



Building robustness for rural revitalization: A social-ecological system perspective

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ABSTRACT

Collaborative governance has the potential to foster co-creative solutions to rural issues. Many rural areas have deteriorated due to rapid and encroaching urbanization and globalization. By building institutions to support and convey collaborative governance processes, rural areas can be revitalized and equipped with the ability to cope and evolve in the face of unexpected shocks and disturbances, they can be made robust. Concepts and arguments developed in a social-ecological systems framework are drawn on to flesh out a theoretical logic to aid understandings of how institutional design can enhance the robustness of a rural social-ecological system through fostering collaboration. A critical instance case study of a rural revitalization project undertaken at a traditional village in Hong Kong, Lai Chi Wo, allows for in-depth analysis of the relationship between institutional design, collaborative governance and robustness. Through this case study, we show how institutions can be designed and built to foster collaborative processes and, hence, enhance the system's robustness. The demonstration of this logic extends theoretical understandings regarding the identification of mechanisms through which institutional variables can impact and condition collaborative processes and so outcomes. While demonstrated here in the case of rural revitalization, these findings contribute to wider understandings of how collaborative endeavors can be fostered and enhanced and how robustness in social-ecological systems can be better supported.

Author contribution statement

All authors contributed to the writing, reviewing and design of the manuscript. The manuscript was conceived by Wai-Fung Lam, who also began the initial draft. Vivian H.Y. Chu and Jessica M. Williams were then responsible for material preparation, data collection and analysis and took over the drafting of the manuscript. Wai-Fung Lam supervised, oversaw and reviewed the manuscript. All authors commented on previous versions of the manuscript and all read and approved the final manuscript.

1. Introduction

Research over the last decades has accumulated important theoretical and empirical insights to show that collaborative governance is a viable institutional alternative to hierarchy or markets in solving many public problems (Emerson and Nabatchi, 2015; Ansell and Gash, 2018; Torfing et al., 2020; Torfing, 2022). In particular, the application of collaborative governance to environmental and sustainability

management has attracted substantial scholarly interest (Hutter, 2016; Florini and Pauli, 2018; Shulla et al., 2020; Sørensen and Torfing, 2022).

Significant progress has been made in identifying institutional variables and processes that are instrumental to understanding and applying collaborative governance (Emerson et al., 2012; Bryson et al., 2015). There has been, however, limited research to identify and decipher the mechanisms through which the institutional variables affect and condition collaborative processes and, hence, outcomes. Interesting exceptions include studies that examine how institutional design of collaborative governance affects learning and value alignment (Gerlak and Heikkila, 2011), the formation of belief systems (Lubell, 2003) and the mitigation of power imbalance (Choi and Robertson, 2013). This study complements this line of research by drawing upon concepts and arguments developed in a Social-Ecological System (SES) framework to flesh out a theoretical logic that explains how institutional design can enhance the robustness of a SES—a system's ability to continue to function and adapt to the changing environment over a period of time—through fostering collaboration. Taking the SESs framework allows for the inclusion of both the social and ecological systems involved

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in complex environments in analysis, enabling the consideration of the human interaction and impacts on ecosystems, and vice versa. Through considering and balancing both systems, sustainable and socially functional environments can be built (Folke, 2006).

We argue that collaboration is an on-going concern that requires those involved to engage continuously with one another in a productive manner, to be willing to invest continuously in joint problem-solving efforts and to be able to work together to cope with disturbances and contingencies. An institutional design of collaborative governance that provides sufficient incentives and supports to sustain this ongoing concern can harness the complexity involved in a SES and, hence, increase the robustness of the system.

Drawing upon the literature of SES and institutionalism, we conduct an in-depth case analysis of the Lai Chi Wo rural revitalization project in Hong Kong—an effort recognized by the UNDP to be a successful example of collaborative governance for rural sustainability—to illustrate how institutions can be designed to facilitate collaboration and, hence, enhance the robustness of a SES. The success story of Lai Chi Wo (LCW) involves collective efforts by actors across different sectors to cope with recurring challenges. In the case analysis, we describe the way that cross-sectoral collaboration in LCW unfolded, juxtapose and compare the empirical patterns with what theory suggests, present conjectures to expand and develop the theory and explicate the implications of the LCW experience for the study of collaborative governance and robustness.

2. Rural communities as social-ecological systems

Across the globe, rural areas are experiencing significant changes, facing pressures from urbanization and globalization. Rapid urbanization and industrialization has contributed to demographic change and socio-economic transitions, resulting in the, often drastic, decline of rural populations (Walsler and Anderlik, 2004; Bjorna and Aarsaether, 2009; Stead, 2011; McGreevy, 2012). The loss of rural communities has been accompanied by the widespread loss of farmland to urban encroachment, the abandonment of rural housing and the degradation of natural and built resources and other ecological services (McGreevy, 2012; Li et al., 2014; Williams et al., 2021). There is increasing recognition from researchers and development practitioners as to the importance of revitalizing rural regions due to their role in underpinning the development of sustainability models, and supporting societal health and wellbeing (Williams et al., 2021). Rural revitalization is the process to reverse rural decline through focusing on the creation and stimulation of opportunities to generate economic and social benefits to local communities and beyond, while preserving and sustaining the dynamics and features that characterize rural life (Kenyon, 2008; Meyer, 2014).

A rural community that comprises natural (lands, water, landscapes) and man-made (built structures, rural infrastructure such as irrigation) resources, resource users and stakeholders (the villagers, public officials, concerned environmentalists) and a governance structure (village decision-making institutions and collaborative governance) is an example of a SES. A SES is composed of both bio-physical and social sub-systems where humans, through harnessing the operation of the systems and their interface, strive to attain desirable systemic consequences (Folke, 2006).

In a SES, each of its subsystems is hierarchic in structure until the lowest level of the elementary subsystem is reached (Simon, 1962; Young et al., 2006; Poteet, 2012; Cole et al., 2019). The structures and processes of these sub-systems at different levels have different spatial and temporal attributes that affect each other (Anderies et al., 2004; Liu et al., 2007). Within the rural community, the operation of its bio-physical sub-systems, for example paddy fields, both affects and is affected by social sub-systems, such as the ownership structure of farmlands and irrigation institutions. The rural community is in turn nested within a larger scale SES at a higher level, such as a rural region in a city. The linkage across different scales can affect the way the SES

operates and how it is affected by higher or lower scales. Highly complex conflicts or issues can arise out of the interactions between SESs of different scales or the influence of larger scale SESs on the operation of smaller ones.

The operation dynamics of a SES are undergirded by the interdependency between the social and bio-physical systems. Neither of these can be considered in isolation of the other when understanding the systemic dynamics or formulating solutions to problems (Folke 2006; Liu et al., 2007). These complex adaptive systems involve many actors interacting and adapting their behavior to each other as well as the biophysical sub-system in which they find themselves. The aggregated patterns of behavior or the systemic features that emerge from such interactions are often counter-intentional and counter-intuitive, very often beyond expectation (Ostrom, 2007; Folke et al., 2010). These adaptive behaviors and interactions coalesce to produce emergent systemic properties that define the characters and dynamics of the SES (Camazine et al., 2001; Carlson and Doyle, 2002). Importantly, the process of aggregation of individual behaviors into systemic properties is often nonlinear and combinatorial. Trivial changes at the individual level may trigger chains of effects that lead to substantive transformation and even surprises at the systemic level (Anderies et al., 2004).

The dilapidation of rural communities amid rapid economic development in many Asian countries is a case in point. In many big Asian cities, rural villagers decided that they would be better off if they abandoned farming as their major economic activity. In other words, their decisions that farming was no longer worthwhile were made based upon the bio-physical and social-economic sub-systems in which they found themselves (Rigg et al., 2016). When more villagers abandoned farming as their primary economic activity, the economies of scale of many farming activities dissipated, triggering a cascade of land fallowing (Lam and Chiu, 2016; Rigg et al., 2018). The large-scale abandonment of farming affected not only the bio-physical system (paddy fields that lie fallow for a long period will become uncultivable) but also the social-economic landscapes that constituted the village community (villagers have lost the incentives to engage in village governance). The dilapidation of rural communities is a result of the collapse of both the bio-physical and social sub-systems.

Revitalizing rural communities, particularly those in the peri-urban setting, requires managing urban and rural connections on the one hand; and ensuring that rural villagers are able to make a sustainable living in the modern context on the other (Williams et al., 2021). It involves stabilizing and increasing the local population, diversifying the economy and employment base, maintaining an acceptable level of services and safeguarding significant rural attractions (Meyer, 2014). The results are rural areas that are more productive, sustainable, healthy and attractive places to live (Steiner and Fan, 2019).

The continual growth or survival of a dynamic SES, therefore, requires that the system be able to adapt continuously to shocks or perturbations generated by the changing environment and its own internal dynamics (Anderies et al., 2004; Folke et al., 2010). The key to the viability of the SES is its robustness—the system's ability to continue to attain and maintain desired outcomes and functionality in the face of uncertainty and external shocks (Capano and Woo, 2017, 2018).

The robustness of SESs hinges on the effective management of three mechanisms of system dynamics, which commonly underline their operation and evolution. First, the high degree of connectedness of components in the system suggests that a small change in one circle could trigger a cascade of feedbacks through the links. Second, complex interactions between individuals means that individual actions will bring about long-term repercussions; time dynamics such as time lags and cumulative effects are almost certain to affect the operation and evolution of a SES (Camazine et al., 2001). Third, complexity also means that the action and interactions of individuals at a particular time point is context specific. Whether and how an action affects the operation of the system depends on when and where that action occurs. With all these

mechanisms taking effect, the impact or effect of any action or shock to the system is always nonlinear, suggesting a high level of uncertainty and risk (Carlson and Doyle, 2002; Capano and Woo, 2017).

The complexity of the SES necessarily precludes the possibility of coordinating the multitude of actions and interactions by command and control. Being able to manage the link between individual action and aggregate systemic patterns is key to building system robustness. Hence, the crafting of a range of institutions that facilitate collaborative dynamics provides a crucial structure for building a robust SES (see Fig. 1).

3. Institutions, collaborative governance and SES robustness in the rural context

A robust system, therefore, requires the collaboration of a wide range of actors under the framework of a sophisticated set of institutions. Conceptualizing a rural community as a SES focuses attention on how institutions can be designed to harness the actions and interactions of villagers and relevant stakeholders to engage in collaboration and build robustness in the system.

3.1. Robustness

For the revitalization of rural communities to occur, ensuring the robustness of the rural SES is vital. While resilience focuses on the ability to return to an equilibrium after a shock, robustness emphasizes the retention of functionality amidst shock or conditions of uncertainty. A robust SES can maintain systemic functionality in unexpected circumstances or conditions of uncertainty. This hinges upon the system's ability to detect problems as soon as possible, to generate and apply solutions to cope with problems of different scales at different levels, to be able to remember the successful solutions and experiences and to imbed them in the institutional and ecological arrangements (Anderies et al., 2004).

Robustness enables rural SESs to respond effectively to encroaching global and urban influences while retaining the functionality of the village community, particularly when such outside influences are uncertain and unpredictable. As is the case with all SESs, a wide array of processes and functions operating at different levels and spatial scales are embedded within a rural community. For example, many rural village's lifestyles and traditions are rooted and integrated with the local ecology, and so are particularly vulnerable to external shocks and disturbances (Williams et al., 2021).

3.2. Collaborative governance

Collaborative governance may be suited to addressing the complexities and vulnerabilities within SESs and, in doing so, enhance the robustness of a SES. Collaborative governance research has so far been focused on two levels. The first is the institutional level, which focuses on the structural design of collaborative governance. At this level, comparative institutional analyses suggest that collaborative governance is an arch-typical institutional arrangement characterized by the

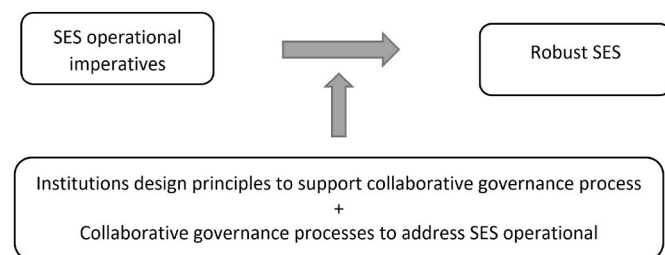


Fig. 1. Relationship between SES operational imperatives, institutional design principles and collaborative governance processes and robust SESs (Authors' own work).

involvement of multiple stakeholders from different sectors involved in consensus-based decision-making and implementation (Ansell and Gash, 2008; Ostrom 2010). In many cases, collaborative governance is a response to the failure of government arrangements or marketized systems (Donahue and Zeckhauser, 2011). An emphasis of recent research has been on how collaborative governance can foster the co-creation of sustainability solutions and innovations (Ansell and Torfing, 2021; Araújo and Franco, 2021).

The second level is managerial, focusing on the process of collaboration and its dynamics. Specific patterns of interaction, including regular communications, consensual decision-making, continual learning and trust-building, have been identified as instrumental to fostering the collaborative process (Agranoff and McGuire, 2003; O'Leary and Bingham, 2009; Huxham and Vangen, 2005). Building upon this knowledge, researchers have developed useful frameworks to inform further research (Ansell et al., 2022).

The governance of collaborations often arises from frequent, structured exchanges that develop network level values, norms and trust enabling social mechanisms to coordinate and monitor behavior. Contextual elements are particularly important, these include external factors such as government policies and mandates as well as pre-existing relationships among members. Internal factors such as network size, collaborative tasks and the degree of trust amongst members can also influence governance structures (Bryson et al., 2015).

Of note to this study are the preconditions of leadership and collaborative processes, which are inclusive, mutually reinforcing and innovative. More specifically, leadership is required to navigate and drive the collaborative process, inclusive processes are necessary to unify and address possible power imbalances, nested arrangements make it possible to address solutions of different scales and scopes more quickly and appropriately, while a diversity of institutions allow for collaborations to produce innovation. Collaborative governance processes of on-going learning and consensus building are also essential for conflict resolution and adaptability (Bryson et al., 2015). Ongoing learning is a product of effective engagement and focuses on boundaries between organizations as sites for learning how to work together. It provides a way of working out common goals and consensus, which helps build a collaboration's capacity to resolve conflicts and organize collective actions (Brunckhorst & Marshall, 2007). Through supporting and maintaining effective collaborative processes, institutions play an important role in contributing to the robustness of a SES.

3.3. Institutions

Building a robust rural community requires diversity in the types of institutions that manage the SES (Lam, 2006; Ostrom et al., 2011). Previous research on the governance of common-pool resources have discovered that self-governing groups that are better nested with institutions at higher jurisdictional levels are more robust (Lam, 2006; Lam and Chiu, 2016). Such distributed decision-making arrangements allow those with the local knowledge and experience of the SES to address issues quickly and directly, without having to go through various bureaucratic hierarchies, which are removed from the relevant context (Lam, 2006; Ostrom et al., 2011).

The robustness of a SES is enhanced when institutions foster the generation of a constellation of options and solutions to problems. The deliberation of different knowledge spheres (as involved in collaborative governance) opens-up the possibility of generating a wider portfolio of solutions and approaches to tackle different challenges encountered by a SES. Institutional complexity should not be mistaken as the necessary and sufficient feature to cope with problems at different levels. It is the conscious and meticulous design of this complex set of institutions that is the key to upholding a SES through shocks and disturbances (Ostrom, 2007).

Alongside these nested arrangements, committed boundary spanning leaders who possess collaborative mindsets are required to navigate

these different institutional arrangements. In the absence of hierarchical power and control, such leadership enables different dimensions of collaboration to form a whole and achieve outcomes (Bryson et al., 2015). In addition, the importance of horizontal coordination has been stressed in research on rural sustainability. In rural revitalization, farmers and landholders who experimented with forming producer alliances for value-adding activities derived significant benefits in terms of reduced risks and uncertainties (Brunckhorst and Marshall, 2007). Given the importance of multi-level and multi-scale coordination, the construction of an array of institutional arrangements connecting organizations across space, sectors and levels becomes an integral part of any robust collaborative system.

Institutional design facilitating inclusive processes is conducive to cross sector collaboration. Institutions that enable stakeholders to engage and communicate with one another help bridge diverse ideas, forge a unifying vision, and attenuate possible power imbalances. In turn, these inclusive processes enhance the governance of collaboration and facilitate the implementation of agreements (Bryson et al., 2015). Based on the premise that the capacity of a collaboration to cope with shocks and disturbances originates from the collective efforts and integrated knowledge of a variety of actors, imbalanced power relations undermine such capacity. In such circumstances, less powerful stakeholders will be prevented from participating in the development of a common understanding of a problem and are unable to contribute to the development of feasible solutions. Significant power imbalances that result from pre-existing hierarchies or disparate resource availability between sectors, therefore, need to be addressed to form and maintain an effective collaboration.

4. Institutional design principles for robust SESs

In general, collaboration processes are governed, supported and maintained by institutions established to mobilize and coordinate the integration of different stakeholders' efforts towards some form of collective goal. Such institutions can facilitate collaborative governance mechanisms to build robust SESs. Institutions are the vehicles through which interactions and processes occur. North provides the common definition of institutions as "the rules of the game in a society", which "reduce uncertainty by providing a structure to everyday life" (1990:3). This also makes institutions vital in regulating and mitigating disputes, which is essential to building SESs that can cope with climatic and political changes (Earle et al., 2015; Williams et al., 2020).

4.1. Design principles

The literature of SESs has identified several institutional features that can support collaborative governance processes and so allow for SESs to cope with disturbances and hence be more robust. The first is redundancy, which describes the existence of components (structures and processes) that serve similar if not identical functions (Perrow, 1999; Low et al., 2003). The failure of a component in a system would not adversely affect the functioning of the system as the redundant components will take over (Hammond, 2007). Redundancy allows a system to continue to perform its desired functions even if some of its components fail due to an unexpected event or development (Capano and Woo, 2018). Designing redundancy into a system requires the introduction of duplication and overlapping functions and properties. The presence of different decision-making centers in the same domain is considered essential when governing natural resource systems (Low et al., 2003). In addition, whether the redundant units are allowed to develop different modes and strategies of operation can affect the number of potential ways of problem-solving.

The second feature is modularity, which refers to the ability of the system's components to operate and evolve relatively independently to each other. Modularity pertains to the concept of decomposability suggested by Simon (1962). The operation and survival of components are

necessarily related to each other and coalesce to energize and activate the system. Each of these components, however, has its own logic of operation and evolution due to their functions or scale. In many instances, these elements must adapt to one another within the system, rather than directly respond to the broader environment for the system. Ensuring that these systems can adapt while maintaining coherent relations with one another is key to systemic robustness. Political scientists note the strength of polycentric structure in which multiple decision-making centers exist, managing problems of different scales at different levels (Ostrom, 1989; Sproule-Jones, 1993; Koontz et al., 2015).

A key institutional design question is how to strike a balance between appropriate levels of power for these decision-making centers with a good degree of coherence. The intricately linked processes and functions at different layers of a SES means that an overall coherence must be achieved between different organizational components. At the same time, they must, to some extent, operate independently to prevent a cascading effect. It is thus necessary to find a delicate balance where the various institutions can function coherently as a whole while still being able to operate relatively independently (Lam and Chiu, 2016).

The third factor is diversity. As SESs must adapt and respond to external shocks and novelties, having a good repertoire of prototype solutions is essential for adaptation. Three design issues can affect diversity (Lansing, 2003; Janssen and Osnas, 2005; Janssen and Anderies, 2007). First, in conjunction with the idea of redundancy, whether the redundant units are allowed to develop different modes and strategies of operation can affect the potential options for problem-solving. Second, whether the SES contains mechanisms that allows the generation of ideas to affect the size and scope of the problem-solving toolkit (Janssen and Osnas, 2005). Third, the repertoire of prototypes can be sustained only if institutional memory is built into the institutions so that ideas and experiences can be systematically recorded, catalogued, and drawn upon. This collection of information provides a fundamental common ground to act as a basis for future decision-making, enabling actors in a SES to coordinate their actions in pursuance of the long-term sustainability of their system (Lam, 2006).

Diversity complements effective learning, which is the fourth process important in ensuring the robustness of a SES and it occurs at both the individual and system levels (Janssen and Osnas, 2005). At the individual level, actors should be encouraged and facilitated to draw upon a repertoire of solutions to cope with disturbance and to document as well as share their successful experiences. Yet sometimes adaptation occurs at the system level and is done through generating new components or getting rid of failing components. What kinds of adaptation are appropriate in particular situations depend on the structure and characteristics of the disturbance regime. As such, robust SESs require features that encourage and support effective learning processes.

4.2. Robustness trade-offs

While these system features are important, it is necessary to strike the correct balance between them when facilitating collaborative governance to ensure a robust SES, particularly from a governance perspective (Capano and Woo, 2018; Janssen and Anderies, 2013). The incorporation and operation of diversity, modularity, redundancy and effective learning into institutional designs needs to occur in an integrated and calibrated manner. If one of these components is overly implemented, the collaborative governance processes could be compromised and the system could fail or be disrupted (Capano and Woo, 2018).

One of the biggest trade-offs is between robustness and performance (Csete and Doyle, 2002; Janssen and Anderies, 2013). The more a system is made robust towards expected disturbances, the more the system may be vulnerable to unknown ones, making the system both robust and fragile (Carlson and Doyle, 2002; Janssen and Anderies, 2013).

Conversely, an over-abundance of diversity could cause gridlock,

particularly if different decision nodes come into conflict. When designing institutions, particularly those that operate relatively independently, therefore, it is important to balance the appropriate levels of power for these decision-making centers with a good degree of coherence. A lack of integration due to too many modular components could disrupt or prevent the full achievement of the system's functioning (Capano and Woo, 2018). There is also the risk that robust policies and institutions can be detrimental to public sector innovation. Robust institutions can become very difficult to change and by eliminating perceived negative aspects of uncertainty, they can shut down potential opportunities for policy entrepreneurs or other stakeholders to reinvent or rethink existing policy processes and procedures (Capano and Woo, 2018).

It is necessary, therefore, to take a coordinated approach to implementing these characteristics into institutions. It is also necessary for institutions to maintain a level of flexibility to ensure their functions are maintained, or that they can be adapted to maintain their functions when disturbances materialize. As a result, the design of diversity, modularity, redundancy and effective learning into components involves rigidity and flexibility. Consequently, when managed well, these system components result in a robust system, however, if badly managed, the sustainable future of the entire SES is at risk (Capano and Woo, 2018). Collaborative governance's emphasis on participatory processes and polycentric or nested institutions means that, when combined with these institutional design features, it is likely to be particularly suited to developing system features to support SESs.

As such, the integration of collaborative governance with robustness is proposed to contribute to the development of a more sustainable, better functioning and equipped SES in the following ways. Adaptable and adaptive institutions can support and maintain collaborative governance processes through the cultivation of processes such as shared understandings, problem solving, trust and commitment. This in turn fosters effective learning, which allows such institutions to react appropriately to changes in the SES. As mentioned, collaborative governance's emphasis on participatory processes and polycentric institutions enables it to manage multiple redundant, diverse or modular system components, and so effectively govern such components to ensure a balance between flexibility and rigidity within the SES. Finally, it is proposed that collaborative features, such as those relating to leadership, trust building, communication, collaborative planning and accountability, can be incorporated and perpetrated by institutions to foster more robust institutional features and arrangements, which in turn creates better equipped SESs.

5. Materials and methodology

An in-depth case study of the revitalization process at a rural village in Hong Kong SAR, Lai Chi Wo (LCW), is undertaken to investigate the design and role of institutions in facilitating and supporting collaborative governance processes and the implications for the SES. This provides an illustration of how the more abstract concept of robustness was manifested within the LCW case study. In this way, the theory on robustness can be advanced through the incorporation of collaborative governance and this logic can further enrich understandings of how collaborative governance can enhance rural sustainability.

This paper focuses on developing the theory on how collaborative efforts build robustness in a SES by examining the logic of how institutions design, employ and operationalize such efforts to influence the robustness of a particular SES. Relatedly, it will also investigate (i) how institutional design can support collaborative efforts to address issues of different nature, and (ii) how trade-offs in institutional design are able to be governed through collaborative processes to contribute to robustness.

A heuristic case study methodology is utilized due to its suitability to examining a specific situation, inducing innovative thinking and in generating new theoretical insights (Eckstein, 1992). This type of case study takes a theory-building approach, the theoretical insights

harvested from the case study can be used to generate further hypotheses to be tested on other cases (Coolsaet, 2016). Heuristic case studies allow for intense analysis and focuses attention on specific variables (Eckstein, 1991), in this instance institutional design and collaborative governance processes, which will allow the logic linking institutional design with collaborative governance and robust SESs to be illustrated and explored. Case selection is important for such analytically inductive research (Coolsaet, 2016), the LCW case was selected due to the wealth of in-depth and detailed data available to the researchers and as it is recognized as a successful case of rural revitalization.

The overall rural revitalization project has generated a wealth of documents and data, which can be utilized when developing the case study. The data from the revitalization program to be analyzed includes both qualitative and quantitative data, of which some are longitudinal. Fifteen in-depth interviews with the principal investigator, project manager, co-investigators, collaborators, researchers, village chiefs, indigenous villagers were conducted to collect firsthand accounts (Table 1). Focus group interviews with those involved in some of the Program's sub-programs, such as the Hackathon, were also conducted (Table 2). Observations of key collaborative and partnership processes were also systematically documented and analyzed. This was combined with satisfaction surveys and independent reviews carried out by experts in the relevant fields on the Program's impact, as well as internal documents, including progress reports, meeting minutes, reflective documents and primary material compiled for various international awards and applications, and external publications such as an information book and a quarterly newsletter (Table 3).

5.1. The revitalization process and the challenges in the Reconstruction of a robust SES

Hong Kong, China, although largely known as a metropolitan city, has a mere 24.3% of urban or built-up land (The Planning Department of HKSAR, 2017). The rural areas of this Special Administrative Region of China, called the New Territories, were once home to hundreds of thriving farming communities. Industrialization and globalization in the 1960s saw many of these villages lose most of their inhabitants to the promise of better employment opportunities in the expanding urban areas. The remaining 586 Indigenous villages (The Electoral Affairs Commission of HKSAR, 2014) are now on the brink of complete abandonment. This has left sensitive ecological systems either at the mercy of unscrupulous developers or suffering from a lack of active management.

Table 1
Interviews with prominent individuals involved in the LCW Programme.

Actor group	Position in/relation to the Programme	Interviewee no.	Year of interview
LCW Programme	Principal investigator	1	2017, 2018, 2019
	Senior project manager	2	2017, 2018, 2019
	Co-investigator (ecology)	3	2020
	Project manager	4	2020
	Project officer	5	2020
	Start-up group A	6	2021
	Start-up group B	7	2021
	Start-up group C	8	2021
	Co-creation group A	9	2020
	Co-creation group B	10	2021
Partner organisation	Partner organisation A	11	2020
	Partner organisation B	12	2020
	Partner organisation B	13	2020
Villagers	Village chief	14	2017
	Village chief	15	2017
	Indigenous villager	16	2017
	Indigenous villager	17	2017
	New villager	18	2020
	New villager	19	2020
	New villager	20	2020

Table 2
Focus group interviews regarding the LCW Programme.

Actor group -	Position in/relation to the Programme	No. of participants	Year of interview
Group 1	Sustainability Hackathon participants	6	2019
Group 2		9	2019
Group 3		12	2019
Group 4		3	2020
Group 5		3	2020
Group 6		5	2020
Group 7		7	2020

Table 3
Types of documents analyzed.

Type of document analyzed	Dept./organisation	Source
Government	Planning department	Meeting minutes General papers Website
	Environmental Protection Department	Information booklet
	Agriculture, Fisheries and Conservation Department	
	Legislative Council Panel on Environmental Affairs	Papers
LCW Programme	Legislative Council	Policy address
	The University Policy for Sustainability Lab	Meeting minutes
		Reflective documents
		Progress report
		Information book
		Funding proposal
		Final report
		Farming Group
Meeting minutes Lease Agreement		

On the social side, the abandonment of villages is seeing village culture and community practices being eroded, with heritage and history at risk of being lost. Consequently, robust systems are required for rural village SESs to retain their functionality and place in the modern world.

The case study village, Lai Chi Wo (LCW), is one of these remote villages¹, which experienced this drastic transformation. Different actors had previously attempted to project diverging visions for the future of LCW, however, innovative and comprehensive efforts were lacking. Villagers were concerned about the cultural heritage and economic viability of their village. On the other hand, conservationists often put biodiversity as their priority. Government officials tend to see the rural landscape as the achievement of various policy objectives, overlooking the cultural and social capital imbedded in such areas (Chu et al., 2022). The first attempt to integrate this spectrum of interests and goals was made by the former Director of Hong Kong Observatory who, since retirement, had become an out-spoken conservationist. He organized many rounds of informal meetings with villagers to gain their trust and invited numerous external parties to visit the village to generate interests in its revitalization. In 2011, he established and became the Chairman of the Hong Kong Countryside Foundation aimed at conserving the rural environment and communities.

The University of Hong Kong later became involved and secured funding from the Hongkong Bank Foundation to launch the 'Sustainable Lai Chi Wo Program' in 2013. The Program has been under the active management of the Policy for Sustainability Lab of the Centre for Civil Society and Governance at The University of Hong Kong (hereinafter the 'Program'). Besides working closely with various interest groups and Indigenous villagers, the Program team works alongside three non-state

partner organizations, the Hong Kong Countryside Foundation, Produce Green Foundation² and the Conservancy Association³. The first was responsible for handling land leasing arrangements for farmland and facilitated the active involvement of the villagers in the Program. Produce Green Foundation is a local organization dedicated to the promotion of organic farming and oversaw the Program's agricultural-related activities. The Conservancy Association, a local environmental NGO, helped with the design and implementation of training and education activities.

5.1.1. Building robustness through collaborative institutions

The following discussion analyzes the ways in which institutions were designed to sustain collaborative governance and address vulnerabilities within the LCW SES. Emphasis is on how institutions can be designed to support collaborative dynamics and their relationship with SES robustness. In particular, the rules and norms created and maintained by these institutions, which are manifestation of institutional design features, and their role in supporting collaborative processes to contribute to a robust SES. The analysis here demonstrates how the design features of modularity, diversity, redundancy and effective learning can be operationalized in a practical setting as well as highlights the interactions between the social and ecological systems in the rural context and how these can be harnessed through collaborative endeavors in moving towards robustness. Collaborative processes are evidenced by those outlined in Fig. 2, namely demonstrations of (i) an array of institutions and connecting organizations that enable frequent, structured enhancing and social mechanisms to coordinate behavior, (ii) leadership in driving and navigating collaborative processes, (iii) inclusive processes to address power asymmetries and ensure representation, and finally, (iv) consensus building processes and conflict resolution mechanisms.

5.2. Agricultural management

Agricultural management forms a large part of the LCW revitalization process. To be sustainable, the SES needed to balance the human needs of developing economically viable and culturally significant agricultural activities with the ecological conservation and protection of the area. As such, several institutions were developed, which incorporated all four of the discussed institutional design features: redundancy, modularity, diversity and effective learning. This array of institutions were built to ensure inclusivity and consensus building while different stakeholders collaborate in agricultural processes in the village. This includes the institutionalization of multiple channels of communication (mainly 'WhatsApp' groups) coupled with frequent and numerous meetings and the establishment of rules regarding farming methods and community practices (Interviewees 1, 2, 4, 5, 14, 15).

The farming community was re-built at LCW largely through the '3 Dous' community building scheme, launched in 2015. This scheme provides training and capacity building to Indigenous villagers and volunteers to develop their own rural start-ups such as farms and local produce processing businesses (Interviewees 18, 19 and 20). There are currently nine groups under this scheme practicing self-sufficient lifestyles, agricultural production and farm-based education. A farmer apprenticeship scheme was also established in 2019 with the aim of providing on the job training to individuals, who could then become equipped to set up their own small-scale farms.

Community farmer meetings have been established and serve as a regular decision-making platform. These meetings, taking place every two months, form the backbone of the collaborative governance of

¹ Located in a remote valley on the north-eastern shore of Hong Kong, the village lacks road access (it is at least a 2-h walk from the nearest road) and is about 13 km from the nearest urban center.

² A local organisation dedicated to the promotion of organic farming. It was in charge of agricultural-related activities in the Programme.

³ A local environmental NGO that was a key partner in designing and implementing training and education activities with the Programme team.

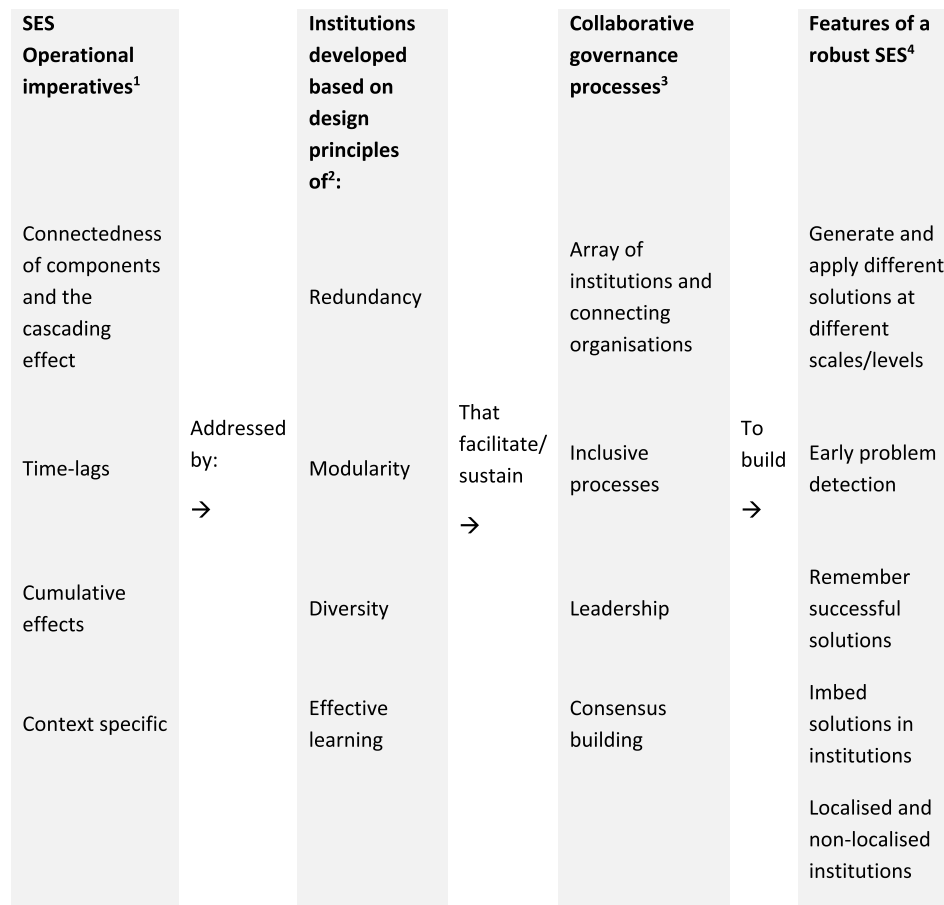


Fig. 2. Components constituting SES operational imperatives, institutional design principles, collaborative governance processes and features of a robust SES (¹Camazine et al., 2001; Capano and Woo, 2017; ²Capano and Woo, 2017, 2018; Low et al., 2003; Koontz et al., 2015; Jansson and Osnas, 2005; ³Bryson et al., 2015; ⁴Anderies et al., 2004).

agricultural activities at LCW. The manager of the Hong Kong Countryside Foundation usually hosts the meetings with at least one member from each farm. The meeting agenda is collectively decided upon through Whatsapp, generally covering the dissemination of farming news, discussions regarding follow-up maintenance work, formulating and refining community rules, planning collaborative marketing and promotional events, resolving disputes, sharing and exchanging resources as well as identifying potential risks and discussing preventative and mitigation measures. The cultivation of a co-management approach and the communal nature of the farmers' community under the Program is reminiscent of the village's traditional management system, which adds to its legitimacy.

The farming community's rules are enforced or clarified through mutual monitoring, with conflicts addressed through the meetings. The management of communal areas, in particular, has proven to be particularly contentious, having to undergo several rounds of meetings to resolve. This involves the management of boundary areas and electric fences, of which the farmers have mutual responsibility (Interviewees 1 and 2). For example, to ease concerns over free-riding regarding the maintenance of such communal resources, the LCW farmers agreed that any farming teams that fail to attend the collective farm works day will need to follow up on remaining farm maintenance tasks in their own time (Farming groups meeting – May 2020). Thus, such meetings help to address conflicts by offering a platform for all farming groups to reach agreements on ways to ensure adherence to the collectively established rules. After a notion has been proposed and discussed during the meeting, a vote is usually taken to pass the notion (Interviewee 12 and 13).

It was found that there were instances where a specific issue could not be resolved in regular meetings. As a response, additional conflict resolution meetings can be arranged where the Hong Kong Countryside Foundation and program team provide leadership in mediating. Sometimes, individual farmers may approach representatives from the Hong Kong Countryside Foundation to raise concerns regarding the management practices of the farmland, where the Hong Kong Countryside Foundation may then bring up the issue to be discussed or voice out the concern to everyone (Interviewee 11).

A diversity of institutions with different modes can be found to address issues of different nature. The frequent and open nature of the regular meetings allow continual/successive discussion on typical issues, which can be re-visited until a mutually agreeable approach is found and can be easily adjusted under changing circumstances. In addition to the conflict solution meetings mentioned above, any of the farming groups can also call for special meetings to discuss issues that have become more pertinent, such as to allocate water during the dry season or to resolve a particular conflict. These may be one-off additional meetings or reconvened at any point deemed necessary. This approach offers much needed flexibility for the stakeholders to effectively respond to changing needs or circumstances pertaining to any related SESs issues.

The farming community is structured to provide modularity to the overall village SES. As the farming institutions can operate fairly independently of the other institutions in LCW, this lowers the risk of a cascading effect if any of the subsystem collapse. In addition, the establishment of multiple farms managed by different groups of stakeholders involved in different agricultural and processing activities

means that the cessation of one farm should not significantly impact the operation and functionality of the other farms, ensuring a robust agricultural SES within the larger LCW SES.

There is substantial documentation in the form of project reports, newsletters and meeting minutes that record farming practices, problems encountered and various solutions trialed and/or successfully implemented to address those problems. Of note is the documentation produced from the Community farmer meetings at LCW. These regular meeting notes form institutional memory, they can be drawn on in subsequent discussions and planning to allow for effective learning to occur. For example, during a Farmers group meeting in January 2021, one of the farming groups proposed cutting down a Chinese Chaste Tree at the edge of their farm as it was damaging the electric fence. In response, another group pointed out that this tree is a nectar source and provides shelter for crops from the wind so it would be best not to cut it down, instead, it should be trimmed every year.

The exchange of knowledge, resources, labor and commodities between the farmers encourages collaboration and cooperation. Perhaps more importantly, documentation has created a repertoire of ideas and potential solutions with which novel innovations could be pondered and forged. The rules also institutionalize the regular meetings to ensure the continuation of the collaborative governance endeavors.

Information exchange and communication between the farms also reinforces the building of collaborative structures (e.g., developing norms and rules of practices) and collaborative processes (e.g., building trust). As well as enabling such effective learning structures through these information exchange processes, perhaps more importantly, this approach ensures modularity, allowing the farming community to function relatively independently of external affairs. This ensures a robust agricultural SES within the larger LCW SES.

Coordination and governance within agricultural management occurs at various levels. For example, the small farm scheme is more localized, governance is concerned with coordination and communication between the different farming groups and the village, while the '3 Dous' scheme has a much wider purview. It relies heavily on communication both between the Program team and within the group as they seek to find solutions to issues such as how to make farming and agricultural production economically and environmentally sustainable and how to preserve the village's culture and traditions while modernizing. Amongst themselves, the farmers make use of various WhatsApp groups, which ensure that these channels of communication are institutionalized to maintain the flow of communication and information.

5.3. Empowerment and capacity building of LCW village

The establishment of multiple decision-making platforms was an integral part of the collaborative governance system in the village, which simultaneously helps to serve the purpose of integrating the institutional design features of redundancy and diversity into this SES. Revitalizing the village with a collaborative approach helps to safeguard the rights and heritage of Indigenous villagers as well as ensuring the inclusion and integration of volunteers and new settlers into the village. It was also important to ensure the Indigenous villager's participation and voice in the Program, as a result, villagers played a prominent role in much of the formulation, management and governance of the Program (Interviewees 14 and 15). As a result, the collaborative governance feature of inclusivity was particularly pertinent as was the creation of several institutions to facilitate and ensure these processes, rules and norms.

Trust building and ensuring legitimacy were found to be essential. Trusting relationships can be perceived as being at the core of collaboration (Lee et al., 2012; Emerson et al., 2012; Bryson et al., 2015). Legitimacy is essential as the structures developed throughout the revitalization process must be perceived by the village community and wider Hong Kong society as legitimate to function effectively and efficiently (Bryson et al., 2015). Due to this, one of the project's goals was to

help the community to build capacity to enable more representative governance, especially as many of the villagers had expressed the need for broader participation in decision-making (Interviewees 1 and 2).

Frequent and open communication through joint decision-making platforms also contributed to building and maintaining trust between the Program and the villagers and within the village community. This also helps build legitimacy and accountability as the village community feel that they have a platform to raise concerns and share their opinion on different issues. This communication between the different actor groups was institutionalized largely through WhatsApp groups. Groups have been set up that include all those involved in LCW, farmers and groups regarding specific tasks. The Indigenous villagers also have their own WhatsApp group as do the village committee. Having a multitude of WhatsApp groups builds redundancy as there are multiple channels for information sharing and the discussion of issues pertaining to different SESs in the village, which offer an important basis for the subsequent formulation of solutions to address such issues.

As with the farming communities, the village management committee established its own governance platform, reviving the *Pui Shing Tong* as a decision-making platform for village affairs. The committee includes four of the five Indigenous LCW families. An annual village meeting occurs every October, aligning with the autumn ancestral worship, which sees the return of many villagers. At this meeting, village affairs are discussed, major disputes resolved and communal decisions made. The *Pui Shing Tong* acts as a coordinator for the village community, establishing rules on issues such as waste management.

The robustness of the village governing structure was tested when certain institutions failed to gain the legitimacy and support of the villagers. For example, an Indigenous villager proposed establishing a social enterprise as a means of taking over efforts from institutions such as The University of Hong Kong and contribute to the governing and management of the village. The board was mainly comprised of Indigenous villagers and the intention was for the enterprise to be non-profit, channeling funds back into the village. The social enterprise, however, has only managed to gain the interest and support of a minority of villagers and so was not perceived to be representative by other villagers (Interviewees 1 and 2). *Pui Shing Tong*, the village management committee, has since taken over some of the roles from the social enterprise. The existence of more than one decision-making platform ensured that the village's governing structure or other functions of the SES did not collapse when one decision-making body suffered a legitimacy crisis.

5.4. Incubating innovation

Several incubation schemes have been established to develop innovative solutions to rural issues and ensure the viability of the LCW SES in the modern world. For this, it was important to develop institutions and processes that would provide leadership efforts for collaborations as well as a number of connective organizations to navigate between different developments and innovations. The 'Co-creation of the Community' Scheme⁴ and 'Rural in Action Start-up'⁵ Scheme provide funding for projects that either engage with local villagers to co-create innovative ways of safeguarding art, natural and cultural capitals and build public awareness as a non-profit initiative or as a start-up. These projects originated under the LCW Program but are not confined to this village. The purpose of the schemes is to encourage the experimentation of different socio-economic models that are built upon unique natural and cultural resources found in rural areas. Each of these projects funded by the Program operate largely independently with the support of The University of Hong Kong, which means that the success of each model is

⁴ 'Co-creation of the Community' <https://ccsg.hku.hk/ruralsd/en/pages/co-creation/themes-and-creators/>.

⁵ 'Rural in Action Start-up scheme' <https://ccsg.hku.hk/ruralsd/en/pages/academy/start-ups-incubation/rural-in-action-start-up-scheme-projects/>.

not dependent on the others. The approach taken to incubate independent innovations incorporated the institutional design features of modularity, diversity and effective learning.

The ‘Sustainability Hackathons’⁶ provided one avenue for building group interest by encouraging communication and collaboration in solving rural issues. It arranges a platform for individuals to gather and collaborate to develop innovative ideas on a rural-related theme. Participants are guided through the process by being furnished with a basic understanding of rural community problems, led through a process of brainstorming, idea development, peer learning and coaching by mentors and then they develop a proposal. The platform provided through the Hackathon allows participants to develop a better understanding of rural history, helping them identify old and new stakeholders and their corresponding interests (Focus Group meeting 1 and 3). Participants shared that they developed new perspectives regarding the resources and expertise available for people interested in rural development in Hong Kong (Focus Group Meeting 1 and 2).

Equipped with the above knowledge and new found perspectives, participants in the Hackathons are guided through a design-thinking process to develop and test the acceptability of their ideas and build their networks as it “successfully brought people who are interested in the sustainability topic together” (Focus Group Meeting 7). The Hackathon participants noted that it was “good to receive genuine comments from the judges”, especially as the judges were from diverse backgrounds as this helped them to “think from the perspectives of different stakeholders” (Focus Group Meeting 4).

While operating independently, the different incubation schemes all aim to produce and develop sustainability solutions at their core, which influences their vetting processes and the guidance they provide. This goal is materialized in different ways through the institutional design of the schemes. For example, the Hackathon takes the form of a competition, and so has in-built redundancy as all the participants are competing to find solutions under the same issue theme⁷. In contrast, the ‘Co-creation of the Community’ and ‘Rural in Action Start-up’ schemes incubate different groups who are pursuing their own projects, introducing modularity and a diversity of sustainability orientated ventures. At the same time, the support provided to project groups include the facilitation of network building and knowledge sharing with different stakeholders such as Indigenous villagers and related organizations.

The schemes can also learn from each other to overcome challenges and refine their approaches. For instance, the first Hackathon, the theme of ‘rural technology’ was found to be too broad and did not effectively utilize the Program’s knowledge resources. This made it difficult to match the expert’s knowledge and training provided to the participants with the support they actually required. The 2020 Hackathon looked to the other incubation schemes and refined its approach, restructuring so that it followed the food chain in Hong Kong. It borrowed on the Rural in Action Start-up Scheme and the 3 Dous scheme by better exploiting the Program’s in-house knowledge and expertise to provide better understanding and support of the local rural context as well as allowing for more targeted expert talks and workshops to be provided. This type of support was important and beneficial as participants had to “become familiar with the place [LCW and nearby villages] in this [Co-Creation] project and have a good knowledge of this place” (Interviewee 9). Several project proponents identified the LCW Village Festivals as a tangible example of network building (Interviewee 10). Effective

learning is enabled through these networks. As the project groups are encouraged to draw upon a wider pool of resources and experiences, their capacity to address challenges is enhanced. Startup project groups have learnt from local experiences, traditional/cultural practices, or industry practices as well as overseas experiences and adopted selected elements into their projects (Interviewees 6, 7, 8). While incorporating different sources of knowledge and experience, they simultaneously developed new knowledge that is locally relevant. Through the use of the Program’s network to invite guest speakers, participants of the Hackathon reported that they “finally feel like [they] are connected to these issues” (Focus Group Meeting 6) and that such “extended collaborations with other industries” can “foster innovation” (Focus Group Meeting 4).

5.5. Revitalizing infrastructure

As part of the village revitalization process, traditional infrastructure was restored and re-purposed. This came with unique contextual challenges that required proactive leadership to navigate the collaborative journey and innovative institutions. This involved the restoration of a dilapidated pig shed to form the “Lai Chi Wo Cultural Hub” through a collaboration between local villagers, architectural conservationists, academics, builders and volunteers to create a multipurpose shared space. Currently the hub is being utilized as an exhibition of the history of the Hakka people’s traditional rice farming practices. The lease arrangement developed to facilitate a new partnership model for infrastructure revitalization is a demonstration of embedding modularity and effective learning into these new institutions. The lease of the Hub is a novel arrangement, ensuring on-going collaborations with the community. The Hub is leased through the Hong Kong Countryside Foundation from its Indigenous owner under a time share arrangement. Under this agreement, The University of Hong Kong provided the funding for the restoration of the building, originally a pig shed, in return, they are allowed to lease the building from the owner for a nominal fee of 1 HKD per year for five years. If neither party proposes any changes to be made, the lease would be renewed for another five years under the specified terms. For the initial two years, the Program has 90% use of the Hub, as the years progress, the percentage of time they can use the space for is gradually reduced to 50% from the 6th to 10th year (lease agreement 2015).

The institution provided by the lease presents an innovative way to address a few context-specific issues at the LCW SES. Several factors contribute to the complexity of maintaining cultural heritage especially in terms of the village houses at LCW. First, Indigenous villagers had agreed to not sell village properties to non-Indigenous villagers. Any individuals or organizations wishing to live or establish a base at the village must lease from an Indigenous villager who owns a property. As most Indigenous villagers do not live in the village and the potential rental income is insignificant in comparison to the cost of renovating such historical village properties, many of the structures were becoming dilapidated. The time share lease agreement meant that external funding can be injected to the village to preserve and/or revitalize its built heritage and more of such buildings could be made available to organizations and individuals to be dedicated to revitalizing and managing different SESs in the village.

As the first of this type of arrangement trialed by the project, this lease arrangement can be considered as a social innovation that also helps to address issues relating to the spending of public funding on private property, and so an example of effective learning within an institution. Proving to be successful in LCW, such sharing arrangements have since been applied elsewhere in the village revitalization context. Under another project at LCW, the Hong Kong Countryside Foundation has undertaken to restore village houses in return for a 20 year lease. Under these leases, the owners can use the property exclusively for two weeks of the year initially and this time will then increase throughout the duration of the agreement. A similar arrangement is also present in

⁶ Two Sustainability Hackathons were organised, one in 2019 <https://ccsg.hku.hk/ruralsd/en/pages/academy/sustainability-hackathon/> And one in 2020 <https://ccsg.hku.hk/ruralsd/en/pages/academy/sustainability-hackathon-2020/>.

⁷ The theme of the Sustainability Hackathon 2020 was Hong Kong’s Sustainable Food System which aims to address issues of food security, food literacy, food waste and to explore the possibility of fostering social cohesion through the food culture.

the neighboring village, Mui Tsz Lam, under the Forest Village Project⁸, where two houses are being leased for restoration work. As such, this type of arrangement is becoming institutionalized, allowing for the spaces to be shared with the wider community, providing venues for collaborations and knowledge exchange, and cultural capital maintained. Thus, these lease agreements have achieved modularity in that they are able to operate independently of other arrangements in safeguarding venues for shared purposes.

A significant challenge in sustaining SESs at LCW has been to ensure the stability of the workforce to maintain its various resources. Through these lease arrangements, the ownership of the built heritage remains in the hands of Indigenous families. This means that after the end of the Program, there are greater incentives for the Indigenous villagers who own a renovated property to maintain it and pass it on through generations. In that case, the future of managing built heritage in the village is not dependent upon existing or other external organizations or continuous funding to be preserved. It is evident that redundancy is built into the design of this institution, which not only enables collaboration between the leasing organization(s) and the Indigenous family but also ensures the sustainability of LCW.

6. Discussion and theory building

The below table (Table 4.) demonstrates how the various institutional features that support robustness are balanced as well as the relationship between collaborative governance features, strategies and robustness. This will help inform theory on robust SESs, particularly, how collaborative governance strategies and features can contribute to building robustness as well as how to balance different institutional features to maintain flexibility and innovation within the SES.

As the institutions in SESs are deliberately designed, attention to this balance is pertinent, particularly as trade-offs often need to be made between investing in which system features (Janssen and Anderies, 2013). Collaborative processes can facilitate the building of robust SESs due to their emphasis on participatory approaches and open communication channels enabling the creation of multiple institutions for managing or governing a SES, while maintaining coordination and an overarching vision. The collaborative governance approach of adaptive management and its incubation of innovation, in particular, goes hand in hand with encouraging effective learning.

All these collaborative processes, facilitated through the above institutions, contribute to enhancing robustness across scales, which is necessary due to the importance of safeguarding both large and small scale SESs. SESs are complex multiscale systems, with each scale being interconnected. As such, events at different scales of a SES can impact its ability to persist over the long term (Janssen et al., 2007). In this case, collaborative governance institutions have been implemented at different levels and across scales, from building small-scale farming communities and developing local agriculture to village level decision-making platforms and linking the LCW SES with the wider SES and community through new partnerships and innovation initiatives. Integrating robustness features across the different scales of a SES in this manner contributes to the likelihood of the SES persisting into the future.

Alongside these findings, some lessons from the SES literature might shed further theoretical light on how institutions can enhance robustness. First, a SES usually involves a multitude of actors and stakeholders who relates to the bio-physical and social sub-systems in different ways. The diverse interests involved pertain not only to the variegated preferences of the actors but more importantly imply very different aspirations and consequences for conditions and operation of the bio-physical sub-system. For instance, farming inevitably requires the clearing of lands, which often implies cutting down on biodiversity (Henle et al.,

2008). As the continual operation and development of the rural community SES requires that the different actors and stakeholders act and interact with one another in a complementary manner, it is important that governance institutions be designed in the way that various interests and concerns of actors and stakeholders be fully recognized in the process of governance (Emerson and Nabatchi, 2015). The collaborative process helped ensure channels of communication were available and accessible between the Program team, villagers, new settlers and the government. As such, it was found to be essential for collaborative processes to be institutionalized to manage and implement the revitalization program.

By building collaborative processes into institutions, the Program's legitimacy was enhanced, trust was built and more innovative ideas and projects could be developed and successfully implemented. It also ensured the sustainability of the Program, as built-in redundancy and modularity will ensure the institutions succeed the Program. The villagers and the village community are also committed to the revitalized village and willing to take ownership and embrace the changes brought about by the Program.

Second, given the complexity involved in the operation and interaction of the bio-physical and social sub-systems, the actors in a SES face the challenge of collecting and processing adequate information to inform their decisions and actions (Janssen and Ostrom, 2006). Documentation throughout the Program was found to be essential in both maintaining the cultural identity of the village and in ensuring the effective adaptive management, and so flexibility, of revitalization efforts. The information concerns not only the conditions and dynamics of the natural environment but also the possible impact of human actions on the environment. Information collection and processing is costly (Janssen and Ostrom, 2006). Other than the resources spent on gathering data and extracting useful information, fallible humans who have only limited cognitive capacity in attention allocation and information processing are subject to an array of constraints imposed by their cognitive architecture (Beratan, 2007). Setting up a centralized agency to take care of information collection and processing en masse is one way of dealing with the information problems. Prior research, however, suggests that SESs often involve intricate flows of information (Olsson et al., 2004; Janssen and Ostrom, 2006). Instead of trying to centralize information processing, it was found that a diffused mode of institutional arrangement that allows actors at different levels to gather, share, and make use of, local information to cope with problems they face in particular scenarios is better able to cope with the complex flow of information (Koontz et al., 2015).

Finally, the variety of incubation processes under the Program allowed for collaborative learning in solving rural issues. This ensured that innovation could be incorporated into the revitalized SES, mediating the potential for rigidity that can accompany a 'too' robust system (Csete and Doyle, 2002; Janssen and Anderies, 2013). Having multiple incubation and co-creation schemes provided both modularity and diversity, ensuring a mix of ideas and solutions could be generated. It also allowed for new technology and actors to be involved in the process, increasing the collaborative input.

By unpacking collaborative dynamics in this manner, the theoretical logic or mechanisms through which institutions foster the collaborative processes are demonstrated and explored. This reveals the importance of managing trade-offs and balancing different robustness features. Many features of collaborative governance are also demonstrated to be suited to operationalizing characteristics of robustness when they are appropriately embedded and perpetuated through institutions. This has the advantage of creating more adaptive institutions and institutional processes as they possess features such as collective decision-making, ongoing learning and adaptability and co-evolution of resources, which further contributes to robustness.

The lessons and experiences undergone at LCW are currently being amended and applied to neighboring villages. For example, the Forest Village Programme is being explored to introduce a similar participatory

⁸ <https://ccsg.hku.hk/forestvillage/>.

Table 4
Examples of robustness features built in at LCW through collaborative governance.

Approaches/ strategies	Institutions	Institutional design feature				Collaborative governance processes				
		Redundancy	Modularity	Diversity	Effective learning	Inclusive processes	Leadership	Connecting organizations	Array of institutions	Consensus building
Agricultural management	- "3 Dous" scheme - Farmers' group	X	X	X	X	X		X	X	X
Empowerment and capacity building of villagers/village Governance	- Multiple decision-making platforms and communication channels	X		X		X		X	X	X
Incubating innovations	- Hackathons - Co-creation and start-up schemes - Rural in Action Start-up Scheme		X	X	X		X	X		
Revitalizing infrastructure and partnerships	- Lease agreements		X		X		X		X	

approaches to the villages surrounding LCW. The LCW case, however, demonstrated the importance of building social capacity and community for revitalization and so the Forest Village Programme is employing similar incubation initiatives, such as a combination of a Hackathon and funding for social innovation projects. These villages, however, are smaller than LCW, and even less accessible, so unable to support communities in the same way as LCW. Instead, the Forest Village Programme learns from the importance of redundancy and modularity at LCW and undertakes several different projects to incubate citizen scientists and rural stewardship, which incubate citizens as rural caretakers to build communities of interest.

7. Conclusions

Rural areas face multiple complex challenges, particularly from the growing threats of development, climate change and urban encroachment. These issues can be particularly challenging as rural areas involve cultural, economic livelihood, ecological and social issues (Walser and Anderlik, 2004; Bjorna and Aarsaether, 2009; Stead, 2011; McGreevy, 2012; Li et al., 2014; Williams et al., 2021). Building robustness into revitalization efforts when tackling rural decline is theorized here to enable sustainable, healthy and functional rural SESs.

This paper provides evidence of collaborative processes shaping institutional design, and by doing so, contributing to the creation of a robust SES. As such, this study finds evidence to support the logic linking institutions to robustness in SESs through their ability to facilitate collaborative processes. Table 4 highlights the relationships between collaborative features, institutional arrangements and robustness features, as well as how these have been distributed amongst the various strategies/endeavors. This can provide important insights to those looking to undertake similar rural revitalization projects as well as into the functioning of village SESs. While there are other factors at play that may have contributed to the robustness of the SES, and the SES has yet to be fully tested, this case study does indicate that the institutions present at LCW have contributed to overcoming challenges that the revitalized village has faced.

The LCW case contributes to theory building as it shows that the role of institutions in supporting and facilitating collaborative governance processes through various design features is likely to have contributed to building the rural SESs robustness. As such, the role of institutions within SESs as well as how their design can support collaborative governance processes merits further testing and investigation. By showing the link between institutions and the robustness of a SES, the LCW case has served to uncover some of the productive dynamics present in rural SESs and gives a greater understanding of how these can be managed and governed. These findings could be beneficial to other

collaborative efforts seeking to reverse rural decline, particularly in providing practical understandings as to how to operationalize and manage these concepts in rural context.

The LCW example also contributes to theory development as it demonstrates that a range of institutional features are required to make a SES truly robust, practitioners cannot just focus on one element. The challenges that the case has faced with decision-making and agricultural revitalization have shown that multiple institutional features are necessary in coping with unknown or unforeseen circumstances. The case also highlights some important points about how to incorporate such features into a SES. For example, it was found that building in redundancy was a crucial design component to ensuring the sustained effect of sustainability programs.

Overall, the case of LCW provides many lessons for rural SESs. It demonstrates the logic that institutions, when properly designed, can create the dynamics to support collaborative processes. As such, this logic enriches the understanding of collaborative governance and how it can be utilized to enhance rural sustainability, shedding further light on the relationships between collaborative governance, institutions and robustness within rural SESs. It also provides some insights into what institutions are required to support collaborative processes in this context.

Declaration of competing interest

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Data availability

The data that has been used is confidential.

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