CHAPTER 9 - VULNERABILITY ASSESSMENTS OF PRIORITY SESS IN QUANG BINH

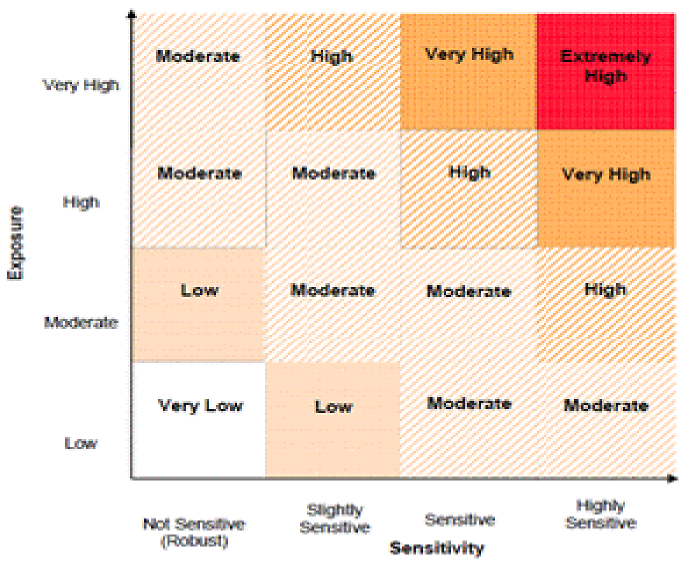
9.1. VULNERABILITY RANKING OF TOP 10 SESS IN QUANG BINH

In Chapter 7, seven specific measures of climate change were identified under the four broad areas of changes in precipitation, temperature, storms, and sea level rise. In this chapter, the results of a detailed assessment of climate change vulnerability each of the top 10 (of the total 41) SESs in Quang Binh are presented. For each top-10 SES, exposure and sensitivity to each of the 7 climate change measures was assessed, using secondary information and expert judgment of the team members. Exposure was plotted against sensitivity to give an overall category for impact as in the matrix shown in Figure 9.1.

Chapter 8 provided a detailed discussion of adaptive capacity. This chapter presents the results of the adaptive capacity assessment of the top 10 SESs. Once again adaptive capacity was considered for each of the 7 climate change parameters and scores assigned as they were for exposure and sensitivity to each of those factors.

Scores for impact were then plotted against scores for adaptive capacity to give an overall score for vulnerability for each of the 7 climate parameters, for each SES, using the matrix shown in figure 9.2. The mean of these 7 vulnerability scores for each SES was then used as the overall vulnerability score (or average vulnerability score) for each SES. The vulnerability scores for the top 10 SESs are provided in Table 9.1. The full vulnerability analysis for each of the 10 SESs is provided in Annex 9.I.

Figure 0.1: Potential Impact matrix



In which:

0.0 - 0.99 = Limited/Slightly vulnerable
1.0 - 1.99 = Moderately vulnerable
2.0 - 2.99 = Vulnerable
3.0 - 3.99 = Highly Vulnerable
4.0 - 5.00 = Extremely Vulnerable

Figure 9.2: Vulnerability matrix

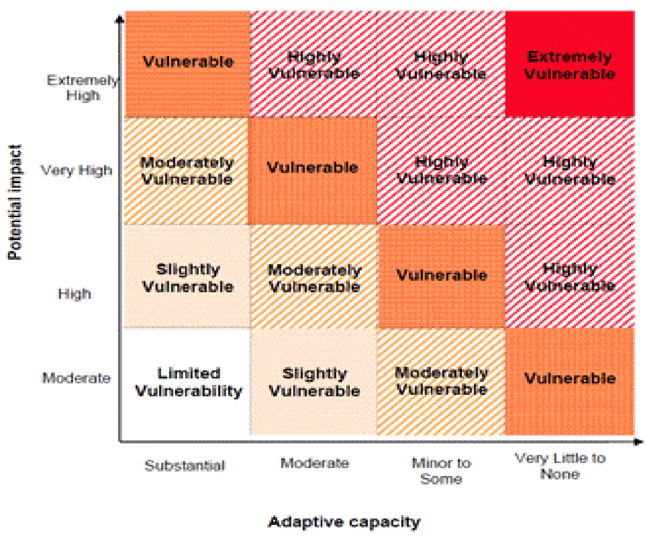


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Table 9.1: Ten most important SESs in Quang Binh and their vulnerability scores

SES Importance Rank	Name of SES	Mean vulnerability score for 7 climate factors	Vulnerability Rank
8	Upland Ethnic minority swidden cultivation	4.0	1
2	Kinh smallholder mixed paddy and tree crops	3.4	2
1	Kinh smallholder coastal floodplain irrigated paddy rice cultivation	3.4	2
10	Irrigation/ hydropower reservoirs and related infrastructure	3.3	4
5	Kinh small-holder/commercial shrimp aquaculture on sand dunes	3.3	4
7	Kinh inshore capture fishermen (estuary to 6 km offshore)	3.1	6
6	Forest PMB on coastal sand dunes and sand	3.1	6
9	Hilly forest commercial rubber estates	2.8	8
3	Phong Nha-Ke Bang NP and WHS	2.7	9
4	Lowland Moist TRF State Forest Enterprise	2.7	9

9.2. KEY RESULTS AND RECOMMENDATIONS FOR EACH SOCIO-ECOLOGICAL SYSTEM

Key information on ecosystem services, vulnerabilities, and recommended EbA actions for each of the top-10 priority SESs is provided below.

In identifying appropriate EbA actions, it is worth considering Figure 9.3. Without the blue arrows, figure 4 represents the understanding of the components of vulnerability that has been popular sine the IPCC first presented the idea that vulnerability is a function of (Exposure X Sensitivity)/Adaptive capacity. EbA actions are intended to reduce vulnerability. They can do this primarily by strengthening adaptive capacity. The addition of the blue arrows to Figure 9.3 shows how strengthened adaptive capacity can be deployed to take action in regard to both the natural/physical environment, and the social environment which together can help manage issues of sensitivity in SESs; and also how strengthened adaptive capacity can take action to manage exposure in SESs. Management of exposure, and management of sensitivity, mediated through increased adaptive capacity, combine to reduce overall vulnerability.

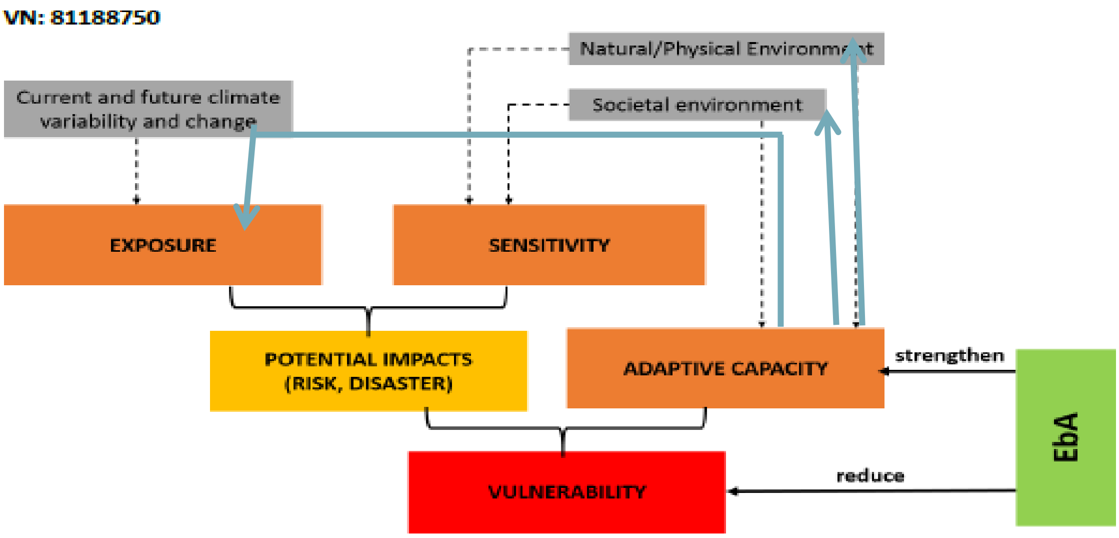
The intention is to provide and to prioritise reasonable EbA related adaptation measures. These recommendations are supported by explanations of why they are necessary and important, giving some indication of what benefits they will provide, and an indication of appropriate phasing/timing for their implementation.

The proposed EbA measure include some which address shocks, and some which address stresses, caused by, or exacerbated by climate change. They do not relate only to disasters caused be extreme climate events, but also to the cumulative stresses on systems derived from accumulation of continuing directional change (in temperature, rainfall patterns, sea level rise, and storm patterns) that will modify or in some cases transform these systems.

Some care has been taken not to label things as EbA if they do not clearly meet the definition, as this would will create (or add to existing) confusion about EbA approaches. Nevertheless, we have attempted to be pragmatic - good interventions do not always have to be about something that is 100% pure EbA and nothing else. In this context:

- Some recommendations relate to "Climate Smart" agriculture. These may include a mixture of EbA and non-EbA elements, but are best considered together as a package of interventions
- Some recommendations relate to "Climate-proofing" infrastructure investments. Bioengineering interventions may be considered as part of this - and in some cases as "stepping stones" necessary as part of the process to help bring back nature so that additional future ecosystem service benefits can be obtained.

Figure 9.3: Pathways of EbA Action in Socio-Ecological Systems



Source: adapted from GIZ, Adelphi and EURAC 2013, based on IPCC 2007

9.2.1. Quang Binh SES: Phong Nha Ke Bang 1-5

Ecosystem Services

Phong Nha Ke Bang (PNKB) National Park SES cluster is the single biggest area of healthy natural ecosystems, and the single biggest provider of ecosystem services in Quang Binh Province. It plays a major role in provision and regulation of water supply on which many downstream activities are dependent. It contributes significantly to tourism in the province - both domestic and international tourism, as its World Heritage status has made PNKB well-known all around the world. It also plays a very significant role in carbon sequestration and carbon storage, as well as micro-climate regulation. It may also provide significant pest control and pollination services to agricultural areas close to the forest, depending on the particular crops being grown.

Main Vulnerabilities

The large area of forest in PNKB, its species rich diversity, and connectivity within the landscape, all ensure that overall the vulnerability of PNKB is relatively low in general, when compared with many of the other SESs in the province. Its elevation and distance from the coastline reduce the impacts of storms and sea level rise. However, there are some specific aspects of vulnerability related to temperature and precipitation changes that should be considered.

In response to increasing temperature, species that are already close to the threshold of their temperature tolerances would have to shift their distribution to stay within their comfort zone and continue to survive. For every one degree of increase in temperature this would normally mean affected species moving either 35km further north, or moving to 100-200 metres higher altitude (or perhaps some combination of the two options). For species presently suited to conditions at the highest elevations in PNKB, this would leave them nowhere to go, as temperature heats up. For species that will need to migrate further northwards outside the present northern boundary of PNKB, the land-use pattern of that area will determine whether there is an opportunity for them to move successfully or not.

Longer hotter dry seasons, and the increasing number of very hot days will increase the risk of forest fire, especially in the very dry limestone areas. While this has not been considered as a major issue in the past, it will be of growing concern in the future. On the other hand, with wetter rainy seasons and more intense rainfall events, erosion and land-slide risk may also increase.

Possible EbA and related Interventions

In a general sense, vulnerability can be reduced by removing or reducing non-climate stressors thereby increasing the resilience of PNKB. That is to say, to be in the best condition to be able to deal with the new threats brought by climate change, it is important to first minimize the existing threats and deal with them effectively. In this case, the immediate priority is to continue to improve management of the National Park in line with its updated management plan, and including a specific focus on:

- Effective enforcement against illegal logging and wildlife poaching
- Improving forest fire prevention (including through visitor awareness-raising)
- Strengthening the relationship between park management and local communities
- Improving visitor education services and outreach into buffer zone communities

In addition, restoration and improvement of degraded areas (and secondary forest where selective logging had previously taken place), should be carried out using native species that are selected for their suitability to the future climate conditions. Further research should also be carried out to identify likely hot spots for erosion and landslides within the national park, and contingency plans should be developed to address these.

Over the medium term, detailed research should be undertaken on key species-especially endemics and endangered species for which PNKB is a key stronghold (such as Calocedris), to understand their temperature and rainfall comfort zones and tolerance thresholds, and to develop specific management responses to ensure their continued survival.

Longer-term planning should ensure connectivity of PNKB to other forests in the larger landscape is maintained (or restored where necessary) along both altitudinal and latitudinal gradients to facilitate the movement of species over time in response to climate change. Collaboration with Lao PDR should be continued and strengthened, to develop effective management of the trans-boundary landscape of Phong Nha Ke Bang-Hin Nam No protected areas, which will further strengthen resilience.

Plans should be put in place to ensure land use in areas up to 35-70km north of PNKB (and/or north of HNN in Lao PDR) will be managed in a way that will allow for the necessary migration of species responding to climate change. This could be achieved through development of a corridor of different land-uses, including production forest, protection forest, and agroforestry areas with appropriate species, linking PNKB to Vu Quang National Park in Ha Tinh province.

To facilitate all of the above there needs to be a very strong relationship between the PNKB Management Board and the District, Commune and village authorities in the buffer zone area around the park, as well between the PNKB Management Board and the PPC.

The composition, organizational structure and functioning of the Management Board and personnel of PNKB should be assessed and recommendations made for revisions to help achieve this. For example, personnel should be clearly assigned to specialist units with different functions of patrolling and enforcement; community outreach and engagement; research survey and monitoring; as well as visitor management and administration. Climate Change Adaptive Capacity training should be provided to all park management personnel.

9.2.2. Quang Binh SES: State Forest Enterprise (SFA)/State Forest Companies

Ecosystem Service

Forest Companies under the former State Forest Enterprise (now referred to as Single Member Company) are managing large areas of natural forest (as well as plantations) and these are also providing significant ecosystem services to downstream areas, similar to those described above for PNKB. The Truong Son Company has achieved Forest Stewardship Certification (FSC) certification for 25,000 hectares of natural forest under its management, and plans to extend this to additional areas in the coming years.

Main Vulnerabilities

The vulnerabilities of the production forest are also similar to those described for PNKB above. Fire hazards may be even greater, because some of the area is single species acacia plantations. In the natural forest, fire risk is high because of different groups (e.g. rattan harvesters) camping in the forest for several weeks at a time on their collecting trips

Potential EbA and related interventions

The overall recommendation is to manage production forest in Quang Binh more effectively and appropriately for a combination of both economic and ecosystem service benefits (not just economic benefits alone). An updated production forest management plan should be developed by each company managing production forest. In these updated plans, for the part that is natural forest, the following should be carried out:

In the short-term:

- existing harvesting and production plans should be updated and revised to take into account climate change considerations
- more effort and resources should be focused on forest fire prevention, including education of people going into the forest for other purposes - such as approved rattan collectors, and effective use of fire-breaks, etc.
- restoration and improvement of degraded areas (and enrichment planting where selective logging has already taken place), should use native high value timber species that are selected for their suitability to the future climate conditions

While over the medium to longer term:

- research should be carried out on temperature and rainfall "comfort zones" and thresholds for key high value native timber species
- efforts should be continued to achieve FSC Certification for additional areas of natural production forest, as this demands a high standard of management and sustainability

For the part of the production forest estate that is acacia plantation, in the short-term, harvesting practices should be changed so that:

- harvesting is done in a larger number of smaller patches (rather than a smaller number of larger patches) that are separated from each other by sizeable non-harvested areas.
- strips of non-harvested trees are left every 50m or so on steep slopes and as a riparian buffers along water courses.

Over the longer-term, the focus should be on adding more value - producing trees mainly for sawn timber and timber for garden furniture, rather than for pulp. (Some pulp can still be produced from poles cut during routine thinning of the plantation after 3-4 years).

- a gradual shift should occur from short term harvesting cycles of around 7 years to longer cycles of around 15 years or more
- a feasibility study and cost-benefit analysis should be conducted to support this transition.

These interventions together will help reduce erosion and land-slide risk that may become more severe with climate change, as well as helping maintain soil fertility and reducing fire risk. They will improve the watershed services of the forest, while also increasing the economic value of production.

Once again, all personnel working for forest companies should be given climate change training.

9.2.3. Quang Binh SES (5a): Upland Ethnic Minority Swidden Cultivation and forest product collection.

Ecosystem Services

The forest is critically important especially for providing sufficient and clean water supply, and fuel-wood for the ethnic minorities. It is also highly important for their religious and spiritual activities, and provides them with important amounts of some wild foods as well as timber for building materials. Agricultural fields close to the forest may benefit from close proximity of insect and animal pollinators, and biological pest control. Seed dispersal by forest species assists rapid regeneration of fallow fields, which is becoming increasingly important as the fallow cycle has now been reduced to 5 years or less.

Main vulnerabilities

Upland rice and other crops are very vulnerable to drought as there is no reservoir and irrigation water supply. These upland areas are also vulnerable to storms, strong winds and flash floods. Flash floods and landslides can block road access and cut them off from outside contact for extended periods. In winter they are also very vulnerable to cold snaps that can lead to the death of significant numbers of livestock.

Potential EbA and related interventions in this SES:

In the short-term:

- Improve soil and water conservation practices especially on steep slopes where field crops are grown, through contour planting, alley cropping, mulching, etc.
- Begin enrichment planting of high value timber and NTFPs in community managed forests
- Establish community-based management groups to for sustainable harvesting of NTFPs such as rattan for local use and income generations

In the medium-longer term:

- Assess the possibilities for returning to a system of fallows that are longer than 5 years, and develop a plan for implementation wherever possible (this will improve the soil formation and soil erosion protection services as well as nutrient cycling and water cycling)
- Assess the feasibility of introducing a PES or REDD+ type scheme, and develop a plan for implementation wherever feasible (this will increase the value of the carbon storage service of the forest to the ethnic forest-dwellers)
- Assess the appropriateness of terracing some slopes, and implement if appropriate

9.2.4. Quang Binh SES (5b): Kinh smallholder mixed paddy cultivation + tree crops (acacia, citrus, rubber, tea

Ecosystem Services

This SES is highly dependent on ecosystem services from other SESs, especially upstream watersheds and natural forests which are a source of water supply, and some physical protection, as well as pollination and pest control services of varying importance (depending on distance away from the forest). Tree crops planted in this SES, while not being natural ecosystems, nevertheless can provide some types of beneficial ecosystem services including provision of some building materials and fuel-wood, as well as nitrogen-fixation in soils by acacia and some protection from erosion (although this is reduced by the short-term harvesting rotation cycle of the plantations). The rice fields themselves may still supply some natural foods in the form of wild fish. Crabs and frogs etc. that can live in the rice fields (although increasing use of chemicals in rice-growing will reduce this wild food supply)

Main vulnerabilities

Cultivation of rice and other field crops is vulnerable to droughts in the dry season (especially in areas without access to irrigation), and also to storms and floods late in the growing season. Acacia trees are generally tolerant of high temperatures, but nevertheless the risk of forest fire may increase, as well as the risk of crop and tree diseases. Citrus fruit trees may be more vulnerable to changes in temperature and rainfall patterns, while rubber is vulnerable to damage by strong winds and storms.

Potential EbA interventions in this SES could include:

In the short -medium term:

- Increase the diversity of species used as tree crops and in tree plantations (this would also increase diversity of animals and plants that can live in the plantations and orchards, and will increase natural pollination and biological pest control services)
- When harvesting tree crops leave some tress standing along the edges of rivers and streams (this will improve the water supply and water quality services)
- Apply soil and water conservation practices when growing upland crops and citrus trees especially on steep slopes through contour planting, alley cropping, mulching, etc.
- Introduce land cover crops that fix nitrogen and help soil fertility
- Change cropping pattern and adapt cropping calendar to suit changing conditions
- Substitute crop varieties for more tolerant types
- Introduce SRI rice where appropriate

In the medium-long term

- Increase the duration of the harvest cycle for acacia (this will improve the soil fertility and soil erosion protection services)
- Investigate possibility of group certification for FSC for smallholders (this will provide an incentive to increase duration of harvest cycle - see above)
- Consider moving out of rice and growing only less water demanding crops such as cassava and maize

9.2.5. Quang Binh SES 5c Commercial rubber plantations in hilly areas

Ecosystem Service

Rubber plantations have a somewhat limited dependence on ecosystem services, other than requirements for a certain amount of soil fertility.

Main Vulnerabilities

Rubber plantations are vulnerable to damage by storms and strong winds, and there have been several times in the past when large areas of rubber plantations were damaged in this way in Quang Binh, most recently in 2010.

Rubber is also vulnerable to extended drought and to high temperatures which can damage trees. In extended periods of large volumes of rainfall, latex production is also reduced.

Possible EbA and related Interventions include:

Avoid storm and wind damage to rubber plantations by

- Locating plantations in sheltered areas protected from wind and storm damage
- Planting windbreaks of other trees

9.2.6. Quang Binh SES 6a Kinh Irrigated paddy rice in coastal plains

Ecosystem Service

This SES is ultimately dependent on upstream forest ecosystems for water supply for rice growing, although this is provided through a system of reservoirs and irrigation canals. The rice fields themselves may still supply some natural foods in the form of wild fish, crabs and frogs etc. that can live in the rice fields (although increasing use of chemicals in rice-growing will reduce this wild food supply)

Main Vulnerabilities

Paddy rice is vulnerable to drought, but if irrigation water supply is adequate, this risk can be effectively addressed. However, in Quang Binh in some years the drought is so intense that there is not enough water in the reservoirs to meet all of the irrigation needs.

Paddy rice is also vulnerable to storm damage and flooding when it is ripe and about to be harvested.

Rice productivity also declines as temperature increases

In Quang Binh in particular, paddy rice growing land in coastal floodplains is also at risk of increasing salinization as saline intrusion penetrates further upstream from river mouths, and seeps under dykes into agricultural fields.

Possible EbA and related Interventions

Restoring environmental flows in rivers would help to reduce saline intrusion and salinization of rice fields. This is the major EbA action of relevance to this SES.

In addition, a number of "climate-smart agriculture" initiatives are already being promoted in the province, and these should be continued and expanded. These include introducing the System of Rice Intensification (SRI) rice growing techniques which can significantly reduce water use in paddy rice growing (as well as reducing the use of fertilizers and pesticides) thereby reducing demand for irrigation water, especially in the dry season. SRI does however require more intensive management of the fields and has an increased labour demand for weeding.

Shifting the crop calendar and using rice varieties with shorter growing periods (less than 100 days) is also an effective strategy to reduce risk of storm and flood damage in late summer.

Growing of ratoon rice allows a second harvest to occur in as little as 45 days after the previous harvest. While productivity may only be around 65% of the previous harvest, all input costs (for preparation of seedlings, ploughing fields, fertilizer, pesticides) are reduced, resulting in relatively high profitability for the farmer. Ratoon rice grows well in low-lying areas where there is plenty of soil moisture remaining after the first harvest. It is particularly popular in Le Thuy district, where ratoon rice is grown after harvesting of the winter-spring rice crop and before the early summer crop.

Climate Smart Agriculture

To support climate change adaptation across multiple agriculture-related SESs (including 5a, 5b, 5c, and 6a, all discussed above), it is recommended that a Climate Smart Agriculture (CSA) Strategy and Action plan should be developed for Quang Binh province, and support should be provided for farmers in the transition to CSA.

This can build on a number of existing pilot activities that have already been started in the province, including:

- Adoption of SRI rice farming and ratoon rice in appropriate areas
- Shifting out of rice to less water intensive crops in areas with no or limited irrigation potential
- Soil management and improved sustainability of cassava production
- Improved housing and bedding for livestock
- Relocation of rubber plantations to areas less likely to be impacted by storms and strong winds
- Shifting of crop calendar to take account of changing climate conditions

However, a fully-fledged approach to CSA needs to go beyond individual activities and requires an integrated programme to develop the appropriate technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. The major benefits of CSA include increasing productivity and the resilience of agricultural systems, reducing GHG emissions or enhancing carbon sequestration, and managing interfaces with other land uses. CSA has three main pillars: (1) sustainably increasing agricultural productivity and incomes; (2) adapting and building resilience to climate change; and (3) reducing and/or removing greenhouse gas emissions; and it integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges (FAO, 2012).

An holistic approach to CSA in fact requires farmers to be weather smart; water smart; carbon smart; nitrogen smart; energy smart, knowledge smart, and income smart.

Weather Smart: For farmers, information of near-term weather events goes a long way in planning for climate-resilient agricultural production. Farmers can be linked to weather information and value- added agro-advisories through radio broadcasts, televisions, newspapers and mobile phone voice messages. Farmers can use index-based insurance schemes to cover risks associated with changes in rainfall and temperature at different stages of crop growth.

Water Smart: Resilient water management practices which enhance the efficiency and productivity of water are critical climate- smart interventions. These could include aquifer recharge, rainwater harvesting, community management of water, mechanized land levelling, water conservation, drip irrigation and on-farm water management practices.

Carbon Smart: Soil organic carbon helps mitigate climate change and improve soil fertility. Carbon content in the soil can be increased through agricultural practices such as agroforestry, crop–livestock system, croptree system, conservation tillage, diversified land-use systems and residue management.

Nitrogen Smart: Farmers can use leaf-color charts and site-specific nutrient management to decide on the most appropriate dosage of nitrogen fertilizers for their crops and livestock management. This saves on costs and also cuts down GHG emissions.

Energy Smart: This involves the use of fuel-efficient agro- machineries, residue management and reduced tillage as interventions to conserve energy and reduce GHG emissions. In some cases, biogas systems are promoted using manure slurry from intensive dairy enterprises as part of the portfolio of innovations.

Knowledge Smart: Partner organizations arrange cross-site visits of farmers to analogue sites and to other areas practicing CSA.

Studies should be conducted into the temperature and rainfall tolerances of key species. If continued production of some species will be unsuitable in the changed climate conditions, plans should be made to promote and support the introduction of alternative species more suited to the new climate conditions. One innovative approach is crowdsourcing seeds. A large number of farmers are provided with seed packets of adapted varieties to evaluate those best suited to their local conditions. They provide feedback to researchers to help them develop better varieties (Aggarwal et al. 2013).

Income Smart: Finally, diversification of rural household economies should be promoted to enhance resilience and lower the risks inherent in depending on few sources of income.

9.2.7. Quang Binh SES: PFMB9: Protection Forest Management Board coastal protection forest in sand dunes and sandy areas

Ecosystem Services

Sand dune ecosystems provide significant physical protection from storms and protection from sea level rise. They also provide a very important function in filtering rain water and storing underground water, providing a critical dry season water supply. Natural vegetation of sand dunes areas can provide grazing for livestock and some edible and medicinal plants used by people. Sand dune ecosystems are very dynamic areas, but if ecological processes are occurring naturally, then on the landward side of the system mature tree cover eventually stabilizes the movement of sand. Intact sand dune ecosystems are now very rare. Quang Binh has very significant sand dune areas, although these have been significantly degraded by development of human settlements, cutting down of the original tree cover, and conversion to a number of different land-uses including commercial shrimp ponds and vegetable growing. Heavy sands mining for titanium has also removed tree cover from large areas of sand dune systems and sandy areas.

The coastal protection forest today is almost exclusively plantations of introduced species – mainly *Casuarina equisetifolia,* and some acacia. While these trees provide some physical protection, air quality maintenance, climate buffering and fuel biomass services, these are not services from a natural ecosystem. The original coastal forests were more diverse and would have provide these services more effectively. Coastal protection forest is dependent on ground water supply that may largely be determined by the sand dune ecosystem and tree cover within the SES itself.

In coastal areas where there are still remnant patches of natural forest including melaleuca forest and other types, it can clearly be seen that the diverse multi-layered, multi-species vegetation provides better physical protection from winds and storms, and together with the more abundant ground cover vegetation that occurs in these forests, is much better at stabilizing movement of sand. Soil formation under these natural forests is much better than under casuarina plantings. These forests also provide more ecosystem service benefits to local communities including firewood, edible plants and medicinal plants (casuarina only provides firewood), and have much greater biodiversity "co-benefits" Finally, natural forests are more effective at reducing erosion and filtering and reducing land-based water pollution flowing into the sea.

Main vulnerabilities

Increased evapo-transpiration with higher temperature, and reduced rainfall in the dry season increases the risk of drought - especially on sandy soils where temperature increases quickly and soil water retention is poor. Reduction in soil water availability and a decline in the water table can lead to the death of casuarina and acacia trees, even large mature trees if the roots cannot penetrate deeply enough to find water. Although both casuarina and acacia are tolerant of high temperatures, the risk of forest fire will be increased with climate change. Coastal plantation forests of mainly casuarina and some acacia are also vulnerable to storm damage and can be blown over by strong winds. The harsh conditions of drought and strong winds also make it difficult to successfully replant these areas. Higher intensity rainfall events in the rainy season will also lead to increased erosion.

Sand dunes are extremely dynamic systems. Natural vegetation cover including native species trees at the landward side of sand dune ecosystems helps to stabilize moving sand, and reduces blowing and flowing sand. However, in their current very degraded state, the sand dune ecosystems of Quang Binh have become the source of major problems of blowing and flowing sand, causing significant damage to housing and agricultural fields of communities living just inland from the dunes. In 2016, construction of the first two of a possible planned 12 golf courses has already started construction in the sand dunes of Quang Binh, as part of broader plans for tourism development. Golf courses require significant amounts of water, and often use significant amounts of fertilizer and herbicides, residues of which can also run off and contaminate the water supply, and careful attention should be paid to management of these issues.

Possible EbA interventions include:

In order to improve physical protection from storms, reduce blowing sand, improve soil formation, improve ground water function and reduce coastal erosion, while also contributing to biodiversity conservation, all remaining natural coastal forests should be clearly identified and existing maps regularly updated; and a provincial Action Plan should be developed. The Provincial Action Plan for Conservation and Restoration of Natural Coastal Forests and Sand Dunes should include the following key actions:

- Implementing a communication, education and public awareness programme to increase understanding of the value and importance of natural coastal forest and sand dune ecosystems
- Establishing community based management systems for all remaining areas of native species coastal forest
- zoning of the sand dunes for different activities (aquaculture, tourism, etc) including identification of core protection zones, as well as restoration zones
- Core protection zones should include a series of regular sections of dunes with intact dune ecosystems running in strips perpendicular to the shoreline, from the beach to the landward end of the dune system. No settlements or permanent activities should be allowed in these areas.
- Restoration of native ground vegetation (beach morning glory, grasses, sedges, etc.) should be carried out in the restoration zones of the sand dune ecosystem
- Construction of tree nurseries and provision of training for propagation and care of native species, to provide seedlings for new planting areas

- Use of native species for enrichment planting of existing casuarina and acacia coastal protection forests
- Use of native species instead of casuarina and acacia in all new coastal protection forest planting
- Investigate the total ground water supply availability and compare with likely future demands (including for golf-course development) and consider introducing livelihood options that use less water if necessary (e.g. growing native species of grass on the dunes and cutting it for fodder for stall-fed livestock-raising)
- Research should be carried out and practical solutions developed on how to improve the effectiveness of tree planting on former heavy sands mining areas
- A feasibility study should be carried out for development of eco-tourism and environmental education programmes in the sand dune ecosystems

In addition to this the company developing the golf courses should be engaged proactively to identify how they can support restoration and management of the dune ecosystem (for example they will plant a lot of trees for the golf course, they could select important native species, and they themselves could establish tree nurseries for native species).

9.2.8. Quang Binh SES (9c): Commercial shrimp pond aquaculture on sandy areas

Ecosystem Services

This SES is critically dependent on two things - underground abundant and good quality water supply within the SES, for freshwater input, and commercial feed based on "trash fish" from other coastal and marine SESs. Any remaining natural forest together with planted coastal protection forest, provides some physical protection from storm damage, and polluted waste water is released directly untreated into the surrounding environment.

Main Vulnerabilities

This SES is vulnerable to drought, which will cause salinity of ponds to increase as well as heavy rainfall events that will cause salinity to suddenly decrease. Both can cause sudden shocks that can harm or kill the cultured species (especially prawns). Increased temperature on the one hand encourages the growth of prawns that will develop faster and grow bigger in warmer water, but on the other hand increased temperature also increases of algae that depletes oxygen supply, reducing growth of the prawns, and increasing temperature also increases the risk of disease outbreaks. If the temperature is too hot the prawns will stop feeding. Storms can also result in physical damage to the facilities.

Possible EbA and other interventions include:

- Reduce physical damage from storms and reduce impacts of high temperatures by restoring natural beach vegetation around ponds to provide physical protection and shade
- Investigate drought impacts on ground water supply and assess future demand (from aquaculture, vegetable growing and tourism development) to develop appropriate management
- Improve management of waste water discharges to reduce pollution of sea water and impacts on fisheries
- Conduct a study on the feasibility of introducing organically-farmed high value prawn, as has been done successfully in Ca Mau province

C.P. Vietnam Corporation that has major shrimp farm business interests in the coastal zone of Quang Binh especially in Quang Ninh District and should also be approached for support for this work through its CSR programme.

9.2.9. Quang Binh SES (10a): Kinh inshore capture fisherman in delta and marine areas up to 6 nautical miles offshore

Ecosystem services

The SES depends provides significant catches of near-shore pelagic fish, shellfish, prawns and crab, depending on good quality water in the coastal area. The SES also absorbs large amounts of carbon dioxide which is dissolved in the sea, but this is causing increasing problems of acidification, which has serious impacts on marine life. The SES provides some waste recycling and detoxification services, but it can be overwhelmed by sudden influxes of large levels of pollution or highly toxic substances, that can have huge impacts on marine life. Coastal habitats including coral, sea-grass and mangroves support fisheries productivity by providing critical spawning, nursery and feeding grounds for a wide range of species during different periods of their life-cycle.

Main vulnerabilities

The SES is vulnerable to storms that make fishing dangerous or impossible. Good storm forecasting means that fishermen know when storms are coming and can stay at home. But their homes and boats can still be damaged by the storms. Sea level rise and coastal erosion may also require them to relocate their houses at some point. Storms can cause physical damage to mangroves, sea grass and coral reefs. Increased water turbidity from storms and run off from heavy rains can also affect penetration of sunlight necessary for corals and sea grass. Surface, water column and bottom water temperature increases may have many effects, including increased risk of algal bloom, and depletion of oxygen supply, as well as impacts on the life-cycle and migration of important fish species. Some fish species such as sardines are already arriving earlier in the year as temperature is warming earlier in spring. If water temperature continues to increase, sardine productivity may decrease over time, but in contrast, anchovy production is likely to increase. Mackerel may migrate to cooler waters. Squid productivity may also increase with warming water and it may provide an increasing proportion of the catch over time. Increasing temperature is a critical issue for coral, with elevated water temperatures beyond a few days causing corals to expel their symbiotic algae. This results in the well-known phenomenon of coral bleaching. Increasing acidification causes problems especially for shell-fish and coral as it is harder to secrete calcium carbonate to build shells and coral structures at lower pH.

Near-shore coastal fisheries in Quang Binh are already under severe stress, which decreases their resilience, making them even more vulnerable to the effects of climate change. The number of fishermen and fishing boats has increased significantly over the last 20 years, engine power has increased, fishing gear has improved and many now use fish finder devices.

Recent mass fish deaths in 4 coastal provinces including Quang Binh, starting in April 2016, have dealt an additional serious blow to fisheries. Speculation is rife that the mass fish die-off resulted from phenol poisoning from the discharge of a huge amount of carbolic acid (an industrial cleaning agent) from the Formosa plant at the Vung Ang Special Economic Zone in Ha Tinh province, but no conclusive statement or report on the investigation of the issue has yet been provided by the government, despite engaging a number of research institutes to assess the situation.

It is also possible that a combination of coastal pollution from other sources including aquaculture and domestic waste water; an extended period of elevated water temperature, and associated significant movement of benthic sediment into the water column also contributed to create a "perfect storm" of deadly conditions for the fish. Media reports have suggested over 2,000 fishing households were directly affected in Quang Binh, with initial losses estimated at over 115 billion VND. (See list of media articles is provided at the end of this report). Government advice against the sale of seafood in hotels and restaurants in Quang Binh, in place since the incident, was lifted on 16th June 2016.

While the mangrove area in the province has steadily declined (despite some efforts at replanting) almost nothing is known about the extent and condition of sea-grass and coral reefs in Quang Binh. The provincial Seas and Islands Department within DONRE has no data at all on these critical habitats.

Possible EbA and other related interventions include:

- Assess fish stocks of key species and monitor them on a regular basis
- Improve fisheries management through community-based management initiatives, a systems of quotas, and limiting the number of fishing vessels to that appropriate to the availability of stocks and catch quotas
- Identify, map and survey all coral reefs and sea-grass beds in Quang Binh Province
- Invest in major efforts for improved management and restoration of mangroves, sea-grass and coral reefs

- Restore native species coastal forest to reduce land-based water pollution flows to the sea and reduce coastal erosion
- Over the longer-term, research water temperature impacts on key fisheries species

9.1.10. Quang Binh SES 10c: Small and large-scale beach tourism development

Ecosystem Service

This SES is critically dependent on fresh water supplies, and seafood supplies originating from other adjacent SESs. Nearby coastal forest is also important for physical protection from storms and blowing sand, and may provide some micro-climate regulation. However, coastal forest is nowadays almost exclusively casuarina plantations. Original natural diverse species coastal forest would be more effective at providing these services.

Main Vulnerabilities

Increasing temperature and increasing number of hot days do not necessarily create vulnerability directly in this SES, as most of the tourists are coming to enjoy a beach holiday and hot weather is part of that experience. However, temperature effects on fisheries productivity in other SESs may have an indirect impact on this SES as the other main attraction for tourists is coming to Quang Binh to enjoy fresh seafood, and if supply is reduced, this could limit tourism growth.

Tourism creates significant demand for fresh water, and therefore tourism development is vulnerable to drought. Existing reservoirs in Quang Binh may ensure there is adequate water supply in most years, but in the worst drought years reservoirs are only filled to a very low level and may not be able to meet all of the needs for the tourism sector as well as domestic use and the increased demand for agricultural irrigation water in times of drought.

Tourism infrastructure (hotels, restaurants, access roads and bridges) is also vulnerable to damage caused by strong winds and storms, as well as to flood damage caused by storms and increases in heavy rainfall in the rainy season.

Use of plastic bags and other forms of plastic, and management of plastic waste is a huge issue. In many coastal communities in Quang Binh waste is simply dumped by the side of the road near to the beach. Plastic bags block drainage channels, increasing the impact of floods, and plastic waste gets into the sea where it is responsible for the deaths of vast numbers of marine creatures. Use of plastic increases with increasing tourists visiting the area. Recent reports have shown that together just five countries - China, Vietnam, Thailand, Indonesia and the Philippines - are responsible for over 60% of all the plastic waste in the world's oceans. Quang Binh small and large-scale tourism is just as much a part of this problem as anywhere else.

Possible EbA and related interventions could include:

Climate proofing tourism infrastructure including:

- Planting windbreak trees to protect buildings from strong winds and storms
- Applying SUDS (sustainable urban drainage systems) in all future tourism development planning - maximising natural drainage. Apply the 1:4 rule: every development of 1m2 of planned concrete must be accompanied by 4 m2 of natural surface
- Using eco-engineering options to protect coastal roads from erosion
- Planting shade trees along roads to reduce road surface temperature and prevent tarmac from melting on hot summer days, and to provide shade for tourists
- Widening of bridges to take account for increased rainy season river flows
- Raising the height of roads to take account of increased depth of future floods
- Increasing the number and size of culverts under roads to increase transparency of roads to more frequent floods and thereby reduce flood damage to roads

Supporting best practices in the tourism industry, including:

- Introducing programmes on water conservation, more efficient use of water and water recycling in hotels and resorts
- Campaigning to reduce use of plastic bags
- Introducing simple sustainable seafood consumption guidelines, and educating restaurant owners and tourists
- Improving solid waste and waste water management for small enterprises along the beaches

In addition, in Dong Hoi in particular, there are a number of urban and peri-urban wetlands. They provide valuable flood management, water supply and purification as well as micro-climate regulation services. They mustn't be filled in and built upon. Instead they can be developed for recreational, educational and scenic benefits that will provide additional attractions for visitors, as well as benefits for local people.

9.1.11. Quang Binh SEA 11a Irrigation Reservoirs and Associated Infrastructure

Ecosystem Services

All reservoirs depend on the inflow of water from the watersheds from forest SESs upstream of their location. The reservoirs are then used to regulate the flow of water to other downstream SESs, through irrigation canals, as well as through the water they release into the natural river channel below the reservoir.

Main Vulnerabilities

Reduced rainfall in the dry season will reduce the water inflow to reservoirs. On the other hand, prolonged periods of intense rainfall in the rainy season can quickly fill reservoirs to their safe limits, and raise the possibility of dam failures. Intense rainfall in the watershed areas can also increase erosion and the flow of sediment into the reservoir, which will cause shallowing of the reservoir as it fills in with sediment. This will reduce the effectiveness of the reservoir, as well as shortening its overall working life. The reservoir facilities may also be vulnerable to physical damage from strong winds and storms.

Possible EbA and related Interventions include:

- Protect reservoir infrastructure from physical damage from storms through planting of wind-breaks
- Increase working life of reservoirs by reducing sediment inflow through improved watershed management
- Install of large areas floating solar cells on reservoir surfaces to generate electricity and reduce evaporation losses
- Conduct scenario planning exercises for future water demand (including climate change considerations) in the area supplied by each reservoir

In addition, Quang Binh should develop a provincial integrated water resource management plan which should incude:

- Consideration of renaturation of some rivers or river stretches, potentially involving removal of some dykes, revetments and other barriers, to allow water to flow more naturally, meandering in the valleys and across floodplains, and restoring "environmental flows" and natural wetland habitats to help slow and absorb flood waters, recharge ground water, combat saline intrusion, and purify water supply, for the benefit of all downstream SESs.
- In rivers where saline intrusion barriers already exist studies should be conducted to identify the optimal operation of the gates for multiple benefits - not only to reduce upstream saline intrusion but also to allow downstream sediment transport, migration of fish, and the continued survival of estuary mangroves. Community-based committees with representative from both upstream and downstream of the barriers should be established to manage their operation.
- In other rivers studies should be conducted to investigate alternatives including introduction of more saline-tolerant rice varieties or transition out of rice-growing into brackish-water aquaculture livelihood activities.

9.3. SUMMARY EBA INTERVENTIONS RECOMMENDED FOR EACH SES

Table 9.2 presents a summary of 39 specific interventions, identifying for each one, which SESs it applies to; who are the lead agencies for implementation; the appropriate time frame, and the level of priority

Table 9.2: EbA and related interventions for priority SESs in Quang Binh

#	INTERVENTION	SES	LEAD	Time frame	Priority
1	Implement strict enforcement against illegal logging and wildlife poaching	PNKB 1-5 SFE 5	PNKB MB and Forest Companies	S-M	1
2	Improve forest fire prevention, including through education	PNKB 1-5 SFE 5	PNKB MB and Forest Companies	M-L	2
3	Restore degraded/previously logged areas with important/high value native species suitable to changing climate	PNKB 1-5 SFE 5	PNKB MB and Forest Companies	M-L	2
4	Conduct research on comfort zones and tolerance thresholds of endemic, endangered, and high value species	PNKB 1-5 SFE 5	PNKB MB and Forest Companies	L	3
5	Improve visitor education and interpretation services	PNKB 1-5	PNKB MB	S-M	3
6	Improve outreach with buffer zone communities	PNKB 1-5	PNKB MB	S-M	2
7	Update harvesting plans taking into account climate change issues	SFE5	Forest companies	M-L	2
8	Prepare for FSC Certification of additional natural forest not yet certified	SFE5	Forest companies	M	1
9	Plan transition to shift acacia plantations from 6-7year rotation to 15 year + rotation for production of higher value timber products	SFE5	Forest companies	M-L	1
10	Improve soil and water conservation practices especially on steep slopes where field crops are grown, through contour planting, alley cropping, mulching, etc.	5a	DARD extension services	S	1
11	Conduct enrichment planting of high value timber and NTFPs in community managed forests	5a	DARD extension services	M	2
12	Assess the feasibility of introducing a PES or REDD+ type scheme, and develop a plan for implementation wherever feasible	5a	DARD	L	3
13	Assess the appropriateness of terracing some slopes, and implement if appropriate	5a	DARD	L	3
14	Locate rubber plantations in sheltered areas protected from wind and storm damage and plant windbreaks of other trees to provide physical protection	5c	Commercial rubber enterprises	S	2
15	Continue to promote wider adoption of SRI rice, growing of Ratoon rice, use of shorter maturing rice varieties and diversification of household economy	6b	DARD Agriculture Extension services	S-M	2

#	INTERVENTION	SES	LEAD	Time frame	Priority
16	Implement a communication, education and public awareness programme to increase understanding of the value and importance of natural coastal forest and sand dune ecosystems	PFMB9,9a, 9c	DONRE	S	1
17	Establish community based management systems for all remaining areas of native species coastal forest	PFMB9	PFMB	S-M	1
18	Zone the sand dunes for different activities (aquaculture, tourism, etc.) including identification of core protection zones, as well as restoration zones and restore of native ground vegetation in the restoration zones of the sand dune ecosystem	PFMB9, 9a,	PFMB/PPC	S-M	1
19	Construct tree nurseries and provide training for propagation and care of native species, to provide seedlings for new planting areas	PFMB9, 9a, 9c	PFMB	S-M	2
20	Use native species for enrichment planting of existing casuarina and acacia coastal protection forests and instead of casuarina and acacia in all new coastal protection forest planting	FPMB9, 9a	PFMB	S-M	2
21	Conduct research and identify practical solutions on how to improve the effectiveness of tree planting on former heavy sands mining areas	PFMB9	DONRE	M-L	3
22	Investigate ground water supply availability and compare with likely future demands	PFMB9,9a, 9c	DARD water resources department	M-L	2
23	Conduct feasibility study for development of eco-tourism and environmental education programmes in the sand dune ecosystems	PFMB9, 9a 9c	DONRE and Department of Tourism	M-L	3
24	Restore natural beach vegetation around aquaculture ponds	9a	Commercial enterprises	S	2
25	Improve management of waste water discharges from aquaculture ponds	9a	Commercial enterprises	S	1
26	Assess fish stocks of key species and monitor on a regular basis	10a	DARD fisheries department	M-L	2
27	Establish community-based fisheries management, reduce number of vessels and establish catch quotas	10a	DARD fisheries department	M-L	2
28	Research water temperature impacts on key species fisheries species	10a	DARD fisheries department	L	3
29	Identify, map and survey all coral reefs and	10a	Seas and	S	1

#	INTERVENTION	SES	LEAD	Time frame	Priority
	sea-grass beds and develop plan for conservation and restoration		islands, DONRE		
30	Plant windbreak trees to protect tourist hotels	10c	Commercial enterprises	S	3
31	Apply 1:4 ratio rule for concrete surface are and natural vegetation in tourism infrastructure developed	10c	Commercial enterprises	M	2
32	Use eco-engineering to protect coastal roads from erosion, plant shade trees along roadsides, and widen bridges and increase culverts to reduce flood damage	10c	Department of transport	M-L	2
33	Introduce water efficiency and conservation programmes in hotels	10c	Commercial enterprises	S	3
34	Implement continuous campaign to reduce use of plastic bags	10c	DONRE	S	2
35	Introduce sustainable seafood guidelines	10c	DARD fisheries department	M-L	3
36	Improve solid waste and waste water management for small and microenterprises along the beach	10c	Commercial enterprises	S	1
37	Reduce sediment inflow to reservoirs through improved watershed management	11a	PNKB MB, Forest companies	M-L	2
38	Consider installation of floating solar cells on reservoirs	11a	Reservoir managers	L	3
39	Develop provincial Integrated Water Resource Management Plan	11a	DARD	M	1

9.4. CONCLUSIONS

Vulnerability assessments were conducted for the top 10 priority Socio-ecological systems (SESs) in Quang Binh Province. Taking into account aspects of exposure, sensitivity and adaptive capacity, vulnerability scores were assigned for each of 7 different climate change parameters in each SES. The mean of the 7 scores in each SES was taken as the overall vulnerability score for that SES. Based on the identified vulnerabilities, a total of 39 appropriate Ecosystem-based and other related adaptation interventions were suggested, specifically identified to each SES.

One main advantage of using the SESs as entry points for vulnerability assessments and identification of EbA interventions is that it facilitates thinking outside of traditional silos of purely social, ecological or economic issues and encourages the identification of interventions which may require collaboration between multiple agencies. Another advantage is that the scale of SESs provides a convenient intermediary step between "whole of province" and "community" scales.

Taking the SES map together with the EbA recommendations for a specific SES, enables provincial level government staff to see in which parts of the province each recommendation should be applied.

Mainstreaming these recommendations into provincial planning, and accessing budgets to address them, are addressed in the final chapter of this report.

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ANNEX 9.I

SES: 1P (1a, 2a, 3a, 4a) - PNKB World Heritage Site and National Park

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TEMPERATURE								
Hot season will be hotter and longer; Summer average maximum temperature will increase 1.8 degree C in 2050, 3.5 degree in 2100	**3**	▪ *High and medium mountain (300-700-1200)* ▪ *It would be hotter in limestone area during hot season and colder in cold season*	**3**	▪ *Coniferous can adapt oneself to dry/waterless for long time* ▪ *High biodiversity (forest types)*	**3**	**4**	▪ *Well-management by PNKB NP; Existing of Ranger stations; Forest patrol regularly (reduce the threads)* ▪ *High biodiversity*	**3**
Number of Dry days increase 17 days in 2050, 15 days in 2100, Number of hot days > 35°C also increase 23 - 24 days in 2050, 34 - 35 days in 2100	**3**	▪ *High and medium mountain (300-700-1200)* ▪ *It would be hotter in limestone area during hot season and colder in cold season*	**3**	▪ *Coniferous can adapt oneself to dry/ waterless for long time* ▪ *High biodiversity (forest types)*	**3**	**4**	▪ *Well-management by PNKB NP; Existing of Ranger stations; Forest patrol regularly (reduce the threads)* ▪ *High biodiversity*	**3**
Temperature will increase faster and earlier in Spring	**3**	▪ *Shorter duration* ▪ *Heat and drought level rise*	**3**	▪ *Increase the risk of insect development, destructive plant diseases*	**3**	**4**	▪ *Well-management by PNKB NP; Existing of Ranger stations; Forest patrol regularly (reduce the threads)* ▪ *High biodiversity*	**3**

PRECIPITATION (RAINFALL)								
Higher rainfall in rainy season; Rainfall in Summer will increase 5% in 2050, 9 - 10% in 2100; **FLOOD RISK**	**3**	▪ *High elevation* ▪ *Limestone area - so water can be withdrawal fast*	**2**	▪ *High biodiversity*	**3**	**4**	▪ *Well-management by PNKB NP; Existing of Ranger stations; Forest patrol regularly (reduce the threads)* ▪ *High biodiversity*	**3**
Dry season will be drier, Rainfall of Spring will decrease 5% in 2050, 10% in 2100 - **DROUGHT RISK**	**4**	▪ *Low humidity Lack of water*	**3**	▪ *High biodiversity of forest types, plants and animals, geology, cave system* ▪ *Animal can migrate*	**4**	**4**	▪ *Well-management by PNKB NP; Existing of Ranger stations; Forest patrol regularly (reduce the threads);* ▪ *High biodiversity*	**3**
STORM/ WIND/ TYPHOON Higher speed (intensity)/ stronger Difficult to forecast the storm frequency Storm season will come later	**3**	▪ *The wind speeds reduced (far from coast & High elevation)* ▪ *Lime stone - less flood*	**2**	▪ *Natural forests High elevation* ▪ *High biodiversity*	**3**	**4**		**3**
SEA LEVEL RISE Increased 3mm/year in last 20 years Would be increase 1m in 2100	**1**	▪ *High elevation* ▪ *Far from the sea*	**1**	▪ *High elevation Far from the sea*	**1**	**5**	▪ *High elevation > 700m*	**1**
	2.9		**2.4**		**2.9**	**4.1**		**2.7**

SES: 5c - Kinh smallholder inland valley paddy cultivation + tree crops (acacia, citrus, rubber, tea)

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TEMPERATURE								
Hot season will be hotter and longer; Summer average maximum temperature will increase 1.9 - 2 degree C in 2050, 3.6 - 3.7 degree C in 2100	**5**	▪ *Temperature increase cause shorten crop duration, shorten of hydrate carbon synthesis, reduce crop yield* ▪ *More disease and new diseases* ▪ *Impact on flowering, polling, evapotranspiration and hydrate accumulation process*	**4**	▪ *More evaporation and evapotranspiration, crops require more water, strongly impacts on metabolically processes* ▪ *Hilly land planting tree crops facing with drought more frequency* ▪ *Change micro climate and change crop grow rate and*	**5**	**3**	▪ *Farmer can use suitable crop varieties from hot regions* ▪ *Use net to protect pomelo and oranges*	**5**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
				crop distribution				
Number of Dry days increase 16 - 17 days in 2050, 14 - 15 days in 2100, Number of hot days > 35°C also increase 33 - 40 days in 2050, 47 -51 days in 2100	**4**	▪ *High risk for crop tolerate with short dry time* ▪ *Soil moisture go down below wilting point, plant die Reduce crop yield when drought period coincide with tellering and flowering period*	**5**	▪ *Drought will be more often damaging crop* ▪ *Some crop will be not suitable* ▪ *Hybrid and new varieties of cattle and poultry very sensitivity with CC*	**5**	**2**	▪ *It is hard to adapt this condition Need to have better water resource management Need to have drought tolerable varieties to adapt drought*	**5**
Temperature will increase faster and earlier in Spring	**4**	▪ *Tree crops will start earlier* ▪ *Some tree crops will not suitable* ▪ *Some vegetable and temperature crops will not be suitable*	**3**	▪ *Some crop change season earlier* ▪ *Redistribution of land use*	**4**	**2**	▪ *Also hard to adapt this condition because it change crop growing pattern* ▪ *Need a lot of experience and*	**4**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
							knowledge to control crop growing and seasoning	
PRECIPITATION (RAINFALL)								
Higher rainfall in rainy season; Rainfall in Summer will increase 4-6% in 2050; 9 - 12% in 2100;	**4**	▪ *Higher rainfall is good for crop production* ▪ *Rainfall will increase cause flood rick to valley paddy rice and other agriculture and aquaculture in lowland area?* ▪ *Infrastructure development (new road, dam, new rural program,..) cause fragmentation of*	**3**	▪ *Crop grow better More rainfall during flowering time may rotten pollen of citrus* ▪ *More rainfall during rainy season may cause nutrient leaching and erosion in citrus land, lack nutrient at the end of season, lower citrus quality*	**4**	**5**	▪ *Use high yield and quality crop varieties to optimal crop production in higher rainfall condition*	**3**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
		land cover/vegetation /forest and more exposure from rainfall increase						
Dry season will be drier, Rainfall of Spring will decrease 5% in 2050, 10% in 2100	**5**	▪ *Drier dry season has strong impact to tree crop because tree crop grow very slowly* ▪ *Drier dry season may lead to longer drier period, associated with soil moisture content drop below wilting point, some crop die* ▪ *Need more irrigation,*	**4**	▪ *Soil will be degraded, lower productivity* ▪ *Some crop may not suitable and farmer have to change crop and crop calendar* ▪ *May cause some delay growing during very low soil moisture content*	**5**	**1**	▪ *Need to have more reservoirs for water resources management* ▪ *Need to change to higher drought tolerable* ▪ *Need to irrigation, improve irrigation method to save water, need increase more fertilizer because*	**5**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
		increase cost					*drought lower fertilizer use efficiency*	
STORM/ WIND/ TYPHOON Higher speed (intensity)/ stronger Difficult to forecast the storm frequency Storm season will come later	**4**	▪ *Tropical low pressure happen yearly Average 1 storm in 2 years*	**2**	▪ *Later storm season may impact on mature periods of citrus and tea* ▪ *Later storm season me associated with later rainfall, good for tea and fruit tree* ▪ *Small storm (level <7) may not impact tree* ▪ *Strong typhoon may break tree (i.e.*	**3**	**2**	▪ *Need to find more option for avoiding negative impacts of strong wind breaking tree crop, especially rubber and citrus* ▪ *Need to have better field design with wind break line, reduce damages from strong wind*	**3**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
				extreme typhoon in 2013 break a lot of rubber)				
SEA LEVEL RISE Increased 3mm/year in last 20 years Would be increase 1m in 2100	**1**	▪ *These area is deeply in mainland, so not impacted by sea level rise*	**1**	▪ *Not impact on this land use*	**1**	**5**	▪ *Not impacted*	**1**
	3.9		**3.1**		**3.9**	**2.9**		**3.7**

SES 6a - Kinh smallholder lowland coastal floodplain paddy rice cultivation

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TEMPERATURE								
Hot season will be hotter and longer; Summer average maximum temperature will increase 1.9 degree C in 2050, 3.6 degree C in 2100	**4**	▪ *Low land - low altitude, high temperature, flat, large area of the same land-use ;* ▪ *More evaporation and evapotranspiration; More exposure in Spring Summer crops, less in Autumn Winter;*	**4**	▪ *Temperature increase cause shorten crop duration, shorten of hydrate carbon synthesis, reduce crop yield* ▪ *More disease and new diseases Impact on flowering, pollen, evapotranspiration and hydrate accumulation process crops require more water, strongly impacts on metabolically processes* ▪ *Crops facing with drought more*	**4**	**3**	▪ *Farmer can use suitable crop varieties from hot regions* ▪ *Agriculture extensions* ▪ *SRI rice* ▪ *RATOON rice* ▪ *Change to other crops*	**4**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
				frequency ▪ *Change micro climate and change crop grow rate and crop distribution*				
Number of Dry days increase 15 days in 2050, 12 days in 2100, Number of hot days > 35°C also increase 37 - 40 days in 2050, 50 - 54 days in 2100	**4**	▪ *Low land - low altitude, high temperature, flat, large area of the same land-use ; More evaporation and evapotranspiration; More exposure in Spring Summer crops, less in Autumn Winter;*	**4**	▪ *Drought will be more often damaging crop; Some crop will be not suitable* ▪ *High risk for crop tolerate with short dry time; Soil moisture go down below wilting point, plant die* ▪ *Reduce crop yield when drought period coincide with tellering and flowering period*	**4**	**3**	▪ *Improve irrigated system to adapt this situation* ▪ *Existing irrigation system can supply 80% water resource* ▪ *There are some drought tolerable varieties to adapt drought but at certain level* ▪ *Need pay more for irrigation*	**4**
Temperature will increase faster	**4**	▪ *Some negative impacts of return*	**3**	▪ *Some crop have to change season*	**4**	**2**	▪ *Also hard to adapt this condition*	**4**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
and earlier in Spring		*warm spring (reduce rice yield strongly)* ▪ *Earlier appear diseases and pest*		*earlier* ▪ *Damaging crops*			*because it is hard to change crop immediate fast weather changes* ▪ *Few experiences to control crop growing and seasoning when weather changed* ▪ *Redistribution of land use*	
PRECIPITATION (RAINFALL)								
Higher rainfall in rainy season; Rainfall in Summer will increase 4-6% in 2050; 9 - 12% in 2100;	**1**	▪ *Higher rainfall is good for crop production* ▪ *Flood risk is very high for summer - autumn crop (harvest). Winter-spring (planting)*	**2**	▪ *Crop grow better* ▪ *More rainfall during flowering time may rotten pollen of some vegetables* ▪ *More rainfall during rainy season may cause nutrient leaching*	**2**	**5**	▪ *Use high yield and quality crop varieties to optimal crop production in higher rainfall condition*	**2**
Dry season will be drier, Rainfall of Spring will	**4**	▪ *Drier dry season has strong impact* ▪ *May lead to saline*	**4**	▪ *Soil will be degraded, lower productivity*	**4**	**2**	▪ *Need to re-design or construct new irrigation system*	**4**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
decrease 5% in 2050, 9% in 2100		*intrusion and salinity*		▪ *Some crop may not suitable and farmer have to change crop and crop calendar* ▪ *May cause some delay growing during very low soil moisture content*			*and look for more water resource* ▪ *Need to change to higher drought tolerable rice varieties* ▪ *Apply new method to save water, need increase more fertilizer because drought lower fertilizer use efficiency;* ▪ *Need more irrigation, increase cos*	
STORM/ WIND/ TYPHOON Higher speed (intensity)/ stronger Difficult to forecast the storm frequency	**2**	▪ *July - November (storm)* ▪ *Crop harvest (April & July)* ▪ *1/2 frequency direct storm but high frequency if indirect storm& low*	**4**	▪ *Later storm season may impact on summer rice at mature period* ▪ *High risk due to high uncertainty forecast* ▪ *Strong typhoon*	**3**	**3**	▪ *Need to setup optimal crop calendar to avoid risk from typhoon* ▪ *Need to have smart action on harvesting to rescue rice from*	**3**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
Storm season will come later		*tropical pressure*		*associated with heavy rainfall cause flooding and loosing harvest*			*falling*	
SEA LEVEL RISE Increased 3mm/year in last 20 years Would be increase 1m in 2100	**4**	▪ *Near the coast, low land, risk of saline intrusion and make drought because of saline river water, no fresh water for irrigation* ▪ *Widespread of saline soil*	**4**	▪ *Degrading soil quality, reducing rice production • Many rice varieties will not be suitable to soil and need to change to higher saline tolerable varieties* ▪ *Salt intrusion make river and irrigation system water salty, difficult for irrigation, especially saline soil and acid sulphate soils* ▪ *Kill some rice when salt content higher than 4 ppm*	**4**	**4**	▪ *Have barrier to prevent salt water intrusion* ▪ *Good dykes to protect cropping from high sea level* ▪ *Have Saline tolerable rice varieties with high yield and quality*	**3**
	3.3		**3.6**		**3.6**	**3.1**		**3.4**

SES: 6b - Kinh smallholder floodplain-hills transition: paddy rice + mixed farming, tree crops

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TEMPERATURE								
Hot season will be hotter and longer; Summer average maximum temperature will increase 1.9 degree C in 2050, 3.6 degree C in 2100	**4**	▪ *Temperature increase* ▪ *Higher Evaporation*	**4**	▪ *More evaporation & evapotranspiration, crops require more water, strongly impacts on metabolically processes* ▪ *All terraces rice and Hilly land planting tree crops facing with drought more frequency* ▪ *Risk of more disease and new diseases* ▪ *Impact on flowering, polling, evapotranspiration and hydrate accumulation process; This SES occupies large land*	**4**	**3**	▪ *Farmer can use suitable crop varieties from hot regions* ▪ *High temperature can shorten crop duration, shorten of hydrate carbon synthesis, reduce crop yield* ▪ *Land-use change*	**4**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
				use area of Quang Binh and impact to livelihood of 1/3 households of the province. ▪ *Change micro climate and change crop grow rate and crop distribution; many change of land use, change of crop rotation, change of plant and animal varieties,...may be make more sensitivity.*				
Number of Dry days increase 17 -19 days in 2050, 16 -18 days in 2100, Number of hot days > 35°C	**4**	▪ *High risk for crop tolerate with short dry time* ▪ *Soil moisture go down below wilting point, plant die* ▪ *Reduce crop yield*	**5**	▪ *Drought will be more often damaging crop* ▪ *Small reservoirs will be emptied before rain season, spring season will be lack*	**5**	**2**	▪ *It is hard to adapt this condition* ▪ *This regions have quite good water resource management* ▪ *There are some*	**5**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
also increase 41 - 50 days in 2050, 52 - 67 days in 2100		*when drought period coincide with tellering and flowering period*		*of irrigation water* ▪ *Need payment more for irrigation*			*drought tolerable varieties to adapt*	
Temperature will increase faster and earlier in Spring	**4**	▪ *Tree crops will start earlier* ▪ *Some tree crops will not suitable* ▪ *Some vegetable and temperate crops will not be suitable*	**3**	▪ *Tree crops have sensitive with early season* ▪ *Rice also sensitive with early season and normally have very low yield in warm spring rice* ▪ *Many crops will not be suitable to new climate conditions*	**4**	**2**	▪ *Also hard to adapt this condition because it change crop growing pattern* ▪ *Need a lot of experience and knowledge to rice season seasoning and fruit trees*	**4**
PRECIPITATION (RAINFALL)								
Higher rainfall in rainy season; Rainfall in Summer will increase 4-6% in 2050; 8 - 12% in 2100;	**2**	▪ *Higher rainfall is good for crop production*	**3**	▪ *Crop grow better* ▪ *More rainfall during flowering time may rotten pollen of fruit tree* ▪ *More rainfall during rainy season may cause nutrient*	**3**	**5**	▪ *Use high yield and quality crop varieties to optimal crop production in higher rainfall condition*	**2**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
				leaching and erosion on hilly land and terraces rice, lack nutrient at the end of season				
Dry season will be drier, Rainfall of Spring will decrease 5% in 2050, 9% in 2100	**5**	▪ *Drier dry season has strong impact to tree crop because tree crop grow on hilly land* ▪ *Drier dry season may lead to longer drier period, associated with soil moisture content drop below wilting point, some crop die* ▪ *Rice on terraces also impacted by long dry periods*	**4**	▪ *Soil will be degraded, lower productivity* ▪ *Some crops may not suitable and farmer have to change crop and crop calendar* ▪ *May cause some delay growing during very low soil moisture content*	**5**	**1**	▪ *Need to have more reservoirs for water resources management* ▪ *Need to change to higher drought tolerable* ▪ *Need to irrigation, improve irrigation method to save water, need increase more fertilizer because drought lower fertilizer use efficiency*	**5**
STORM/ WIND/ TYPHOON Higher speed	**3**	▪ *Small storm (weaker level 7) may not impact*	**4**	▪ *Later storm season may impact on mature periods of*	**3**	**2**	▪ *Need to find more option for avoiding negative impacts*	**3**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
(intensity)/ stronger Difficult to forecast the storm frequency Storm season will come later		*tree* ▪ *Strong typhoon may break tree (i.e. extreme typhoon in 2013 break a lot of tree crops)*		*fruit trees* ▪ *Later storm season may associated with later rainfall, good for tea and fruit tree* ▪ *monoculture such as rubber, acacia, pepper, cashew plantation may be make more sensitivity from CC*			*of strong wind breaking tree crop, especially fruit crops* ▪ *Need to have better field design with wind break line, reduce damages from strong wind*	
SEA LEVEL RISE Increased 3mm/year in last 20 years Would be increase 1m in 2100	**1**	▪ *These area is allocated on terraces and hilly land, so not impacted by sea level rise*	**1**	▪ *Not impact on this land use*	**1**	**5**	▪ *The area is not impacted by sea level,*	**1**
	3.3		**3.4**		**3.6**	**2.9**		**3.4**

SES: 5a: 5a - Upland Ethnic minority small holder swidden cultivation and forest product collection

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TEMPERATURE								
Hot season will be hotter and longer; Summer average maximum temperature will increase 1.7 - 1.9 degree C in 2050, 3.2 - 3.6 degree C in 2100	**5**	▪ *Temperature increases.* ▪ *More serious with Laos wind*	**5**	▪ *Upland rice, maize, vegetable would be die because of hot.* ▪ *It's more serious with Laos wind.*	**5**	**3**	▪ *It would be changed to other trees like cassava, but it would cause risk of food security.*	**5**
Number of Dry days increase 17 - 20 days in 2050, 14 - 19 days in 2100, Number of hot days > 35°C also increase 34 - 48 days in 2050, 41 - 63 days in 2100	**5**	▪ *draught become more serious*	**5**	▪ *There are no irrigation system and reservoir.* ▪ *Draught cause rice, maize, vegetable die, and plantation trees grow slowly.* ▪ *Lack of drinking water*	**5**	**2**	▪ *It requires high investment for irrigation system.*	**5**
Temperature will	**5**	▪ *Hot season*	**5**	▪ *Temperature*	**5**	**2**	▪ *It would be*	**5**

increase faster and earlier in Spring		*come earlier in dry season.*		*increase in Spring when starting rice season cause rice grow slowly.* ▪ *Temperature decrease in winter cause rice and cattle die*			*changed to other trees like cassava, but it would cause risk of food security.*	
PRECIPITATION *(RAINFALL)*								
Higher rainfall in rainy season; Rainfall in Summer will increase 3-5% in 2050; 7 - 9% in 2100;	**4**	▪ *High land field, sloping land are at high risk*	**4**	▪ *Heavy rain cause flash flood, and slide land, erosion*	**4**	**2**	▪ *No solution in poor areas*	**4**
Dry season will be drier, Rainfall of Spring will decrease 5% in 2050, 8 - 10% in 2100	**5**	▪ *Draught comes earlier*	**5**	▪ *Draught cause rice, maize, vegetable die, and plantation trees grow slowly.* ▪ *Lack of drinking water*	**5**	**2**	▪ *It would be changed to other trees like cassava, but it would cause risk of food security.*	**5**
STORM/ WIND/ TYPHOON	**3**	▪ *Tropical low pressure*	**4**	▪ *Serious impact by strong*	**3**	**3**	▪ *No solution especial in*	**3**

Higher speed (intensity)/ stronger Difficult to forecast the storm frequency Storm season will come later		*happen yearly* ▪ *Average 1 storm in 2 years* ▪ *Far from the sea.* ▪ *Strong storm does not often come*		*storm. Storm No. 10 in 2013 so serious. 80% roofs flow out. 80% rubber of farm was broken.*			*poor areas*	
SEA LEVEL RISE Increased 3mm/year in last 20 years Would be increase 1m in 2100	**1**		**1**		**1**	**5**		**1**
	4.0		**4.1**		**4.0**	**2.7**		**4.0**

SES 10c - Small and large scale beach tourism enterprises

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TEMPERATURE								
Hot season will be hotter and longer; Summer average maximum temperature will increase 1.8 degree C in 2050, 3.4 degree C in 2100	**4**	▪ *Temperature increase out door and sand areas.*	**4**	▪ *Summer is season for tourism. Tourists spend their time out door. it cause increasing of power for air conditioner, and water using;* ▪ *Human is sensitive with high temperature*	**4**	**3**	▪ *It need time and budget to change the way of power and water using to environmentally friendly*	**4**
Number of Dry days increase 19 days in 2050, 18 days in 2100, Number of hot days > 35°C also increase 43 - 46 days in 2050, 55 - 59 days in 2100	**4**	▪ *Dry often comes with high temperature.* ▪ *Air becomes hot and dry.*	**4**	▪ *It cause increasing of power using for air conditioner, and water using.* ▪ *May suffer risk of lack of water using*	**4**	**2**	▪ *Tourism is the most water using sector. It affects ground water resource.* ▪ *Waste water also is problem cause pollution.*	**4**

Temperature will increase faster and earlier in Spring	**2**	▪ *Hot and dry season come earlier.*	**2**	▪ *Tourism may start earlier*	**2**	**3**	▪ *Tourism start earlier, spend more power, water, discharge more water and solid waste*	**3**
PRECIPITATION (RAINFALL)								
Higher rainfall in rainy season; Rainfall in Summer will increase 4% in 2050; 8% in 2100;	**2**	▪ *Temperature be cooler in hot season.* ▪ *More rain more water.*	**2**	▪ *Increase rain may provide more ground water* ▪ *Risk of flood and storm surge*	**2**	**2**	▪ *No response*	**3**
Dry season will be drier, Rainfall of Spring will decrease 5% in 2050, 9% in 2100	**3**	▪ *It is dry in sand areas.*	**4**	▪ *May suffer lack of water in dry season*	**3**	**4**	▪ *Quang Binh has many freshwater lakes and reservoirs;* ▪ *Water resources is plenty.* ▪ *Protection forest is reducing.*	**3**
STORM/ WIND/ TYPHOON Higher speed (intensity)/ stronger Difficult to forecast the storm frequency Storm season will come later	**4**	▪ *Near the shoreline, impact directly from storm*	**4**	▪ *Hotel and other tourism constructions would be damaged and destroyed.* ▪ *Flood and storm*	**4**	**3**	▪ *Require high investment and technology*	**4**

				surge				
SEA LEVEL RISE Increased 3mm/year in last 20 years Would be increase 1m in 2100	**4**	▪ *Near the shoreline, impact directly from sea level rise.*	**4**	▪ *Hotel and other tourism constructions would be damaged destroyed.*	**4**	**2**	▪ *Require high investment and technology*	**4**
	3.3		**3.4**		**3.3**	**2.7**		**3.6**

SES 8a - Kinh cage and pond aquaculture in estuary, mangrove, mudflat areas

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TEMPERATURE								
Hot season will be hotter and longer; Summer average maximum temperature will increase 1.8 - 2.0 degree C in 2050, 3.5 - 3.8 degree C in 2100	**4**	▪ *Ponds Temp. increase ; Location in estuary* ▪ *Low elevation - high temperature* ▪ *Increasing salinity*	**3**	▪ *Mangrove is not so sensitivity but aquaculture life in mangrove ecosystem and mudflat areas is* ▪ *Temp. increase:* *- Shrimp stop eating, move to bottom water layer, decrease, shrimp die* *- Increase algal cyanophyta (tảo lam), dinophyta (tảo giáp)* *- Poor Oxygen in water* ▪ *Sea fish appear in mangrove in river mounth because of increasing salinity (Platycephalus indicus - C. Chai, Siganus spp. Dia, Glossogbius spp.*	**4**	**2**	▪ *Local people expanding their cultivation land and cuting mangrove for land use purpose change* ▪ *Increasing oxygen to water in pond* ▪ *Poor mangrove restoration and restore estuary and mudflat mangrove ecosystem*	**4**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
				Bong, Leiognathus equulus spp. Liet ...)				
Number of Dry days increase 14 - 17 days in 2050, 10 - 16 days in 2100, Number of hot days > 35°C also increase 22 - 44 days in 2050, 25 - 59 days in 2100	**2**	▪ *Temperature increase but not serious to mangrove* ▪ *Higher temperature may cause dead shrimp in pond and enlarge mudflat areas*	**3**	▪ *Mangrove is not so sensitivity but aquaculture life in mangrove ecosystem and mudflat areas is some natural shrimp and other fishes, aquatic life's change*	**3**	**2**	▪ *Need restoration mangrove forest* ▪ *Estuary and mudflat protection*	**3**
Temperature will increase faster and earlier in Spring	**3**	▪ *Life circle of the fish; Mangrove is evergreen tree species, it is better when Spring come earlier* ▪ *Temperature of water*	**4**	▪ *Natural species composition may change* ▪ *Food chain may change* ▪ *Some sea fish appear in estuary earlier replace living areas of fresh water fish such as Leiognathus spp.,*	**3**	**2**	▪ *Restore ecological system* ▪ *Shrimp can be put earlier*	**3**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
		surface is hotter and salinity increase		*Saurida tumbil (mối) in estuary and deeper in river mouth* ▪ *Shrimp growth up faster in early Spring but when temp. increase higher and faster shrimp stop eating because poor oxygen in water*				
PRECIPITATION (RAINFALL)								
Higher rainfall in rainy season; Rainfall in Summer will increase 4 -6% in 2050; 8 - 11% in 2100;	**4**	▪ *Change water salinity* ▪ *High risk of flood* ▪ *Reduce temperature of ponds* ▪ *pH water reduce by heavy rain*	**5**	▪ *Shrimp molting because of pH decrease* ▪ *Fresh water fish replace of sea water fish in water mouth water surface* ▪ *Water salinity cause some change biome and food chain* ▪ *Change species composition*	**5**	**3**	▪ *Water reservoir in upland may manage water flow regime*	**5**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
Dry season will be drier, Rainfall of Spring will decrease 5% in 2050, 10% in 2100	**4**	▪ *More temperature more water: good for mangrove and estuary biome* ▪ *Increase water salinity*	**3**	▪ *Mangrove is not so sensitivity but aquaculture life in mangrove ecosystem and mudflat areas is* ▪ *Temperature increase:* *- Shrimp stop eating, move to bottom water layer, diseases increase, shrimp die* *- Increase algal cyanophyta (tảo lam), dinophyta (tảo giáp)* *- Poor Oxygen in water* ▪ *Sea fish appear in mangrove in river mouth because of increasing salinity (Platycephalus indicus - C. Chai, Siganus spp. Dia, Glossogbius spp. Bong, Leiognathus equulus spp. Liet ...)*	**4**	**3**	▪ *Need good estuary ecological management strategy of local authorities*	**4**
STORM/ WIND/	**4**	▪ *Trees break*	**5**	▪ *Strong wind cause*	**5**	**3**	▪ *It needs detail and*	**5**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TYPHOON Higher speed (intensity)/ stronger Difficult to forecast the storm frequency Storm season will come later		*by strong wind* ▪ *Change water flow in estuary* ▪ *Mangrove also play the role of wind break* ▪ *Reducing pH* ▪ *Reducing salinity*		*mangrove damage and change water flow* ▪ *No more intensive shrimp pond in this season but extensive is still some* ▪ *Shrimp may die because of low pH, low salinity* ▪ *Appearing fresh water fish in mangrove and estuary tidal areas*			*intensive mangrove in estuary restoration and annual maintaining*	
SEA LEVEL RISE Increased 3mm/year in last 20 years Would be increase 1m in 2100	4	▪ *Increase water salinity*	3	▪ *High salinity cause increase algae in water and hurt shrimp* ▪ *Change pH in mangrove cause change algae and more sea fish in mangrove* ▪ *Change areas of mangrove and mudflat…*	4	3	▪ *It needs detail and intensive mangrove in estuary restoration and annual maintaining*	4

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
	3.6		3.7		4.0	2.6		4.0

SES 10a - Kinh inshore capture fishermen in delta and marine areas 6 nautical iles offshore

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TEMPERATURE								
Hot season will be hotter and longer; will increase 2 - 2.5 degree C in 2050, 3.6 degree in 2100	**2**	▪ *Sea surface temperature would increase a little* ▪ *Increasing salinity in surface water* ▪ *Low oxygen in sea surface and bottom water*	**2**	▪ *Increasing algae's and blome algae in water* ▪ *Change pH bottom water* ▪ *Bottom water fish may die*	**2**	**3**	▪ *Dry fish processing*	**3**
Number of Dry days increase, Number of hot days > 35°C also increase	**2**	▪ *Increasing temperature water surface* ▪ *Increasing salinity* ▪ *Low oxygen in water*	**2**	▪ *Change water surface with by algae density and sediment* ▪ *Increasing algae's and blome algae in water* ▪ *Change pH bottom water* ▪ *Bottom water fish may die*	**2**	**3**	▪ *No actions*	**3**
Temperature will	**3**	▪ *Temperature*	**2**	▪ *Change pH*	**3**	**3**	▪ *No actions*	**3**

increase faster and earlier in Spring		*surface water increase* ▪ *Seasonal fish come early in spring such as Apogen aureus, Encrasicholina zollengeri, Anodontostoma chacunda come earlier*		*bottom water*				
PRECIPITATION (RAINFALL)								
Higher rainfall in rainy season; Rainfall in Summer will increase 5 - 10% in 2050; No. heavy rains (>50mm) increase	**2**	▪ *Change pH water surface*	**2**	▪ *Heavy rain may cause loss fishes* ▪ *No fish in heavy rain*	**2**	**3**	▪ *No actions*	**3**
Dry season will be drier, Rainfall of Spring will decrease 4 - 9% in 2050	**1**	▪ *Not so exposure with fish in the sea*	**2**	▪ *It may change some fishes in surface water*	**2**	**3**	▪ *Change fishing tools*	**3**
STORM/ WIND/ TYPHOON Higher speed	**5**	▪ *No exposure to the offshore fish*	**5**	▪ *Typhoon change water flow and*	**5**	**3**	▪ *Typhoon prevention plan*	**5**

(intensity)/ stronger Difficult to forecast the storm frequency Storm season will come later				*bottom fish*				
SEA LEVEL RISE Increased 3mm/year in last 20 years Would be increase 1m in 2100	**1**	▪ *No exposure*	**1**	▪ *No sensitive*	**1**	**3**	▪ *No actions*	**2**
	2.3		**2.3**		**2.4**	**3.0**		**3.1**

SES 9b - Kinh small scale vegetable growing on sand

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TEMPERATURE								
Hot season will be hotter and longer; Summer average maximum temperature will increase 1.9 - 2 degree C in 2050, 3.6 - 3.8 degree C in 2100	**3**	▪ *A bit impact on vegetable with small yield reduction because vegetable has short duration* ▪ *More disease and new diseases* ▪ *Impact on flowering, polling, evapotranspiration and hydrate accumulation process, especially for squash family*	**3**	▪ *More evaporation and evapotranspiration, crops require more water, impacts on metabolically processes* ▪ *Vegetable facing with drought more frequency* ▪ *Change micro climate and change vegetable distribution*	**3**	**3**	▪ *Farmer can use suitable crop varieties from hot regions* ▪ *Some high tech farm can control temperature well*	**3**
Number of Dry days increase 14 - 16 days in 2050, 10 - 13 days in	**5**	▪ *High risk for vegetable because it will be spend energy for respiration, reduce*	**5**	▪ *Drought will be more often damaging vegetable*	**5**	**3**	▪ *It is hard to adapt this condition* ▪ *This regions*	**5**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
2100, Number of hot days > 35°C also increase 32 - 43 days in 2050, 45 - 57 days in 2100		*quality* ▪ *Soil moisture go down below wilting point, need more irrigation* ▪ *Reduce vegetable yield and quality when drought period coincide with ripening time*		▪ *Water resources in sand area will be reduced quickly* ▪ *Need payment more for irrigation*			*have limited water resource* ▪ *There are some drought tolerable vegetable to adapt*	
Temperature will increase faster and earlier in Spring	**5**	▪ *Winter vegetable will be end earlier, reduce productivity* ▪ *Some vegetable will not be suitable* ▪ *Some vegetable and temperate crops will not be suitable*	**3**	▪ *Vegetables have sensitive with early season* ▪ *Vegetable season will also be changed* ▪ *Some vegetable will not be suitable to new climate conditions*	**4**	**2**	▪ *Also hard to adapt this condition because it change vegetable and calendar* ▪ *Need a lot of experience and knowledge to vegetable seasoning*	**4**
PRECIPITATION (RAINFALL)								

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
Higher rainfall in rainy season; Rainfall in Summer will increase 4 -6% in 2050; 8 - 11% in 2100;	**2**	▪ *Higher rainfall is good for some vegetable but not good for some other e.g. salad, tomato, melon (we call sun is good for melon but rain is good for rice)*	**2**	▪ *Some vegetable for harvesting leaf, root will grow better, but melons, tomato, potato will be impacted* ▪ *More rainfall during vegetable flowering time may rotten pollen* ▪ *More rainfall during rainy season may cause nutrient leaching and erosion on hilly land and terraces rice, lack nutrient at the end of season*	**2**	**3**	▪ *Use high yield and quality vegetable varieties and vegetable suitable to higher rainfall condition*	**3**
Dry season will be drier, Rainfall of Spring will decrease 5 - 6%	**5**	▪ *Drier dry season is not good for vegetable because vegetable need a lot of water*	**4**	▪ *Soil will be degraded, lower productivity* ▪ *Some crops may*	**5**	**2**	▪ *Need to have more water resources* ▪ *Need to*	**5**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
in 2050, 10 - 11% in 2100		▪ *On sandy lands, wilting point is very high and time to reach wilting point is fast. Drier means time to reach wilting point earlier, plant die faster*		*not suitable and farmer have to change crop and crop calendar* ▪ *May cause some delay growing during very low soil moisture content*			*introduce higher drought tolerable vegetable* ▪ *Need to irrigation, improve irrigation method to save water, need increase more fertilizer because drought lower fertilizer use efficiency*	
STORM/ WIND/ TYPHOON Higher speed (intensity)/ stronger Difficult to forecast the storm frequency	**4**	▪ *Vegetable is high exposure on storm because it will be crashed and fall and easy to die, attached by diseases* ▪ *Strong wind bring a lot of solid waste the field*	**2**	▪ *Later storm season may impact on winter vegetable* ▪ *Later storm season may associated with later rainfall, destroy vegetable bed and new*	**3**	**2**	▪ *Rich farm can adapt better poor farm* ▪ *Need to have better field design with to reduce damages from*	**3**

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
Storm season will come later		▪ *Associated with heavy rainfall under violence wind, damaging vegetable*		*planted vegetable*			*strong wind*	
SEA LEVEL RISE Increased 3mm/year in last 20 years Would be increase 1m in 2100	**3**	▪ *These area is allocated on very near seas shore and river bank, quickly influenced by salinity intrusion and sea water flood* ▪ *Some area, vegetable will not be suitable and have to change another crops*	**4**	▪ *Vegetable sensitive with high pH and salt content* ▪ *Vegetable sensitive with drought sand, lack of fresh water*	**4**	**2**	▪ *Irrigated area can adopt but only for rich farm, high tech farm*	**4**
	3.9		**3.3**		**3.7**	**2.4**		**3.9**

SES 9C - Commercial pond aquaculture on sand areas

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TEMPERATURE								
Hot season will be hotter and longer; Summer average maximum temperature will increase 1.8 - 2 degree C in 2050, 3.5 - 3.8 degree in 2100	**4**	▪ *Location: on sand area - little vegetation* ▪ *Hotter - higher evaporation* ▪ *Ponds temperature increase ;* ▪ *Low elevation - high temperature*	**5**	▪ *Shrimp is very sensitive with temperature change*	**5**	**2**	▪ *Low adaptive capacity (required high investment, and technology)* ▪ *Change the time for putting the juveniles*	**5**
Number of Dry days increase 14 - 17 days in 2050, 10 - 15 days in 2100, Number of hot days > 35°C also increase 19 - 41 days in 2050, 22 - 54 days in 2100	**3**	▪ *Shrimp farming by seasonally*	**4**	▪ *Shrimp season starting depends on the temperature high enough*	**3**	**2**	▪ *Low adaptive capacity (required high investment, and technology)*	**3**
Temperature will increase faster and earlier in Spring	**2**	▪ *Shrimp season start earlier and longer*	**2**	▪ *Shrimp season starting depends on the temperature high enough*	**2**	**3**	▪ *Change the crop cycle*	**3**
PRECIPITATION (RAINFALL)								

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
Higher rainfall in rainy season; Rainfall in Summer will increase 4 - 6% in 2050, 9 - 11% in 2100;	3	▪ *The impacts happens only when extreme high rainfall* ▪ *Reduce the pH level* ▪ *Salinity would be changed*	5	▪ *Shrimp is very sensitive with the change of salinity concentration & pH level - that easily diluted by rain water*	4	3	▪ *Medium capacity to adapt (e.g. pumping equipment)*	4
Dry season will be drier, Rainfall of Spring will decrease 5 - 6% in 2050, 10 - 11% in 2100	2	▪ *Higher evaporation -> need more water input - Lack of freshwater input*	2	▪ *Shrimp is very sensitive with the change of salinity concentration & pH level but it can be solved by adding fresh water*	2	3	▪ *Near the sand-dune - the people can get freshwater*	3
STORM/ WIND/ TYPHOON Higher speed (intensity)/ stronger Difficult to forecast the storm frequency Storm season will come later	5	▪ *Near the shore - direct impact* ▪ *High rainfall - high risk of harvest loss totally*	5	▪ *Storm may cause the shrimp die immediately* ▪ *Take longtime to recover/ rebuild*	5	3	▪ *The infrastructure is not concreate* ▪ *Limitation of budget*	5
SEA LEVEL RISE Increased 3mm/year in last 20 years Would be increase 1m in	3	▪ *Location: on sand, near the coast* ▪ *1m rising MSL*	3	▪ *Change the salinity concentration, pH and water environment - impact the growth rate*	3	2	▪ *Improvement dyke system* ▪ *Improvement flood gate*	3

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
2100		▪ *Salt/ sea water*		*and distribution of shrimp and fish* ▪ *More land for aquaculture* ▪ *Higher opportunity & MSL* ▪ *Easy to take salt water to ponds* ▪ *Some areas would be lost or rebuild the bunds;* ▪ *Flood risk*			*system* ▪ *Limitation of budget*	
	3.1		**3.7**		**3.4**	**2.6**		**3.7**

SES 11a - Irrigation and hydropower reservoirs and related infrastructure in Tropical BL Forest < 700 m

CLIMATE CHANGE RISKS (2050 & 2100)	Exposure	Explanation (E)	Sensitivity	Explanation (S)	Impact	Adaptive Capacity	Explanation (AC)	Vulnerability
TEMPERATURE								
Hot season will be hotter and longer; Summer average maximum temperature will increase 1.9 degree C in 2050, 3.6 degree C in 2100	**3**	▪ *Higher water requirement* ▪ *Higher evaporation*	**3**	▪ *Water required at intake slightly increased* ▪ *Less water come into the reservoirs*	**3**	**3**	▪ *Budgets for maintenances, improvement are limited*	**3**
Number of Dry days increase 15 - 16 days in 2050, 12 - 13 days in 2100, Number of hot days > 35°C also increase 41 - 44 days in 2050, 55 - 59 days in 2100	**4**	▪ *Higher water requirement* ▪ *Higher evaporation*	**3**	▪ *Less water come to the reservoirs & infrastructure* ▪ *Lower soil moisture in catchment*	**4**	**3**	▪ *Budgets for maintenances, improvement are limited*	**4**
Temperature will increase faster and earlier in Spring	**3**	▪ *Water level would be impacted earlier due to evaporation*	**2**	▪ *Less water come to the reservoirs & infrastructure* ▪ *Lower soil moisture in catchment*	**3**	**3**	▪ *Budgets for maintenances, improvement are limited* ▪ *Change crop season or change the crop species*	**3**
PRECIPITATION (RAINFALL)								

Higher rainfall in rainy season; Rainfall in Summer will increase 5% in 2050; 9% in 2100;	**4**	▪ *More water would be supplied* ▪ *High risk of overflow*	**4**	▪ *Risk flood,* ▪ *Risk of dam security* ▪ *A chance to get more water*	**4**	**3**	▪ *Budgets for maintenances, improvement are limited* ▪ *Ununiformed investment* ▪ *Lack of equipment's to measure rainfall*	**4**
Dry season will be drier, Rainfall of Spring will decrease 5% in 2050, 10% in 2100	**4**	▪ *Lacking water during dry seasons seriously*	**4**	▪ *Lacking water during dry seasons seriously*	**4**	**3**	▪ *Budgets for maintenances, improvement are limited* ▪ *Change crop season or change the crop species*	**4**
STORM/ WIND/ TYPHOON Higher speed (intensity)/ stronger Difficult to forecast the storm frequency Storm season will come later	**4**	▪ *Tropical low pressure happen yearly* ▪ *Average 1 storm in 2 years* ▪ *Would cause high rainfall, flood, flash flood, landslide*	**4**	▪ *Dam security* ▪ *High risk of overflow* ▪ *Would cause high rainfall, flood, flash flood, landslide* ▪ *Risk of dam broken*	**4**	**3**	▪ *Budgets for maintenances, improvement are limited* ▪ *Storm warning system* ▪ *Storm forecast has not high accurate*	**4**

SEA LEVEL RISE Increased 3mm/year in last 20 years Would be increase 1m in 2100	**1**	▪ *Would not impact*	**1**	▪ *Far from sea, high elevation*	**1**	**5**	▪ *Higher elevation*	**1**
	3.3		**3.0**		**3.3**	**3.3**		**3.3**