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Review

Ecosystem-Based Adaptation for Food Security in the AIMS SIDS: Integrating External and Local Knowledge

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Abstract: This paper critically reviews ecosystem-based adaptation (EbA) approaches for food security under climate change, specifically for the Small Island Developing States (SIDS) comprising the Africa, Indian Ocean, Mediterranean and South China Sea (AIMS) region. The focus is on integrating different knowledge forms. An analysis of current EbA approaches for food security is undertaken, alongside a review of methodologies for integrating local and external knowledge. Key gaps and actions for EbA for food security in the AIMS region, and potentially further afield, are identified. The gaps indicate the lack of coherence in AIMS SIDS approaching food security, in terms of policies and actions not reflecting the ecosystem-food-climate nexus, the lack of a regional framework despite similarities amongst the SIDS, and the infrequency with which knowledge integration occurs. To fill these gaps, suggested actions highlight knowledge identification and combination, learning from others and from history, using local champions, and regularly monitoring and evaluating progress. These actions will push forward the EbA agenda through improved development and use of knowledge, better connections amongst the AIMS SIDS and farther afield, and more local-national-regional collaboration.

Keywords: AIMS region; climate change; ecosystem; food security; local knowledge; small island developing states

1. SIDS and Food Security

Small Island Developing States (SIDS) are a diverse group of tropical island and coastal countries divided into three regions: Caribbean, Pacific, and Africa, Indian Ocean, Mediterranean and South China Sea (AIMS). Under the United Nations, they have joined together to address common sustainability challenges including their small land size, limited terrestrial natural resource base, high land use intensity, remoteness, large coastal zones, exposure to global developments, dependence on external finance and trade, high transportation costs, and rapidly expanding populations [1–3]. Under the auspices of the United Nations, three international conferences on SIDS and sustainable development have been organised: Barbados in 1994, Mauritius in 2005, and Samoa in September 2014.

One significant issue yet to be wholly addressed for SIDS is the impact of climate change on food security. As net importers of food, SIDS are especially vulnerable to food availability and price fluctuations. Climate change impacts are expected to further exacerbate this situation by affecting the ability of SIDS to produce their own food [1,4]. This situation is particularly concerning given their high dependence upon natural resources for livelihoods [5].

Significant research and projects on food security and climate change are underway for Pacific SIDS (e.g., [6–8]) and Caribbean SIDS (e.g., [9–11]). Such work is not as widespread in the AIMS region. That is despite all SIDS' vulnerability to a range of climate change impacts including increased temperatures and longer dry seasons, changing rainfall regimes, inadequate freshwater supplies, sea-level rise and saltwater intrusion, increased health risks (e.g., water- and vector-borne diseases), land loss and degradation, coastal erosion, and coral bleaching [12]. All have the potential for significant, detrimental impacts upon food security [13]. In response, ecosystem-based adaptation (EbA) has been highlighted as one potential approach to tackle food insecurity and to enable climate change adaptation [14–17].

Given the limited focus on food insecurity and climate change for AIMS-region SIDS, this paper critically reviews the use of EbA approaches to address food insecurity and climate change in the AIMS-region SIDS. These SIDS are usually listed as Cape Verde, Comoros, Guinea-Bissau, the Maldives, Mauritius, São Tomé and Principe, the Seychelles, and Singapore but Bahrain is sometimes included. The particular focus here is on methodologies used to integrate external and local knowledge. Highlighting local knowledge is necessary given its increased abandonment in favour of external and usually technology-based knowledge, which is considered more up-to-date and more relevant for the future. Whilst neither knowledge base should be considered a panacea, a balance is needed between external and local views when applying EbA to food security. This paper identifies key gaps and actions for integrating external and local knowledge within EbA for food security in a changing climate across the AIMS region. It contributes to developing existing strategies whilst providing possible ways forward for addressing food insecurity simultaneously with climate change impacts.

The next Section summarises EbA topics pertinent to food security in a changing climate followed by a Section examining methodologies for combining knowledge forms in SIDS. This topic is then discussed for AIMS SIDS regionally, nationally, and locally. The paper's final two Sections are, respectively, discussion of the gaps and actions, and conclusions indicating possible ways forwards for the AIMS SIDS.

2. Ecosystem-Based Adaptation and Food Security in a Changing Climate

Healthy ecosystems and their services are critical for global food security, supporting the availability, access, and use of farmed and wild foods while strengthening the stability of food systems [18,19]. To meet the rapidly growing demands for food, freshwater, timber, fibre and fuel over the past fifty years, ecosystems have been rapidly and extensively altered with subsequent declines in ecosystem health and services (e.g., soil and water quality) [20]. Subsequently, people's ability to adapt to and cope with existing and anticipated climate change impacts is reduced, further threatening long-term environmental sustainability and food security [21].

EbA is seen as an important approach for addressing food security challenges and for enabling climate change adaptation [19,22,23]. EbA is defined as "an approach that builds resilience and reduces the vulnerability of local communities to climate change…EbA integrates sustainable use of biodiversity and ecosystem services in a comprehensive adaptation strategy" [24] (pp. 15–16). The phrase EbA is a modern term which is largely absent within relevant literature prior to 2009, although earlier uses of the phrase have been identified in Spehn [25] and Racey [26]. Beforehand, common terminology was more focused on "ecosystem-based management" and "ecosystem management", which "reflect three common origins…protected areas, cooperative management, and management responses to complex demands and pressures" [27].

Post-2008, there has been a noticeable expansion in the use of the phrase EbA and the development of EbA approaches (see [28] for examples), as well as analyses of their strengths, limitations, and applicability (Table 1). A closer review of the United Nations Framework Convention on Climate Change (UNFCCC) EbA database demonstrates the direct and indirect impacts such initiatives have on food security. The project: "Responding to shoreline change and its human dimensions through integrated coastal area management" in Cape Verde (and other West African countries) does not mention food security directly, yet contributes to it through maintaining coastal ecosystem resilience to climate change. Munang *et al.* [15] outline EbA approaches to better manage ecosystems for food security given climate change, including managing soil, improving agricultural biodiversity, using local and scientific knowledge, providing farmers with better access to new technologies, and establishing "payment for ecosystem services" schemes. Most recently, in a conference on African Food Security and Adaptation, almost 800 delegates from across Africa backed EbA approaches as a key tool for ensuring food security [29].

Table 1. Strengths and limitations of participatory planning methodologies, tools and approaches for integrating local and external knowledge for climate change adaptation (CCA) and/or disaster risk reduction (DRR) alongside opportunities for ecosystem-based adaptation (EbA) approaches for food security in a changing climate (adapted from [10]; see also Section 3).

No	Methodology & Pilot Site of Implementation	Strengths	Limitations	Opportunities for EbA approaches for food security in a changing climate.
Participatory Planning Methods and Approaches				
1.	Integrated Community-based Risk Reduction (piloted in the Maldives) [30]	Focuses on obtaining mutual understanding between inside and outside stakeholders. Incorporates all basic societal functions including food security and how these are interconnected within and across a community. Enables stakeholders to determine jointly the levels of risk and how to address them. Considers both rapid and creeping changes to vulnerabilities and capacities across ecosystems, rather than isolating a specific disaster, hazard or climate change related hazard [30]. Further develops and expands the Process Framework (see the next row).	Only tested in part on one island in the Maldives, so further work is required to determine the method's efficacy. Focused upon one hazard–tsunamis. Need to create multi-hazard scenarios in any future implementation/use of method. Need to determine how to consider changes over multiple time scenarios to incorporate future climate projections; the present model does not consider time scenarios beyond ten years [30]. A lengthy and time-consuming process.	A holistic approach addressing identified risk in a specific area offers the potential to utilize an EbA approach incorporating food security and climate change. An EbA approach facilitates an integrated community-based risk reduction process as, by definition, all ecosystems, their services and their societal interactions would be included.
2.	Process Framework (piloted in Papua New Guinea) [31,32].	Assists community members in identifying and relating to changing vulnerability patterns and how their activities could have contributed to the changes. Encourages a proactive response amongst community members for addressing their own vulnerability. Uses available knowledge thereby identifying options which can be implemented by communities immediately to reduce their risk. Provides a simple process which is easy to follow and manage by community members.	Scientific information is not frequently available in a format which local communities are able to understand and use. The process is facilitated by outsiders, whereas facilitators should preferably be local people for understanding the local context. As with all participatory techniques, there is a risk of introducing facilitator bias rather than enabling community members to reach decisions and consensus based on an exploration of their own situation. Specific tools or methods are not provided for building trust amongst stakeholders [33].	Developing mutual understanding amongst inside and outside stakeholders offers enormous potential for implementing EbA approaches for food security in a changing climate. This methodology addresses the underlying principles of EbA and could easily be replicated and expanded to implement EbA approaches for food security in a changing climate.

Table 1. *Cont.*

No	Methodology & Pilot Site of Implementation	Strengths	Limitations	Opportunities for EbA approaches for food security in a changing climate.
3.	Risk and Vulnerability Assessment Methodology (RiVAMP) (piloted in Jamaica) [34]	Focuses on governance to identify opportunities for influencing policy and initiating change. Technical analyses are balanced with local knowledge and real-life experiences to identify ecosystem benefits and drivers of ecosystem degradation. Helps to analyse links amongst ecosystems, drivers of ecosystem degradation, and socio-economic vulnerability.	Focused on coastal ecosystems, tropical cyclones and their associated effects, so it will not fully assist the locations which lie near the equator, and so rarely experience tropical cyclones, such as Singapore and much of the Maldives. The donor purchased scientific data and tools, an expense potentially beyond the local level. Further education is required to enable communities to understand linkages amongst ecosystem degradation, food security and climate change impacts prior to using tool. The methodology focuses upon governance and power structures, yet a full assessment of local governance is not undertaken, even though that is needed for ecosystem protection and for addressing food insecurity and climate change impacts.	Highlights the importance of ecosystems in addressing food insecurity and climate change impacts. Potential exists to expand beyond coastal ecosystems and beyond tropical cyclones. It already takes an EbA approach and integrates local and outside knowledge. A focus upon food security and climate change impacts naturally follows.
4.	Adaptive Co-Management and Cooperative Research (utilised in many SIDS especially in the Pacific and Caribbean regions) [35–37].	Emphasises group decision making accommodating diverse views and shared learning [38]. Recognises that multiple sources of knowledge are critical to problem-solving and emphasises trust building, institutional development and social learning. Provides a process for mediating conflict and addressing power dynamics [36]. Builds on culturally embedded formal and informal rules and norms to form horizontal and vertical networks. Enhances the capacity of resource management organizations to respond proactively to uncertainty. Can contribute to trans-generational transfer of local knowledge through youth engagement [37]. Enables collaborators to develop a shared cross-cultural understanding of the research [37].	Creating the social and institutional space for the necessary interactions is a difficult task. Requires multi-level governance arrangements. The formalized nature of interactions between locals and government can create barriers to participation. Establishing effective institutional arrangements and trust takes time. An in-depth governance assessment is required to understand society dynamics and power structures prior to implementing adaptive co-management structures. Adaptive co-management processes are slow or will fail to develop unless policy environments support multi-level learning networks, and, in turn, scientists and others are rewarded for participating in these networks. It often focuses upon one specific area or sector rather than the multiple interactions existing between ecosystems and their services.	Has been used for specific ecosystems, e.g., marine protected areas in Fiji [39] and food sectors, e.g., fisheries in Ghana [40], and is starting to be used to address the challenges of climate change adaptation [41,42]. A large amount of literature, knowledge and practice exists for using such a methodology for EbA approaches for food security in a changing climate. An opportunity exists to expand the approach to include all ecosystems as opposed to a sole focus upon one specific area or sector.

Table 1. *Cont.*

No	Methodology & Pilot Site of Implementation	Strengths	Limitations	Opportunities for EbA approaches for food security in a changing climate.
5.	Participatory Planning Processes (utilised in a large number of SIDS especially by non-governmental and local organisations) [43]	Enables stakeholders to appraise, analyse and address issues through recognising and sharing all available knowledge in order to reach agreed upon, acceptable solutions. Effective consultation can lead to high-impact results [43]. Plans are formally signed and owned by government, private agencies and communities with responsibilities allocated to each body, reinforcing the significance of "partnership". It is easier to implement and maintain within smaller countries like SIDS. An integrated viewpoint can be taken, successfully linking knowledge bases to address development challenges including ecosystem degradation, food security and climate change [43,44]. Can be led by local officials and community members. Visual photographs can be used to aid discussions and to link local and outside expertise. It blends traditional decision-making systems with contemporary ones, so the process is flexible and adaptive.	It is time consuming and costly to directly consult with large numbers of people. It increases the workload on government staff. It is difficult to keep all agencies involved motivated throughout the lengthy process. Often, there is a gender bias with a tendency for men to be more outspoken and for women to sit in the background. The influence of participatory planning processes and their impact upon community livelihoods and food security needs to be further explored and analysed [43].	The principal interest of the majority of communities worldwide is secure livelihoods, for which ecosystems and their services are essential. Using EbA approaches would address food security, climate change and other concerns related to ecosystem services. This would significantly strengthen the resilience of community livelihoods to external impacts such as climate change while enhancing food security. Experiences and knowledge from the development of participatory planning processes to reduce climate vulnerability for coastal communities and ecosystems in Samoa [43] could be used to develop EbA approaches for other ecosystems which specifically address food security and climate change concerns. There is a need to reconcile EbA approaches for food security in a changing climate with existing management systems (see [45]).
6.	Strengthening Resilience of Coastal and Small Island Communities (implemented in Timor-Leste) [46]	Not a specific methodology, but rather a process developed within a specific project to integrate local and external knowledge for strengthening resilience to hydro-meteorological hazards and climate change impacts. Identified opportunities to integrate and mainstream local knowledge into local and national disaster risk management processes. Developed a checklist for communities and governments (local and national) to help identify and integrate local knowledge with scientific knowledge. Established a participatory process with communities and scientists whereby local knowledge was validated [46].	Has not been implemented beyond a single SIDS (Timor-Leste) or islands and coastal areas of Philippines and Indonesia. Currently implemented in isolation as a project rather than being integrated within other local development plans and processes in order to ensure sustainability in the long term. Further policy support is needed at the national level. Focuses upon coastal areas, but an EbA approach was not taken. Links amongst food security, climate change, and the impacts of hydro-meteorological hazards need to be further explored through an ecosystem-based approach.	A potential opportunity exists to widen the focus of this project beyond coastal areas utilizing the knowledge and expertise built up in these areas. The focus upon climate change and hydro-meteorological hazards is clearly linked to food security and would benefit from an EbA approach. There would be benefit in exploring the transferability of local knowledge identified in developing EbA approaches for food security in a changing climate [47].

Table 1. *Cont.*

No	Methodology & Pilot Site of Implementation	Strengths	Limitations	Opportunities for EbA approaches for food security in a changing climate.
Participatory Planning Tools				
1.	General Participatory Tools (utilised in a large number of SIDS especially by non-governmental and local organisations) [34].	Listening instead of lecturing to learn from local knowledge. The emphasis is on visual techniques, theatre and story-telling as opposed to written techniques, ensuring that those with limited literacy can participate and engage. Enables the verification of information using a range of overlapping methods. Focuses on community strengths rather than dwelling on weaknesses. Identifies and empowers local analysts. Potentially establishes a common ground for communication which demystifies science.	There is a tendency to over-romanticise local knowledge when it may not always be applicable or appropriate. Community expectations are often raised beyond what can be delivered. Using participatory tools can take time. It is often difficult to engage outside experts in local level assessments and planning, so instead need to link with wider local and national government processes. It can be difficult to integrate scientific and local knowledge and expertise in terms of climate change. Whilst these techniques enable the identification of knowledge, they do not necessarily facilitate integration, so further steps are needed [48].	There is a large range of participatory tools which facilitates the integration of knowledge for DRR, including CCA, which would equally be replicable for EbA for food security in a changing climate (see [34]). International conservation organisations such as IUCN have developed a number of documents outlining guidelines and principles for EbA, utilizing participatory techniques which are also appropriate for EbA approaches for food security in a changing climate [19,49].
2.	Participatory 3-D Mapping (utilised in a number of SIDS e.g., Solomon Islands and Trinidad and Tobago) [50].	Is a collaborative, low-cost activity involving a wide range of stakeholders [50]. Participants are able to plot desired criteria, e.g., resources, landmarks, environmental features, and household occupants, contributing to the credibility of local knowledge. Facilitates interpretation, assimilation and understanding of geo-referenced information by making it visible and tangible [50]. Raises local awareness of territories, provides stakeholders with powerful mediums for land use management and serves as an effective community organising tool [51]. As maps are scaled and geo-referenced, scientists are rigorously able to integrate their own knowledge with local knowledge.	Material is prepared by facilitators first, e.g., a scaled and geo-referenced base map using Geographical Information Systems (GIS). This means the methodology is not necessarily replicable by communities who may not have access to or understand this technology. If not carefully facilitated, maps may be used by facilitators to either replace local conceptions of territory or impose their own worldviews [52]. It is difficult to map all dimensions of vulnerability and capacity, e.g., social networks. Because all knowledge and mapping is made public, some elements might not be revealed by the community, such as gender-based violence.	This tool has been widely employed for DRR and CCA activities and is starting to be used within EbA (e.g., [53]) from which lessons could be learnt for EbA approaches for food security under climate change.

Table 1. *Cont.*

No	Methodology & Pilot Site of Implementation	Strengths	Limitations	Opportunities for EbA approaches for food security in a changing climate.
3.	Scenario Planning (utilised in several SIDS including Papua New Guinea) [54].	Scenario models are flexible, transparent and able to use narratives to describe possible futures in all their complexity and hence are suitable for examining food security issues in a changing climate. Suited to engagement with stakeholders who do not have scientific backgrounds. Scenarios can integrate knowledge and underlying epistemologies of different actors [55]. Comprises information at multiple scales, plus scenarios help to identify drivers of change that are both exogenous and endogenous to the system of interest. Scenarios can be used to evaluate knowledge by (a) indicating where knowledge needs to be updated as new information is available or perceptions change; (b) assessing the relevance and credibility of scientific knowledge and (c) revisiting assumptions underpinning scenarios. Scenario planning provides a mechanism for integrating knowledge temporally (into the future) as well as spatially.	Scenarios do not integrate knowledge explicitly, but rather implicitly through building stories based on different information sources [55]. Scenarios risk being a "knowledge dump", whereby issues of accuracy and precision, weighting, standardization and resolution of discrepancies do not often receive attention [55]. Scenarios developed are qualitative only, so they do not include many quantitative aspects. There is often a trade-off between giving too little information to enable participants to analyse future scenarios and giving too much information which could introduce a bias. Ample space and time is necessary to accommodate differences in opinion and to reach consensus.	Scenario planning has been utilized for ecosystem management (e.g., [56,57]), for strengthening livelihoods in light of climate change (e.g., [58]) and for community resilience (e.g., [59]). In addition, scenario planning has been used as a method to link science and policy on food security under climate change in East Africa (e.g., [60]). Lessons for EbA for food security in a changing climate could be drawn from all these studies. It would facilitate the analysis of multiple ecosystems and their services by a large range of stakeholders, thereby enabling food security and climate change concerns to be identified and addressed where necessary.
4.	Participatory GIS (utilised for different purposes in a large number of SIDS) [61].	Provides a stimulating forum for inter-disciplinary analysis allowing physical and social scientists and communities to participate in rigorous evaluations of dissimilar data [62]. Produces maps of varied scales and content related to different actors and process purposes. Helps promote more robust community decision-making. Has the potential to contribute positively to good governance by improving dialogue, legitimizing and using local knowledge, generating some redistribution of resource access and control rights, and enabling local community groups by means of new skills training [63]. Improves transparency and visibility of relationships between communities and local government. Legitimises local knowledge and enables accessibility by outside stakeholders [64].	Fails to address boundaries as identified by local participants, although GPS can be used to counter-act this and geo-reference point data. Has difficulty including all intricate details of local knowledge. The translation of community boundaries onto maps using GIS is often inadequate for spatial analysis.	As with participatory 3-D mapping, this tool is also in the early stages of use for ecosystem-based management (e.g., [65]). Lessons for its use may be drawn from its wider application and use in integrating knowledge bases within DRR including CCA.

In June 2011 a group of international, mostly conservation organisations, drafted some key principles including [66]:

(1) EbA promotes multi-sectoral approaches;
(2) EbA operates at multiple geographic scales;
(3) EbA integrates flexible management structures that enable adaptive management;
(4) EbA minimizes trade-offs and maximizes benefits with development and conservation goals to avoid unintended negative social and environmental impacts;
(5) EbA is based on the best available science and local knowledge, and should foster knowledge generation and diffusion;
(6) EbA is about promoting resilient ecosystems and using nature-based solutions to provide benefits to people, especially the most vulnerable;
(7) EbA must be participatory, transparent, accountable, and culturally appropriate, while actively embracing equity and gender issues.

Point (5) is particularly significant in highlighting both science and local knowledge. Local people are custodians of extensive environmental knowledge and experience built up over numerous generations (e.g., [67]). Using local knowledge and non-infrastructural approaches is, in many cases, more cost-effective and accessible by community members than measures emphasising external, technical knowledge and infrastructure [68–70]. Smaller and more isolated communities such many communities in the AIMS-region SIDS may not have the population size, knowledge or technical resources for building and maintaining large-scale infrastructure, especially if engineered [71–73].

Yet local knowledge itself is neither homogenous nor straightforward. Sillitoe [74] describes different phrases, including "indigenous knowledge", "traditional knowledge", "indigenous technical knowledge", "traditional environmental knowledge", and "folk knowledge", many of which can mix to comprise "local knowledge". For this paper, "local knowledge" is adopted as an all-encompassing phrase, while recognising that it has detractors, but is nonetheless a useful phrase to describe knowledge that has developed in a specific community or location and has often incorporated or been partially moulded by external knowledge [67]. In parallel, external knowledge tends to have some element of being empirically "proven" within a certain scientific paradigm and often (not always) links to modern, technical components such as technology or engineered structures [67]. The EbA literature and techniques implemented in the field (Table 1) demonstrate the importance of both knowledge forms in tandem for using EbA to achieve food security in a changing climate.

3. Combining Knowledge Forms for SIDS

The significance of local knowledge has long been recognised for disaster risk reduction (DRR), including CCA [75–77]. Use of local knowledge and practices to engage with those "at risk" is a key approach within Community-Based Disaster Risk Reduction (CBDRR) and its subset of Community-Based Adaptation [78]. SIDS have numerous vulnerabilities resulting in many of their communities suffering loss and hardship, however these same communities have also demonstrated significant strategies developed over centuries to deal with the challenges [79].

Local knowledge is valuable for developing EbA strategies to support food security. Yet such knowledge should not be over-romanticised, since not all of it applies all the time or in all circumstances, especially given how quickly social and environmental changes are occurring today. Rather, it is useful to assess local and external knowledge so that both knowledge bases can be integrated to contribute to food security [67,80] without which measures might not have local support and are prone to failure.

There are many examples demonstrating how local and external knowledge are used in relation to ecosystems (e.g., [10,44,81,82]), food security (e.g., [83–86]), and climate change impacts (e.g., [87–92]). Table 2 provides a few SIDS examples, including from the AIMS region.

Table 2. Examples of Small Island Developing States (SIDS) case studies linking local and external knowledge for EbA approaches to food security in light of climate change (Africa, Indian Ocean, Mediterranean and South China Sea (AIMS) region examples are bold).

Date	SIDS	Study/Project	Notes
2012	The Seychelles	Conservation of rare local food crops for diversity in the region of Val D'Andorre [93].	Ecosystem approach. Use of local knowledge. Addressing food security.
2009–2014	The Maldives	Community Integration in Marine Conversation, Research and Management through the establishment of Voluntary Marine Conservation Areas [94].	Ecosystem approach covering marine ecosystems. Participatory approach involving local and external stakeholders. Improves food security for local fishers and their families through regeneration of marine life and biodiversity.
2012	Tonga	Investigating local EbA initiatives [81]	Specific focus on EbA (and CBA). Provides lessons from local initiatives on EbA. Stresses the importance of local knowledge. Stresses the importance of EbA for food security in a changing climate.
2007–2014	Coral Triangle including SIDS of Solomon Islands, Timor-Leste and Papua New Guinea	Coral Reefs, Fisheries, and Food Security: Integrated Approaches to Addressing Multiple Challenges in the Coral Triangle [95].	An EbA approach stressing importance of all ecosystems but with a focus on marine and coastal. Builds upon local knowledge. Addresses food security in a changing climate.
2013–2014	Vanuatu	South Pentecost Community: EbA [96].	An EbA approach focusing on multiple ecosystems. Addresses food security and climate change concerns. Uses existing knowledge and practices.
2012	Caribbean SIDS	Food Security, Women Smallholders and Climate Change in Caribbean SIDS [11].	Research brief outlining the need for urgent action with regards to food security and climate change. Stresses the importance of ecosystem approaches in this process. Refers to the use of local resources and knowledge.

A key principle of EbA is integrating relevant and applicable local and external knowledge [66,97], yet there is no single approach for integrating different knowledge forms for EbA [98]. In the Maldives, Peters [99] outlines vast differences in perceptions of climate change impacts at local and international levels (see also [100]). Such differences need to be reconciled through further dialogue between local and external knowledge holders before effective implementation of EbA approaches for food security can occur. In many cases, projects with a focus on EbA, including those identified in Table 2, outline a need to integrate knowledge, but specific methods beyond stakeholder consultation and coordination are not discussed.

This Section builds upon a desk-based literature review originally undertaken for Caribbean SIDS. That study identified ten methodologies from DRR, including CCA, which are used for integrating knowledge bases [10] and which could be applied to EbA for food security. Two further methodologies are included here. The methodologies fall into three specific categories (see Table 1):

(1) *Participatory planning methodologies and approaches* including: (a) Integrated CBDRR [30]; (b) Process Frameworks [31,32]; (c) Risk and Vulnerability Assessment Methodology (RiVAMP) [34]; (d) Adaptive Co-Management and Cooperative Research [35–37]; (e) Participatory Planning Processes [43]; and (f) Strengthening Resilience of Coastal and Small Island Communities [46].
(2) *Participatory tools* including: (a) General Participatory tools [33]; (b) Participatory 3-D Mapping [50]; (c) Scenario Planning [54]; and (d) Participatory GIS [61].
(3) *Networks or consortia* (for which two examples are given, discussed below).

The only methodology outlined in Table 1 specifically developed in an AIMS-region SIDS (the Maldives) is the "Integrated Community-based Risk Reduction" method [30]. This method was designed to ensure that, in addition to knowledge integration, all other essential components for the effective identification, analysis and assessment of community risk were incorporated. These included up-scaling local level plans to be relevant to national level policies; sectoral integration (focusing upon basic societal functions, e.g., access to food and ecosystem services); stakeholder, spatial, temporal, risk factor and multi-disciplinary integration; and integration of qualitative and quantitative methodologies [30]. The study was undertaken in the Maldives to identify and analyse risks of islands which had been designated to receive an influx of people and development investment under the Maldives Population Transmigration Consolidation Plan [30]. As 80% of the Maldives' land consists of coral islands raised less than one metre above sea level, this methodology naturally included all ecosystems [22]. However, it is not clear how this methodology contributed to strengthening islander resilience to identified risks, including food insecurity and climate change. Further research is required to refine the process and to follow-up on decisions implemented to reduce risk [30].

One methodology was specifically designed to account for ecosystem and climate change factors within disaster risk and vulnerability assessment (see Table 1). The RIVAMP methodology developed in Jamaica aimed to assist national and local government decision-makers in evaluating development options by recognising the role of ecosystems in DRR including CCA [34]. Whilst this methodology balanced technical analyses with local knowledge and real-life experiences, it worked with national and local level government decision-makers plus some community members. With enough resources, the method could and should be expanded to involve much wider community participation.

In addition to the methodologies described above, there are several consortia, groups, and networks dealing with DRR, including CCA, and linking those processes to food security. These networks are prevalent for Caribbean and Pacific SIDS but less evident for AIMS SIDS. In many cases they are large bodies operating across regional scales (e.g., CCCCC) with little focus upon knowledge integration.

The "Many Strong Voices" (MSV) network is a programme linking people from the Arctic and SIDS that does focus on knowledge integration. Established in 2005, MSV brings these communities together to develop approaches to tackle climate change within wider contexts whilst sharing climate change knowledge and expertise. MSV is community-driven, aiming to ensure that people from these vulnerable regions are given stronger voices at local, national and international forums. MSV also engages in policy-relevant integrated research incorporating local and external knowledge, local organisational capacity building, and access to forums for knowledge exchange [101]. In 2013, MSV was named as one of the top ten most influential climate change campaigns in the world [102]. However, MSV still relies on Arctic and SIDS peoples through their individual and organisational voices, often using electronic media to ensure that local voices are indeed heard, even though internet access is difficult for many Arctic and SIDS communities.

To overcome such challenges, as with Caribbean SIDS (see [10]), the AIMS SIDS can learn from the Arctic region's "Exchange for Local Observations and Knowledge of the Arctic" (ELOKA) [103]. Similarly to MSV, but for the Arctic only, ELOKA's goal is to facilitate the collection, preservation, exchange, and use of local knowledge by providing data management and by fostering collaboration between local and international researchers. ELOKA assists community members to document knowledge in their own language using various methods, such as drama, video and photos. While this approach helps to preserve knowledge in the communities, it also presents difficulties in linking it with scientific information, given the diverse data sets. Nonetheless, the documentation of local knowledge alongside enhanced collaboration between local and international researchers has resulted in increased initiatives using local and external knowledge (e.g., [104,105]), with further legitimacy given to local knowledge [106].

Applying lessons from MSV, ELOKA, and others to AIMS-region SIDS would contribute to developing context-specific resources and tools relevant to the AIMS region, especially through using the AIMS region's local, national, and regional knowledge. A need exists for a regional network which would host local and external knowledge for EbA, given the food security and climate change concerns, alongside the current lack of connectivity amongst the SIDS. Without such a regional network, a lack of exchange will slow down implementation across all the SIDS, since they will each have discover each step on their own. Given the diversity and spread of AIMS-region SIDS, significant thought would need to go into documenting, using and transferring local knowledge to be used for EbA. Caution would be required in presenting local knowledge without considering its local and cultural contexts, because SIDS are diverse and not everything applies to all SIDS [107]. Engagement amongst outside researchers and community members requires continuity to be effective, as shown by MSV and ELOKA.

The predominant themes arising are communication and the need for trust and linkages amongst all those involved, so that top-down and bottom-up actions can be joined. Gaillard and Mercer [108] outline the difficulties of this task for DRR, including CCA, such as a lack of trust amongst stakeholders, unequal power dynamics, absence of space for dialogue, and low priority accorded to DRR and those

most at risk. These difficulties are equally relevant and applicable for EbA approaches for food security. All of the methodologies, tools and networks described here are consultative, encouraging local decisions and actions without losing wider perspectives regarding sustainable natural resource management strategies. Although this form of connection and incorporation of different views has not always been part of EbA, many programmes mentioned here, such as RiVAMP and MSV, are taking steps to do so.

The methods and approaches outlined above have been used in a number of regions around the world with community support, yet few have been independently analysed or evaluated, especially regarding their use of integrated knowledge for EbA. To support EbA approaches for food security, further evaluation of these approaches for AIMS-region SIDS is required. That would contribute to identifying methods, individually or in tandem, which are particularly applicable to the AIMS region. An example is identifying and recording local knowledge so that it can be assessed for efficacy and validity. So far, however, only a few examples, such as "Strengthening Resilience of Coastal and Small Island Communities", P3DM, PGIS, MSV and ELOKA, have moved towards such action. In parallel, other knowledge forms such as external science ought to have formats which are easily understandable and usable by the locals which EbA purports to serve. Consequently, the different knowledge bases would be brought closer together for EbA approaches to be applied for food security in the AIMS region and further afield.

4. EbA, Food Security, and AIMS SIDS under Climate Change

AIMS-region SIDS are spread across the Atlantic Ocean (Cape Verde, Guinea-Bissau, São Tomé and Principe), the Indian Ocean (Comoros, the Maldives, Mauritius, the Seychelles), the Persian Gulf (Bahrain) and the South China Sea (Singapore). Two small island states in the Mediterranean, Cyprus and Malta, are no longer included due to their European Union membership and subsequent status as developed countries [109]. The AIMS-region SIDS are diverse, ranging in size from the Maldives with an area of 298 km^2 to Guinea-Bissau with an area of 36,120 km^2, and with arable land ranging from 2% in Singapore to 49% in Mauritius (see Table 3) [110]. They share several common features. All are located between the Tropic of Cancer and Tropic of Capricorn, rely heavily upon natural resources for livelihoods (with fish being the common resource), and face significant challenges regarding economic development, social justice and environmental preservation [110]. Many have increased investments in tourism, fisheries, sugarcane, offshore financial centres, gambling havens, and trading hubs to overcome these challenges. This has resulted in rapid declines in ecosystem health and detrimental impacts on socio-economic indicators [110].

Table 3. AIMS-region SIDS (information from [110,111]).

	Cape Verde	**Comoros**	**Guinea-Bissau**	**The Maldives**	**Mauritius**	**São Tomé and Principe**	**The Seychelles**	**Singapore**	**Bahrain**
Area (km^2)	4033	2235	36125	298	2040	964	455	697	760
Archipelagic status	10 islands and 8 islets	3 major islands and many minor islets	Borders North Atlantic Ocean between Guinea and Senegal.	1190 coral islands grouped into 26 natural atolls	1 main island and a large number of smaller islands and islets.	2 islands and several islets	155 islands	1 island and 63 smaller islets	33 islands
Highest elevation	2829 m	2360 m	300 m	2.4 m	828 m	2024 m	905 m	166 m	122 m
Arable Land	11%	44.06%	8.3%	10%	38.24%	9.06%	2.17%	0.89%	1.79%
Natural Resources	Salt, limestone, fish	Arable land, Fish	Fish, timber, phosphate, arable land	Fish	Arable land, fish	Fish, hydropower	Fish, copra.	Fish	Fossil fuels, natural gas, fish and pearls
Main ecosystem-based livelihoods	Fisheries, tourism.	Smallholder agriculture, fisheries and forestry.	Agriculture, timber, fisheries, tourism	Fisheries and Tourism.	Agriculture, fisheries, property development.	Cocoa, Fisheries	Fisheries	Fisheries	Fisheries
Population	512,096	766,865	1,693,398	393,595	1,331,155	190,428	91,650	5,567,301	1,314,089

The most significant threats to ecosystems identified by AIMS-region SIDS are climate change and accelerated sea-level rise [110]. In recent decades, all countries have experienced warmer temperatures, rising sea levels, and degradation of coral reefs and mangroves due to increased sea temperatures [110] potentially with ocean acidification impacts as well. Climate change impacts also have the potential to significantly affect local food production, already vulnerable to other stressors. Fish, for example, are an important source of protein for islanders, but many stocks are diminishing due to overfishing, habitat destruction, and changing seas [110,112].

Given the land resource limitations on SIDS, along with SIDS' sea-based heritage, protecting coastal and marine ecosystems is high on the food security agenda [113,114]. That does not preclude terrestrial ecosystems and food sources, because SIDS need to use all their territory to enhance food security, especially in helping to adapt to climate change [110]. The foremost principle of the Maldives Government's Environment Policy, for example, is to view the natural environment as key to socio-economic development and to ensure the provisioning of fundamental services from the environment [115]. That matches the extensive uses of ecosystems by humanity, often called "ecosystem services", for needs such as water, food, risk reduction, shelter, and livelihoods [14,19,116].

In a review of climate change adaptation (CCA) in all but two (Singapore and Bahrain) of the AIMS-region SIDS, many actions emphasised the importance of an EbA approach for improving food security [117]. Apart from São Tomé and Principe which referred to "coastal management", each individual country review specifically referred to either "EbA", "ecosystem management", "ecosystem restoration", and/or "ecosystem resilience" as a strategy to ensure food security within CCA [117]. Cape Verde specifically mentioned terrestrial and marine ecosystems, in addition to coastal ecosystems [118]. Only one regional project (involving Guinea-Bissau and Cape Verde) was identified which specifically outlined the need to improve fishing practices and policies in light of climate change using local and scientific knowledge [118,119]. The lack of regional approaches reduces coherence of initiatives and limits opportunities for learning from each other and for providing mutual support.

EbA approaches demonstrate significant gaps regarding food security in a changing climate in the AIMS region. That is despite Andrade *et al.* [66] outlining how EbA approaches are flexible in terms of their usability at different time and space scales for different sectors with different knowledge bases. The rest of this Section assesses the extent to which EbA approaches involving external and local knowledge bases are applied at regional, national and local levels for food security in light of climate change. It builds upon and supplements the reviews undertaken by the Adaptation Partnership [117] which focused on Cape Verde, Guinea-Bissau, São Tomé and Principe, Comoros, the Maldives, Mauritius, and the *Seychelles*.

4.1. Regional Level Action in AIMS SIDS

AIMS-region SIDS are scattered over a large geographical area and do not have a common first language, presenting challenges for coordinating, developing, and implementing regional action. Unlike the Caribbean and Pacific SIDS, the AIMS-region SIDS do not currently have a devoted regional organisation for general regional challenges or for more specific topics such as food security, ecosystems, and climate change.

Despite recognising the significant impacts that climate change could have upon food security in the AIMS region, progress to address this at a regional level has been slow due to the lack of a regional framework. The Indian Ocean Commission (IOC) has contributed to promoting regional-level collaboration but involving only Comoros, Mauritius and the Seychelles as IOC members under the IOC's CCA project. This project involves capacity building and policy formulation, but does not specifically assess ecosystems or food security. Caribbean SIDS, on the other hand, are linked to the Caribbean Community Climate Change Centre (CCCCC) which has implemented projects related to climate change and food security. A regional roadmap for Caribbean adaptation action was developed in 2009 (to 2015) [120] and a three-year project funded by the European Development Fund started in 2013 to "improve Caribbean food security in the context of climate change". A similar situation exists amongst Pacific SIDS which are connected through a number of secretariats including the Secretariat of the Pacific Community, the Pacific Islands Forum Secretariat and the Secretariat of the Pacific Regional Environment Programme. Here, too, there are numerous regional initiatives on climate change and food security (e.g., [6,121]).

AIMS-region SIDS are involved in wider regional initiatives addressing climate change, ecosystem and/or food security concerns. The Seychelles, Mauritius, and Cape Verde are most involved with regional and global initiatives to address CCA and food security [118,122,123]. To date, the majority of these regional and global initiatives have focused on capacity building, leadership, integration of adaptation activities into development plans, policy dialogue and formation, development of climate change scenarios, provision of technical support, support to regional initiatives between IOC countries and research. For example, one significant project involving Cape Verde and Guinea-Bissau undertook "interdisciplinary and participative research on interactions amongst ecosystems, climate, and societies in West Africa" [118]. Whilst it is a welcome contribution to research, and to local and national government capacity building, it is not clear how this translated to local-level action.

Programmes such as "Mangroves for the Future" (the Maldives and the Seychelles), and the "Regional Initiative for Smallholder Agriculture Adaptation to Climate Change in the Indian Ocean Islands" (the Seychelles and Comoros) which have translated into local-level action have been significantly narrow in their activity, focusing on one specific ecosystem for food security [122,124,125]. Another regional-level project, the "Adapting Fishing Policy to Climate Change with the Aid of Scientific and Endogenous Knowledge" [118] aimed to improve fishing practices and policies in light of climate change in six countries including Guinea-Bissau and Cape Verde. Whilst the significance of ecosystems for food security is not specifically highlighted and the focus is solely upon marine ecosystems, the project has included key principles of EbA (e.g., consulting local communities and utilising local and external knowledge). However, this too was a research project and it is not clear how results have translated into action at national and local levels.

4.2. National Level Action in AIMS SIDS

Some AIMS-region SIDS are undertaking steps at the national level towards addressing declining ecosystem health and ecosystem services. Mauritius, for example, has a National Forest Policy adopted in 2006 and a National Strategic Biodiversity Action Plan for 2006–2015 with clear guidelines on reforestation with native species, biodiversity conservation, and eradication of alien invasive species.

Fifty per cent of the state forest plantation areas have been set aside to protect ecosystem services, including soil and water conservation essential for food production [125]. The Seychelles is currently implementing their third Environmental Management Plan (2010–2020) contributing to the sustainable management of ecosystems. The Maldives, Cape Verde, Guinea-Bissau, Comoros and São Tomé and Principe have submitted National Adaptation Programmes of Action (NAPAs) to the UNFCCC. All NAPAs outline links between conserving ecosystems and their services, and maintaining food security, but little mention is given to the importance of local knowledge.

The Maldives' Ministry of Environment [126] produced a report outlining climate change impacts on food security and a food security strategy [127]. The latter refers to the need to use "traditional knowledge" (p. 15) and to "[enhance] the role of natural resources and ecosystem functions [as] essential for food security" [127] (p. 19). Mauritius' Ministry of Agro Industry and Food Security [128] produced a "Food Security Fund Strategic Plan 2013–2015" in light of challenges including climate change. This document refers to the need to "adopt environmentally friendly production practices" (p. 44), yet it does not discuss ecosystem approaches or using local knowledge. These documents reflect a strong focus upon the importance of ecosystem-based approaches for food security in a changing climate but they do not specifically discuss EbA for food security or the need to integrate local and external knowledge. Consideration is given to a wide range of ecosystems, but the lack of focus on food security and knowledge integration means that these topics are being bypassed.

Donor support in the AIMS region is centred upon the implementation of identified environmental, food security and climate change strategies. There are many projects at the national level where, compared to the regional level, further consideration is given to the actual implementation of EbA approaches. In some countries, there is a bias towards coastal ecosystems and, again, little mention is given to the importance of local knowledge. The one project identified which specifically refers to EbA is in the Seychelles, entitled "EbA in Seychelles" [129] and aiming to incorporate all ecosystems [130]. The overall goal is to ensure that the Seychelles' development is sustainable and resilient to anticipated climate change impacts, with activities directly related to food security including forest restoration to enhance water-soil infiltration and water storage capacities, wetland and mangrove restoration, coral reef construction, rehabilitation, restoration and protection, and coastal erosion management [130]. Despite the use of an EbA approach, there is no mention throughout the project documentation of the use of local expertise and knowledge, despite the key principles of EbA [130].

Other national level projects directly and indirectly stress the importance of ecosystems for food security in a changing climate but in most cases do not specifically discuss EbA or the need to integrate local and external knowledge. The government of São Tomé and Principe, for example, established a National Adaptation to Climate Change Program focusing on land and coastal adaptation. The World Bank funded component contributes to increased fisheries security through improved safety measures for fishermen at sea and coastal protection measures for vulnerable communities. Whilst the project documentation does not mention ecosystems directly, the focus is clearly upon coastal ecosystems [131]. No reference is made to using local knowledge and expertise. The UNDP funded component of the programme, however, directly describes a focus on terrestrial ecosystems and food security. Through the protection of agriculture and forest ecosystems, this project aims to strengthen climate resilience in vulnerable communities and increase food security [132]. The integration of traditional farming practices with modern processes is also briefly mentioned [132].

AIMS-region SIDS are for the most part implementing national level action in isolation of each other due to the lack of a regional approach, meaning that transferring lessons and exchanging advice is limited. Whilst this prevents opportunities for learning and sharing as has occurred in the Pacific and Caribbean SIDS, it does allow for more context-specificity. That has the potential to build upon locally-based knowledge in addition to external knowledge. Indeed, large national projects funded by major donors such as those mentioned above are increasingly linking with local level action. Linking national and local actions, and using both local and external knowledge, will help to contribute to the development and implementation of appropriate, context-specific EbA approaches for food security in a changing climate within AIMS-region SIDS.

4.3. Local Level Action in AIMS SIDS

There are many initiatives occurring at the local level to address food insecurity and climate change impacts, although not to the extent of those in Pacific and Caribbean SIDS. In many cases, they are not well documented or publicised, presenting difficulties in evaluating their impact and the extent to which EbA approaches using local and external knowledge are applied to food security.

The majority of EbA actions at the local level have been or are being implemented by local and/or international non-governmental organizations (NGOs). This movement has been mostly led by international conservation organizations e.g., International Union for the Conservation of Nature (IUCN), BirdLife International, World Wide Fund for Nature and The Nature Conservancy, and subsequently adopted by local organizations, such as Live and Learn Environmental Education, and Reef Conservation in the Maldives.

At the local level, more attention is paid to specific EbA approaches and their benefits for food security and CCA. One example of an ecosystem-based project improving food security at the local level comes from Reef Conservation in the Maldives who work with local communities to establish voluntary marine conservation areas, thereby regenerating marine life and biodiversity, and contributing to fisheries food security [94]. Also in the Maldives, Live and Learn Environmental Education are addressing ecosystem conservation and restoration through the development, and implementation of a community-based environmental awareness programme. That, in turn, will lead to improved ecosystem health and services as community members become more aware of their actions, and further links with food security.

In the Seychelles, the Val d'Andorre Farmers Association [93] works to conserve traditional agricultural techniques and food crops. That maintains the balance within the ecosystem and provides further protection against climate change impacts. The Government of the Seychelles, through a project implemented by IFAD, is also promoting small-scale agricultural and artisanal fisheries development on the islands of Mahe, Praslin and La Digue. This is to promote climate-proof agriculture and fisheries practice while ensuring food security. These projects explicitly highlight the importance of involving local communities and their knowledge in the development of ecosystem-based solutions for food security concerns.

5. Discussion: Gaps and Actions

This review of EbA-related approaches for food security, focusing on the need to integrate local and external knowledge in AIMS-region SIDS, reflects the limited experience in using EbA for food security. This situation is compounded by the lack of a regional framework connecting AIMS-region SIDS and their initiatives to address food insecurity and climate change impacts. There is also limited emphasis upon the integration of local and external knowledge. SIDS in the AIMS region are considerably diverse and spread across a wide geographical area. Hence, a "one size fits all" approach would not be appropriate. There could nonetheless be some value in bringing together existing approaches, so that lessons and good practices could be used while balancing potential transferability and local contextuality. There is also merit in learning from similar initiatives in Caribbean and Pacific SIDS which are more advanced in applying approaches to address food insecurity and climate change. That would provide practical guidance to help improve the implementation of EbA approaches for food security, including knowledge integration across scales within the AIMS region.

Yet despite this critical review and the possibilities for improvement, the lack of mention of local knowledge in national or regional policy does not prove that local knowledge is not considered at all. Government workers live in the country and bring their local knowledge to their jobs. Proving that implicit local knowledge is or is not included in specific documents is difficult. Conversely, without specifying the importance of local knowledge and being implicit about its inclusion, there is no guarantee that those living in a SIDS develop or apply their own knowledge. Although there is no evidence for plans or desires to eliminate or avoid local knowledge anywhere in the AIMS-region SIDS, that could be an unintended consequence of not highlighting it.

To avoid the fate of "eliminate by attrition" or "avoid by inertia", it is important to be explicit about the need to use local knowledge and how to do so—and to celebrate its inclusion without expecting or assuming local knowledge to do everything. In contrast, being explicit about the need to integrate knowledge forms is the key to applying EbA approaches for food security under climate change. It is that key which is most frequently missing from the initiatives discussed above and its continued absence will perpetuate the gaps identified below. Consequently, that key forms the basis for this Section identifying gaps to be filled and actions which contribute towards filling those gaps.

Gap 1: Ecosystems are strongly connected with food security and climate resilience, yet there is little connection with food and climate policy and action at national and local levels.

As IUCN [19] (p. 3) describes, "Ecosystem degradation and weak ecosystem governance can undermine the effectiveness and impacts of food security policies, while inappropriate policies can damage ecosystems and their ability to support food systems". Developing and implementing food security policy needs to move beyond the conventional focus upon productivity, trade and macro-economic issues towards an ecosystem-aware approach connecting inter-linked issues such as climate change, sustainable development, land use planning, EbA and food security, vertically and horizontally within national and local government [19]. Without that, long-term food resilience will remain ephemeral in light of climate change.

Some AIMS-region SIDS, such as the Maldives and Mauritius, have recently taken steps to determine connections amongst food security, climate resilience and ecosystems in their national level strategies.

Whilst the Maldives food security strategy outlines a need for "…a collaborative effort to build more locally-based, self-reliant food systems…" [127] (p. 13) there is no clear direction as to the involvement of local communities. Large gaps remain pertaining to the implementation of such policies at national and local levels, again showing that not making local knowledge explicit can mean that little happens on the ground.

Meanwhile, other AIMS-region SIDS have yet to make strong connections amongst ecosystems, food and climate policies. There is little evidence of participatory decision-making or the integration of local and external knowledge in addressing ecosystem, food and climate concerns. Consequently, those SIDS are not expected to be able to maintain solid food security. In AIMS-region SIDS, it is largely the rural poor who are the custodians of ecosystems and those who are most often affected by food insecurity and will be most affected by climate change. The implementation of policies that ignore local knowledge and experience of these key stakeholders are unlikely to succeed [19].

Gap 2: Although AIMS-region SIDS are spread over a wide geographical area, they share several common features and vulnerabilities, yet no regional framework connects these SIDS to address ecosystem, food security and climate change concerns.

Approaches to address ecosystem, food security and climate change concerns—whether termed EbA, CCA, food security, DRR or other processes—are occurring in a very ad hoc and disparate fashion with limited connections across local, national and regional scales. That makes it hard to coordinate, to learn lessons, and to transfer knowledge. The development and establishment of a regional-level framework similar to, for example, CCCCC for Caribbean SIDS and SPREP for Pacific SIDS, would enable lessons, knowledge and experience to be shared across and within the AIMS region—in addition to sharing knowledge with other SIDS and beyond the SIDS. Without that sharing, it will be much harder to implement EbA approaches for food security under climate change, because everything needs to be developed from the beginning rather than learning from others. Furthermore, actions to address ecosystem management, food security and climate change impacts could be consolidated and generic principles could be developed and applied to disparate case studies to further the development and implementation of EbA approaches for food security.

Gap 3: EbA stresses the need to build on local knowledge, yet integrating local and external knowledge for EbA approaches for food security in AIMS-region SIDS rarely occurs in practice.

A wide range of EbA-related actions for food security are underway or have been completed in AIMS-region SIDS with many multi-country and national level projects mentioning ecosystems and links with food security [117]. Nevertheless, little reference is given explicitly to EbA, with only one project specifically labelled "EbA", and even less attention is given to the integration of local and external knowledge. That is not necessarily problematic in principle, since EbA is the same as ecosystem-based management; as long as ecosystem management is being enacted, EbA is being effected. It could be a problem in practice when donors seek projects and programmes labelled "EbA" and so might not support appropriate actions being undertaken because those actions have the wrong label. In contrast, at the local level, national-based NGOs are starting to adopt EbA approaches for food security, which are more focused on using local and external knowledge, e.g., in the Maldives and the *Seychelles*.

Given the increased focus upon the need to use local knowledge and experiences by international NGOs, many multi-country and national level projects have stressed the incorporation of local knowledge into project activities, e.g., UNDP in São Tomé and Principe [132] and the International Development Research Centre in Guinea-Bissau and Cape Verde [118]. How that is achieved in practice is not always fully articulated, despite the methods discussed in Section 4 with a consequence that the idea of integrating knowledge forms remains articulated on paper without being fully put into practice. The methodologies, tools and networks outlined are a base upon which further evaluation, consolidation and development within the AIMS region context is required in order to facilitate further the integration of local and external knowledge. In particular, differences amongst and within communities, including indigenous peoples, need to be respected in order to ensure local support of any EbA approach for food security. Local communities are critical actors in sustaining ecosystems and their services for food security and should be assisted in engaging with external actors in designing and implementing appropriate solutions [19,133,134].

Action 1: Identify and highlight local and external knowledge for EbA for food security in a changing climate.

Similarly to other SIDS (see [10]), there is a lack of specific information regarding local and external knowledge for EbA for food security. Methodologies and tools reviewed in Section 2 identify the "how" of integrating knowledge with the references, often giving step-by-step methods accompanied by case examples. These methods need to be contextualised for AIMS-region SIDS using relevant and applicable local and external knowledge, as an explicit action by those implementing EbA—including setting up a regional framework and network to fill in gap 2. At the local level, EbA approaches are often not differentiated from non-EbA activities, and are frequently integrated into wider development actions as most communities have immediate life and livelihood needs including food, water and health. It is important that these needs are recognised in order to engage local people in EbA or else a danger exists that the community will lose interest and be unsupportive, as has occurred in Tonga [81]. To keep the local community on board, it is important to demonstrate some immediate gains as a way to introducing and engaging with long-term EbA approaches to food security, helping to fill gap 3.

Action 2: Draw upon past knowledge and practice.

Since EbA is a modern term, the development and implementation of approaches for food security would benefit from building upon the extensive literature available on "ecosystem-based management" and "ecosystem management", the breadth and depth of which is often not fully considered in current approaches. Otherwise, it is likely that the same ideas will be re-tested, with similar failures and successes, rather than learning from past experience. Additionally, EbA approaches for food security should draw upon past work in a variety of sectors which has incorporated local and external knowledge. Often, false assumptions exist that communities are homogenous or that local knowledge is one coherent entity [135]. In reality, there are many different sub-groups within and outside a community that hold diverse points of view and diverse levels of influence, especially regarding knowledge integration. In many cases, the techniques discussed in Section 2 are designed to resolve conflict and air different opinions, especially from minority or marginalised groups, so these can be discussed and compromises can be reached in order to integrate all perspectives into final actions as best as possible. Drawing on past

experience to achieve full inclusiveness helps to ensure that local knowledge is explicitly highlighted and applied, helping to fill Gaps 1 and 3.

Action 3: Use local champions.

With no current regional framework in place, EbA approaches for food security in AIMS-region SIDS would benefit from local champions who, in turn, could benefit from a "champion network" created as part of filling gap 2 to support their community work. Involving local community members, as MSV does and as is done within wider DRR initiatives, can often be enhanced by recruiting local community champions who are able to generate enthusiasm within a community [136]. Local champions can establish links between community and external bodies in addressing specific issues and help to ensure continuity of initiatives, contributing to filling in gaps 1 and 3.

Action 4: Monitor and evaluate regularly, including in-depth reviews of ongoing work and gaps.

The AIMS region needs to build up a repository of good practices regarding EbA approaches for food security in order to further develop and refine future implementation. Existing approaches related to EbA and food security need to be carefully monitored and evaluated to determine their successes and challenges, and how local and external knowledge is integrated. A regional framework and network, such as that which would fill in gap 2, could be one mechanism for doing so. Given the extent of initiatives in AIMS-region SIDS which do not specifically mention EbA, but which still use an ecosystems-based approach for food security, it is particularly important to determine generic principles for EbA approaches that ensure the integration of local and external knowledge. That would enable a clear analysis and examination of disparate case studies across the AIMS region and identification of good practice examples to further the development and implementation of EbA. As with EbA itself, monitoring and evaluation should involve the input of local and external actors to ensure all observations and interpretations are accounted for—and again supporting the filling in of gaps 1 and 3.

6. Conclusions: The AIMS-region SIDS and Beyond

From this review of EbA for food security in AIMS-region SIDS, focusing on the integration of external and local knowledge, three main ways forward are suggested to ensure that the proposed actions do indeed fill in the identified gaps in AIMS-region SIDS—while contributing further afield. The ways forward also connect the actions suggested to ensure that the actions are not implemented in isolation, but work together to boost each other.

First, there is a clear need to deepen the understanding of relationships amongst ecosystems, food security, and climate change within and across AIMS-region SIDS. This would involve reviewing the food security status of each SIDS, and how ecosystems and ecosystem services contribute to food security. Such a review would help to identify inter-sectoral linkages, e.g., between agriculture and fisheries, and synergies, e.g., amongst food, health, and nutrition [19]. In turn, this would highlight the necessity of incorporating ecosystem factors and linkages within different sectors and promote good governance. Establishing a regional network would assist AIMS-region SIDS in collaborating to interpret this information for effective ecosystem-based food security policy and practice at regional, national, and local levels. Lessons should be drawn from SIDS which have started to explore these relationships, e.g., the Maldives and the Seychelles, while recognising differences from other SIDS

regions, e.g., that the Caribbean SIDS often neglect the diverse range of inland ecosystems which can support food security [10], a problem which was not as prevalent in the AIMS-region SIDS, perhaps due to their comparatively small size.

The second way forward is to ensure information developed and shared at regional and national levels is accessed in applicable and usable formats at local levels. In addition to accessing external knowledge regarding linkages amongst ecosystems, food security, and climate change, community knowledge should be shared in usable formats with external stakeholders. The development and implementation of EbA approaches for food security would be considerably improved through cataloguing knowledge and its efficacy in addressing food security concerns in a changing climate. Methods outlined in Section 2 would need to be researched, piloted, and evaluated before full-scale implementation in a specific area or SIDS. Using local champions to establish strong "inter-community" and "inter-island" networks and exchanges would help to cultivate knowledge building and sharing on EbA through identifying and cataloguing applicable local knowledge. Quantitative and qualitative evaluations of approaches implemented would then enable good practices to be recognised which could potentially be transferable across other communities, ecosystems, and AIMS-region SIDS, as well as beyond the SIDS.

The third way forward is to empower action by communities. Given that rural communities are often the custodians of ecosystems and are most affected by food insecurity, these communities should be able to implement EbA approaches and to access external knowledge across diverse ecosystems. The planning, development and implementation of a training-of-trainers programme promoting "community-to-community" learning and exchange, in addition to engagement with external stakeholders in identifying solutions for EbA for food security, would contribute to an evidence base supporting knowledge integration in AIMS-region SIDS. The resulting development of research, policy, and practice tools, the application of materials and guidance on EbA approaches for food security, and the integration of external and local knowledge into local and national development processes, would enhance linkages with wider governance processes at all scales.

Using the AIMS-region SIDS, this paper has critically reviewed EbA approaches for food security under climate change, focusing on the need to integrate external and local knowledge. Proper application of EbA policy and action for food security in a changing climate within AIMS-region SIDS would facilitate its integration within wider development processes, lessons from which could be applied to other SIDS—and further afield to join forces in dealing with climate change.

Author Contributions

Tiina Kurvits designed the research, Jessica Mercer undertook the literature review, and all authors contributed equally to analysing the data for results and interpreting the data for discussion and conclusions. All authors also contributed equally to writing the paper. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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