D7.2 VISIONS, BELIEFS AND VALUES

Project acronym: BCOMING

Project title: Biodiversity Conservation to Mitigate the risks of emerging infectious diseases

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Executive Summary

Report structure

The Biodiversity COnservation to Mitigate the risks of emergING infectious diseases **(**BCOMING) project is an EU funded participatory based research program being conducted in Stung Treng and Battambang Provinces, the Kingdom of Cambodia, Guinea and Guadeloupe. The main objective of the BCOMING project is to reduce the risk of infectious disease emergence in biodiversity hotspots by developing a standardized data collection and analysis framework. Integrating ecology, virology, social sciences and participatory processes, the project supports the co-construction with all stakeholders of innovative biodiversity conservation strategies and zoonotic disease surveillance systems (Binot et al., 2015a; Duboz et al., 2018a; De Garine-Wichatitsky et al., 2020).

The primary objective of Work Package 7 (WP7) of the BCOMING program is to co-design and convene the effective participation of indigenous and local communities in pandemic prevention strategies, risk management and opportunities for biodiversity recovery. The main objective is supported through extensive collaboration with BCOMING work packages WP3, WP5 and WP6 and the integration of their multi-disciplinary outputs into the Challenge and Reconstruct Learning (ChaRL) participatory process. Ultimately the co-design process is intended to facilitate transformative change to simultaneously sustain biodiversity and promote human, animal and ecosystem health.

WP7 Objectives

In collaboration with WP5 and WP6 the first step was to select and confirm the case study sites in Cambodia, Guinea and Guadeloupe. Site criteria selection focused on zoonotic prevalence and reported or potential community exposure; biodiversity-livelihood interactions, historical research activities and existing data sets. WP6 (CIRAD and Institut Pasteur du Cambodge) in Cambodia, WP5 (Flora and Fauna International in Guinea) and CIRAD in Guadeloupe co-designed the processes, metrics and the criteria to recruit representatives of communities participating in the ChaRL participatory workshops. The collaborative processes and design principles to select the specific case study region in Cambodia, Guinea and Guadeloupe and selection criteria to recruit stakeholders in the ChaRL participatory workshops are detailed in the BCOMING D7.1 report.

The D7.2 ChaRL workshop report details the ChaRL inception workshop process with selected communities in Cambodia, Guinea and Guadeloupe.

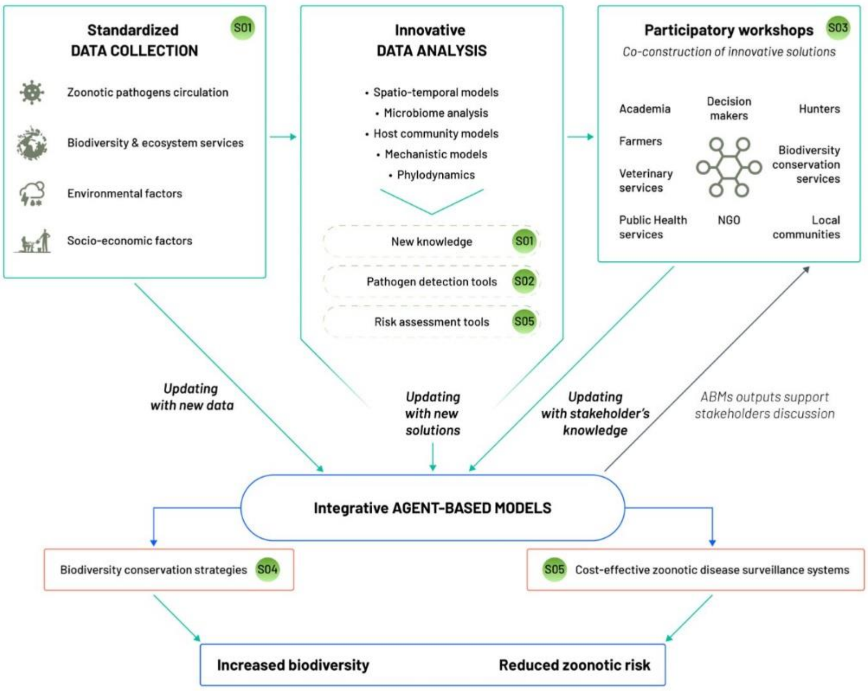
The results of the ChaRL participatory systems mapping exercise revealing participant perceptions of the impacts and key causal relationships of zoonotic virus exposure for Cambodia, Guinea and Guadeloupe are described in the first section of the report. The participatory workshop analysis of the psychometric life-guiding values and causal beliefs are described in the second section of the report.

Report D7.2 is one of five complementary reports for WP7. Case study site selection is described in D7.1. The a priori testing of zoonotic surveillance for each case study site is described in D7.3; insights into One Health Systems learning are described in D7.4; and the final report of the ChaRL participatory workshop series to facilitate co-design of community zoonotic surveillance strategies are detailed in D7.5.

Empirical data from randomized household livelihood and adaptive strategies (D5.3 and D5.4) support the co-design process of the community surveillance strategies. D5.3 and D5.4 detail the sampling rationale, household attributes, livelihood descriptive statistics and adaptive responses to proposed surveillance strategies of the three BCOMING case study countries: Guinea (Gueckedou, Seredou and Guecke), Cambodia (Stung Treng and Battambang provinces) and Guadeloupe (Petit-Bourg). The survey is anticipated to be administered in Cambodia and Guadeloupe in the third quarter of 2024.

WP7 contributes to and supports the data and analytical requirements of the remaining BCOMING Work Packages (Figure *1*) and will inform future participatory workshops convened with case study communities and decision makers.

Figure 1: The role and integration of the BCOMING Work packages



Contents

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List of Figures

List of tables

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Introduction

The Biodiversity COnservation to Mitigate the risks of emergING infectious diseases **(**BCOMIING) project is an EU funded participatory based research program being conducted in three countries: Cambodia, Guinea and Guadeloupe. The main objective of the BCOMING project is to reduce the risk of infectious disease emergence in biodiversity hotspots by developing a standardized data collection and analysis framework. Integrating ecology, virology and participatory processes, the project supports the co-construction with all stakeholders of innovative biodiversity conservation strategies and zoonotic disease surveillance systems.

A central pillar of the BCOMING project is the active engagement with communities that live in close proximity to areas where zoonotic risks are high and biodiversity conservation under threat. Zoonotic risk in Cambodia is linked to bat populations that bivouac in caves in close proximity to Sam'ang commune, Stung Treng province and Chhue Teal commune, Battambang province. Cohorts of these bat colonies have been identified as hosts of the SARS-COV 2 virus (Furey et al., 2016; Cappelle et al., 2021). Both communities engage in guano collection and have human-wildlife interactions through wild animal hunting, consumption and trading.

Critical for developing effective solutions that minimize or even eradicate zoonotic risks the co-construction of surveillance strategies between research, decision making and rural communities as past experiences indicate that centralized, externally imposed solutions that fail to incorporate local community experience and knowledge are rarely effective.

The first Challenge and Reconstruct Learning process (ChaRL), utilizing a participatory system mapping (PSM) exercise with community and provincial government experts, was implemented by the Mekong Region Futures Institute (MERFI), the Institut Pasteur du Cambodge (IPC) in Cambodia, Flora and Fauma International in Guinea and CIRAD in Guadeloupe. The main objective was to convene and facilitate the effective participation of local communities to co-construct pandemic surveillance strategies, prevention-risk management and opportunities for biodiversity recovery.

The goal was to actively collaborate with Stung Treng and Battambang communities to minimize zoonotic exposure and risks through the discovery of their own plausible and tested surveillance practices.

A spatially referenced agent-based model, developed for each of the case study sites, will be deployed to test the proposed and co-constructed surveillance strategies and actions.
The Challenge and Reconstruct Learning (ChaRL) participatory visioning is a facilitated process that serves as a learning framework to understand the governance, management and planning for One Health system outcomes (Binot et al., 2015b; Duboz et al., 2018b; De Garine-Wichatitsky et al., 2021). ChaRL allows participants to reveal and test what zoonotic surveillance strategies are feasible for affected communities and what strategies are not.

Through a well-tested participatory workshop process (ChaRL):

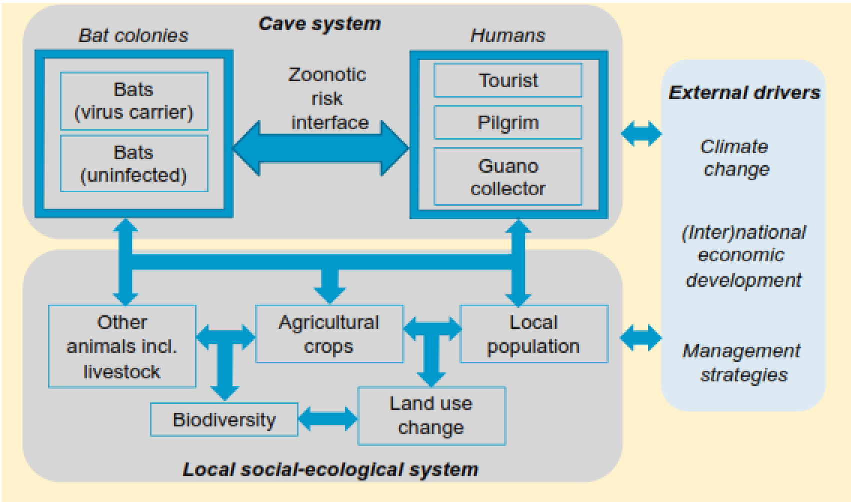
- Convenes and facilitates communities from Cambodia, Guinea and Guadeloupe to co-construct One Health zoonotic surveillance systems;
- Tests the surveillance strategies proposed by communities against indicators that are important for communities;

- Convenes and facilitates transformative change to jointly sustain biodiversity and promote human, animal and ecosystem health.

Learning in the ChaRL process involves:

- Learning by understanding the One Health Systems in Cambodia, Guinea and Guadeloupe;
- Learning by questioning and revising beliefs;
- Learning surveillance strategies that meet the One Health system; and
- Learning to save lives and protect community livelihoods

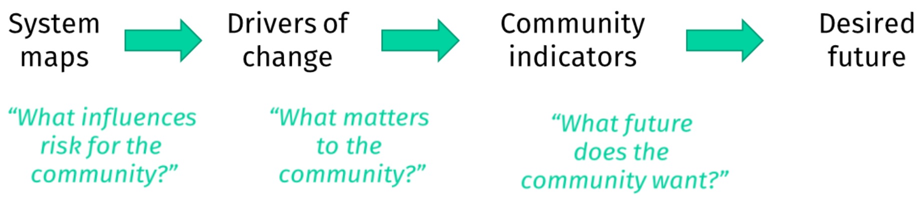
Figure 2: Schematic diagram of the cave-bat-animal-human health system interactions



ChaRL is a structured participatory process extensively field tested in Cambodia, Lao PDR, Thailand and Vietnam over the past 12 years (Smajgl and Ward, 2013, 2015; Smajgl, Toan, et al., 2015; Smajgl, Ward, et al., 2015). The process involves a sequence of workshops focusing on: (a) visualizing and understanding the One Health-zoonotic system; (b) the existing possible developments and tensions affecting community zoonotic risk; (c) the causality between proposed developments, biodiversity regimes, zoonotic surveillance and shared community visions of the future; and (d) enabling case study communities and decision-makers to discover actions to generate One Health system-based surveillance strategies.

Participating community members in Cambodia, Guinea and Guadeloupe developed a One Health systems map of causal relationships reflective of exposure to zoonotic pathogens (SARS-CoV-2 in Cambodia; Ebola and SARS-CoV-2 viruses in Guinea; mosquito-borne Dengue and West Nile viruses in Guadeloupe); identified some of the factors affecting zoonotic risk; and in the case of Cambodia and Guinea, articulated a partial set of community relevant indicators to monitor surveillance effectiveness.

Figure 3: ChaRL workshop one process and outputs



Community participation in the workshops was voluntary, subject to being informed of the project objectives and process by way of a consent form and paid for their time based on the official DSA rates in the case of Cambodia. Provincial authorities and village heads were consulted to explain the project, answer their questions, seek their support and endorsement and to assist in participant invitations and selection.

Twenty six people participated in the ChaRL processes in Cambodia; up to 80 participants in the three Guinea workshops and 23 people in Guadeloupe. Workshop participants typically comprised village leaders and community members, representatives from provincial public and animal health agencies, and in Cambodia, local law enforcement.

The Cambodian field Team was comprised of Dr John Ward and Dr Alex Smajgl of the Mekong Region Futures Institute and Sokha Chea from the Wildlife Conservation Society. Dr Ward, Toupou Koighae, Neus Estela, FFI staff and local translators facilitated the Guinea workshops. Dr Smajgl, Dr Sylvie Lecollinet and Joanna Cozier facilitated the Guadeloupe workshops.

Participatory Systems Mapping to explore co-constructed community based zoonotic surveillance

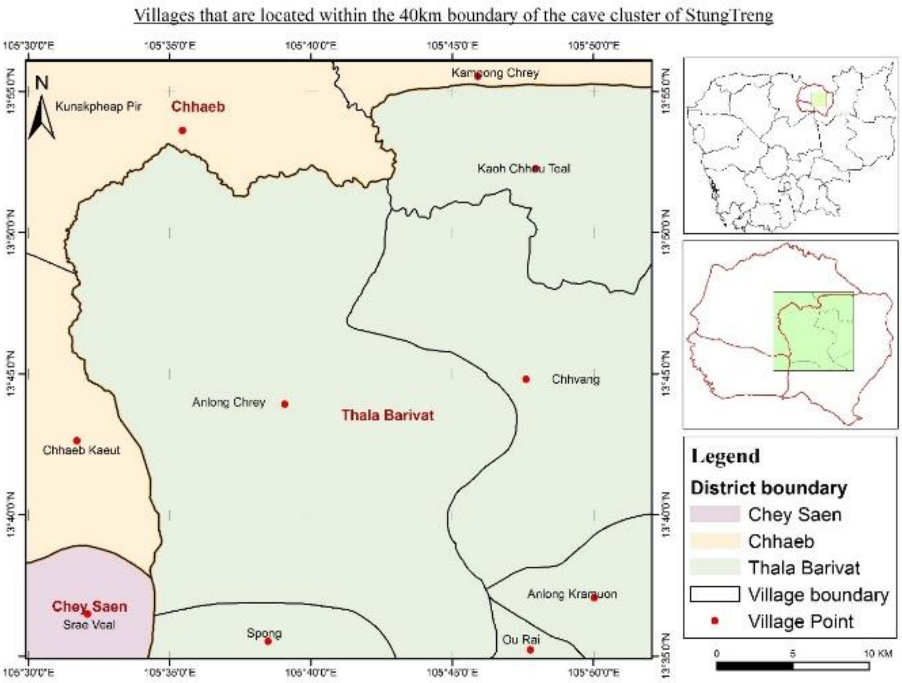
Cambodia

Collaboration over several meetings throughout 2023 with IPC, CIRAD and WCS confirmed the participant selection process. Consistent with previous survey approaches and community engagement (e.g. ZooCov and the Living Lab project), Sam'ang and Chheu Teal community members, village heads, representatives of the provincial animal and public health authorities and local police were confirmed as workshop participants. Gender balance and livelihood diversity were additional selection criteria.

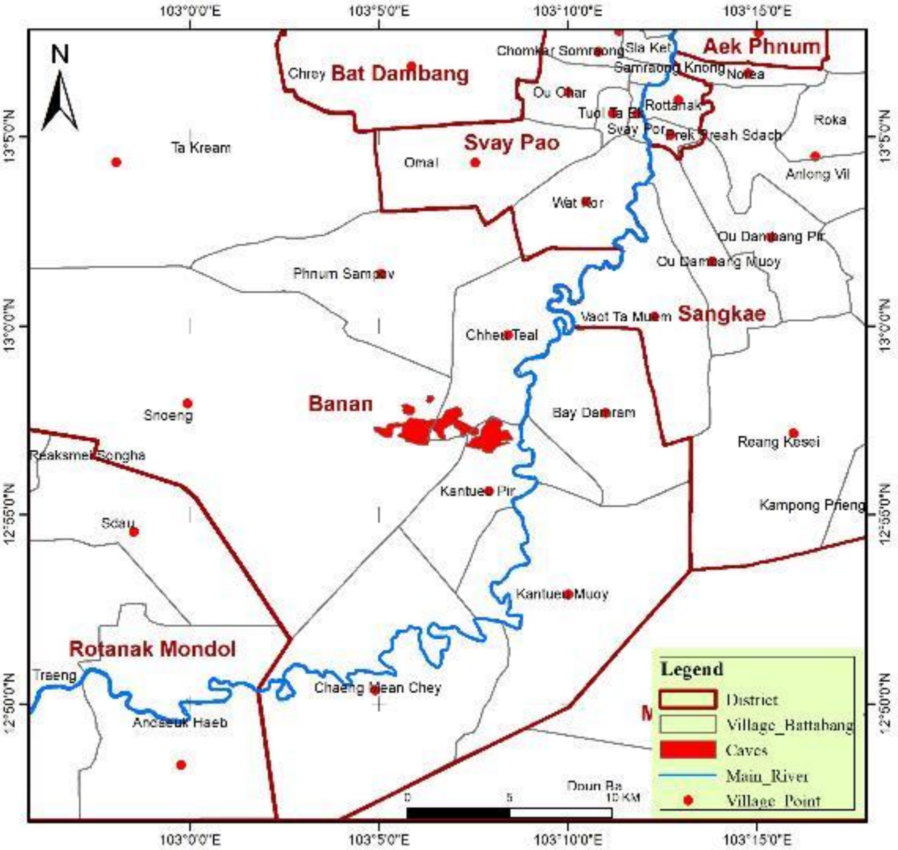
Provincial authorities and village heads were consulted to i) explain the project, ii) answer their questions, iii) seek their support and endorsement and iv) to assist in participant invitations and selection. Translated concept notes and invitations were forwarded to Stung Treng and Battambang village heads and local authorities to confirm workshop dates, venue and the participants for the 1st ChaRL workshops (March 2023 for Stung Treng and April 2023 for Battambang). Village heads were responsible for the final selection of workshop participants.

The Sam'ang and Chhue Teal case study boundaries are illustrated in Figure 4.

Figure 4: 40 km boundary of the Sam'ang, Stung Treng and .Chhue Teal, Battambang case study sites



Villages that are located within the 40km boundary of the cave cluster



Sam'ang commune

On March 9th and 10th at the Sam'ang community hall the first two-day Cambodian workshop was convened with 26 community members from Sam'ang and nearby villages, the commune leader and deputy leader and provincial animal and public health representatives.

As a first step, the project team explained the BCOMING objectives and proposed activities. The project team presented background on the relationships between bats and zoonotic viruses, referencing the ZooCov research into cave dwelling bats, guano collection, bridging and amplifying species and the potential effects on human health.

The project team explained that the SARS-COV 2 virus has been detected in bats roosting in nearby caves, and that this virus has caused COVID among humans. A vigorous discussion unfolded concerning the ways humans could get infected.

In a second step, the BCOMING team, consisting of Dr John Ward (MERFI), Dr Alex Smajgl (MERFI), and Chea Sokha (WCS), conducted the Participatory Systems Modelling (PSM) exercise.

The zoonotic participatory system maps were digitally transcribed and the first iteration of potential co-designed strategies documented. Data of the entry and exit survey of psychometric variables (causal beliefs via the system maps and life guiding values questionnaire) were recorded and analysed.

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Chheu Teal commune

On April 4th at the Chheu Teal community centre, the project team convened the second Cambodian workshop. 26 community members from Chheu Teal and nearby villages, provincial animal and public health representatives and the commune leader and deputy leader participated.

Consistent with the sequence of steps introduced in Sam'ang, the project team explained the BCOMING objectives and proposed activities. The project team presented background on the relationships between bats and zoonotic viruses, referencing research into cave dwelling bats, guano collection, bridging species and the potential effects on human and domestic livestock health. This bundle of variables, synthesized as "Bats and Covid -19", was defined as the focal intervention for the PSM exercise and the initiating point for identifying community identified cause-effect relationships.

Participatory system mapping

Participatory system mapping (PSM) is a member of the family of practice-oriented network/system analysis tools developed to investigate and support cross-sectoral energy planning and natural resource governance[1].

A PSM is a structured and facilitated mapping tool that assists community decision-making participants to understand, visualise, discuss, and improve situations in which multiple, diverse actors either influence zoonotic surveillance strategies or are affected by those strategies. PSM is a collaborative approach used to understand and visualize the complex relationships and dynamics within a system by involving stakeholders directly in the mapping process. This method combines systems thinking and participatory techniques to create visual representations, or maps, of the interconnections and feedback loops that exist among various elements within a system.

PSM is particularly valuable in addressing complex, multifaceted issues as it incorporates diverse perspectives and knowledge from stakeholders, ensuring a more comprehensive understanding of the zoonotic-wildlife-human system. By engaging participants in the mapping process, PSM fosters a sense of ownership, encourages collaborative problem-solving, and helps identify leverage points for effective intervention. This approach is widely used in fields such as environmental management, public health, and community development to address systemic challenges and co-create sustainable solutions.

Workshop participants produced a map comprised of factors, which can represent anything as long as they are expressed as a variable (i.e. can in some sense go up and down) and the connections between factors which represent causal relationships. Bats-SARS CoV-2 was the core factor presented as a reference proxy for zoonotic virus prevalence, exposure and surveillance. The factors that are impacted by Bats- SARS CoV-2 come from the economic, agricultural, political, social and ecological domains. The PSM is intended to represent what stakeholders believe to be the causal structure of the ecological-human-animal-health (One Health) system (De Garine-Wichatitsky et al., 2020, 2021) affected by Bats-SARS CoV-2.

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[1] Barbrook-Johnson, P. and Penn, A.S. 2022. Participatory Systems Mapping. In Barbrook-Johnson, P. and Penn, A.S. (Eds), *Systems Mapping: How to build and use causal models of systems*, pp. 61–78. Cham: Springer International Publishing, https://doi.org/10.1007/978-3-031-01919-7_5
Smajgl, A. and Ward, J. 2013. *The Water-Food-Energy Nexus in the Mekong Region Assessing Development Strategies Considering Cross-Sectoral and Transboundary Impact*. NY: Springer

The PSM method was adapted to actively enable workshop participants to jointly identify the potential positive and negative consequences that the exposure to zoonotic viruses is likely to have on their community and a set of possible surveillance and management strategies and actions.

Sam’ang PSM results

Sam’ang commune, March 2023


Chheu Teal commune, April 2023


The One Health system map was developed by the participants in three stages: 1st, 2nd and 3rd order consequences with Bats-Covid as the core factor. First order effects are the direct consequences of the prevalence and exposure to a zoonotic virus within their community.

Second and third order effects are more indirect consequences arising from the first order impact/consequences. For example in Chheu Teal virus exposure reduces the volume of trade and the number of visiting traders (1st order), which reduces household income (2nd order), which leads in turn to increased poverty and less children attending school (3rd order).

Typically, the first round is focused on developing a systems representation, which captures the most relevant cause-effect relationships. This can be focused on the consequences and impacts a focus intervention (or focus factor, here bats-Covid) has on a wide variety of issues relevant for the participating stakeholder.

These impacts are often referred to as ‘downstream’ impacts or ‘downstream’ causality. The process can also be focused on the prerequisites and enabling conditions for the realistic introduction of focal interventions. This perspective is referred to as ‘upstream’ mapping or ‘upstream’ causality. The

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systems map revealed a wide range of impacts caused by zoonotic exposure through interaction with cave dwelling bats and bridging species, possible synergies and trade-offs. Once these synergies and trade-offs are understood, co-constructed surveillance strategies can be tailored to minimise mal-adaptation, maximise synergies and manage identified risks across the social, economic and biodiversity domains.

PSM 1st order process: Sam'ang

PSM typically reveal first-order impacts (yellow post-its), second order impacts (orange) and third order impacts (pink).

A One Health systems map combines the first, second and third order impacts perceived and defined by the Sam'ang and Chhue Teal communities, revealing a range of opportunities and risks, including:

- the development of a community vision;
- the analysis of causal beliefs held by community members;
- the analysis of possible ripple effects, and the identification of risks and opportunities;
- the identification of the relative influence different stakeholder groups have; and
- the specification of interception points, strategies and action plans to mitigate zoonotic risks.

Participants were asked in the first workshop plenary session to identify the *direct* impacts of the bats-Covid core factor. Participants, either in small groups or individuals, captured their ideas on post-its (or sticky notes). Then participants were invited to place their ideas on a white board. In the next step, contributions were explained by the proposing participant(s) if unclear and grouped (if multiple post-its had the same meaning).

In the next step, participants were asked to disregard the focal intervention (bats-SARS CoV-2) and focus on only the 1st order consequences shown in the diagram (yellow post-its). Participants deliberated over a wide range of impacts resulting from the effects identified in the first round. These consequences are referred to as 2nd order impacts of Bats- SARS CoV-2 and distinguished by the orange post-its. The process was repeated for third order impacts (pink post-its). A schematic of the entire PSM process is illustrated in Figure 5.

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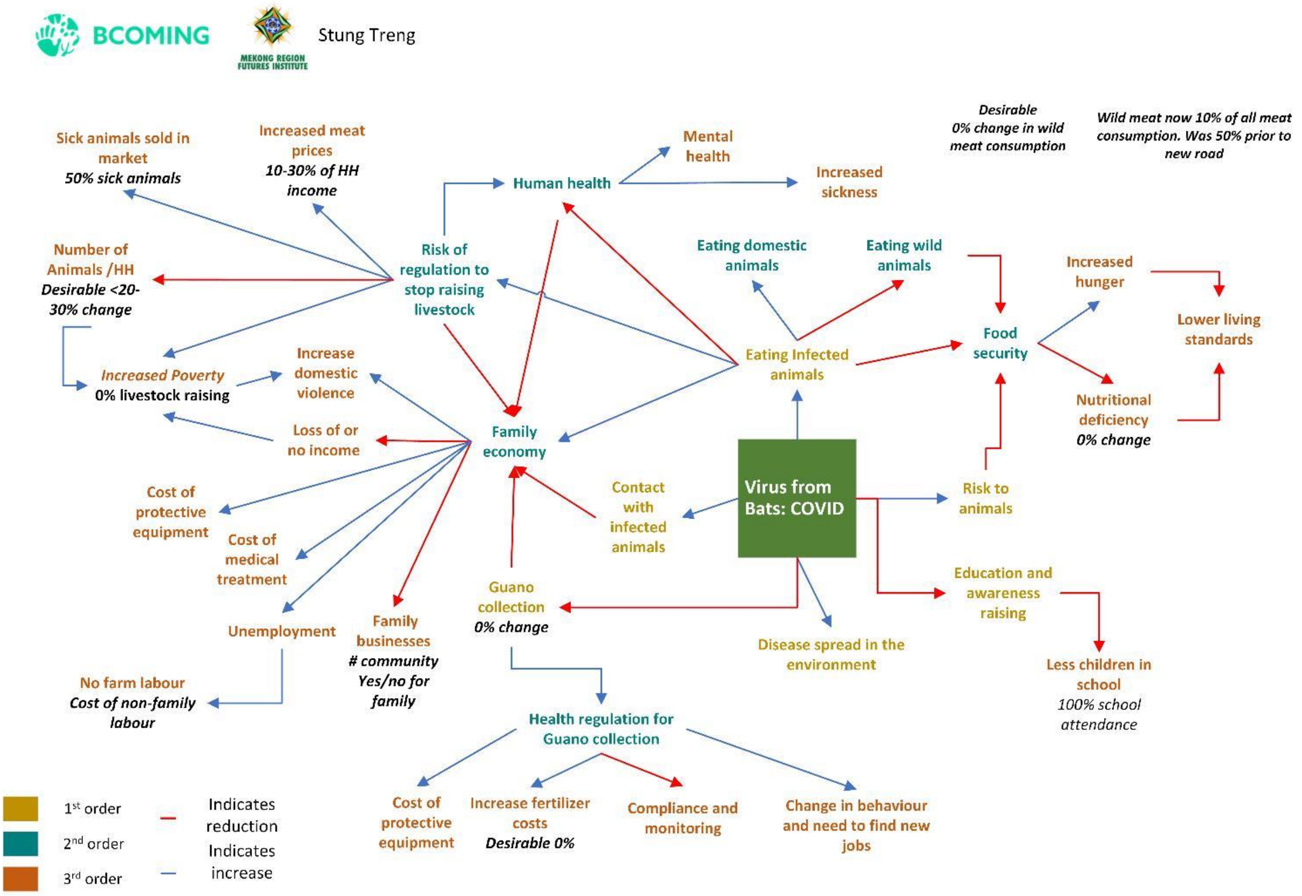
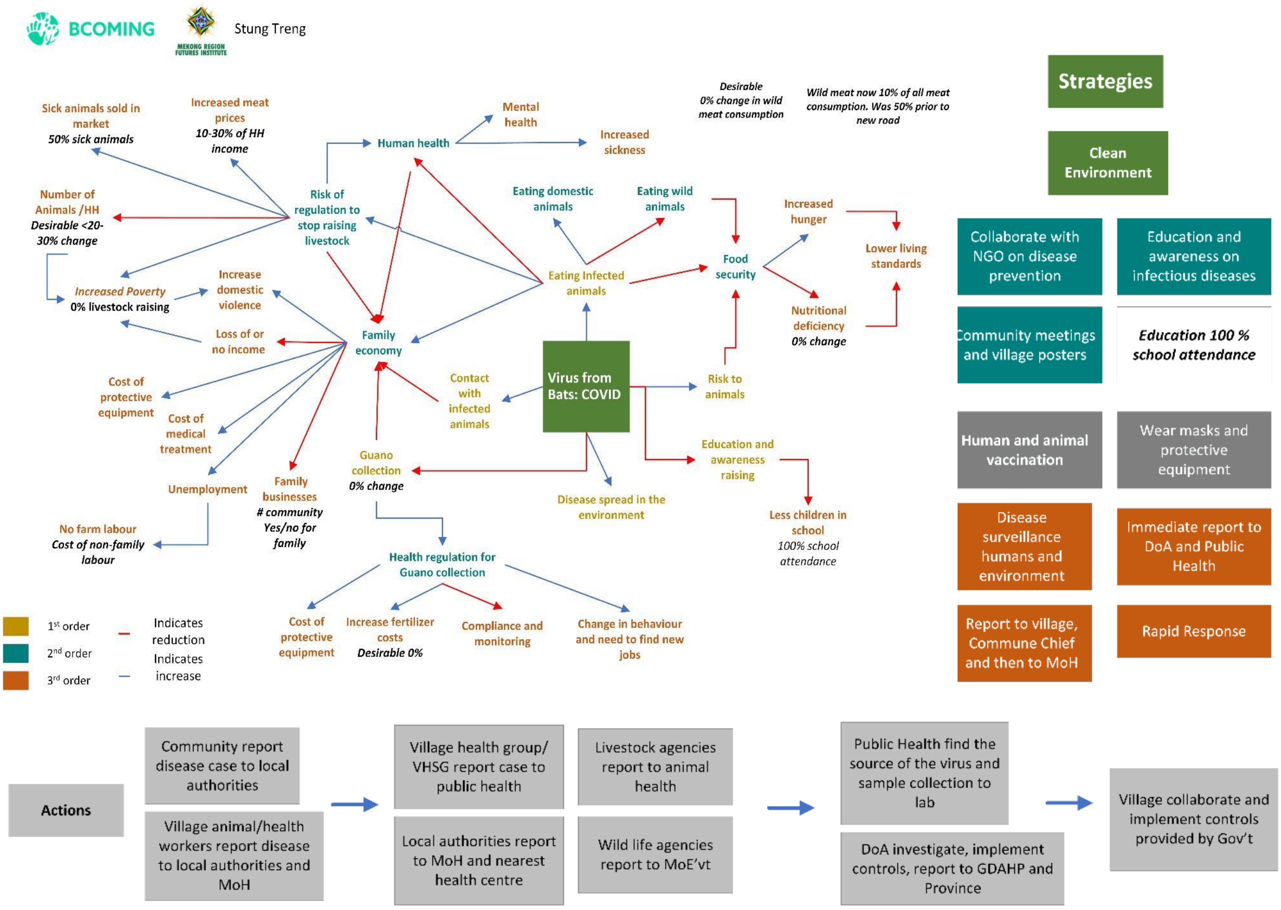
Figure 5 PSM of 1st, 2nd and 3rd order impacts of bats- SARS CoV-2 exposure in Sam'ang



Note: the red lines indicate a decline in the variable: the blue line represents an increase. Increase and declines do not indicate normative changes or relative benefits or costs, only a change in the variable valency.

The Sam'ang participants were invited to propose a series of surveillance strategies and actions to mitigate SARS CoV-2 exposure and manage human-bat interactions (Figure 6).

Figure 6: PSM of 1st, 2nd and 3rd order impacts and proposed surveillance strategies of bats- SARS CoV-2 exposure in Sam'ang



The strategies can be grouped into three main categories:

- technical training, disease prevention and education;
- human and animal vaccinations and prophylactics;
- monitoring and reporting processes.

Actions refer to the sequence of reporting from community detection and surveillance through local authorities and wildlife agencies and finally to regional public and animal health authorities.

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Chheu Teal PSM results

The Chheu Teal PSM workshop followed the same sequence and processes as the Sam'ang PSM workshop. That is explanation of the BCOMING project, participant instructions, ethics approval and signed consent to participate, and the co-creation of the 1st, 2nd and 3rd order impacts as perceived by the Chheu Teal community. The results of the workshop are illustrated in Figure 7.

Figure 7: PSM of 1st, 2nd and 3rd order impacts of bats-SARS CoV-2 exposure in Chheu Teal

A series of proposed community-based actions are depicted in Figure 8. The proposed actions and associated agency responsible for implementation follow a similar categorization as Sam'ang: disease prevention, animal husbandry and education; vaccination and quarantine programs and surveillance and reporting of diseased (wild and domestic) animals at market.

Figure 8: PSM of 1st, 2nd and 3rd order impacts and proposed surveillance strategies of bats-SARS CoV-2 exposure in Chheu Teal

Beliefs and causal relationships

The participatory systems mapping workshops allow us to make a series of observations that contribute to the ultimate goal of designing incentives to promote community participation in a co-constructed surveillance scheme. Participants stepped through the PSM process and revealed a set of causal beliefs relevant for the design of a surveillance scheme for bat transmitted SARS CoV-2.

Cognitive psychology emphasizes the importance and complex interaction of values, beliefs, norms and attitudes in influencing an individual's disposition towards learning (Fishbein and Ajzen, 1975; Ajzen, 1991). Behavioural beliefs relate to the cause effect relationship between an individual's action and an observed or expected outcome in the perceived social-ecological system, in this case the surveillance of zoonotic viruses and biodiversity relationship. Causal beliefs are shaped against the backdrop of individual life guiding values expressed as attitudes and actions (Stern et al., 1998). These three components can be directly mapped into prominent conceptualizations of human behaviour, such as Ajzen's Theory of Planned Behaviour (Ajzen, 1981) and Value Belief Norm Theory (Stern et al., 1999).

The causal beliefs extracted from the Sam'ang and Chheu Teal PSMs are listed in Table 1 and Table 2 respectively. Data of the entry and exit survey of psychometric variables (causal beliefs via the system maps and life guiding values questionnaire) were recorded and analysed.

Table 1: Causal beliefs extracted from the Sam'ang PSM

If SARS CoV-2 from bats is present, ….then				
Ist Order impact	**THEN**	**THEN**	**THEN**	**THEN**
Increased risk of eating infected animals	Increased risk of regulation to limit livestock Reduction in food security Household economy declines	Reduced number of HH animals Increased meat prices More diseased animals sold at market Reduced nutritional security (protein)	Increased poverty Increased human disease Reduced wellbeing Childhood malnutrition	Increased domestic violence Reduction in mental health
Increased contact with infected animals	Household economy declines	Reduced income Increased medical costs Increased unemployment Less family businesses	Increased poverty	Increased domestic violence
Guano collection declines	Increased health/guano regulations	Increased costs of protective clothing Increased fertilizer costs Reduced compliance and community monitoring		
Education declines	Less school attendance	Childhood illiteracy		

Table 2: Causal beliefs extracted from the Chheu Teal PSM

1st Order	**THEN**	**THEN**	**THEN**	
Trading stops: merchant fear of infection	Reduced farm income	Livestock cannot be sold Reduced agricultural production and livestock Reduced nutritional security (protein)	Increased poverty Ability to pay for school Reduced human health Emigration	Increased poverty and crime
National income declines	Decline in funding for roads, electricity connection, irrigation Fertilizer prices increase Livestock and crop prices decrease	Guano quantity limited		
Decline in education	Reduced school attendance Increased illiteracy	Declining community safety, increased crime		

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Reduced social contact	Loss of relationships	Decline in mental health Reduced business collaboration and social learning		
Reduced livestock and wild animal health	Increase in infected meat consumption	Reduction in human health Increased health expenses	Reduced wild meat consumption	

Stung Treng and Battambang system analysis

Bats infected with the SARS-COV 2 pose a risk for humans if in close contact

Bats are known to carry several viruses, including SARS-CoV-2, and can transmit them to humans through bites, scratches, or contact with bat droppings or urine. However, the risk of transmission depends on the prevalence of the virus in bat populations, the proximity of human populations to bat habitats, and the frequency and intensity of human-bat interactions.

Studies suggest that the risk of exposure to and transmission of SARS-CoV-2 or other bat-borne viruses maybe highest in regions with high bat diversity and human-bat interactions, such as Southeast Asia (Sánchez et al., 2022). To minimize the risk of exposure to bat-borne diseases, it is important to avoid direct contact with bats or their droppings, to avoid handling sick or dead bats, and to seek medical attention if you are bitten or scratched by a bat. It is also important to follow public health guidelines and take precautions to prevent the spread of COVID-19 and other infectious diseases, such as wearing masks, practicing good hand hygiene, and avoiding large gatherings.

Bats are known to carry several viruses, including SARS-CoV-2, and can transmit them to humans through bites, scratches, or contact with bat droppings or urine. The risk of transmission from bats to humans depends on several factors, such as the proximity of humans to bats, the frequency and duration of contact, and the characteristics of the virus itself (Wang et al., 2018). A study conducted in Cambodia by the Institut Pasteur du Cambodge found that although SARS-CoV-2 RNA was detected in some bats, the prevalence was low, and there was no evidence of ongoing transmission from bats to humans in Cambodia (Kimsan et al., 2021). In contrast. a study conducted in Thailand found that people living near bat caves had a higher risk of exposure to several bat-borne viruses, including coronaviruses (Olival et al., 2018).

According to the World Health Organization (WHO)[2], it is recommended that people avoid direct contact with bats and their droppings, and that they should not consume raw or undercooked bat meat. Additionally, it is recommended that individuals take appropriate precautions, such as wearing personal protective equipment, when handling bats or entering caves where bats are known to reside. While there have been reports of bat-to-human transmission of coronaviruses in other parts of the

[2] World Health Organization. (2020). Coronavirus disease (COVID-19): How is it transmitted? Retrieved from https://www.who.int/emergencies/disease-outbreak-news/item/2020-DON-01-February-COVID-19-transmission.

world, there is no evidence to suggest that SARS-CoV-2 specifically originated from bats in Cambodia. The origins of the virus are still under investigation.

References:
However, a study published in the journal PLOS Neglected Tropical Diseases in 2020 investigated the presence of coronaviruses in bats and other wildlife in Cambodia. The study analysed samples from 110 bats, 12 rodents, and 1 shrew, and found evidence of coronavirus infection in some of the animals. However, none of the coronaviruses detected in the study were closely related to SARS-CoV-2. Another study published in the journal Emerging Infectious Diseases in 2021 investigated the presence of coronaviruses in bats in Thailand, which borders Cambodia. The study analysed samples from 293 bats and found evidence of coronavirus infection in several bat species. However, none of the coronaviruses detected in the study were closely related to SARS-CoV-2 (Wacharapluesadee et al., 2021).

While these studies do not provide direct evidence of the risk of exposure to SARS-CoV-2 virus from bats in Cambodia or neighbouring countries, they highlight the potential for bats to carry coronaviruses and the importance of continued surveillance and monitoring of wildlife populations.

However, it is known that bats are natural hosts for a variety of coronaviruses, and there is evidence to suggest that SARS-CoV-2 may have originated from bats. Zhou et al., (2020b) sequenced the genome of SARS-CoV-2 and related viruses found in bats and pangolins, and concluded the virus likely originated in bats and was transmitted to humans through an intermediate host.

Another study published in The Lancet in March 2020 examined the clinical and epidemiological characteristics of the first 99 patients with COVID-19 in Wuhan, China, and found that a significant proportion of the early cases were linked to the Huanan Seafood Wholesale Market, which sold live animals, including bats.

While it is not clear how likely it is for people in Cambodia to be exposed to SARS-CoV-2 specifically from bats in nearby caves, it is important to note that the virus can be transmitted through respiratory droplets and close contact with infected individuals. Therefore, the most effective ways to prevent the spread of COVID-19 are to practice good hygiene, wear masks, maintain physical distance from others, and follow public health guidelines and recommendations. These studies suggest that bats are natural hosts for a variety of coronaviruses, and that SARS-CoV-2 likely originated from bats and was transmitted to humans through an intermediate host.

Bats infected with the SARS-COV 2 pose a risk for animals

There is limited scientific evidence on the risk of bats infected with SARS-CoV-2 for other animals, including livestock and wild animals, in the context of Cambodia. However, given that bats are known to be natural reservoirs of a variety of coronaviruses, including the closely related SARS-CoV-2 virus, it is possible that they could play a role in the transmission of SARS-CoV-2 to other animal species (Delaune et al., 2021). However, the study did not investigate the potential transmission of the virus from bats to other animals.

(Wong et al., 2021) reviewed the current understanding of the role of bats as reservoirs and carriers of coronaviruses, including SARS-CoV-2, and discussed the potential for spillover to other animal species. The authors noted that while there is limited evidence on the potential for SARS-CoV-2 transmission from bats to other animals, it is important to consider the potential risk for domestic and wild animals in areas where bat populations are known to carry coronaviruses (Fischhoff et al., 2021).

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Additionally, (Hul et al., 2021) reported the detection of SARS-CoV-2 RNA in several species of wild animals, including civets, pangolins, and rats, in Cambodia, indicating that they have been infected with the virus. However, the study did not investigate the source of the virus or the potential role of bats in transmission. SARS-CoV-2 has been detected in both wild and domestic animals (Das et al., 2023).

Overall, while there is limited scientific evidence on the specific risk of bats infected with SARS-CoV-2 for other animals in Cambodia, there is evidence to suggest that bats can play a role in the transmission of coronaviruses to other animal species. It is important for further research to be conducted to better understand the potential risks and transmission pathways of SARS-CoV-2 in different animal populations.

Bats infected with the SARS-COV 2 pose a risk for humans due to eating infected animals

There is evidence to suggest that eating infected animals can increase the risk of transmission of SARS-CoV-2 to humans. While the exact mechanisms of transmission are still not fully understood, it is believed that the virus can be transmitted to humans through contact with contaminated surfaces or through the consumption of infected meat (Li et al., 2020, 2021).

A recent study reported the detection of SARS-CoV-2 antibodies in samples from domestic pigs and wild boars in Vietnam indicating that these animals have been infected with the virus (Latinne et al., 2023). The authors of the study suggest that the close contact between humans and domestic pigs in Cambodia could increase the risk of transmission of the virus from pigs to humans.

Li et al (2021) investigated the potential for transmission of SARS-CoV-2 from farmed animals, including poultry and pigs, to humans. The authors concluded that there is a risk of transmission of the virus from infected poultry to humans through the consumption of infected meat or contact with contaminated surfaces.

It is important to note that the World Health Organization (WHO) recommends that people should handle raw meat, including meat from wild animals, with care to avoid contamination with pathogens, and that meat should be cooked thoroughly before consumption to reduce the risk of transmission of zoonotic diseases.

Overall, while the exact risk of transmission of SARS-CoV-2 to humans through the consumption of infected animals is still not fully understood, there is evidence to suggest that there is a potential risk. It is important for further research to be conducted to better understand the potential transmission pathways and risks associated with the consumption of infected animals.

One study published in the journal Emerging Infectious Diseases in December 2021 investigated the prevalence of SARS-CoV-2 antibodies in livestock and wildlife in Cambodia. The study found that a significant proportion of animals, including domestic pigs, cattle, and wild boars, had antibodies against SARS-CoV-2, indicating past infection with the virus. The authors of the study suggest that the high prevalence of SARS-CoV-2 antibodies in livestock and wildlife in Cambodia could increase the risk of transmission of the virus to humans through contact with infected animals or consumption of contaminated meat.

Another study published in the journal PLOS Neglected Tropical Diseases in February 2022 investigated the potential for SARS-CoV-2 transmission from wildlife markets to humans

(Wikramanayake et al., 2021)[3]. The study found that bats, including several species known to carry coronaviruses, were commonly hunted and consumed in Cambodia. The authors of the study suggest that the high prevalence of bat hunting and consumption in Cambodia could increase the risk of transmission of SARS-CoV-2 and other coronaviruses from bats to humans.

It is important to note that while these studies provide important new evidence regarding the potential for SARS-CoV-2 transmission from infected animals to humans in Cambodia, further research is needed to better understand the risks and transmission pathways associated with the consumption of infected meat and contact with infected animals.

However, some animals that are commonly hunted and consumed in Cambodia, such as civets, may also occasionally prey on bats. A study in Vietnam found that the common palm civet (Paradoxurus hermaphroditus) was a predator of the cave-dwelling bat species Hipposideros larvatus (Huong et al., 2019).

Overall, while there is limited information on the predation of bats by animals commonly hunted and consumed in Cambodia, it is possible that some of these species, such as civets or pythons, may occasionally prey on bats.

Bats infected with the SARS-COV 2 pose a risk for humans due to collecting Guano

There is limited scientific evidence available on the risks to humans due to collecting and using guano. However, there is some evidence to suggest that guano can be a potential source of zoonotic diseases, including coronaviruses.

Studies in Thailand found that several species of bats were infected with coronaviruses, and the viruses were also detected in villagers in close proximity to bat populations and guano collected from bat roosting sites. (Wacharapluesadee et al., 2013; Suwannarong et al., 2021). The authors of the study suggest that guano may serve as a reservoir for coronaviruses and other zoonotic pathogens, and that the collection and handling of guano may pose a risk of infection to humans and livestock.

(Lim et al., 2018; Cappelle et al., 2021) found that several bat species in Cambodia were infected with coronaviruses, and the viruses are likely to be detected in the guano samples collected from bat roosting sites. The handling and use of guano from bat roosting sites may pose a risk of infection to humans and livestock, and that further research is needed to better understand the risks associated with the use of guano as fertilizer. It is important to note that while these studies provide some evidence regarding the potential risks of collecting and using guano, further research is needed to better understand the risks and transmission pathways associated with the handling and use of guano, particularly in the context of SARS-CoV-2 transmission.

[3] https://www.telegraph.co.uk/global-health/science-and-disease/not-matter-scientists-alarm-ubiquitous-pathogens-wildlife-trade/ June 2024

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Guinea PSM results

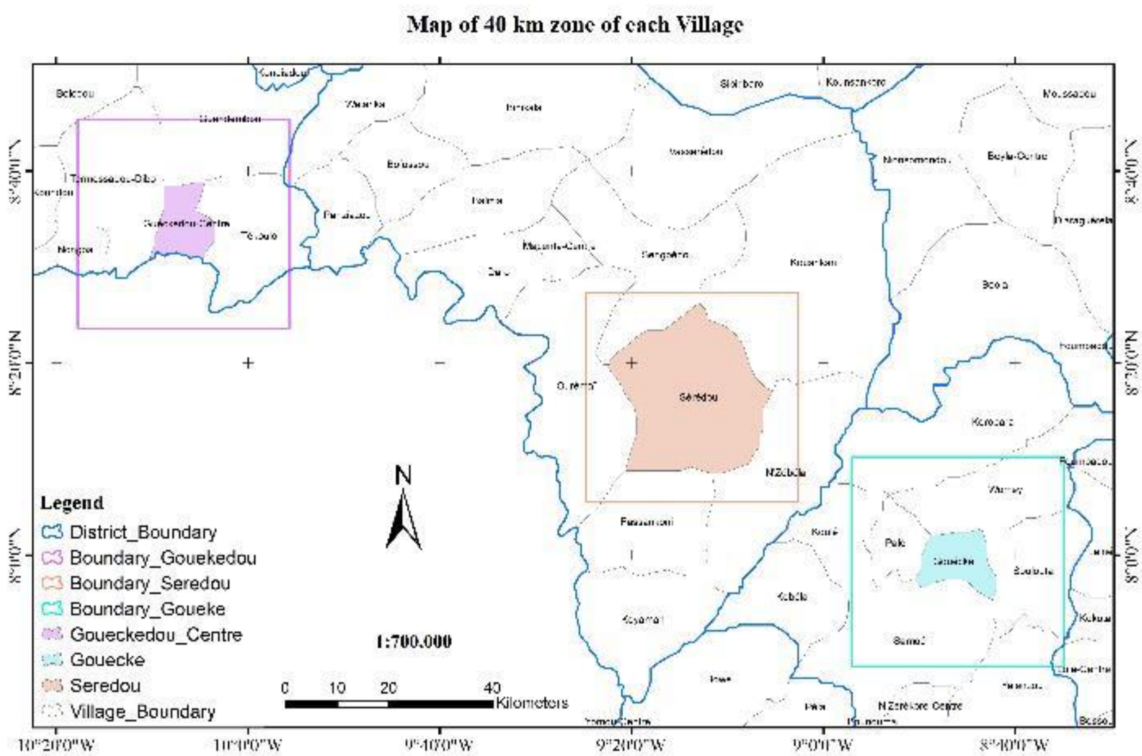
Planning and convening the PSM workshops in Seredou, Gueckedou and Guecke (in that order) followed the same process and protocols as the PSM workshops in Sam'and and Chheu Teal, Cambodia. Translated concept notes and invitations were submitted to village heads and local authorities to confirm dates, venue and participants for the 1st ChaRL workshops, successfully convened across the three BCOMING sites in July of 2023. The three case study sites and the 40 km system boundaries are illustrated in Figure *9*.

As a first step of the PSM workshop, the project team explained the BCOMING objectives and proposed activities. The project team presented background on the relationships between zoonotic viruses wild animals, bridging and amplifying species and the potential effects on human health.

In a second step, the BCOMING team, consisting of Dr John Ward, Toupou Koighae, Neus Estela, FFI staff and local translators facilitated the Guinea Participatory Systems Mapping (PSM) exercise. The zoonotic surveillance system maps were digitally transcribed and the first iteration of potential co-designed strategies documented. Data of the entry and exit survey of psychometric variables (causal beliefs via the system maps and life guiding values questionnaire) were recorded and analysed.

Ongoing meetings to coordinate WP6 and WP7 activities with WP5 ABM development commenced in August 2022. Meetings with WP5, WP6 and WP7 (FFI, CIRAD, IPC, MERFI and WCS) are continuing throughout 2024 to discuss potential external scenarios to be tested in the WP5 agent-based models (ABM). These will complement the co-designed community scenarios for zoonotic surveillance strategies. Th 2024 meetings have refocused of ABM objectives and surveillance strategies co-designed with communities.

Figure 9: 40 Km boundaries of Seredou, Gueckedou and Guecke, Guinea



Seredou

The first PSM Guinea workshop was held in Seredou with 80 community members from nearby villages, sub-prefecture animal and public health representatives and the village elders and leaders.

The completed and digitized PSM is illustrated in Figure 10. Communities in Seredou, Gueckedou and Geucke have suffered recent and severe ebola and SARS CoV-2 outbreaks. Compared to their Cambodian counterparts, the system maps of impacts and causal effects reflect a deeply traumatized community, with substantial declines in social cohesion and trust, mental health, household incomes and agricultural production, and increases in poverty, crime rates, family breakdown, child malnutrition and stress. Consistent with the Cambodian 3rd order impacts, declines in children's education and wellbeing and increase in delinquency were identified as important indirect impacts.

Emigration levels, albeit subject to border closures and lock-down, are critical 3rd order impacts affecting disease transmission and infection rates. The beliefs and causal effects extracted from the 1st order direct impacts and, 2nd and 3rd order indirect effects are depicted in Table 3.

Figure 10: PSM of 1st, 2nd and 3rd order impacts of exposure to viruses from wild animals in Seredou

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Table 3: Causal beliefs extracted from the Seredou PSM

Causal beliefs	If viruses from wild animals are prevalent…. THEN	
Lockdown, border closures increase	→Reduced regional trade Crop losses and decay	→Reduced labour for hire →Famine
Increased family dispersal **Reduced travel and immigration**	→Increased crime →Decreased respect for society →Decline in skills and talent	→Declining mental health
Decline in education	→Delays in school commencement and School closures	→Early/forced marriages →Illiteracy
Increased in animal disease and biodiversity loss	→Increased human exposure, transmission and illness →Climate change	→Increased emigration →Reduced viability of endangered species →Increased fires/drought and ecosystem disruption
Reduced crop/livestock health	→Decline in subsistence products	→Reduced nutrition, livelihoods, →Increased HH expenditures and emigration
Reduced HH income (increased poverty)	→Divorce →Increased emigration →Crime →Social conflict	→Delinquency and family separation →Decline in mental health →Increased child malnutrition →Increased social violence
Increased mis-information	→Decreased trust →Decreased community security, cohesion, cultural activities	→Increased poverty and conflict →Unemployment →Crime and community violence
Decline in investment and economic activities	→Increased unemployment, corruption and inequality →Declining quality of governance	→Increased emigration, reduced HH income and inflation

Gueckedou

The second PSM Guinea workshop was held in Gueckedou with 50 community members from nearby villages, sub-prefecture animal and public health representatives, the Prefecture Governor and village elders and leaders.

The completed and digitized PSM is illustrated in Figure 11. Communities in Gueckedou have suffered recent and severe Ebola and SARS CoV-2 outbreaks reflected in the system maps of impacts and causal effects. The 3rd order impacts depict a deeply traumatized community, with substantial declines in social cohesion and trust, mental health, household incomes and agricultural production, and increases in poverty, crime rates, family breakdown, child malnutrition and stress. Participants from Gueckedou emphasized the decline in children's education and wellbeing, and increase in delinquency, malnutrition and abandonment. The reduced frequency of health centre attendance was a 1st order effect, subject to fears of stigmatization and isolation.

PSM enables a visualization of complex cause and effect relationships which may not be immediately evident or visible. For example, the Gueckedou participants identified increased mis-information as a crucial direct impact, leading to stigmatization, fear reduced trust and community security and

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increases in suicide, corruption, divorce and crime. Reducing mis-information as a management strategy would then lead to reduced levels of delinquency, discrimination, community violence, poverty, and improved social cohesion and nutritional security.

The mis-information sequence of causal effects was a belief sequence also revealed in the Seredou, and Guecke PSM workshops. The extracted causal effects and beliefs are depicted in Table 4.

Figure 11: PSM of 1st, 2nd and 3rd order impacts of exposure to viruses from wild animals in Gueckedou

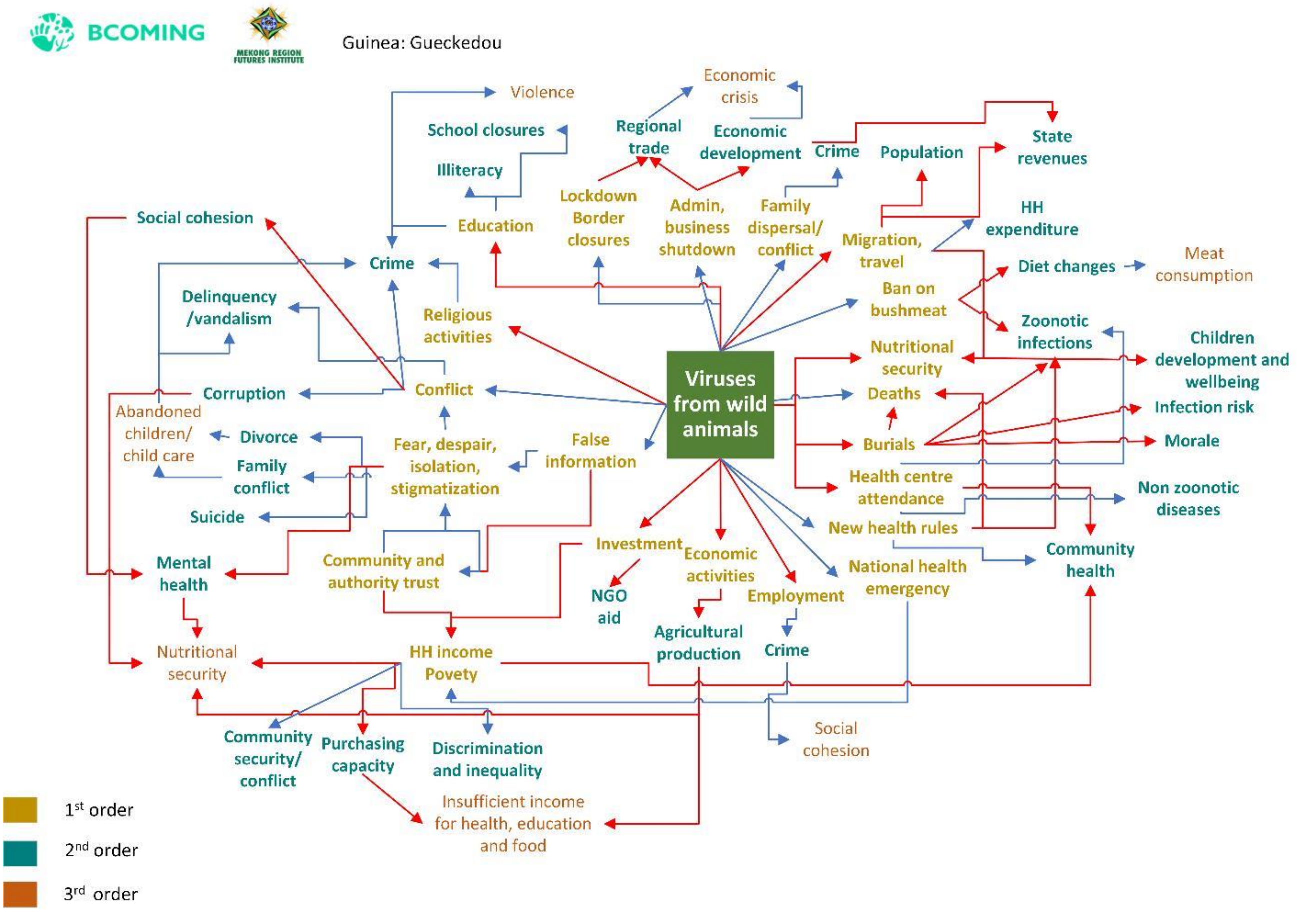

Table 4: Causal beliefs extracted from the Gueckedou PSM

Causal beliefs	**If viruses from wild animals are prevalent…. THEN**	
Lockdown, border closures and shutdown	→ Reduced regional trade → Reduced economic development	→ Reduced state revenues, labour → Famine
Increased family dispersal **Reduced travel and immigration**	→ Increased crime → Decline in population, skills and talent	→ Decline in child development/ wellbeing → Increased HH expenditure → Decline in nutritional security
Decline in education	→ Delays in school commencement and School closures	→ Increased violence and Illiteracy
Decline in health centre attendance **New Health rules**	→ Increased human exposure, transmission and illness → Decline in community health → Improved community health	→ Increased non-zoonotic diseases

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Reduced # burials	→ Decline in zoonotic infections and risk → Reduced community morale	→ Reduced nutrition, livelihoods, → Increased HH expenditures and emigration
Reduced Economic aid and investment **Reduced employment**	→ Reduced agricultural production → Increased crime	→ Decline in nutritional security → Inability to pay health, education, food → Increased conflict → Decline in social cohesion
Increased mis-information, stigmatization, fear and despair which leads to: **Decreased trust, community security, religious activities, cultural activities**	→ Increased community and family conflict, suicide, corruption, divorce → Crime, delinquency and community violence → Decreasing mental health → Increased poverty → Reduced social cohesion	→ Abandoned children → Increased conflict → Discrimination and inequality → Decline in nutritional security

Guecke

The third PSM Guinea workshop was held in Guecke with approximately 50 community members from nearby villages, sub-prefecture animal and public health representatives, and village elders and leaders.

The completed and digitized PSM is illustrated in Figure 12 and the extracted beliefs listed in Table 5. Communities in Guecke have also suffered recent and severe Ebola and SARS CoV-2 outbreaks, reflected in the system maps of impacts and causal effects. Similar to Seredou and particularly Gueckedou, the 3rd order impacts depict a deeply traumatized community, with substantial declines in social cohesion and trust, mental health, household incomes and agricultural production, and increases in poverty, crime rates, family breakdown, child malnutrition and stress. Participants from Guecke emphasized the decline in children's education and wellbeing, and increase in delinquency, malnutrition and abandonment. The reduced frequency of health centre attendance was a 1st order effect, subject to fears of stigmatization and isolation.

Figure 12: PSM of 1st, 2nd and 3rd order impacts of exposure to viruses from wild animals in Guecke

Table 5: Causal beliefs extracted from the Guecke PSM

Causal beliefs	If viruses from wild animals are present…. THEN	
Lockdown, border closures **Increased migration**	→ Reduced regional trade and transport options	→ Increased food shortages, workloads (women) → Reduced disease exposure → Reduced LH opportunities
Increased conflict	→ Increased family dispersal → Civil war → Increased crime and violence	→ Decline in mental health → Increasing misinformation →
Decline in education	→ Increasing family dispersal → Reduced innovation and community meetings	→ Misinformation → Illiteracy
Decline in health centre attendance	→ Increased human exposure, transmission and illness → Decline in community health → Self-medication → Increased deaths	→ Increased non-zoonotic diseases → Reduced surveillance → Poisoning → Abandoned children
Reduced crop production	→ Decline in field maintenance	→ Price increases and reduced plantation area
Reduced Economic aid and investment	→ Reduced employment → Increased debts, poverty, conflict and crime	→ Decline in community motivation &security → Increased violence and imprisonment
Decreased trust, and traditional customs and activities **Increased stigmatization, fear and despair** **Decreased community security, religious activities**	→ Increased mis-information → Delinquency and violence → Decreasing mental health → Increased poverty → Increase in self interest → Reduced social cohesion	→ Suicide, panic and conflict → Disease relapse → Reduced knowledge exchange → Discrimination and inequality → Decline in nutritional security and mental health →
Ban on bushmeat	→ Reduced nutritional security (protein)	→ Increased child morbidity → Reduced community security → Increased crime

Baseline monitoring indicators

Vigorous discussions at the Seredo, Gueckedou and Guecke workshops prompted the development of a set on monitoring or baseline indicators, developed by the workshop participants. Participants nominated 17 indicators representing the major changes that occurred and they had experienced during Ebola and SARS CoV-2 outbreaks (

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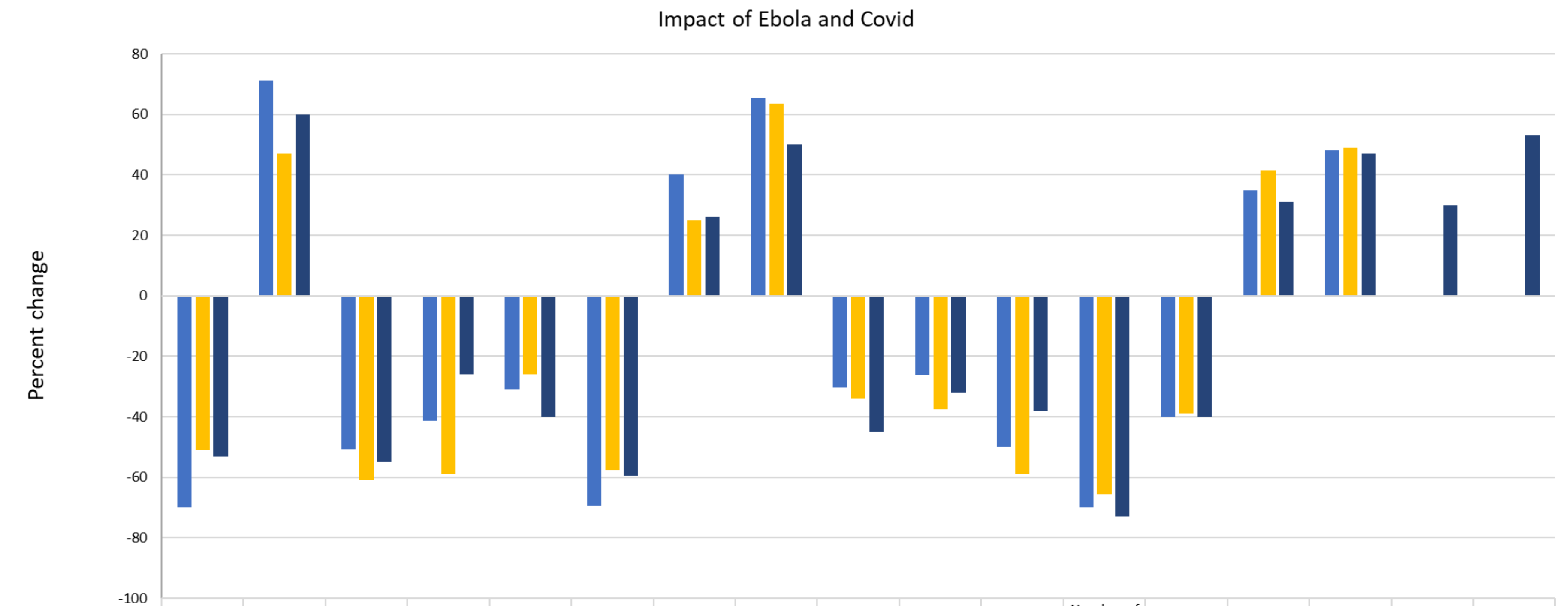
Figure 13). Break out groups of approximately 10 workshop participants were asked the percentage change they had experienced, across each indicator, during the zoonotic outbreaks. The scores were aggregated and mean values calculated.

Overall the percent changes and valency are relatively consistent across the three Guinea case study sites. For example household incomes? declined between 51% and 70%; malnutrition increased between 47% and 71%; crop production declined by 58% and 69%.

A critical topic of discussion was co-constructed surveillance systems can be evaluated by their ability to avoid the percentage changes across the 17 indicators.

Figure 13: Mean percent change of baseline indicators to monitor the effects of Ebola and SARS CoV-2 (Guinea)



	HH income	mal-nutrition	children education	migration	population	crop production	crime	unemployment	wild life loss	loss of domestic animals	Bushmeat	Number of people atending clinics or hospital	Investment	Deaths	Distrust	Inter community conflict	Rejection by health authorities
Seroudou mean	-70	71	-51	-41	-31	-69	40	66	-30	-26	-50	-70	-40	35	48		
Gueckedou mean	-51	47	-61	-59	-26	-58	25	63	-34	-37	-59	-66	-39	42	49		
Guecke mean	-53	60	-55	-26	-40	-60	26	50	-45	-32	-38	-73	-40	31	47	30	53

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Life Guiding Values

Life guiding values are the guiding principles in the life of a person. They reference the ways in which humans orient themselves ideologically, politically and emotionally towards the environment, and society. Human values also underpin disagreements between actors over natural resources. In short, *human values underpin all environmental governance*, and identifying them can help to understand what motivates environmental concerns (or its absence), and to predict how people will respond to change due to, for example, policy interventions and governance decisions to construct zoonotic surveillance programs.

The Theory of Basic Human Values is derived from Schwartz (1992) and further articulated by Stern *et al.* (1998). It measures 15 human values, grouped under five value dimensions or scales (Table 6) that also underpin the Value, Belief, Norm Theory (Stern et al., 1999).

Table 6: Human value scales

Bio-centricity	**Egocentricity**	**Altruism**	**Openness to Change**	**Conserving family**
1. Respecting the earth (harmony with other species). 2. Unity with nature (fitting into nature). 3. Protecting the environment (preserving nature).	4. Wealth (material possessions, money). 5. Authority (the right to lead or command). 6. Influence (having an effect on people and events).	7. Equality (equal opportunity for all). 8. A world at peace (free of war and conflict). 9. Social justice (correcting injustice, care for the weak).	10. A varied life (filled with challenge, novelty and change). 11. Curious (interested in everything, exploring). 12. An exciting life (stimulating experiences).	13. Honouring parents and elders (showing respect). 14. Self-discipline (self-restraint and resistance to temptation). 15. Family security (safety for loved ones).

At each of the PSM workshops at both commencement and conclusion, participants were asked to self-complete a questionnaire indicating how important each value was for them as a guiding principle in their lives on a scale from -1 to 4:

- -1: the value opposed the principles that guided their lives.
- 0: the value was not at all important as a guiding principle.
- 1, 2 and 3: meant that the value was of increasing importance.
- 4: the value was of supreme importance as a guiding principle in their lives. Usually, there are no more than two such supreme values.

The higher the number (0-4) the more important the value was as a guiding principle in each person's life.

To facilitate statistical interpretation and analysis, the scores were recoded as follows: -1=1; 0=2; 1=3; 2=4; 3=5 and 4=6.

The objectives of the human values questionnaire were to:

- Establish an empirical basis to estimate current and future statistical relationships; i) across cohorts and locations; and ii) between values and behaviour;
- Establish an empirical basis to estimate the likelihood of inter-group cooperation and trust; and
- Establish an empirical foundation of program monitoring and evaluation (Smajgl and Ward, 2013, 2015; Smajgl, Ward, et al., 2015).

Shared values, both actual and perceived, are central to levels of trust and a key indicator of the likelihood of cooperation in co-constructing community led surveillance strategies and understanding potential variance in compliance (Höppner, 2009). The perception of shared values rather than shared interests is likely to be important where trust judgements cannot be based solely on personal interaction, a situation typical of the diverse Cambodian and Guinea communities.

The workshop entry and exit scores for Sam'Ang (Stung Treng), Chheu Teal (Battambang) Seredou, Gueckedou and Guecke are listed in Table 7.

Table 7: Life guiding values: mean entry and exit scores across the Cambodia and Guinea PSM workshops

Case Study	PSM Entry/Exit	Altruism	Egoistic	Conservative	Biocentic	Open to Change	Supreme importance
Stung Treng	Exit	14.9	15.0	15.2	14.3	14.4	5.1
Battambang	Entry	16.3	15.5	15.9	15.4	14.3	7.0
	Exit	15.9	16.2	16.9	16.1	15.6	8.3
Seredou	Entry	15.1	13.4	14.4	15.1	13.8	5.7
	Exit	15.3	13.6	14.6	15.6	13.6	5.8
Geuckedou	Entry	16.7	13.5	16.8	17.2	13.9	7.7
	Exit	15.0	12.1	15.7	15.7	13.8	4.8
Guecke	Entry	16.2	14.5	15.9	16.3	13.9	7.0
	Exit	16.2	14.4	15.9	16.7	15.1	6.8

Supreme Importance is calculated as the number of times a respondent scores one of the life guiding scale items as a 4 (supreme importance). The aggregate score is an indication of the level that respondents discriminate between the 15 scale items. A low score indicates a higher level of discrimination (Smajgl and Ward, 2015).

The decrease in the mean exit supreme importance scores (4.8) and the entry scores (7.7) of Gueckedou participants indicates increasing discrimination; that is fewer scale items were scored as a 4. Human value scores will continue to be monitored throughout field surveys and future ChaRL workshops.

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Guadeloupe: PSM Process

The workshop was organised on 2 May 2024 with 23 participants attending. Participants were selected to represent targeted stakeholder groups relevant to a future co-created implementation of an innovative surveillance scheme for Dengue and West Nile Viruses (WNV) in Guadeloupe. In a first step, the BCOMING project was explained with its goals to minimise zoonotic risks for a range of diseases around the globe, including the goal to reduce risks of Dengue and West Nile in Guadeloupe. Then, the main method of the workshop, Participatory Systems Mapping (PSM), was explained.

It was explained that PSM is a collaborative approach used to understand and visualize the complex relationships and dynamics within a system by involving stakeholders directly in the mapping process. This method combines systems thinking and participatory techniques to create visual representations, or maps, of the interconnections and feedback loops that exist among various elements within a system.

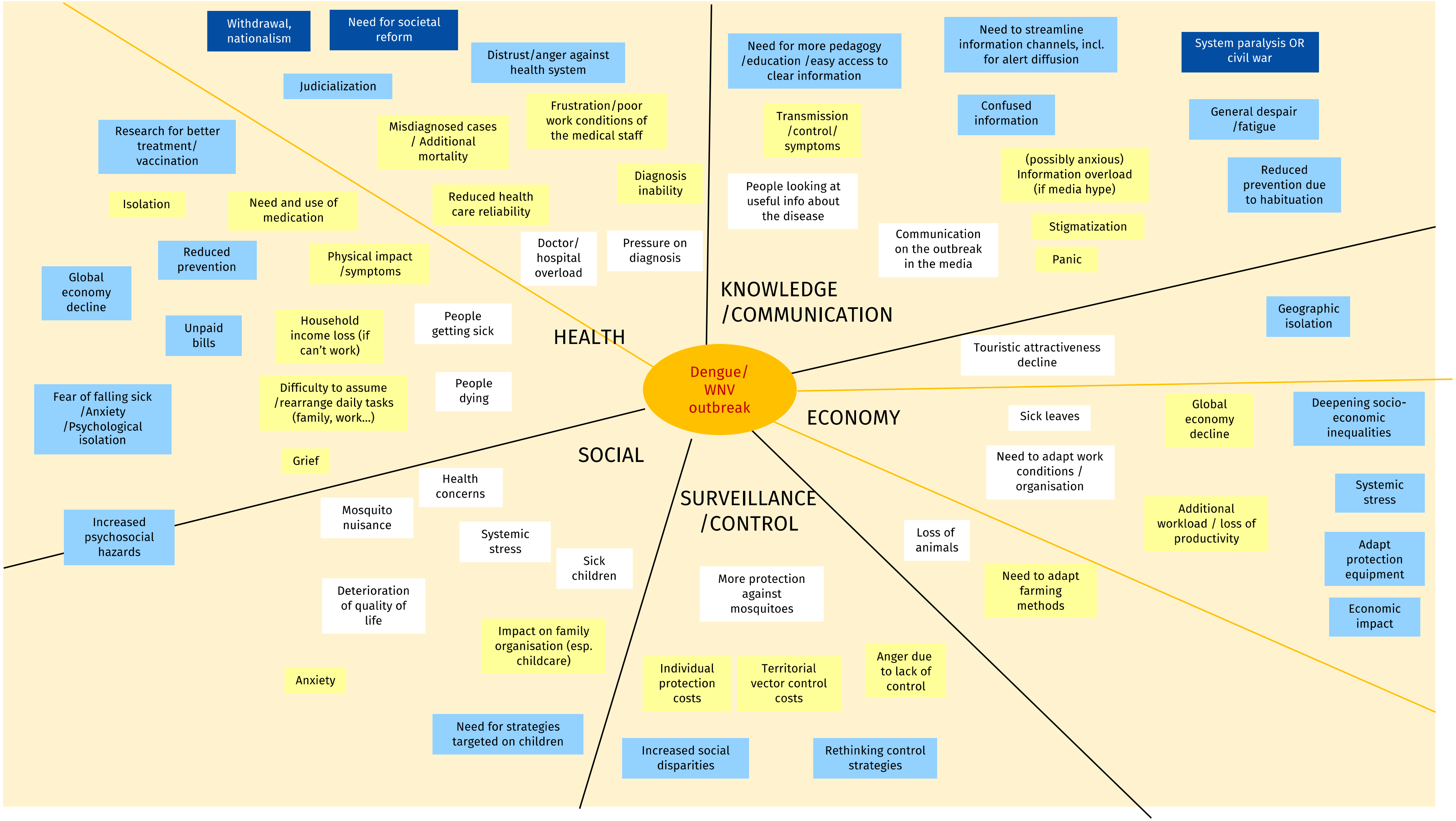
It was further clarified that PSM is particularly valuable in addressing complex, multifaceted issues as it incorporates diverse perspectives and knowledge from stakeholders, ensuring a more comprehensive understanding of the system. By engaging participants in the mapping process, PSM fosters a sense of ownership, encourages collaborative problem-solving, and helps identify leverage points for effective intervention. This approach is widely used in fields such as environmental management, public health, and community development to address systemic challenges and co-create sustainable solutions.

The focal factor for the PSM process was presented as “Dengue/WNV outbreak”. Participants noted first order impacts (direct consequences of the outbreak) on post-its, which can be seen in

Figure 14 as white notes. Facilitators clarified each note and grouped them if the meaning was identical. Then, participants were asked to note what they perceive as (possible) second order impacts, which are direct consequences of first order impacts. These were handed in on yellow post-its. Facilitators clarified again in plenary the meaning of each note handed in, grouped them if they had a similar meaning, and placed them close to the relevant (or causing) first order impact. In a third round, participants noted direct consequences of second order impacts, which were handed in on blue post-its. Facilitators discussed again the exact meaning of each consequence, then grouped post-its if necessary and placed them where participants saw main causalities playing out. Some of these third order impacts were turned into fourth order impacts (dark blue, Figure 11).

Figure 14 shows the final “systems map”. Due to participants repeatedly referring to multiple connections, no explicit links (arrows) were added to the systems map. Facilitators placed post-its on the whiteboard according to themes. The main themes that emerged during the workshop were Health, Economy, and Social, receiving most notes. Additional topics were Knowledge/Communication and Surveillance/Control.

Figure 14: Final systems map for Dengue and West Nile outbreak in Guadeloupe



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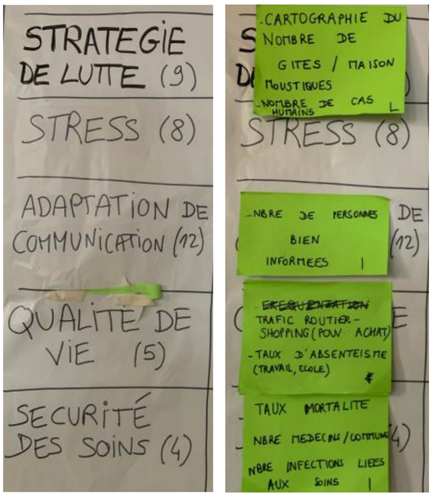
In a next step, participants were asked to prioritize factors/consequences (post-its) shown on the whiteboard, independent from them being first, second, or third-order impacts. Each participant was given five small post-its and they were asked to place them on top of the factors they consider the five most important ones. Then, the 'votes' were counted. Figure 15 shows on the left the highest scoring factors. Communication received 12 votes, Control strategies 9, Stress 8, Quality of life 5, and Reliability of health care 4 votes.

Figure 15: Factor prioritisation and subsequent indicator specification

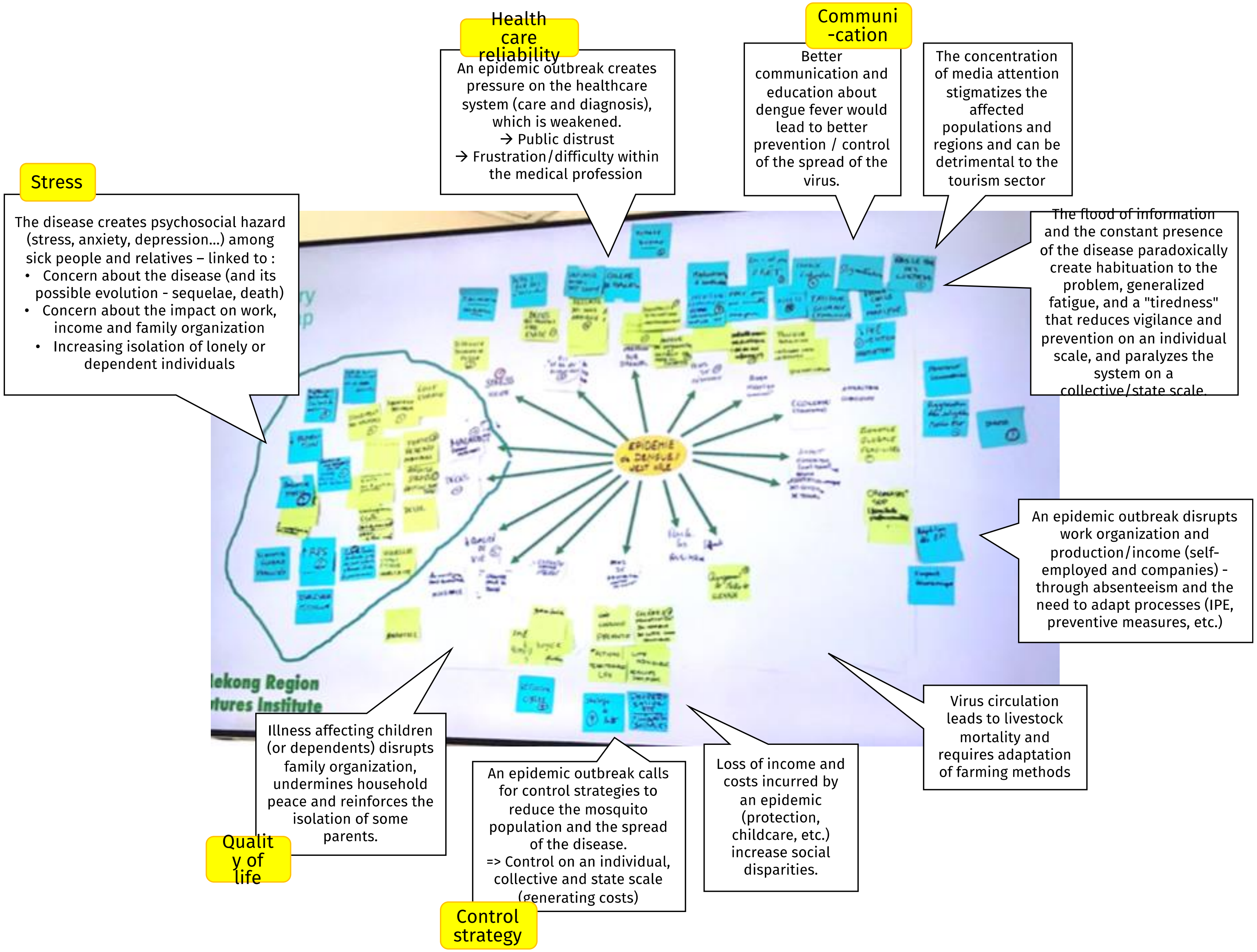


Control strategies	• **Number (and spatial pattern) of breeding sites & mosquitos per house** • **Number of human cases (infections)**
Stress	• Consumption of anti-anxiety medication • **Number of Google searches** • Stress levels for individuals
Tailoring the communication	• Number of well-informed people
Quality of life	• **Count of sick days (of children)** • Time for shopping ("Retail therapy"?) • Efficiency of public services
Reliability of health care	• **Number of mortalities (age) per community** • Number of doctors per community • **Misdiagnosed cases** • **Capacity overload of hospital system** (RF: diagnostic time, number of symptomatic cases…)

Based on these results, facilitators discussed in plenary what participants would perceive as effective indicators for these five high-priority factors. It was explained that indicators would need to be measurable to allow for monitoring improvements. All indicators are shown on the right of Figure 15, with the ones perceived as the most operational ones listed in bold.

Figure 16 summarises the main discussion points made across all workshop sessions for each theme. Which reveals causal beliefs participants hold. Causal beliefs and values will be discussed and analysed in more detail in subsequent sections.

Figure 16: Summary of discussion points for each theme



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In the final step of the workshop, participants focused on solutions. They were encouraged to consider all cause-effect relationships the PSM process revealed. Strategies were discussed and defined within break-out groups. As workshop participants were divided into three break-out groups, only the three top ranking factors were addressed.

For improving *communication* to counter the possible impacts of a Dengue or West Nile outbreak, participants suggested the following strategies/actions:

- Implementing mobile educational workshops, moving between classes and schools
- Creating an online training with « follow-up / update » obligation
- Information through occupational medicine (médecine du travail) and mandatory control strategy/plan for employers (same as what was imposed during COVID)
- Campaign "My city without mosquitoes" (like the « ville fleurie » label)
- Awareness raising / information messages on social networks
- SMS alerts (same as for tsunami alert).

Overall, the group emphasised the relevance of a targeted communication strategy.

For the second highest ranking factor, *Control strategies*, the second break-out group deliberated possible intervention options:

- Local communication / pedagogy (at school, pop science, neighbourhood association, touristic areas)
- Inspections on the presence of breeding sites at people's homes
- Regional support/funding to install mosquito nets on windows
- Removal of all garbage tending to be breeding sites

The break-out group focussing on the third factor, *Stress*, proposed the following strategies:

- Promoting happiness; sharing the right information through neighbourhood associations, not via mail box, regular lessons at school and parent-children activities
- Promote culture and sports
- Filter/Monitor information on social networks.

In this context it was clarified that stress included mental issues such as anxiety.

This session concluded the workshop. The following section provides the analysis of workshop results described so far.

Beliefs

The participatory systems mapping workshop allowed us to make a series of observations that contribute to the ultimate goal to design incentives for public participation in a surveillance scheme. Participants stepped through the PSM process and revealed thereby a set of causal beliefs relevant for the design of a surveillance scheme for Dengue and West Nile.

Table 8: PSM derived causal beliefs, Guadeloupe.

CAUSAL BELIEFS:	**If Dengue / WNF outbreak …then**		
People getting sick	→ Household income loss	→ unpaid bill	→ Anxiety
Health concerns	→ Anxiety	→ psychosocial hazards	
Hospital overload	→ Frustration/poor work conditions of the medical staff	→ Misdiagnosed cases / Additional mortality	→ Reduced health care reliability → Distrust/anger against health system
Pressure on diagnosis	→ Diagnosis inability		
Sick children	→ Impact on family organisation (child care need)	→ Anxiety	
Mosquito nuisance	→ Deterioration of quality of life		
More protection against mosquitoes desired	→ Individual protection costs increase	→ Increased social disparities	
Touristic attractiveness decline	→ Geographic isolation increases	→ Economic impact	
Sick leave	→ Deepening socio-economic inequalities		
Communication on the outbreak in the media	→ Information overload → Stigmatisation	→ Panic → General despair	→ System paralysis → Social conflict

Incentives for Public Participation

To design an effective surveillance scheme for mitigating the risk of Dengue or West Nile outbreaks in Guadeloupe, various incentives for public participation could be considered to ensure engagement and commitment from the community. The following discusses possible incentives for Guadeloupe in six groups.

The first group of relevant incentives are financial incentives:

- Compensation for time and resources spent on participating in surveillance activities.
- Subsidies or vouchers for mosquito protection products (e.g., nets, repellents).

Typically, financial incentives are a crucial motivator for participation. Providing compensation for the time and resources spent on surveillance activities can alleviate the economic burden on individuals. Additionally, offering subsidies or vouchers for mosquito protection products, such as nets and repellents, can make these essential items more accessible and affordable, reducing the overall cost for families and encouraging widespread use.

The second group is related to healthcare benefits:

- Priority access to medical care and diagnostic services.
- Free or subsidized vaccination programs (if available).
- Regular health check-ups for participants and their families.

Healthcare benefits also serve as significant incentives. Participants could receive priority access to medical care and diagnostic services, ensuring they are promptly attended to during an outbreak. Free or subsidized vaccination programs, where applicable, would further protect individuals from disease. Regular health check-ups for participants and their families can also be a valuable incentive, promoting overall well-being and early detection of any health issues.

The third group of incentives are community and social incentives:

- Community recognition programs (e.g., certificates, public acknowledgment).
- Organizing community events or workshops that are both educational and engaging.
- Creating a sense of community ownership and pride in contributing to public health.

Community and social incentives can foster a sense of pride and collective responsibility. Implementing community recognition programs, such as certificates or public acknowledgments, can highlight the contributions of participants, making them feel valued and appreciated. Organizing community events or workshops that are both educational and engaging can strengthen community bonds and provide a platform for sharing knowledge and experiences. Creating a sense of community ownership and pride in contributing to public health can motivate sustained participation.

The fourth group are educational incentives:

- Providing educational materials and training on how to prevent mosquito-borne diseases.
- Opportunities for participants to become community health ambassadors.

Educational incentives are vital for empowering the community with knowledge. Providing educational materials and training on preventing mosquito-borne diseases can equip individuals with the skills needed to protect themselves and their families. Opportunities for participants to become community health ambassadors can further enhance their role, allowing them to educate and influence others in their community.

The fifth group of incentives are technological incentives:

- Access to apps or tools that help track and report mosquito activity and outbreaks.
- Providing gadgets or tools that assist in monitoring (e.g., mosquito traps, sensors).

Technological incentives can modernize and simplify the surveillance process. Offering access to apps or tools that help track and report mosquito activity and outbreaks can make participation more convenient and interactive. Providing gadgets or tools that assist in monitoring, such as mosquito traps or sensors, can empower participants with the means to contribute effectively to the surveillance efforts.

The sixth and final group of incentives are collaborative incentives:

- Establishing partnerships with local businesses to offer discounts or rewards for participants.
- Collaborating with schools and educational institutions to involve students and parents.

Collaborative incentives can harness the power of local partnerships. Establishing partnerships with local businesses to offer discounts or rewards for participants can create additional value and encourage participation. Collaborating with schools and educational institutions to involve students and parents can also widen the reach of the surveillance scheme and integrate it into the daily lives of the community.

Values

Addressing challenges identified in the workshop is crucial to ensure the incentives are effective and inclusive. Implementing mental health support programs and providing resources for managing stress and anxiety can help alleviate the psychological impact of outbreaks. Ensuring that participation is accessible to all socio-economic groups is essential to avoid deepening inequalities. Offering support services for families, such as childcare during participation in surveillance activities, can address the specific needs of families with young children.

To enhance quality of life and reduce social disparities, it is important to ensure that mosquito protection measures are affordable and accessible to all. Developing community-led initiatives to collectively reduce mosquito populations can also improve the living conditions for everyone. Communicating the community's proactive measures in promoting a safer environment for tourists can mitigate the decline in touristic attractiveness and highlight the efforts being made to control outbreaks.

Clear, accurate, and reassuring communication strategies are vital to prevent panic and stigmatization. Creating channels for community feedback ensures that the information provided meets the community's needs and concerns, fostering trust and collaboration.

By implementing these incentives and addressing the associated challenges, a robust and effective surveillance scheme can be created that not only mitigates the risk of Dengue or West Nile outbreaks but also fosters community participation and resilience.

Addressing the Challenges

Given the identified consequences, a range of highly held values would need to be supported by the targeted surveillance scheme:

- **Anxiety and Socio-economic Inequalities**:
  - Mental health support programs would need to be implemented and resources provided for managing stress and anxiety.
  - It will need to be ensured that participation is accessible to all socio-economic groups to avoid deepening inequalities.
- **Childcare Needs**:
  - Support services will need to be offered for families, such as childcare during participation in surveillance activities.
- **Quality of Life and Social Disparities:**
  - It will need to be ensured that mosquito protection measures are affordable and accessible to all.
  - The solutions will need to be community-led initiatives to collectively reduce mosquito populations.
- **Economic Impact:**

- The initiative will need to collaborate with the tourism boards to control outbreaks, potentially mitigating the decline in touristic attractiveness.
- The community's proactive measures will need to be highlighted in promoting a safer environment for tourists.

- **Communication and Social Impact:**
  - Clear, accurate, and reassuring communication strategies will need to be developed to prevent panic and stigmatization.
  - Channels for community feedback need to be created to ensure that the information provided meets the community's needs and concerns.

Designing Solutions

1. **Linking Childcare Services to Reporting via a Smartphone App**

Concept: People sign up on an app and regularly report data such as mosquito encounters, bite incidents, and other relevant information. In return, they receive free childcare services if their children or they become sick during an outbreak.

This design has a few advantages. It provides a clear, tangible benefit that directly impacts families, which is a strong, direct incentive. It also encourages active participation and increases community involvement in public health, which has additional synergetic side effects for a range of social indicator, incl. social cohesion and public safety. Furthermore, the scheme ensures continuous and reliable data collection, which can be crucial for timely interventions.

However, there also challenges. For instance, accessibility is a challenge. The implementation would need to ensure that all segments of the population have access to smartphones and are comfortable using apps. A solution for this challenge could be to provide subsidized or free smartphones to low-income families and conduct training sessions on using the app.

Data accuracy can be a challenge, which involves motivating accurate reporting while minimizing false reports or neglect. This challenge means that a verification system would need to be implemented, perhaps using location services to confirm reporting locations and cross-referencing data points.

Further, setting up and maintaining a robust childcare support system during outbreaks is costly and potentially challenging. This challenge could be solved by partnering with local childcare providers and train additional caregivers to scale up services during outbreaks.

Finally, building trust in the system so that people believe in and commit to using the app could be a challenge. A solution for this challenge could be to launch a community-driven awareness campaign to explain the benefits and workings of the app, involving local leaders and health professionals.

2. **Gamified Community Health Engagement**

Concept: A gamified platform is created where individuals and communities earn points for participating in surveillance activities (reporting mosquito sightings, attending health workshops, etc.). Points can be redeemed for local services, products, or community improvements (e.g., park enhancements). This mechanism has a similar angle to the previous design but targets more population segments as the benefits are attractive incentives not only for parents of young children.

An obvious challenge is that engagement needs to be sustained. This could be addressed by regularly updating game mechanics to keep them interesting and ensure point redemptions are meaningful and diverse.

3. **Blockchain-Based Reporting System**

Concept: Develop a blockchain-based reporting system where data submitted by users is encrypted and immutable, ensuring privacy and accuracy. Users receive tokens for their contributions, which can be used for discounts on health services and products. This is similar to solution 2 but founded on blockchain technology.

The challenge is the technical complexity and user adoption. However, user interfaces could be simplified and clear instructions could be provided on how to use the system, alongside community education campaigns about the benefits and security of blockchain.

4. **Health Credit System**

Concept: Implement a health credit system where participants earn credits for reporting data, participating in clean-up drives, and attending health workshops. Credits can be redeemed for health insurance discounts, medical supplies, or local health services.

A potential challenge is the setting up and managing of the credit system, and ensuring equitable distribution across all population segments. This could be addressed by partnering with local health providers and insurers to integrate the credit system, and establish transparent criteria for earning and redeeming credits.

5. **Neighbourhood Health Ambassadors Program**

Concept: This approach would train and incentivize local residents to become health ambassadors who educate their communities about Dengue and West Nile prevention and gather data. Ambassadors receive stipends, community recognition, and additional training opportunities.

Challenges here are to recruit and retain motivated individuals, and ensuring consistent data quality. This challenge could be met by offering ongoing training, support networks, and opportunities for career advancement in public health fields.

6. **Community-Driven Environmental Management**

Concept: As a variation of the previous mechanism, a community-led program could be established where residents adopt local areas to manage and maintain, focusing on eliminating mosquito breeding sites. Participants receive environmental stewardship credits that can be used for various community services.

A key challenge for this strategy is to ensure sustained participation and effective management. This challenge could be addressed by providing ongoing support, training, and incentives for high-performing areas, and integrate with local environmental and health agencies for broader impact.

By focusing on innovative, multi-faceted approaches that provide tangible benefits and engage the community in meaningful ways, it is possible to enhance public participation in Dengue surveillance and management efforts in Guadeloupe.

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