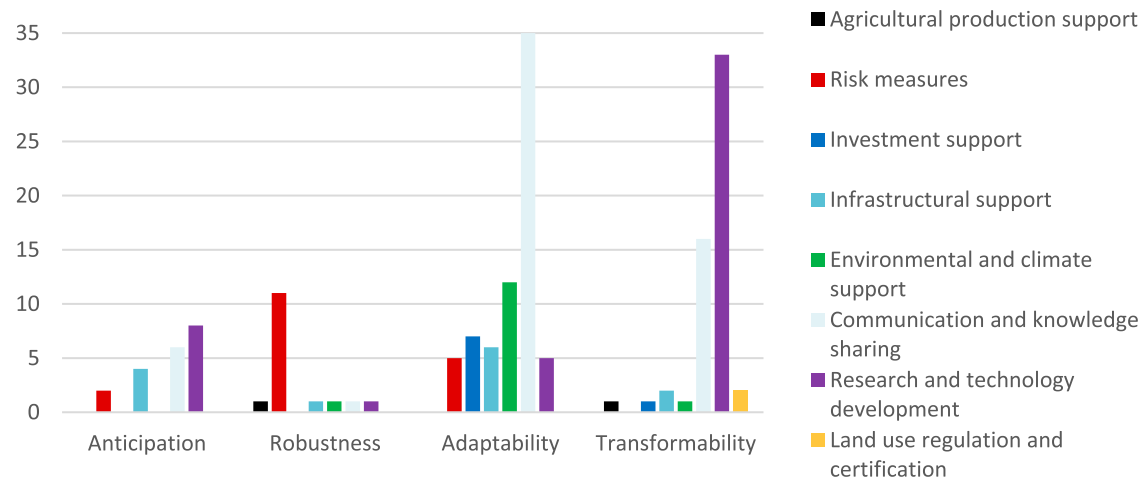

Figure 4. CRA policy categories and corresponding CRC dimensions of anticipation, robustness, adaptability, and transformability.

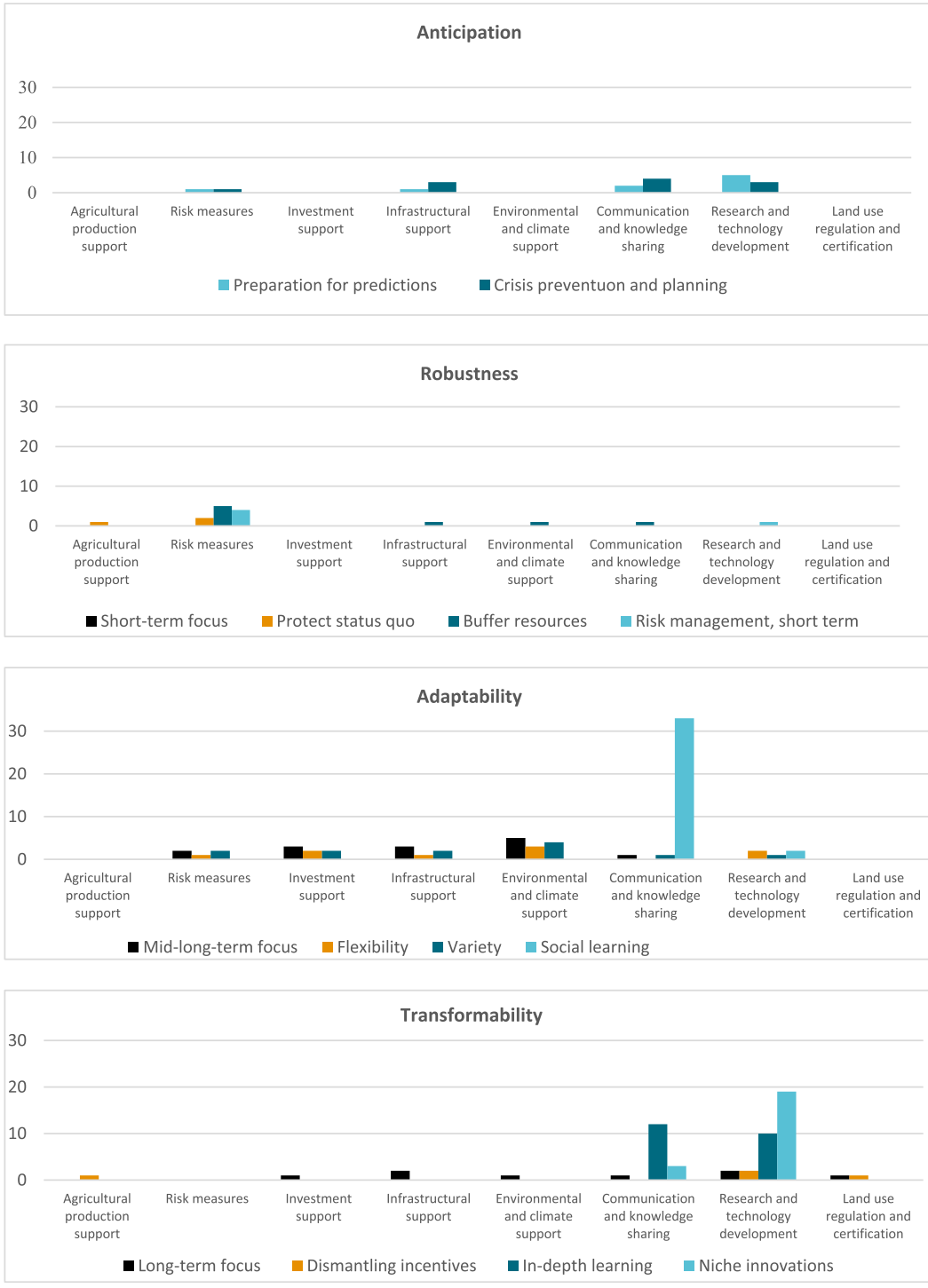

Figure 5. CRA policy categories and their respective CRC dimensions of anticipation, robustness, adaptability, and transformability.

common practice of maintaining the status quo as appropriate for building CRC (Berrang-Ford et al., 2021), preferring instead a focus on adaptation and transformative change – driving adaptability and transformability.

According to Folke et al. (2010), promoting policies that enable robustness while neglecting the remaining CRC dimensions tends to protect the status quo, and hinders the sector from undertaking adaptive and transformative changes, and developing along the required trajectory. On the other hand, the absence of policy recommendations enabling robustness might increase the vulnerability of ASEAN agriculture to sudden shocks (Darnhofer, 2014). In the systematic review by Fedele et al. (2019), responses made via incremental adaptation have been seen as key to addressing climate change challenges. Main constraints are the lack of human capital and familiarity with transformative adaptation, the need for high financial investments, the lack of institutional interventions, and the length of time needed for the benefits to take place, followed by a high degree of uncertainty and risk. In our findings, policy recommendations enabling adaptability and transformability of CRA in ASEAN are focused on *communication and knowledge sharing*. To enable transformability of CRA, strong emphasis has been placed on policies supporting *research and technology development*. Other policies supporting investment are underrepresented, e.g. investments in productive and non-productive infrastructure.

Furthermore, apart from responsive policies enhancing adaptability and transformability, proactive initiatives enabling anticipation are needed to address future problems and climate change (Islam & Kieu, 2020). According to DeLeo (2017), any governmental response to climate change challenges is anticipatory by definition. However, historically, researchers have shown low research interest in studying anticipation in climate change policies (Buitenhuis et al., 2020; Manevska-Tasevska et al., 2021; Travis et al., 2018). Raghavan et al. (2019) show that lack of data availability is one of the key constraints to conducting CR-related research in ASEAN in general. In our framework, data availability is the main feature of anticipation. Appropriate knowledge, capital, and communication channels is needed to measure and register applicable data in order to provide accurate climate predictions and develop forecasting models which can communicate the climate projections necessary for long-term planning.

Communication and knowledge sharing mainly targets adaptability – especially social learning – and transformability via in-depth learning (Figures 4 and 5). Our results regarding social learning – i.e. characteristics of the adaptability dimension – implies that supporting *communication and knowledge sharing* should enable cooperative efforts and dissemination of knowledge and information among all relevant stakeholders. Relevant stakeholders include policy makers and authorities who are involved in planning and implementing CR actions (Enriquez et al., 2021). It also implies enabling an environment for farmers' self-organization, collaborative learning, information sharing, agricultural training, and skills development (Brown et al., 2018; Dang et al., 2013; Hein et al., 2019; Hoan et al., 2019; Renaud et al., 2015; Rondhi et al., 2019; Thoai et al., 2018; Tran et al., 2019). *Communication and knowledge sharing* that enables transformative in-depth learning considers the support for participatory approaches in discussing appropriate solutions. Some examples of support suggested by the studies included in our review include: (i) establishing field/climate schools for farmers (Bosma et al., 2012; Masud et al., 2015); (ii) learning networks to turn learner farmers into innovative practitioners (Tran et al., 2019); (iii) demonstrations of complex climate projection methods to users (Daron et al., 2018); (iv) national and local climate science–policy dialogue (Jacobson et al., 2018); and (v) connecting stakeholders with conflicting interests so they can learn from each other and build partnerships (Dumrongrojwatthana et al., 2020). In some studies, support for *communication and knowledge sharing* is considered to be an instrument for anticipation in terms of crisis prediction (Figure 5) (Daron et al., 2018; Masud et al., 2015). From the conducted scoping review, an overall understanding is that *communication and knowledge sharing* raises awareness and knowledge of the impact of climate change on the agricultural sector (Akhtar et al., 2019; Bosma et al., 2012; Hoan et al., 2019).

Research and technology development support is the most commonly suggested dimension when it comes to enabling transformability, especially aimed at accelerating niche innovations and experimentation, and at strengthening the linkages among research, policy making, and practice via in-depth learning (Figures 4 and 5). Some articles emphasize the need for research and technology developments to enable anticipation – especially prediction, namely the development of technology and methods to provide accurate climate forecasting models and measures (Kiguchi et al., 2021; Lansigan et al., 2000; Masud et al., 2017). As mentioned previously, a single policy category might relate to multiple CRC characteristics. With respect to *research and technology development*, in-depth learning is often complementary (Van Huynh et al., 2020; Wassmann et al., 2009). Furthermore, our findings show that both research &

technology development and in-depth learning benefit from connecting science, policy, and practice for the generation of knowledge, development, and the adoption of adaptation plans (Dany et al., 2016; Van Huynh et al., 2020; Wassmann et al., 2009). Hence, policy actions supporting *research and technology development* call for encouraging transdisciplinary science.

The evidence from this scoping review shows that *risk management* mainly targets robustness, especially by reducing sectoral sensitivity to resources, i.e. through buffer resources and short-term risk prevention measures (see Figures 4 and 5). Buffer resources are attained via public interventions, offering: (i) insurance to deliver human and asset safety (Dang et al., 2013); (ii) loans for coping with adverse events such as floods (Wassmann et al., 2009); or (iii) loans to low-income families to buffer modest incomes under the adaptation process (Vo et al., 2021). Financial support for insurance appears to be the most typical instrument of short-term risk management (Dang et al., 2013; Dewi et al., 2018; Jabin et al., 2015). Regional food reserves have been documented as a safeguard mechanism to tackle the after-effects of major production failures (Islam & Kieu, 2021). Last but not least, environmental and/or climate-related financial support mainly targets adaptability, helping to cover adaptation costs, as a mid-long-term policy (Ahmed et al., 2016; Enriquez et al., 2021; Masud et al., 2015), for example, to support diversification of monocultures with other crops or shade trees to allow variety, and thus improve the resilience of the monocultures to the impacts of climate change (Pham et al., 2020).

Policy recommendations identified in this review typically connect multiple CRA policy categories. Furthermore, a single CRA policy category can target multiple CRC characteristics (see examples in Textbox S2 in Supplementary Material). Yet, in most cases, policy recommendations are limited to two to three policy categories. Both *risk management* and *environmental/climate support* are regularly suggested, along with *communication and knowledge sharing* and/or *research and technology development*. For instance, Jabin et al. (2015) recommended provision of public financial support for insurance at the beginning of the implementation stage of newly-developed technologies for precision agriculture – facilitating robustness. The authors also emphasized the need for increased investment in technological developments. Precision agriculture technology was proposed as an alternative to transform traditional agriculture through proper resource utilization and management practices – so enabling transformability. Last but not least, support of *communication and knowledge sharing* is needed for gradual provision of proper education and information to increase transformability through the raising of awareness of local stakeholders to contribute to adaptabililty or adaptive management, mainly in the mid-to-long term. Interventions recommended by Vo et al. (2021) are a combination of *risk management* and *communication and knowledge sharing* categories. The former takes the form of short-term support in terms of preferential loans to low-income families to buffer resources – so driving robustness – while the latter involves adaptability through guidance for social learning.

3.3. Limitations

This study has limitations in the analytical approach and the applicability of the results. Particularly, this study applied a scoping review, which does not aim to produce a critical assessment of the feasibility of CRA policies in ASEAN. As such, the question of policy feasibility, which is important for ASEAN, remains unanswered. Rather, this study provides an overview of the policy recommendations considered in existing research published in English. Given that limitation, there might be differences between the actual policies applied on the ground, and research policy topics (climate change issues) on which researchers and stakeholders are focused. Moreover, since this review does not cover policy documents and grey literature published in local languages, our findings cannot refer to all possible existing policies supporting CRA and CRC in ASEAN. This also means that we are unable to draw a complete picture of research-based policy recommendations for CRA in ASEAN.

With regard to the applicability of the research results, it is worth mentioning that there is a difference among the ASEAN member states regarding the level of connection between the research and the policy making (Dany et al., 2016, 2017; Fujisawa & Kanamaru, 2019). Also, in terms of building joint programmes for anticipating, coping with, and responding to climate change, ASEAN's consensus on respecting the national sovereignty of its member countries will inevitably limit what can be done through coordination and collaboration (Islam & Kieu, 2020).

4. Conclusions

This study explores research on climate resilient agriculture (CRA) policy and policy recommendations in ASEAN. It classifies policy recommendations from 47 reviewed studies (published in the English language) into eight different CRA policy categories. It then investigates how these policies in the literature reinforce the capacity for climate resilient agriculture (CRC) identifying four different dimensions or characteristics of CRC: anticipation, robustness, adaptability and transformability.

Articles included in this systematic review differ in terms of agricultural production systems covered, geographical location, the territorial level of assessment, and the methodological approach. The evidence shows unbalanced representation of studies across (i) the ASEAN member states, with Vietnam and Malaysia being the most-often represented and (ii) the type of agricultural production system. On the latter, rice production, and rice combined with other crop production, are among the most studied, with limited attention to livestock systems. Research on climate change adaptation for other important agricultural production systems in ASEAN countries, such as livestock, is needed to fill this gap. Since climate change affects all ASEAN countries, related research is also encouraged in other countries not yet covered (e.g. Brunei and Singapore) in the literature.

Also, we found that policies for enhancing adaptation (mostly via social learning) and transformative change (e.g. via in-depth learning and research and technology development) are those most often recommended in the reviewed literature as solutions to build CRC of adaptability and transformability, and thereby CRA. The literature places special emphasis on policies that support communication and knowledge sharing and research and technology development. Policy recommendations identified in the literature emphasize that policies supporting communication and knowledge sharing are needed to increase awareness and knowledge of climate change impact on the agricultural sector (e.g. by establishing field/climate schools for farmers, or demonstrating complex climate projection methods to users); and to enable cooperation and share knowledge and information among all relevant stakeholders. Policy recommendations for research and technology development include accelerating niche innovations and experimentation; developing technology and methods for climate forecasting models and measures; and encouraging transdisciplinary research. The focus in the literature on building capacity for communication and knowledge sharing and for research and technology development, is in line with previous review studies on the determinants of CRA adoption in the low- and middle-income countries (Acevedo et al., 2020). Future research is needed to provide in-depth analysis and further insights into these categories of capacity-building activities and their interactions with policy to provide an even sounder base for CRA policy making.

There is insufficient evidence of other specific policies enabling CRA. These include policies such as risk management; environmental and/or climate support; infrastructure and investment support; agricultural production support; and land/market regulation and certification. Furthermore, our findings highlight the need for more policy-related research, beyond the dimensions of adaptability and transformability but also the functions of anticipation and robustness. Policies enabling anticipation, for example, are expected to be crucial in supporting long-term risk management by developing systems for monitoring, measuring, and registering climate data, and forecasting models, but also for communicating understanding about the past and possible futures to society at large. These knowledge and research gaps suggest a need to raise awareness about the importance of policies enabling anticipation and prediction capacity, and preparations for crisis prevention and planning.

Last but not least, there is no research evidence on the potential of existing ASEAN policies to enable the CRC needed for CRA. Further research on the relationship between actual farming practices and implemented CRA policies is also needed. This could include reviews of national policy documents and of experience in a wider range of countries/regions – also outside of ASEAN – to help identify lessons learnt for countries to strengthen CRA policies.

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