A no-regrets framework for sustainable individual and collective flood preparedness under uncertainty

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Review

A No-Regrets Framework for Sustainable Individual and Collective Flood Preparedness Under Uncertainty

Joy Ommer [1,2,*], Milan Kalas [1], Jessica Neumann [2], Sophie Blackburn [2] and Hannah L. Cloke [2,3]

[1] KAJO s.r.o., Sladkovicova 228/8, 01401 Bytca, Slovakia
[2] Department of Geography and Environmental Science, University of Reading, Reading RG6 6UR, UK
[3] Department of Meteorology, University of Reading, Reading RG6 6UR, UK
* Correspondence: joy.ommer@kajoservices.com

Abstract

Why should we prepare for a flood which might never happen? Uncertainty around potential future hazards significantly limits citizens' disaster preparedness, as it influences decision-making and action-taking greatly. To bridge this knowledge–action gap, we developed a novel, no-regrets framework for sustainable flood preparedness under uncertainty, building on a systematic literature review (PRISMA method) and an integrative review of preparedness actions. The review of 364 articles revealed that while no-regrets principles are widely applied in climate policy and risk management, they are not tailored to personal preparedness. Our resulting framework defines clear no-regrets criteria for individual and household-level preparedness (robustness, flexibility, cost-effectiveness, co-benefits, and ease of implementation) and categorizes 80+ flood preparedness actions according to four levels of uncertainty, from unknown futures to imminent hazards. Notably, we found that long-term preparedness actions remain underutilized, psychological preparedness is largely absent, and existing guidance is biased toward physical risk reduction in high-income contexts. This framework offers a practical tool for practitioners, local authorities, and community groups to promote actionable, context-sensitive flood preparedness worldwide and can be adapted to other hazards in future work.

Keywords: disaster preparedness; climate change adaptation; sustainable development; disaster risk reduction; psychological preparedness; uncertainty

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1. Introduction

When a flood enters our home, we are trapped in a situation where we have to make quick but effective decisions on last-minute preparations. Effective disaster preparedness relies on people taking informed decisions in advance of a threat [1]. However, in reality, we (as citizens) tend to start preparing when a flood is forecasted and very likely to happen, but not any earlier unless we may have experienced flooding before [2,3]. The dilemma is that long-term preparedness can support us in decision-making and action-taking in emergency cases, but who prepares for a flooding event when it is uncertain whether it happens this year, in 48 years, or when we might actually never be affected by it? Addressing this dilemma, this paper develops a conceptual framework for individual and collective flood preparedness under uncertainty by building on the no-regrets approach.

Uncertainty is a well-known barrier to decision-making and action-taking. In plain language, uncertainty reflects that something is unsure [4]. It often arises from the fact that there is not sufficient information about something [5]. Uncertainty may be related to

where and when a hazard might occur, the frequency and magnitude of its occurrence, its impact, or its cascading hazards [6]. Advances in flood forecasting are aiming to minimise this uncertainty. However, in practice, higher uncertainty remains a barrier for taking preparedness actions in advance, as people are often only starting to prepare when the hazard becomes more certain or is already striking [7–9]. In the context of decision-making, uncertainty is categorised into four levels ranging from low to deep uncertainty [3,10]: (1) clear enough futures (low uncertainty); (2) alternative probable futures; (3) plausible scenarios; and (4) unknown future (also referred to as deep uncertainty).

Looking back to the 1990s, the uncertainty around how climate would be changing challenged mitigation policymaking because it was difficult to know for which future the policies should be designed [11,12]. In response to this, it was manifested that uncertainty shall not be used as an excuse to not take decisions or actions (Rio Declaration 1992 (A/CONF.151/26)). Hence, the no-regrets approach was adopted for decision-making on different pathways for an uncertain future [12]; that is, taking actions that will not be regretted in any future climate scenario [13]. In contrast to other decision-making strategies under uncertainty, such as big bets and options which focus only on a few selected scenarios, no-regrets moves are chosen, as they shall have benefits in any scenario [14].

Since the 1990s, the no-regrets approach has evolved globally into a 'unifying lens' for mitigation and adaptation but also including risk management and vulnerability reduction at various levels (except the citizens level) [13–24]. Only recently, the European Commission recognised the need for no-regrets actions to prepare in advance for unfamiliar risks and impacts of disasters not only at the national but also at the individual level (HORIZON-CL3-2022-DRS-01-02).

Citizens' unpreparedness, as well as the unexpectedness of some hazards (due to uncertainty), often cause stress, resulting in panic, not knowing what to do, or the feeling of being powerless, which can lead to inaction [25,26]. Therefore, longer-term preparedness for a hazard with deep uncertainty is important to be able to cope better with a hazard once it strikes in order to take valuable actions [27]. Yet, flood preparedness is often limited to awareness-raising campaigns or structural measures for damage prevention, such as moving valuable things or installing pumps in the basement. However, in addition to these actions, taking stronger (non-structural) preparedness actions under uncertainty is of high importance. Stronger actions may include, e.g., developing a household emergency plan and testing it, learning how to identify and deal with stress situations, or fostering disaster education for the youth in your community. These actions will not only enhance physical preparedness but also increase psychological preparedness [28,29].

However, not many citizens are keen to take actions for something uncertain, especially if these actions are costly [30]. In addition, it has been highlighted that citizens need to be guided and pointed at potential actions, and therefore, a practical guidance needs to be developed on how to prepare for different (unexpected) hazards [31]. This need in practice shows that current flood preparedness efforts are not sufficient. For instance, the risk perception approaches are primarily focused on understanding the lack of citizens' preparedness but do not move ahead to approach action-taking [25], while another approach focuses on the reduction of vulnerabilities but, again, does not go into concrete actions for individuals [13]. We argue that the no-regrets approach with its criteria (i.e., robustness in different future scenarios, of low or no cost, and entailing benefits) can be a valuable approach to promote long-term preparedness by increasing knowledge and capacities to cope with and recover from hazards by primarily focusing on the action side [27]. Despite the adoption of the no-regrets approach in different research fields (including topics around disasters and climate change), to date, it has not been applied for individual and household preparedness yet.

To fill this gap, this paper will introduce a novel framework to guide citizens' disaster preparedness under uncertainty with no-regrets actions in a sustainable manner. In support of this, this paper will, firstly, review criteria for no-regrets actions based on the existing no-regrets literature and tailor these criteria to citizens. Secondly, following the no-regrets criteria, flood preparedness actions around the world will be reviewed and categorised into the four levels of uncertainty. The framework and list of actions will be designed to assist citizens and citizen groups in taking action under uncertainty. Since the no-regrets strategy is not place-bound, the framework shall be applicable for decision-making worldwide. Considering that the collection of disaster preparedness actions, in general, would go beyond the scope of this paper, the focus will be set on flood preparedness. However, the framework may also be applicable for other hazards.

The following Section 2 will introduce the literature review process that was performed to develop no-regrets criteria for actions and to identify no-regrets actions according to these criteria. The resulting no-regrets criteria will be introduced in Section 3.1, and the no-regrets actions for flood preparedness will be presented in Section 3.2. Section 4 will discuss the framework, and Section 5 will conclude with the insights gained from the review and provide recommendations for future research and practice.

2. Methodology

Two literature reviews were performed to (1) identify criteria that characterise the no-regrets approach and (2) collect flood preparedness actions that fulfil the defined no-regrets criteria. The literature reviews were not limited to a specific research area but rather aimed to grasp a global understanding of the no-regrets approach.

2.1. Systematic Review of No-Regrets Criteria

In a first step, a systematic review of the existing literature thematising the no-regrets approach was performed following the PRISMA method [32] (Figure 1). For the purpose of this paper, the literature was reviewed to gain an overview on different criteria of the no-regrets approach. Considering that the no-regrets approach is adopted across various disciplines such as mathematics, computer sciences, and medicine, this review focused on the adoption of the no-regrets approach in climate and disaster sciences.

For the review, the databases Web of Science and Scopus were searched with the key word 'no-regrets' in combination with either 'climate change' or 'disaster*'. This search could have caused the exclusion of research articles written in other languages than English. Screening each of the two literature databases with these two keyword combinations, 364 research articles were identified (Figure 1). After removing duplicates (n = 51), 313 articles were screened. A total number of 133 articles were excluded due to differing research focusing on unrelated fields such as economics or medicine and not climate/disaster topics. The remaining 180 articles were reviewed for (1) their potential to define no-regrets criteria and also (2) no-regrets actions applicable for citizens.

Reviewing the abstracts and the articles themselves revealed that most articles do not extend the no-regrets criteria but rather cite the authors who initially defined some no-regrets criteria several years ago. Furthermore, the term 'no-regrets' was often used in the abstract but not directly thematised or defined within the article itself. Therefore, another 165 articles were excluded, and 15 articles (out of the 180) were included for the first objective of defining no-regrets criteria. The identified no-regrets criteria are introduced in Section 3.1.

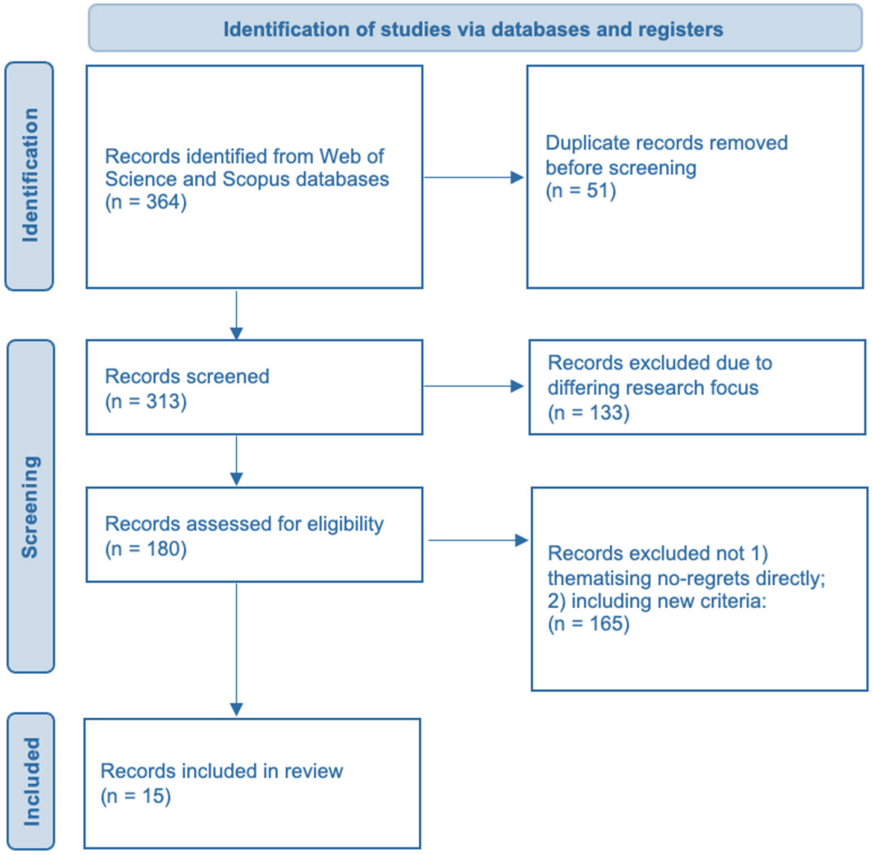

Figure 1. Systematic review of no-regrets criteria (adapted from Page et al. [32]).

2.2. Literature Review of No-Regrets Actions

The above introduced review further underlined the fact that the no-regrets approach is primarily used at international, (sub)national, and local levels, and hence, actions or strategies listed in these articles were not applicable for citizens. Therefore, only 8 articles (of the review described in Section 2.1) could be included for the review of no-regrets actions for citizens.

Because no-regrets flood preparedness actions are not always named 'no-regrets' [33] even though they might fulfil the no-regrets criteria, an additional literature review of actions was performed in support of the results from the systematic review. This second review of preparedness actions was performed in an integrative manner by performing searches in Google Search, Google Scholar, and the databases Web of Science and Scopus with terms such as 'emergency measures', 'adaptation actions', 'adaptation measures', 'adaptation interventions', 'resilient measures', 'robust measures' in combination with one of the keywords 'flood*', 'individual', 'citizen*', or 'collective'. At this point, it needs to be acknowledged that the selection of search criteria could have an impact on the applicability of the action around the world, as they can be named differently in other regions of the world, and therefore, the actions can have a bias towards European preparedness actions. Hence, the identified actions (enlisted in the Appendix A) do not present a holistic list. The review identified different types of literature, including research studies, review papers, reports, and similar, published between 2011 and 2024.

The identified literature was screened, and actions were included that fulfilled the no-regrets criteria as framed in Section 3.1. The selection was performed using the requirements of the framework and expert judgement. In more detail, actions needed to be (1) suitable for individual and/or community level, (2) of no or low costs, (3) robust in different future

scenarios but also adaptable (flexible), (4) easy to implement, and (5) entailing at least one co-benefit.

The review further identified actions that fulfilled most but not all criteria and which could be argued to be non-regrettable or of low regret. These actions can be costly, do not have obvious co-benefits, or are not easy to implement:

- Several actions were found to be of higher economic cost, such as installing flood barriers, creating green roofs, or similar. The fact that they are of high cost should have excluded them. However, in this framework, costs are not considered solely but in combination with their effectiveness. This may often be the case for increasing building resilience or Nature-based Solutions (NbS) (e.g., green roofs). For the first case, these actions may not be regretted because they are very efficient in damage mitigation. Similarly, for NbS, it could be argued that they are costly but more efficient in terms of flood mitigation, and, additionally, they can entail many co-benefits. Hence, costs need to be considered in a cost-effectiveness/benefit framework where benefits can be direct (e.g., flood reduction) or co-benefits (e.g., health benefits).
- Similarly, some actions may not be easy to implement (e.g., because it can be difficult to motivate others for collective action), do not have co-benefits, or are not of a collective character. However, their effectiveness in hazard reduction or damage mitigation could be argued to outweigh the lack of some no-regrets values.

Hence, actions falling into the above-explained categories were integrated into the action list but are referred to as low-regret actions. All identified actions are listed in Appendix A, while Section 3.2 provides a summary of these actions, linking them to different levels of uncertainty.

3. The No-Regrets Framework for Individual and Collective Flood Preparedness Under Uncertainty

This section will outline the no-regrets framework for citizens to support their flood preparedness. The framework, firstly, defines no-regrets criteria based on the literature review (Section 3.1) and, secondly, introduces flood preparedness actions that can be referred to as no-regrets actions and can be taken under various levels of uncertainty (Section 3.2).

3.1. No-Regrets Criteria

The no-regrets approach fosters the acceptance of uncertainty as far as possible and promotes action-taking under uncertainty [15,34]. For instance, having a household emergency plan will improve decision-making in the case of an approaching flood. Moreover, having an emergency plan is likely not to be regretted if flooding never occurs [35]. In fact, no-regrets actions are likely not to be regretted because they shall be (1) robust, in the sense that they are suitable for difference future scenarios and are targeting the reduction of risks [33,36], but, at the same time, they are flexible and can be adjusted [35]; (2) of no or low costs, which can be outweighed by their effectiveness and co-benefits for the environment, society, and economy [37]; and (3) easy to implement with least effort and material [36,38]. For the case that all criteria are fulfilled, the action is classified as a no-regrets action. However, if all but one or two criteria are fulfilled, the action is classified as a low-regrets action. In the following, each of the above-listed no-regrets criteria is introduced in more detail.

3.1.1. Robust but Flexible

Actions should work well in different scenarios under uncertainty (robust) but can also be adjusted when needed (flexible) [38–40]. For instance, emergency plans should work for various flood risks but allow updates when new information becomes available [41]. For

the decision on the most suitable robust action(s), we are evaluating different criteria, e.g., its costs, effectiveness, benefits, or flexibility [42,43].

With the changing climate, it is likely that, e.g., flooding probabilities might vary; therefore, an emergency plan (or other actions) also needs to be flexible. Hence, if flooding probabilities change in the future, the robustness and suitability of actions needs to be reviewed and then perhaps adjusted.

3.1.2. Cost-Effectiveness

No-regrets actions are often promoted for their low cost or lack of cost. In fact, economic costs of actions play a major role in decision-making, as they are well-known to be one of the 'dragons of inaction' [44]. For instance, the willingness-to-pay for flood preparedness measures was evaluated to be around EUR 50 in Germany [30]. However, different no-regrets actions (strategies, options) are not only selected based on their costs but also on their effectiveness or efficiency at reducing flooding or potential damages [36,38]. Therefore, this framework will not exclude actions that are of higher cost (e.g., more than 50 euros) if they are more effective in flood impact reduction than other actions. These actions can be considered as low-regret actions.

3.1.3. (Co-)Benefits

Another commonly acknowledged criterion of no-regrets actions is its potential benefits which should be given in all scenarios. Benefits may be perceived as a reward and, hence, function as an extrinsic motivation [45].

Benefits can be (1) direct benefits (simply referred to as benefits) or (2) co-benefits, which describe positive side effects of an action [46]. For instance, a direct benefit of an NbS such as a green roof is the reduction of flooding because of its water retention ability and a positive side effect (co-benefit) can be the increased biodiversity.

No-regrets actions can have various environmental, social, and economic (co-)benefits: from a broader perspective, no-regrets actions can benefit building resilience and adaptive capacity, reducing vulnerability, sustainable development, environmental protection, or avoided damages [13,16,47]. In more detail, (co-)benefits can be, e.g., informed decision-making, socialising, or financial stability [48]. Moreover, there may be co-benefits linked to policy instruments such as insurance incentives [49]. These (co-)benefits can be effective immediately or a bit delayed, but they shall be long-term [46].

However, (co-)benefits are not always perceived to be highly important by citizens. For instance, NbS are primarily promoted with their co-benefits, but a study found that cost-effectiveness was ranked more important by local citizens than the co-benefits of the solutions [36]. Therefore, this framework includes actions that may not have co-benefits but may be suitable because they are not regrettable due to their cost-effectiveness or because they may be easy to implement.

3.1.4. Easy to Implement

Besides the commonly communicated criteria (robustness/flexibility, costs, and benefits), actions need to be easy to implement to encourage engagement and uptake by citizens [38]. Actions are commonly selected based on, e.g., their benefits or their cost-effectiveness and each in combination with what is easiest to implement. Easy to implement can be understood as an action that does not require specific material, effort, knowledge, or capabilities. Especially, the capabilities to take an action are one major enabler for preparedness behaviour [50].

3.1.5. Collective Action

A final optional addition to the no-regrets criteria is the idea of taking actions together with neighbours, family members, friends, etc. The connectedness of citizens, social norms, and culture can motivate individuals to take collective actions and also increase their self-responsibility [2,51–53]. Moreover, collective actioning can leverage into bottom-up initiatives that can function as a bridge between citizens and local authorities [54,55]. Continuous engagement and collective visioning can, in turn, increase individual action [53,56]. For these reasons, this framework does not only consider individual actions but also encourages collective actions.

3.2. No- and Low-Regrets Actions for Flood Preparedness Under Uncertainty

Based on the criteria defined in Section 3.1, flood preparedness actions were reviewed and selected if they fulfilled the no-regrets criteria. All identified no- and low-regrets flood preparedness actions are enlisted in Appendix A. In accordance with the concept of the no-regrets approach, all selected actions shall support preparedness under uncertainty.

As we have seen, uncertainty can be divided into four levels (ranging from low to deep uncertainty). Hence, moving a step ahead, this framework delves deeper into uncertainty by, firstly, relating the four levels of uncertainty defined by Marchau et al. [3] to flood risk (Figure 2) and, secondly, allocating preparedness actions to these four levels of uncertainty based on the suitability of their uptake in these levels (Appendix A).

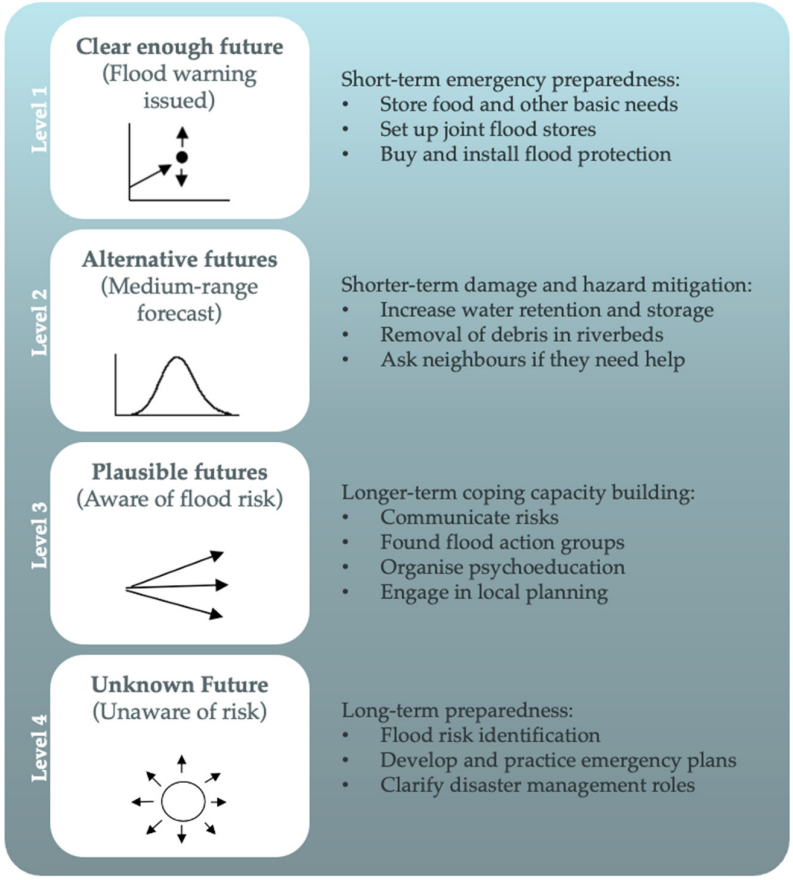

Figure 2. The no-regrets framework for individual and collective flood preparedness under uncertainty: The four levels of the flood preparedness no-regrets strategy under uncertainty (adapted from Marchau et al. [3]). Each level is introduced with the degree of uncertainty, the time dimension towards the hazard (flood), disaster preparedness category, no-regrets action focus, and example actions.

As a result, it was found that when citizens are either unaware (Level 4) or aware (Level 3) of a local flood risk, the focus of flood preparedness actions is on long-term preparedness actions, including raising awareness, gaining knowledge and building coping capacities, reducing vulnerability, and mitigating flooding. When a forecast (Level 2) or warning (Level 1) is being communicated, the focus shifts towards short-term actions to mitigate potential damages and cope with the hazard.

In more detail, the four levels of no-regrets flood preparedness under uncertainty (Figure 2) are as follows:

Level 4 (unknown future—unaware of risk):

- *Uncertainty:* This level is often referred to as deep uncertainty, meaning that it is unknown how the future looks, as there are uncountable different scenarios. This level also includes disasters ranging from more common hazards such as flooding to unknown hazards.
- *Time:* Anytime—not related to a specific event or risk.
- *Disaster preparedness:* Long-term preparedness is needed to focus on gaining knowledge on potential future scenarios and building capabilities to cope with (surprising) emergency situations.
- *No- and low-regrets action focus:* Gaining knowledge on local hazards, risks, disaster management, and early warning; developing emergency response capabilities; connecting with other citizens and communities; increasing awareness, imagination, and action on climate adaptation; observing the weather and environment to develop local thresholds and awareness of changes; enhancing psychological preparedness for emergencies; and considering economic preparedness.

Level 3 (plausible futures—aware of risk):

- *Uncertainty:* In this level, citizens are aware of local risk, but there is a great uncertainty around the timing, magnitude, and impact of a hazard, which can be translated into different scenarios (e.g., flood return periods).
- *Time:* Anytime—after becoming aware of the risk.
- *Disaster preparedness:* Based on these scenarios different long-term preparedness actions can be taken to reduce the risk.
- *No- and low-regrets action focus:* Founding action groups; raising awareness within your community; assessing local disaster risk; reducing disaster risk with NbS; increase collaboration in risk management between the community and local authorities; developing community emergency plans and practices; ensuring individual economic preparedness; psychological preparedness; increasing property resilience; and stocking up of emergency resources.

Level 2 (probable future—medium-range forecast is available):

- *Uncertainty:* The hazard occurrence is probable, but there might be an alternative future. Uncertainty arises due to the timely or spatially manner of the hazard, or to its impact.
- *Time:* Days (or weeks) before a hazard strikes.
- *Disaster preparedness:* As a hazard is becoming likely, a shift too short-term preparedness is initiated.
- *No- and low-regrets action focus:* Preparing the home and garden for potential water intrusion; setting up an evacuation plan and kit; and raising awareness of the probable hazard within the community.

Level 1 (clear enough future—warning is issued):

- *Uncertainty:* Weather forecasts provide a clear (enough) prediction about the approaching hazard; thus, the uncertainty about the hazard is low.

- *Time:* Hours up to few days before the hazard strikes.
- *Disaster preparedness:* Due to the imminent hazard, actions are focused on preparing for response and recovery, as well as reducing damage.
- *No- and low-regrets action focus:* Last preparations such as placing sandbags; installing pumps; switching off gas, etc.; or reparking the car.

4. Discussion

The aim of this review paper was to tailor the no-regrets approach to citizens' flood preparedness under uncertainty in the form of individual or collective action. For this purpose, a framework was developed in Section 3 including, firstly, no-regrets criteria for citizens' actions and, secondly, a list of no-regrets flood preparedness actions that can be taken under uncertainty. The development of the framework highlighted several limitations and considerations around existing flood (as well as disaster) preparedness approaches, while the no-regrets framework emphasises robustness across uncertainty levels. The framework integrates aspects from different preparedness approaches but was found to go beyond these, as it focuses on the motivational side of preparedness. The review itself highlighted different aspects to consider for flood preparedness in general, which are discussed in the context of the framework in the following subsections: long-term preparedness (Section 4.1), context-specific actions (Section 4.2), psychological preparedness (Section 4.3), and the need for integration with behavioural theories (Section 4.4).

4.1. Long-Term Preparedness

The review highlighted that the older literature (i.e., [57]) rather focuses on short-term flood preparedness actions, primarily focusing on damage mitigation. According to the definition of the Sendai Framework terminology [58], disaster preparedness should focus on knowledge and capacity-building and hence, rather be pursued as long-term preparedness to avoid time deficits. More recently, the literature (i.e., [47]) also includes long-term or strong preparedness actions but refers to them as adaptation and mitigation actions [28].

The no-regrets framework aims to combine both short- and long-term preparedness. In fact, most of the identified actions of this framework can be taken today, even when the occurrence of hazards is deeply uncertain (unknown future). These long-term actions can be implemented once and then persist (in contrast to single-use actions (e.g., reparking the car before a flood)). Furthermore, they are robust for different scenarios but also flexible; thus, they can (or must) be adjusted in the future. For instance, the flood risk maps in Europe (developed in line with the EU Floods Directive 2007/60/EC) are updated every few years; hence, the understanding of flood risk areas needs to be adapted with these updates or personal experiences.

4.2. Contextual Transferability

As indicated in the methods section, the list of actions is rather biased towards developed countries. This bias arose primarily due to the lack of a globally harmonised terminology on flood preparedness actions. Hence, future work needs to focus on identifying more actions from other regions around the world, for instance, by working with local experts or studying traditional methods.

Yet, the actions that could be identified from various areas around the world (enlisted in Appendix A) highlighted that actions can differ depending on the geographical, cultural but also individual context [59]. For instance, this study showed that, in India, citizens are keeping ropes to build boats from banana leaves for evacuating flooded areas. This type of action may not be considered as suitable or even feasible in other countries such as

Germany. Another example is flood insurance mechanisms [49,60], which are largely in place in Europe but may not be available or publicly accessible in some countries in Africa or Asia. Moreover, even low-cost measures may be inaccessible in low-income contexts, raising equity and justice concerns that must be integrated into future facilitation strategies.

In this regard, the list of actions in Appendix A is not complete, and neither are all actions applicable for all people around the world. It must also be acknowledged that people may regret different decisions and actions; thus, some actions may be regretted by some people while others may not [16,39]. Summarising the above, actions need to be selected based on the geographical and cultural characteristics but also the hazard's evolution and its potential cascading impacts, as well as individuals' socio-economic situation. In this sense, we argue that the actions enlisted in Appendix A can function as an inspiration, but actions need to be selected and adapted emphasising the local context while considering the no-regrets criteria. From a community perspective, it is important to decide on actions together to also enhance the feeling of responsibility and ownership of these actions [61]. Hence, approaches such as participatory risk mapping and adaptation planning should be implemented to decide on actions and their implementation.

4.3. Psychological Preparedness

The majority of the identified actions target the physical preparedness of citizens by focusing on reducing damages. While physical preparedness actions dominate the literature, psychological preparedness can yield similar co-benefits with lower material cost. The review identified only a few psychological preparedness actions, e.g., on how to deal with emotions, especially stress, in emergency situations. The behaviour in emergency situations likely varies from the 'usual' behaviour, and therefore, it is important for citizens to understand how they can act in and cope with these situations [62,63].

An example for a psychological preparedness action is the AIM method [64] which includes the following three steps: (1) anticipating our psychological reactions by preparing ourselves emotionally that a hazard might be happening and that it might be stressful; (2) identifying the feelings (e.g., racing heart, shortness of breath) and thoughts (e.g., I cannot do anything) that we might have in a stress situation; (3) managing how we will acknowledge that we are stressed and how to respond.

In addition, it can be important to discuss emotional barriers such as denial and fatalism or cognitive barriers (e.g., wishful thinking) and how to realise these and overcome them. Yet, the identified actions do not include these and other aspects. Therefore, it is important to expand research on psychological disaster preparedness and integrate actions from other disciplines into existing preparedness frameworks, like the approach of this no-regrets framework.

The no-regrets framework further supports psychological preparedness indirectly, as actions should be easy to implement and implemented in advance, and hence, it can reduce stress during emergency situations. For instance, having prepared an emergency plan and practiced it sets people in a situation of knowing what to do. Furthermore, some co-benefits like peace of mind indirectly support the psychological preparedness.

Moreover, mental health impacts from experiencing disasters are increasingly recognised. For instance, flooding can cause distress, anxiety, or even depression [65]. Hence, it is important to anticipate post-disaster mental health impacts in the preparedness stage [66]. However, this is also not yet addressed in identified actions.

Overall, it needs to be acknowledged that even if psychological preparedness actions are taken, issues or limitations can appear in hazard situations when the practice needs to be taken into action.

4.4. Towards Behaviour Change

The shift from reactive to proactive behaviour does not only include action-taking but also implies a behaviour change [67]. According to the COM-B theory on behavioural change [68], it takes capabilities, opportunities, and, lastly, motivation to change. In this framework, no-regrets actions shall be easy to implement. Not having this criterion would mean that, perhaps, many people would not be capable of taking these actions, which would directly limit the likelihood of change.

To some extent, the no-regrets criteria address the components of behavioural change (Table 1): (1) actions need to be easy to implement and of no/low cost; thus, citizens are capable of implementing them; (2) actions being robust but flexible offers the opportunity to implement the actions at any stage; and (3) motivation to implement actions can be triggered through the co-benefits, which can be perceived as rewarding, while collective action may intrinsically enhance individuals' motivation and self-responsibility [69].

Table 1. No-regrets criteria addressing behaviour change, as exemplified by the COM-B method.

COM-B Components	No-Regrets Criteria
Capability	• Easy to implement • No/low costs
Opportunity	• Robust and flexible
Motivation	• (Co-)benefits • Collective action

Yet, this paper acknowledges that it is not enough to build this framework and list possible actions. The next (and probably most important) step—in practice—is to facilitate their uptake by creating opportunities with specific guidance [31]. The uptake of no-regrets actions needs to be facilitated, for instance, through gamified tools, policy instruments, community actions, or similar. This facilitation needs to focus on creating opportunities and increasing motivation. Finally, it shall be acknowledged that behavioural change can be stressful for people; thus, it needs to be further considered to improve psychological resilience at the same time [70].

5. Conclusions

This review article presents a novel framework for citizens' flood preparedness under uncertainty with no regrets. Based on a systematic review (PRISMA 2020), the framework defines five criteria for no-regrets actions: robustness, flexibility, cost-effectiveness, co-benefits, and ease of implementation. In addition, the framework builds on existing theories on decision-making under uncertainty and, hence, discusses four levels of uncertainty, ranging from flood warnings to a completely unknown future. Along with the framework, a list of preparedness actions was identified that fall into the outlined criteria.

The review of the literature revealed the following four key findings: (1) no-regrets actions are rarely explicitly labelled as such in existing research, even though many current preparedness actions meet the no-regrets criteria; (2) long-term preparedness, especially psychological preparedness, remains largely overlooked in current practice; (3) existing guidance is strongly biased towards European countries and physically focused actions with limited incorporation of cultural and contextual factors; and (4) citizens require practical action-oriented guidance to overcome uncertainty-related barriers and challenges in behavioural change for their preparedness under uncertainty.

Overall, this paper advances disaster risk reduction research by operationalising the no-regrets approach for citizen-level preparedness but also by further integrating behavioural

and psychological dimensions. Hence, the framework offers a practical tool for practitioners, local authorities, and communities to promote sustainable context-sensitive flood preparedness. Moreover, it can be adapted for other hazards (e.g., heatwaves, droughts) supporting a broader resilience-building in the face of uncertainty.

The main limitation of this framework is the lacking practical implementation. Therefore, future work should focus on testing and validating the framework in diverse cultural and geographic contexts. In addition, it is necessary to develop facilitation tools to support the uptake, consider weighting or other multi-criteria decision-making strategies for action selection, and further integrate psychological and collective preparedness dimensions.

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Appendix A Long and Short-Term Preparedness Actions

This appendix lists all preparedness actions identified from the literature review.

Table A1. Table on preparedness actions. This table summarizes all preparedness actions identified within the literature review. The actions are presented in line with the earlier introduced no-regrets framework. It relates the actions to (1) the four levels of uncertainty and preparedness timing (Unknown Future = anytime (unaware of risk); Plausible Future scenarios = anytime (aware of local risk); Probable Alternatives = forecast indicating probable threat; and Clear (enough) Future = hazard warning issued) grey-highlighted fields mean that this action can be applied in this preparedness time; (2) individual (I; including individual or household preparedness) and collective (C; referring to community preparedness) action; (3) robust (R) and flexible (F) actions; (4) cost-effectiveness of the action; (5) potential benefits of the action; (6) implementation level (E = easy to implement; M = moderate; D = difficult); (7) the expected regret level of the action if no hazard occurs; and (8) references where this action was described.

Action	Unknown Future	Plausible Future	Probable Alternative	Clear Future	Individual (I)/Collective (C)	Robust (R)/Flexible (F)	Cost-Effective	Benefits	Likely Co-Benefits	Easy to Implement	Probable Regret Level	References
Familiarise yourself with local risk areas—is your home in a risk area?					I, C	R, F	Cost: no	Awareness and knowledge	Co-benefits: motivation for flood preparedness; disbenefit: potential anxiety	E	No regret	[27]
Future visioning and hazard imagination workshop					C	R, F	Cost: no	Awareness and knowledge	Co-benefits: enhanced self-efficacy, collective agency, challenge anticipation, long-term vision; disbenefit: potential anxiety	E-M	No regret	[71,72]
Developing a household and/or neighbourhood emergency plan					I, C	R, F	Cost: no	Coping capacity	Peace of mind	E	No regret	[27]
Evacuation (when to evacuate; where to go; which route to take; where to find shelters)					I, C	R, F	Cost: no	Coping capacity	Peace of mind	E	No regret	[16,59,73]
Practice household emergency plan					I, C	R, F	Cost: no	Coping capacity	Peace of mind	E	No regret	[27]

Table A1. *Cont.*

Action	Unknown Future	Plausible Future	Probable Alternative	Clear Future	Individual (I)/Collective (C)	Robust (R)/Flexible (F)	Cost-Effective	Benefits	Likely Co-Benefits	Easy to Implement	Probable Regret Level	References
Learn how the local or national early warning systems works; co-develop a system if it is not available at the community level	■	■	■	■	I, C	R, F	Cost: no	Awareness and knowledge; coping capacity	Peace of mind	E-M	No/low regret	[74]
Learn about and clarify roles and responsibilities in disaster context	■	■	■	■	I, C	R, F	Cost: no	Awareness and knowledge	Self-responsibility; empowerment; social cohesion	E-M	No regret	[75]
Be attentive to weather warnings and updates	■	■	■	■	I	R, F	Cost: no	Awareness and knowledge	Gaining an understanding of local weather patterns and thresholds	E	No regret	[76]
Lobby against urban developments that will increase runoff onto one's property	■	■	■		I, C	R, F	Cost: no–low	Awareness and knowledge; flood mitigation	Raising awareness within the community and authorities	M	No/low regret	[77]
Communicate interventions within community including vulnerable neighbours; make sure information is understandable by as many people as possible by including indigenous community members	■	■	■	■	I, C	R, F	Cost: no	Awareness and knowledge	Peace of mind; anticipation guilt of not having helped; increased self-responsibility	E	No regret	[59,78]
Start a conversation about how an emergency might affect your local community	■	■	■		C	R, F	Cost: no	Awareness and knowledge	Peace of mind; increasing social capital	E	No regret	[63]

Table A1. *Cont.*

Action	Unknown Future	Plausible Future	Probable Alternative	Clear Future	Individual (I)/Collective (C)	Robust (R)/Flexible (F)	Cost-Effective	Benefits	Likely Co-Benefits	Easy to Implement	Probable Regret Level	References
Identify climate champions in your community	■	■			C	R, F	Cost: no–low	Awareness and knowledge	Motivation for action-taking	E	No regret	[79]
Establish climate schools (e.g., for farmers, young generation)	■	■			I, C	R, F	Cost: no–medium	Awareness and knowledge	Motivation for action-taking; self-responsibility; empowerment	E-M	No/low regret	[80]
Develop a climate youth club	■	■			I, C	R, F	Cost: no–low	Awareness and knowledge	Motivation for action-taking; self-responsibility; empowerment	E-M	No/low regret	[73]
Restore wetlands	■	■			C	R, F	Cost: low–high Efficacy: medium–high	Flood mitigation	Increasing biodiversity; community cohesion; re-creational area	M-D	Low regret	[47,81]
Increase local water retention capacity by planting trees and local species	■	■			C	R, F	Cost: low–high Efficacy: medium–high	Flood mitigation	Peace of mind; increasing biodiversity; community cohesion/well-being	M-D	Low regret	[82–84]
Increase local water storage capacity with, e.g., detention and retention ponds, rechannelling streams, etc.	■	■			C	R, F	Cost: low–high Efficacy: medium–high	Flood mitigation	Peace of mind; increasing biodiversity; community cohesion/well-being	M-D	Low regret	[47,82–84]
Removal of debris, litter, foliage, or similar from river sides; dredging riverbed	■	■	■		I, C	R, F	Cost: no–low	Flood mitigation	Peace of mind; social cohesion; well-being	E-M	No/low regret	[59,76,84,85]

Table A1. *Cont.*

Action	Unknown Future	Plausible Future	Probable Alternative	Clear Future	Individual (I)/Collective (C)	Robust (R)/Flexible (F)	Cost-Effective	Benefits	Likely Co-Benefits	Easy to Implement	Probable Regret Level	References
Start monitoring rainfall amounts, water depths, etc. with low-cost sensors, and establish your own local thresholds	■	■	■		I, C	R, F	Cost: no–low	Awareness and knowledge	Peace of mind; gaining an understanding of local weather patterns and thresholds	E	No/low regret	[27,86]
Create monitoring networks	■	■			C	R, F	Cost: no–low	Awareness and knowledge	Social connectedness; common understanding of local weather patterns and thresholds	M	Low regret	[47]
Observe the environment for changes	■	■	■	■	I, C	R, F	Cost: no	Awareness and knowledge	Gaining an understanding of local changes	E	No regret	[73]
Organise psychoeducation for community members on stress reactions and coping to reduce distress and promote adaptive functioning	■	■	■		I, C	R, F	Cost: no–medium	Coping capacity	Peace of mind; better understanding of one's own behaviour and emotions	E	No regret	[78]
Create a self-care plan in advance of a disaster or emergency. Anticipating, monitoring and understanding your own and your loved ones' reactions will really help during an emergency	■	■	■		I	R, F	Cost: no	Coping capacity	Peace of mind; increasing psychological strengths	E	No regret	[63]

Table A1. *Cont.*

Action	Unknown Future	Plausible Future	Probable Alternative	Clear Future	Individual (I)/Collective (C)	Robust (R)/Flexible (F)	Cost-Effective	Benefits	Likely Co-Benefits	Easy to Implement	Probable Regret Level	References
What are the things in your life that cannot be replaced, and that have great meaning for you or your loved ones? Think about ways you can protect these things in an emergency	■	■	■		I	R, F	Cost: no	Coping capacity	Peace of mind	E	No regret	[63]
Diversify household incomes	■	■			I, C	R, F	Cost: no–high Efficacy: medium-high	Reducing economic vulnerability	Peace of mind	M-D	Low regret	[59,83,87]
Learn about government schemes (e.g., for agriculture and farming practices)	■	■	■		I	R, F	Cost: no	Reducing economic vulnerability; flood mitigation	Learning/adopting new practices; reduced costs; increased revenue	E	No regret	[59]
Adopt flood resistant/climate resilient agricultural practices	■	■			I	R, F	Cost: no–high Efficacy: low–high	Reducing economic vulnerability	Peace of mind; knowledge of new practices	E-D	Low regret	[59]
Preparing for power outages by developing an off-grid energy supply, having battery back-ups	■	■	■		I, C	R, F	Cost: no–medium	Coping capacity	Peace of mind	E	No/low regret	[59]
Store food and other items of basic need in a safer place; increase stilted food storages		■	■	■	I	R, F	Cost: no–low	Coping capacity	Peace of mind	E	No/low regret	[59]
Keep drains clear		■	■	■	I	R, F	Cost: no Efficacy: low–medium	Flood mitigation; damage mitigation	Peace of mind; physical exercise	E	No regret	[88]

Table A1. *Cont.*

Action	Unknown Future	Plausible Future	Probable Alternative	Clear Future	Individual (I)/Collective (C)	Robust (R)/Flexible (F)	Cost-Effective	Benefits	Likely Co-Benefits	Easy to Implement	Probable Regret Level	References
Increasing property water retention capacity (e.g., remove paving in the garden; plant local species; green roofs; rain gardens; tree planting and protection; bioretention cells; vegetated swales)		■	■		I	R, F	Cost: low–high Efficacy: low–high	Flood mitigation	Aesthetics; promoting biodiversity; improving air quality	E-M	Low regret	[34,59,82,89,90]
Increasing property water storage capacity (e.g., tanks, retention pond) and harvest rainwater		■	■		I	R, F	Cost: low–high Efficacy: low–high	Flood mitigation	Water storage for watering plants during dry periods; biodiversity	M-D	Low regret	[16,90]
Act as a flood warden		■			I	R, F	Cost: no	Awareness and knowledge; coping capacity	Increasing self-responsibility; empowerment; improving communication between citizens and authorities	M-D	No/low regret	[76]
Join or found a flood action group		■	■		I, C	R, F	Cost: no	Awareness and knowledge; coping capacity	Increasing self-responsibility; empowerment; improving communication between citizens and authorities	E	No regret	[76]
Develop hazard and vulnerability maps based on local knowledge; extend already existing hazard maps with local knowledge		■	■		C	R, F	Cost: no–low	Awareness and knowledge; coping capacity	Increasing social capital and social cohesion	E-M	No/low regret	[47]

Table A1. *Cont.*

Action	Unknown Future	Plausible Future	Probable Alternative	Clear Future	Individual (I)/Collective (C)	Robust (R)/Flexible (F)	Cost-Effective	Benefits	Likely Co-Benefits	Easy to Implement	Probable Regret Level	References
Engage in the planning and implementation of local strategies and actions for flood mitigation		■			I, C	R, F	Cost: no	Awareness and knowledge; flood mitigation	Peace of mind; anticipation guilt of not having helped; increasing self-responsibility	E-M	No/low regret	[59,73,76,91,92]
Be politically active to guide the community towards flood preparedness		■	■		I, C	R, F	Cost: no	Awareness and knowledge; coping capacity	Peace of mind; increasing self-responsibility; empowerment	E-M	No/low regret	[76]
Create a joined neighbourhood flood network; mutual help associations		■	■		C	R, F	Cost: no	Awareness and knowledge; coping capacity	Peace of mind; increasing social capital and cohesion	E	No regret	[57,83]
Develop a community emergency plan including evacuation meeting points		■	■		C	R, F	Cost: no	Awareness and knowledge; coping capacity	Peace of mind; increasing social capital and cohesion	E	No regret	[91,93]
Set up joint flood stores with tools and materials for emergency cases		■	■	■	C	R, F	Cost: no–medium	Coping capacity	Peace of mind	E-M	No/low regret	[76]
Conduct joint flood drills with neighbours		■	■		C	R, F	Cost: no	Awareness and knowledge; coping capacity	Peace of mind; increasing social capital and cohesion	E	No regret	[76]
Educate younger generations on traditional flood protection methods		■	■	■	I, C	R, F	Cost: no–low	Awareness and knowledge; coping capacity	Peace of mind; preservation of traditions	E-M	No/low regret	[94]
Move to a no-risk area		■			I	R	Cost: high Efficacy: high	Reducing economic vulnerability	Peace of mind	D	Low regret	[76,95]

Table A1. *Cont.*

Action	Unknown Future	Plausible Future	Probable Alternative	Clear Future	Individual (I)/Collective (C)	Robust (R)/Flexible (F)	Cost-Effective	Benefits	Likely Co-Benefits	Easy to Implement	Probable Regret Level	References
Obtain or renew a property insurance (for flooding)		■			I	R, F	Cost: medium–high Efficacy: medium–high	Reducing economic vulnerability	Peace of mind	E	Low regret	[13,16,34,57,91]
Encourage your neighbour to purchase an insurance (for flooding)		■			I, C	R, F	Costs: no	Reducing economic vulnerability	Good neighbourhood relations; peace of mind	E	No regret	[91]
Try to influence the property owner/housing cooperative to take preparedness measures		■			I, C	R, F	Cost: no	Damage mitigation	Peace of mind	E-M	No/low regret	[77]
Building a house in a flood risk area, consider elevating the ground floor, floating options, stilts, water insensitive materials, suitable positioning of utility networks (e.g., electricity, drinking water, sewage), placing a tub around the basement, etc.		■			I	R	Cost: high Efficacy: high	Damage mitigation	Peace of mind	M-D	Low regret	[47,91,96]
Installation of backflow preventers		■			I	R	Cost: low–high Efficacy: medium	Damage mitigation	Peace of mind	M-D	Low regret	[76,95]
Adapting the building use and interior fitting		■	■		I	R, F	Costs: no–high Efficacy: medium	Damage mitigation	Peace of mind	E-M	No/low regret	[57,95,97]

Table A1. *Cont.*

Action	Unknown Future	Plausible Future	Probable Alternative	Clear Future	Individual (I)/Collective (C)	Robust (R)/Flexible (F)	Cost-Effective	Benefits	Likely Co-Benefits	Easy to Implement	Probable Regret Level	References
Buying, maintaining pumps and learning how to use them		■	■	■	I	R, F	Cost: low	Coping capacity	Peace of mind	E	No regret	[76,77]
Buying sandbags and making them easily accessible		■	■	■	I, C	R, F	Cost: low	Coping capacity	Peace of mind	E	No regret	[76,77]
Buying and installing stationary or mobile flood barriers		■	■	■	I	R	Cost: medium–high Efficacy: medium–high	Coping capacity; damage mitigation	Peace of mind; potential price reduction for flood insurance	E-M	Low regret	[16,57,59,77,91,95]
Knowing where to park the car in an emergency		■	■		I	R, F	Cost: no	Coping capacity	Peace of mind	E	No regret	[57,88]
Communicate dangerous behaviour including going into flooded basements, walking or driving in flood water		■	■	■	I, C	R, F	Cost: no	Awareness and education	Peace of mind	E	No regret	[27]
Talk to your neighbour about flood preparedness and mitigation		■	■	■	I	R, F	Cost: no	Awareness and knowledge	Peace of mind; good neighbourhood relations	E	No regret	[91]
Knowing your neighbours and who might need support in case of an evacuation or in long- and short-term preparedness		■	■		I, C	R, F	Cost: no	Awareness and knowledge	Peace of mind	E	No regret	[76,77,91]
Redirect water flow around the house		■	■	■	I	R, F	Cost: no	Damage mitigation	Peace of mind	E	No regret	[98]
Keep feed for livestock in a waterproof place		■	■	■	I	R, F	Cost: no	Coping capacity	Peace of mind	E	No regret	[89,99]

Table A1. *Cont.*

Action	Unknown Future	Plausible Future	Probable Alternative	Clear Future	Individual (I)/Collective (C)	Robust (R)/Flexible (F)	Cost-Effective	Benefits	Likely Co-Benefits	Easy to Implement	Probable Regret Level	References
Knowing where to evacuate livestock to		■	■		I	R, F	Cost: no	Coping capacity	Peace of mind	E	No regret	[89,100]
Seek guarantees that the area will get special attention from rescue authorities in case of a new emergency			■		I, C	R, F	Cost: no	Reducing vulnerability	Peace of mind; increasing awareness	M	Low regret	[77]
Moving valuable items, documents, etc. upstairs			■	■	I	R, F	Cost: no	Damage mitigation	Peace of mind	E	No regret	[57,76,97]
Organising temporary accommodation or knowing where shelters are			■	■	I, C	R, F	Cost: no–medium Efficacy: high	Coping capacity	Peace of mind	E	No regret	[27,59,76]
Preparing an emergency kit including important documents, medicines, clothes, water, and food, etc.)			■	■	I	R, F	Cost: no	Coping capacity	Peace of mind	E	No regret	[59,73]
Having medicines for pet and livestock prepared			■	■	I	R, F	Cost: no	Coping capacity	Peace of mind	E	No regret	[89]
Keep ropes to make boats from banana trees			■	■	I, C	R, F	Cost: no–low	Coping capacity	Peace of mind	E	No regret	[59]
Communicate flood warnings within the community (e.g., via social media); avoid the spreading of fake news			■	■	I, C	R, F	Cost: no	Awareness and knowledge	Peace of mind; prevention of guilt	E	No regret	[77,88]
Switch off gas, electricity, etc.; protect oil tanks; seal air conditioning or ventilation systems; secure dangerous substances				■	I	R, F	Cost: no	Damage mitigation	Peace of mind	E	No regret	[57,95]

Table A1. *Cont.*

Action	Unknown Future	Plausible Future	Probable Alternative	Clear Future	Individual (I)/Collective (C)	Robust (R)/Flexible (F)	Cost-Effective	Benefits	Likely Co-Benefits	Easy to Implement	Probable Regret Level	References
Waterproof your home by installing flood barriers, pumps, or placing sandbags around the house					I	R, F	Cost: no–low	Damage mitigation	Peace of mind	E-M	No/low regret	[16,57,59,76,91,95]
Reparking the car					I	R, F	Cost: no	Damage mitigation	Peace of mind	E	No regret	[27]

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