**Systems knowledge to decision support: Roles of stakeholders in the**

**(pre-)transition of agro-climate services**

**Abstract**

Transitioning from conventional way of providing climate and agriculture information towards agro-climate services (ACS) demand decision-makers to make-decisions that can generate benefits for the socio-economic and environmental development. However, defining effective solutions and valuing the benefits such decisions often struggle with complexity and uncertainty. In addition, how such evidences could be brought-up to political decisions is known with limited understanding.

Previous studies on ACS hardly address uncertainty, complexity, multi-stakeholders, inter-organizational governance, decision-making in a comprehensive way. Our study aims to address the methodological gap by proposing a transparent and systematic method to engage stakeholders in translating systems knowledge into decision-making processes.

We demonstrate our method in a case study in Dien Bien District, Vietnam to engage stakeholders in generating systems knowledge and in defining roles of stakeholders in the decision-making process. All of this process involve the analysis of multi-dimentional roles of stakeholders.

In order to engage those stakeholders, key attributions of stakeholders identified include their availability, experience, gender, expertise, stake, interest, influence, relevance and attitude. The results show that our approach is novel in engaging stakeholders to support systems knowledge generation and in determining windows of opportunities to influence the (pre-) transitions stage of agro-climate services.

# Keywords: decision-making, uncertainty, complex, inter-organization, attributions

1. **Introduction**

Agro-climate services (ACS) play a vital role in supporting agricultural planning and practices in the context of climate change (Luu et al., 2022a). In many developing country settings, however, the transition towards climate-informed agriculture management is restricted by complex systems issues. Such issues include a lack of finer resolution weather and climate data, uncertain weather forecast accuracy, lack of capacity to interpret climate information into actionable advice to different agricultural users, lack of capacity and infrastructure to deliver timely and actionable information, limited resources for adaptation, and lack of robust evidence showing the socio-economic benefits of ACS (Luu et al., 2022a). The delayed transition toward climate-informed agricultural management will result in the losses of agricultural inputs, damaged yields and limiting the appropriate use of agro-climatic resources (Luu et al., 2022a).

For transitions to happen, ACS solutions to address these complex issues and decisions to put those solutions in policy and practice are needed. These solutions must build on the understanding of political, economic, environmental, social, cultural, and technological systems that might affect the effectiveness of the solutions. For example, it is needed to understand the political prioritization and decision-making in investing in ACS. It is also vital to identify technology/resource availability for delivering information to a diverse groups of farmers, to ensure farmers can access information. Proposed solutions also need to include the justification for the return on investment given the limited resources for adaptation, especially in developing countries. The cost-benefit analysis aggregated for each stakeholder will provide insights on the potential “winners” and “losers”, if the decisions are being made. To gain this system understanding for supporting the ACS decisions, it requires engaging with diverse stakeholders who might affect, be affected or have an interests in the transition of climate-informed agricultural management. Among those stakeholders, some might play vital roles by engaging in the ACS policy formulation and decision making processes.

Previous studies on ACS remains having challenges in valuing uncertainties, especially in quantifying economic, social and environmental benefits (WMO, 2015). While there is a lack of data on ACS benefits, some efforts have been made to engage experts in generating data. However, a critical challenge is the management of biases in the expert data generation processes (Luu et al., 2022b; Perrels et al., 2013; WMO, 2015). Furthermore, to our understanding, preceding studies also focused on the overall cost-benefits of ACS with limited considering the potential costs and benefits aggregated for different stakeholders (Luu et al., 2022b). This will result in a high ambiguity in decision making, as well as uncertain incentives for stakeholders to engage in ACS. In the meanwhile, studies on stakeholders in natural resources management mainly focus on mapping and analyzing stakeholders’ power and interest, to better manage or engage them in supporting some intended goals (Reed et al., 2009; Yang et al., 2011). Efforts have been mentioned extensively in mobilizing stakeholder representatives to generate knowledge through workshops, surveys, interviews, and group discussions (Reed et al., 2009; Yang et al., 2011). Nevertheless, stakeholder studies hardly focus on the methods to engage stakeholder representatives in creating unbiased systems understanding and how stakeholders play a role in translating systems understanding in influencing decision-making processes.

Decision analysis (DA) has recently been introduced by Luu et al. (2022b) as a robust methodology to value agro-climate services. The aim of DA is to create current systems understanding through integrating knowledge and system thinking. Traditional research formulation is often based on problems and might not target specific decisions (Shepherd et al., 2015). Such research is often restricted by the capacity to collect data. The DA approach employs different view in conducting research in which the central point relies on the argument that research should target specific decision making. Furthermore, important variables should be all included in the decision analysis regardless of the restrictions on data collection. The limitation of data availability can be addressed through collecting existing knowledge from desk study and from relevant experts. DA acknowledges that it is difficult and resource intensive to gain every details of system understanding. Therefore, DA acknowledge our uncertainty and develop methods and tools to express such uncertainties. One of the key methods in DA is to mobilize experts from stakeholders and calibrate them through a calibration training. The aim of the calibration trainings is to help experts generating data. A critical improvement of calibration training in compared to other conventional expert knowledge elicitation lies in the advantages of the techniques that support expert realizing their biases, reducing their biases and elicitating their knowledge with clear expression of uncertainty. For example, the expert might state that they are 90% confidence that if ACS is introduced, the adoption rate of farmers might reach 20% to 50% after three year of implementation.

While DA offers many advantages in supporting decision making in complex systems, especially in engaging stakeholders to generate system knowledge, it is unclear how stakeholder concept and method can be systematically incorporated in DA. This ambiguity raise a central research question in our study on “How stakeholders can engage in generating and translating systems understanding into decision-making processes”? This overall question entails several sub-questions, including (i) who are the stakeholders? (ii) among stakeholders, who should be the representative experts to generate systems understanding?, (iii) what are the decision outcome implications for relevant stakeholders if a potential decision is being made, (iv) what are the other attributions of stakeholders that are important in facilitating decision-making processes, (v) what are the important aspects (e.g. organizational decision-making model, barriers to a rational decision-making process, policies related to decision-making, coordination or actors in decision-making) that stakeholders have knowledge on the decision-making processes, (vi) should and how can these stakeholders engage in policy formulation/decision-making processes given their knowledge of systems understanding?

1. **Background of the study**
   1. **Development pilot projects and their efforts to advocate for the scale-up of ACS**

CARE in Vietnam (CVN) has implemented several ACS projects in Dien Bien since 2015. While there were some adjustment in their work, the main aim was to “enhance livelihoods and increase the resilience to effects of climate change and variability of poor ethnic minority women and men in rural areas” (Luu et al., 2022b). By the time when we started conducting our study in July 2019, CVN was in the process to define their advocacy plan for the sustainability and scalability of ACS approach once the current project was going to be finished by March 2022. At that time, the aim was to have local government supporting the sustainability and scalability process. It was considered challenging at that time given the challenges of the limited finance in a resources limited province, as well as the alignment of CVN’s approach with the Government’s conventional approach in development interventions. However, a general strategy for policy advocacy is still needed to support advocacy efforts. This strategy will necessarily include the consideration of relevant policies, relevant stakeholders and the justification for a recommended business-model for the scaling of ACS.

To provide evidence on the feasibility of the ACS scaling, Luu et al. (2022a) conducted a study to map-out the impact pathway of possible ACS scaling interventions. The study also valued the overall cost-benefit of the four potential investment decisions. Results of the study suggested a high likelihood for positive signal for investing in ACS in Dien Bien across all the candidate interventions.

* 1. **Government’s socio-economic development planning in Vietnam**

Decision making in Dien Bien in climate, agriculture planning and budgeting follow the overall administrative structure and nested budget system in Vietnam (Strauch et al., 2018) (**Figure 1**). The National Assembly (NA) is the highest organ of state power in Vietnam (National Assembly, 2022). The NA is responsible for legislating state plans and budgets (Asian Development Bank, 2017; National Assembly, 2022; Strauch et al., 2018). The NA provides supervision and guidance to People’s Councils, which are elected by citizens, at provincial, district and commune (Asian Development Bank, 2017; Strauch et al., 2018). These People’s Councils elect the respective People’s Committees which are executing body of the state plans (Asian Development Bank, 2017). The execution of the Government and Peoples’ Committees are assisted by specialized assisting agencies (i.e. sectoral ministries, departments, divisions and commune units) (Asian Development Bank, 2017).

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**Figure 1.** Administrative structure and nested budget system in Vietnam. Adapted from (Asian Development Bank (2017) and Strauch et al., (2018)

Vietnam state budget follows a nested system. This means that budget of the subordinate organs are included in the higher level organs. The state budget includes central budget (e.g. budget for national ministries) and all provincial budgets. Provincial budget include budgets from all districts. District budget include budget from all communes. Budgets are prepared by the central Government and People’s Committees at provincial, district and commune levels (Asian Development Bank, 2017; World Bank, 2015). The most important guiding policy in development in Vietnam is the 10-year Socio-Economic Development Strategy and the 5-year Socio-Economic Development Plans (SEDP). Budget for implementing SEDP must be approved by the NA and respective People’ Councils before entering the implementation phase (Asian Development Bank, 2017; Strauch et al., 2018; World Bank, 2015).

We set out to support designing solutions for the transition of agricultural practices through provisioning of ACS in Vietnam’s Dien Bien District. This includes the generation of systems knowledge and how such knowledge can be brought in decision-making process. CARE……..

We used a decision analysis approach to identify and analyze specific decisions that decision-makers have to make to stimulate the transition. We used stakeholder analysis methods to identify stakeholders and representative experts. Together we created conceptual models and then generated mathematical simulations based on these. To better understand the barriers to rational decision-making (i.e. following through with decision recommendations) we made an overview of the different types of organizations and decision-making processes involved. We identified several challenges to the decision-making process and suggested a potential pathway to engage stake-holder in setting agenda, policy formulation and decision-making in investing in ACS in Dien Bien, Vietnam.

1. **Methods**

While Luu et al. (2022a) used decision analysis to forecast the overall outcomes of the potential decisions to invest into agro-climate services, our research explicitly focused on methods to explore the roles of stakeholders in defining, analyzing and following up with the decisions. We used the mixed-methods, including decision analysis, stakeholder identification and analysis, and organizational making analysis to identify potential pathways to support inclusion of discourses in ACS and relevant evidences of its impacts into the political decision making processes **(Figure 1)**.

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**Figure 2.** Schematic representation for the combination of decision analysis, stakeholder identification and analysis, and organizational decision-making analysis to suggest the potential pathways for engaging stakeholder in agro-climate services planning and decision making processes. The methodological steps are further developed based on the decision analysis procedure used in study by Luu et al. (2022a).

* 1. **Decision analysis**

We followed the decision analysis procedure and used data set collected by Luu et al. (2022b). Luu et al. (2022a) used decision analysis to forecast the overall outcomes of the potential decisions to invest into agro-climate services. The decision analysis procedure (Luu et al., 2022a) consisted of seven interactive and reflective steps, combining participatory and modelling techniques, aim to identify ACS decisions (step 1.1) and to analyze the implications for decision outcomes (step 1.6). Due to the nature of an ex-ante evaluation of ACS options, the complexity and uncertainty in valuing ACS, Luu et al. (2022a) attempted to capture the potential outcomes by identifying experts (step 1.2) who are capable to support categorizing ACS solutions (step 1.3), generating the conceptual model (step 1.4) and providing inputs for developing mathematical model (step 1.5). Luu et al. (2022a) used the Monte-Carlo technique and functions in decision support package in R to simulate the data and generate decision outcomes (step 1.6). Decision analysis is an interactive and reflective process that provide opportunities for sharing and critical reflection (step 1.7).

* 1. **Stakeholder identification and selection**

We defined (Bourne and Walker, 2008; Freeman, 2010; Reed et al., 2009; Yang et al., 2011) stakeholder as “any individual or group who has an interest in the a decision and/or who can affect or is affected by a decision”. This definition, combined with various methods, tools/techniques **(Figure 2)** helped us to identify (step 2.1) the potential stakeholders of the decisions to invest in ACS.

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**Figure 3.** Methods and tools/techniques used to identify stakeholders of the potential decisions to invest in agro-climate services in Dien Bien District, Vietnam.

We conducted desk review, primality targeting at other ACS studies conducted in Vietnam and within CARE International to gather understanding of potential stakeholders in designing and implementing ACS projects. We also reviewed organizational and decision-making charts of the Vietnam Government systems to capture the representation of political stakeholders. We reviewed CARE in Vietnam’s project report and their project advocacy plan to gain understanding of the local-specific context of project implementation and potential engagement of stakeholders. We reviewed other general agricultural value chain reports in Vietnam to capture the concept of value chain analysis and value chain stakeholder mapping in the context of ACS. We organized focus group discussion CARE in Vietnam’s team involving in the management and implementation of ACS projects in Dien Bien. These team include persons with expertise in project management, advocacy, agro-climate services and communications. Subsequently, we interviewed stakeholder experts (i.e. project manager, climate change networking expert at CARE in Vietnam) to map-out government and development partners involving in providing ACS in Vietnam. Once we developed an initial list of stakeholders, we interviewed individuals (e.g. person from the Vietnam National Hydro-Met Services, CCD ) to get recommendations for other potential stakeholders. Together, we obtained a list of stakeholder across the ACS value chain in Dien Bien.

In the next step, once the potential decisions have been identified, a list of narrower stakeholders have been identified using several criteria. These criteria include (i) the focus on local stakeholders, (ii) the inclusion of national stakeholders who already had established network with CVN, (iii) the challenges to engage some local stakeholders (e.g. engagement of agricultural input suppliers).

Among those stakeholders, we used another set of criteria to identify potential experts who would be joining us in designing ACS solutions. They will be given score by key project implementation team. The score range from 0 to 5. The score helped to inform to choose experts based on the following criteria

* Potential experts: Availability score > 2.5 and experience > 2.5
* Potential resource persons: Availability score < 2.5 and experience > 2.5
  1. **Aggregate cost-benefit analysis for each stakeholder**

While Luu et al. (2022a) used decision analysis to forecast the overall outcomes of the potential decisions to invest into agro-climate services, our research explicitly analyzed the costs and benefits for each stakeholders given the potential decisions. Experts helped to attribute potential costs and benefits for each stakeholder. For example, costs for rice farmers are calculated based

While it is quite clear for some stakeholders (e.g. rice, animal raising famers, provincial people’s committee) to attribute the respective costs and benefits, there are some challenges to define costs-benefits for other several stakeholders.

For the Agricultural Service Centre and Women’s Union who are the potential stakeholders involving in the implementation, we assigned costs and benefits as funding they receive from the implementation of the services.

* 1. **Further categorize stakeholders based on their attributions**

We conducted focused group discussion (FGD) with the expert team to map-out the perceived attributions of stakeholders. Those attributions included interest, influence, relevance to stakeholders’ mandate, and stakeholders’ attitudes. Interest means…. Influence regards their authority in the government decision-making system. Due to limited resources, we were unable to explore “soft” power of stakeholders. Relevance relate to the alignment between each stakeholders’ mandate or core business and their potential roles in the implementation of the ACS solutions. Attitude represent the perceived ….towards the potential solutions of ACS.

* 1. **Analyzing organizational decision making processes**

We first map-outed the types of organizations (e.g. hierarchical, functional or division) related to the ACS decision-making (what decision), using the organizational charts of the organizations. We also explored the decision making-process by reviewing the instituitional set-up and policies in Vietnam. Those policies included guideline on socio-economic development planning in Vietnam, governance system on climate change in Vietnam.

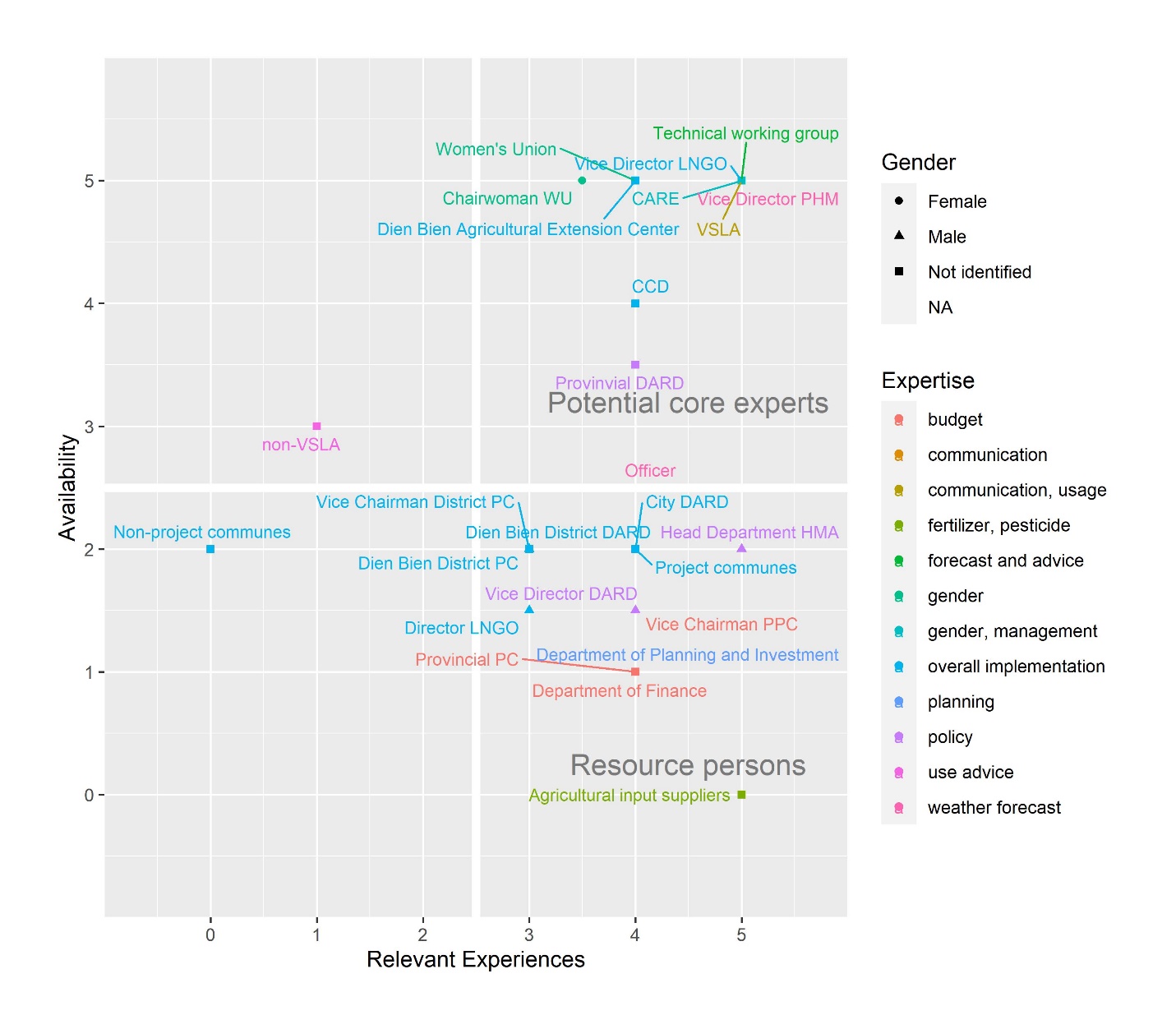
In addition, we referred to the five aspects which are limiting a rational decision making process in organizational-decision making and mirrored it in Dien Bien contexts. These factors include (1) imperfect and incomplete information, (2) the complexity of the problems, (3) human information-processing capacity, (4) the time available for decision-making processes, and (5) the conflicting preferences decision makers have for organizational goals.

Credibility, salience, legitimate

1. **Results**
   1. **Decisions and stakeholder identification**

A list of 85 stakeholders that are organizations/ groups/ individuals have preliminary identified from the initial stakeholder identification process. These stakeholder are from both national and local levels. We decided to mainly focus on local level. We remain include national stakeholders for those who have known about Dien Bien context (nói luôn là chọn bao nhiêu stakeholders ở địa phương?). As a result, 31 stakeholders have been identified as potential stakeholders in designing solutions for ACS scaling. We classified stakeholders based on their expertise, availability, experience and gender **(Figure 4)**. As a results, ….were identified as experts. These potential experts come from provincial DARD, Dien Bien Agricultural Extension Centre, Muong Ang Agricultural Extension Centre, chairwoman of the provincial Women’s Union, director and vice-director of the Dien Bien Hydromet Stations, vice-director of CCD, CARE implementation team, Village Saving and Loan Association groups, CVN’s project technical working group. Resource persons are potentially Head of Department of Hydro-Met Administration, Dien Bien Phu City Department of Agriculture and Rural Development, vice chairman of the Pronvincial People’s Committee, Dien Bien District Division of Agriculture and Rural Development, Muong Ang District People’s Committee, vice chairman of Muong Ang District People’s Committee, Dien Bien District People’s Committee (chairman and vice chairman?), director of CCD, vice director of Provincial Department of Agriculture and Rural Development, Provincial Department of Finance, Provincial Department of Planning and Investment, Provincial People’s Committee, agricultural input suppliers and project communes.

Their expertise ranges in various areas, including budgeting, communications, use of information, fertilizer and pesticide uses, weather forecasting and/or translation into agro-advice, gender, ACS intervention management, overall ACS implementation, socio-economic development planning, ACS policies. There were various stakeholders that we could not identify their gender yet since there were from organization/group.

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**Figure 4.** Categorization of stakeholders to identify potential core experts and resources persons. Potential experts are having perceived score on availability score > 2.5 and experience > 2.5. Potential resource persons: availability score < 2.5 and experience > 2.5

* 1. **Analyzing decisions to invest in agro-climate services and the implications for stakeholders**

We calculated the cost-benefit for each stakeholders and we also analyzed the perceived interest, influence, relevance and attitude of stakeholders towards the solutions designed.

* + 1. **Net-Present Values for each stakeholder**

In all the four investment options (i.e. in all 10,000 model runs), the patterns are quite consistent. There are very high likelihoods that the potential “winners” are the Provincial People’s Committee (98.30%-99.85%), rice farmers (99.89%-100%) and fish farmers (100%). The Hydro-Meteorological Station, Provincial Agriculture and Rural Development (DARD), District Agricultural Service Centre, SMS service providers, Women’s Union/LNGO, village leaders seem to bear no risk of loss (if no traffic accident) in all the investment scenarios in which they have a role in the implementation. There are some small chances of losses among animal husbandry farmers (17.16%-17.74%) and the public (4.80%-4.82%). Meanwhile, there are very high chances that the potential “losers” include seed suppliers (99.39%-99.69%), fertilizer suppliers (93.81%-95.47%) and pesticides suppliers (98.98%-99.04%).

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**Figure 5.** Net Present Values of four agro-climate service (ACS) interventions in Dien Bien District, Vietnam, aggregated for stakeholders. Results were obtained through Monte Carlo simulation with 10,000 runs for each investment scenario.

Based on a 90% confidence interval (CI), the overall investment NPVs **(Figure 5)** range from 0.89 to 4.48 million USD for Weather station-SMS-Gender, from 0.46 to 3.57 million USD for SMS-Gender, from 0.98 to 4.94 million USD for SMS-Loudspeaker and from 0.22 to 2.71 million USD for Paper-Loudspeaker. This is the nominal benefits attributed to the PPC

For other stakeholders, each actor will mostly expect a different benefit from each intervention. Here we report the results reflecting the whole possible ranges in all investment scenarios.

Overall, rice farmers can expect the overall NPVs in between 0.69 million USD and 5.23 million USD (90%CI) while fish farmers can expect the overall NPVs (90%CI) in between 701.52 USD and 6.53 thousand USD (kUSD). On average, one rice farmer can expect the NPVs in between 34.50 USD and 255.32 USD per 5 year implementation of the intervention. We did not calculate the average benefit for each fish farmers since we relied on the area to calculate the overall benefits.

Hydro-Meteorological Station can anticipate receiving contracts to improve and provide weather forecasts in between 8.26 kUSD and 51.48 kUSD (90% CI). Provincial Agriculture and Rural Development (DARD) may expect receiving funding to provide capacity building for sub-ordinate agencies in between 4.03 kUSD and 4.92 kUSD. ASC may also expect receiving funding in between 212.29 kUSD and 247.03 kUSD (90% CI) to translate weather forecasts into agricultural advice, as well as to roll-out the program at community levels. The expected funding for PDARD and ASC remain the same in all interventions.

SMS service providers might expect having contracts to provide SMS services if interventions Weather station-SMS-Gender or SMS-Gender are being implemented. The values of contract remain the same in the two interventions, amount between 297.18k USD and 490.48 kUSD (explain interventions) (90%CI). The SMS service providers might expect a service contract with a less value (4.99 kUSD-7.92 kUSD, 90% CI) if intervention SMS-Loudspeaker is being implemented.

Similar to SMS service providers, Women’s Union/LNGO might expect receiving funding if interventions Weather station-SMS-Gender or SMS-Gender are being implemented. The grants remain the same in the two interventions, amount between 185.22 kUSD and 198.61 kUSD (explain interventions)

Village leaders can expect receiving allowance for broadcasting ACS in between 57.57 kUSD – 92.47 kUSD (90% CI) if SMS-Loudspeaker is being implemented. They can expect higher allowance between 236.32 kUSD and 300.57 kUSD (90% CI) for both broadcasting and transportation to collect ACS bulletins from their respective commune if Paper-Loudspeaker is being chosen.

Animal husbandry farmers can expect the NPVs in between -133.55 kUSD and 441.60 kUSD (90%CI) as the result from their changed practice on protecting animals during the extreme cold weather. This result translates into the average NPVs for each farmer in between -18.38 USD and 61.44 USD.

The public can expect the NPV between 0.41 USD and 2,198.62 USD as the result from improved access to better water quality.

With 90% confidence interval (CI), the NPVs for seed suppliers range between -1.06 million USD and -0.09 million USD. Fertilizer suppliers can expect the NPV (90% CI) in between -1.65 million USD and 0.04 million USD while plant protection suppliers can expect a loss (90% CI of the NPV) in between -1.25 million USD and -0.08 million USD.

* + 1. **Stakeholders’ perceived interest and influence**

Stakeholders were further categorized in 4 different groups following the two year 2019 and 2020 **(Figure 6)**. Group 1 include stakeholders having high influence and high interest in the planning and budgeting process. Group 2 comprises of stakeholders having high influence and less interest. Group 3 are made up of stakeholders having less influence and high interest. Group 4 embraces stakeholders with less influence and less interest.

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**Figure 6.** Perceived interest, influence, relevance and attitude of stakeholders in the decision to scale agro-climate services in Dien Bien District, Vietnam. Results were captured through expert consultation in 2019 and 202

In 2019, ten stakeholders were perceived to have high interest and high influence (group 1) were PDARD, Head of the Department of Hydro-Meteorological Administration, Women’s Union, Chair Woman of Women’s Union, Dien Bien District Agricultural Extension Center, CARE in Vietnam, Dien Bien District DARD, Vice Chairman of the District People’s Committee and the project technical working group-a group established by the project to support direct implementation of CARE’s projects. All these ten stakeholders are perceived to have positive attitude towards the scaling of ACIS. Their mandates in the government system are mostly highly relevant. In 2020, there were three stakeholders newly joined the group 1. These stakeholders are Vice Chairman of the PPC, Vice Director of DARD and the Vice Director of the PHM.

In 2019, six stakeholders in group 2 are perceived as having high influence and less interest (group 2) in the ACS planning and budgeting. There stakeholders include PPC, Vice Director of DARD, Department of Finance, Department of Planning and Investment, Dien Bien District PC and non-project communes. In 2020, the Vice Director of DARD moved to group 1. At the same time, the Director of DARD, a vacant position in 2019 when we conducted our study, was newly appointed, joined group 2.

In 2019, group 3 shares six and “a half” stakeholders who had high interest and less influence on the ACS planning and budgeting. These stakeholders comprised of the Vice Chairman of PPC, the Centre of Community Development (CCD), Director of CCD, Vice Director of CCD, Director of PHM (half), non-VSLA and one officer. In 2020, there Vice-Chairman of the PPC and the Director of PHM moved to group 1 while the VSLA and the SMS company has newly joined group 3.

In 2019, group 4 included two and “a half” stakeholders. These stakeholders are VSLA group, agricultural input suppliers and the Vice-Director of PHM (half). In 2020, the Vice-Director of PHM moved to group 1 and VSLA joined group 3. Meanwhile, one officer and Dien Bien City DARD newly joined group 4.

https://www.theprojectmanagementblueprint.com/blog/stakeholder-management/stakeholder-power-interest-grid

* 1. **Possible pathways to engage stakeholders**

The possible pathways to engage stakeholders include the multi-level interventions (Figure 7).

ACS innovations (a) are expected to be linked to the existing socio-technical regimes. In this case, the regimes include village, commune, district, provincial, national and international levels. While the critical decision making are expected to happen at the provincial level (e), efforts must be supported from village, commune, district and national levels. The decision-making process is expected to start at the recognition step where efforts need to be supported mainly in the written and oral reporting process. This reporting process involves reflection from various stakeholders, including communities, village leaders, Commune People’s Committee, District Division of Agricultural and Rural Development, Provincial Department of Agricultural and Rural Development, District People’s Committee, Women’s Unions at provincial, district and commune levels (b), and NGOs (i.e. CARE in Vietnam, CCD) (c). In addition to reflections on the issues of the current ACS provision as well as the potential solutions of ACS are acknowledged in the provincial’s reporting system, it is also needed to have support from upper levels i.e. support from national ministries. MONRE and MARD are expected to signal support on the necessity and feasibility of the innovations. MPI and MOF are expected to advise on the appropriateness for funding acquisition, the potential source of funding and relevant policies. Having combined basis on needs and policy support, PPC would be able to support for the scaling plan. This support can be materialized in a form of the SEDP planning guidance, indicating that it is possible to plan for ACS innovations. This guidance will guide the planning at DARD, DDARD, commune units and villagers. Similarly, the guidance will also support SEDP planning at district, commune and village levels. Importantly, SEDP reports must be approved by the respective People’s Councils. For SEDP development at commune level, supporting workshops at all communes are needed to record the needs for ACS. For SEDP at district level, it is needed to have a proposal outlining the necessity to include ACS innovations in the SEDP planning. This proposal should propose a detailed plan for scaling, the requested costs needed for investments as well as the justification for the benefits (d). DPI is expected to draft provincial SEDP that include ACS innovation. This plan should be checked by DOF. Once the plan is developed, the next step is to defend SEDP with the Provincial People’s Councils before applying funding at the national level?

**C:\GIANG LUU THI THU\STUDY\FFtF\3. Implementation\1. Core research\3. Stakeholder analysis\Stakeholder-Analysis-ACIS\Figures\FIG4.TIF.Pathway.Print_with_color.tifFigure 7. Possible pathways for agro-climate service transition and roles of stakeholders (adapted from Gee)**

1. **Discussion**

In the context of climate change, decision makers must take decisions to support and invest in transitioning agricultural sector towards climate informed agricultural planning and management. However, valuing the benefits and defining effective solutions of the decisions need to consider the complexity, uncertainty and the engagement with various stakeholders across the ACS system. Previous studies have touched base on some aspects of decision making, stakeholder identification and engagement. However, such studies often conducted independently and those concepts are often not integrated or implicit. Our decision analysis approach combined with stakeholder engagement approach suggest an integrated approach to engage stakeholders in generating, translating system knowledge into decision making processes. These pathways include the process to define decisions, to identify potential stakeholders, to identify potential experts among stakeholders to generate their knowledge supporting the socio-economic valuation of the proposed decisions, to realize the interest, influence, relevance and attitude of stakeholders regarding the decisions, and to explore the possible pathways to engage stakeholders in influencing the decision making process.

Studies by Luedeling et al. (2015) engaged experts in system knowledge generation to support decision making in uncertain and data scarce environment. These experts are often selected from relevant stakeholders, based on their availability and expertise (Do et al., 2019; Luedeling et al., 2015). However, it is often implicit how stakeholders were defined and how experts represented among stakeholders. Our integrated approach offers the method to identify stakeholders based on an explicit definition. We further illustrated the method to identify experts among stakeholders with the consideration of stakeholders’ experiences, availability, gender and expertise. While the relevant experience and availability attributions help to identify the overall strategy to engage stakeholders as core experts and resource persons. This strategy is highly appropriate given that stakeholders’ availability are often the restriction in conducting studies (). Furthermore, we also selected expertise and gender attributions to capture the representation of stakeholders. With our categorization matrix, analyst can easily identify expertise shortage, gender imbalance as well as the over dominance of some expertise.

While DA approach aim to support decision-making based on evidence. However, how such evidences could be brought-up to political decisions is known with limitations. It might not always possible for decision makers to simply decide. In the multi-stakeholder, cross-sector and multi-level collaboration systems, evidence will need to go through a long planning process. Therefore, in such context, the engagement of stakeholders, who owned the system knowledge, in the decision-making planning and budgeting are crucial. This should be done in combination with obtaining the overall governance system related to the decisions. Concurrently, the engagement of stakeholders should take into consideration of decision impacts to relevant stakeholders since it can help to design a proper strategy to engage and dialogue ().

Stakeholder analysis studies in natural resource management (Reed et al., 2009) often focused on defining and categorizing stakeholders to further inform the way to engage stakeholders. While multiple attributions are suggested to categorize stakeholders (Reed et al., 2009), the most commonly used attributions to categorize stakeholders were their interest, power/influence in a form of power internet matrix (Reed et al., 2009). In our study, we used four aspects for the categorization, including interest, influence, attitude and the relevance of ACS intervention with their core mandate. Interest of stakeholders is the most commonly used attribution to categorize stakeholder. On the aspect of influence, we refer it more to the aspect of authoritative influence. Due to our limited time and resources, we acknowledged our limitation in exploring the “soft” power of different stakeholders in the potential decision making process. On the relevance aspect, incorporation of stakeholders’ mandate is critical since it is the most often reference for decision-makers to decide if they should involve in any business. Attitude could play a decisive role in decision-making. Study by …shows that while farmers do not have a high interest and understanding of ACS, their positive attitude drive the adoption results of ACS ().

Monitoring the changes of stakeholders over the time helps to gain the insights and dynamics and therefore adjust the engagement process. Without such insights, interventions might fail to strategically aim at the important stakeholders. Remain static and internal focused

In sustainability transitions, Gonzalez-Porras et al. (2021) identified four levels of stakeholders that can engage in sustainability transitions. These levels are individual, firm, industry and societal levels. Gonzalez-Porras et al. (2021) also argues that stakeholder engagement as a relational process that can be understood as change agency. This study also points out the necessity to understand how such stakeholders collaborate, develop and connect them to effectively make changes in in the transitioning process. This this study, the levels include individual, village, commune, district, province and national levels

Stakeholder analysis has been seen as an approach to empower marginal stakeholders in influencing decision-making (Reed et al., 2009). Our approach in translating system-knowledge into decision-making supports the notion of stakeholder empowerment. We further advance the stakeholder analysis approach through a transparent and systematic method where the multi-dimensional attributions of stakeholders (i.e. knowledge, experience, expertise, gender, stake, interest, influence, relevance and attitude, role in decision-making) are explicitly analyzed. Strengths and suitability of stakeholders are therefore considered in the whole process. Depending on the purposes, those attributions could help to determine the appropriate engagement of stakeholders in the whole knowledge generation to decision-making process. We believe that this approach will help to increase the legitimacy and salience of evidence generated from our study.

Our results also reveal insights into the complexity of inter-organizational decision-making. First, the organizations feature the different organograms that existed within the government structures. Organizations embrace both hierarchical (i.e. institutional, organizational and operational decisions) and functional (i.e. decisions made by different departments such as finance, planning, technical departments) decision-making structures. We suggest the importance to understand these structures in influencing decision-making process. For example, in this case it is important to consider community, communal, district, provincial, national decision-making levels while regarding the roles of different departments (e.g. planning, finance, agriculture and rural development). In addition, we also realize the importance to understand shared common goals among stakeholders. Linking their roles and relevance (i.e to stakeholders’ mandate) are considered important to be able to engage them in the decision-making process.

Costs-benefits of each stakeholders

We observe factors affecting a rational decision-making process

We acknowledge that we have not managed to engage the “losers” in our studies and therefore we did not gain much insights on stakeholdes’ conflict resolutions. However, there are also some good reasons for that. First, while some connections were set-up, the project did not have official partnership with the agricultural input service providers. Due to time and resource constraints, we were not be able to establish contacts and engagement in the project. In addition, according to the law in Vietnam, recommendations on agricultural input uses can only come with the names of inputs (e.g. type of fertilizers, pesticides, breed) without mentioning the names of service providers. Therefore, it was also difficult for us to ensure a fair representation of stakeholders. Hence, we suggest future studies to focus on a more systematic engagement with such stakeholders.

1. **Conclusions**

Sustainability transitions are long-term processes. The pre-stage often feature the uncertainty, scattered knowledge, conflicts of different views (i.e traditional and new perspectives) and the challenge to bring stakeholders to the same table. Such “incubation” process can take a very long time if no coordination or triggering point/ big-power is in place. Our study offers a transparent and systematic method to address some key challenges in the decision-making process, through engaging stakeholders in generating and translating system knowledge to decision-making process. Roles of stakeholders in the process are crucial and multi-dimensional. Our method is a combination of decision analysis, stakeholder management, organizational theory, sustainability transitions concepts and approaches. However, with our overall view on system knowledge and inter-organizational governance, we further developed the method as an overall tool to generate, translate system knowledge into decision-making process with explicit roles of stakeholders in all the process. The overall approach can be used directly or adapted to support comple, multi-stakeholder decision making process.

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