MINISTRY OF EDUCATION AND TRAINING MINISTRY OF AGRICULTURE AND ENVIRONMENT

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RESEARCH ON BASELINE DEVELOPMENT AND EVALUATION OF THE EFFECTIVENESS OF CLIMATE CHANGE ADAPTATION IN THE MID-CENTRAL COASTAL REGION

Field: Climate Change
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SUMMARY OF DOCTORAL THESIS ON CLIMATE CHANGE

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INTRODUCTION

1. Problem statement

The development and implementation of policies and actions to adapt to climate change (CC) aim to reduce vulnerability (V) and risks to existing or potential negative impacts of CC [35]. In particular, CC risk assessment is the process of predicting the likelihood of consequences or losses caused by CC [16] and serves as an important source of information for governance as well as for developing effective adaptation policies and measures [60], [63].

Although the steps for local climate change adaptation planning have been studied, there has been insufficient focus on the systems and methods for monitoring and evaluation, methodologies for assessing effectiveness, or how to use those results to build, adjust, and refine the established plans [58]. Furthermore, the monitoring and evaluation (M&E) of local adaptation activities face numerous difficulties [67], [32], [57]. To assess adaptation effectiveness, the key method involves setting a 'Baseline' based on quantified climate risk, where effectiveness is measured by the level of risk reduction from the original state. In Vietnam, particularly the coastal provinces of the Central Coast region - an area with specific geographical and topographical conditions - are frequently affected by climate change and require the development of effective adaptation plans, strategies, and solutions.

Therefore, the dissertation "*Research on baseline development and evaluation of the effectiveness of climate change adaptation in the Mid-Central Coastal Region*" was identified and carried out.

2. Research objectives

- To identify the scientific and practical framework for developing an adaptation baseline and evaluating the effectiveness of climate change adaptation.

- To successfully establish a climate change adaptation baseline and evaluate the effectiveness of adaptation activities and measures for a pilot study area in the central region of Vietnam.

3. Research Objects and Scope

- Research object: Baseline for climate change adaptation and the effectiveness of adaptation activities and solutions.

- Geographical scope: The study was conducted within the Central Coastal Region of Vietnam, with the former Quang Nam Province selected as the pilot study area.

The former province of Quang Nam was selected as the pilot study area as it is one of the localities most severely impacted by climate change. It exhibits high exposure due to the concentration of its population and economic assets in the coastal zone, while also possessing a diverse topography that is representative of the entire region. Despite a subsequent change in administrative boundaries involving the city of Da Nang, the dissertation maintains its original research scope, as the data collection and analysis process had been continuously underway for five years. This does not alter the scientific value of the thesis, given that its core objective is to establish a methodology. Moreover, the former Quảng Nam province's territory constitutes 88% of the total area of the combined administrative unit further affirms the representativeness of the study area.

The place names used in the dissertation are based on the administrative boundaries prior to the provincial merger and the implementation of the two-tier government model.

- Time scope: Climate hazard (H) data up to 2020, and climate change and socio-economic development scenarios projected to 2030 and 2050.

- Research content scope: (1) Establishing a baseline for climate change adaptation; and (2) Evaluating the effectiveness of climate change adaptation activities and measures in key sectors and subjects, including: agriculture, water resources, people, and infrastructure.

4. Research questions and thesis defense

4.1. Research questions

(1) What role does the climate change adaptation baseline play in assessing climate change adaptation actions and measures?

(2) Which methods are appropriate, and what factors should be considered in developing climate - resilient baselines?

(3) What effects can the proposed climate change adaptation actions and measures in Quang Nam have on reducing exposure, vulnerability and climate risks compared to the baseline?

(1) What are the scientific and practical bases for developing an adaptation baseline and evaluating the effectiveness of climate change adaptation solutions?

(2) How can the methodology and set of indicators be developed for establishing an adaptation baseline and for the quantitative assessment of climate change adaptation effectiveness?

(3) What are the potential effects of the planned climate change adaptation actions and measures in Quang Nam province on reducing exposure, vulnerability, and climate risks, relative to the baseline?

4.2. Defense arguments

(1) The climate change adaptation baseline for the Mid-Central Coastal region can be developed through a set of climate risk indicators (including: Hazard, Exposure, Vulnerability).

(2) The effectiveness of adaptation to climate change can be determined by assessing the change in the level of climate risk when implementing adaptation measures compared to *the* baseline (*Effectiveness = Risk at baseline* - Risk *after adaptation*).

5. Research methods

The research methods used in the dissertation include: (1) Desk review method; (2) Data and document collection and synthesis method; (3) Index calculation method, including: (i) method for normalizing index values; (ii) weight determination; (iii) calculation of the values of the main indices, and (iv) determination of the climate risk index and classification of risk value thresholds; (4) Spatial analysis method (GIS); and (5) Consultation workshop method.

6. New contributions of the Thesis

- Proposed and systematized a method for developing a Climate Change Adaptation Baseline based on a composite risk index set. This is a methodological contribution that provides a quantitative, objective approach to serve as a reference for evaluating adaptation effectiveness, as opposed to previous qualitative approaches or those lacking a clear reference basis.

- Quantified and compared the effectiveness of individual measures and groups of measures in the climate change adaptation plan in Quang Nam. These results provide scientific evidence on the degree of risk reduction for each measure, thereby identifying the most effective measures within the local practical context.

- Developed a set of detailed climate risk zoning maps for Quang Nam province for current and future timelines, which helps in identifying "hotspots" for prioritizing adaptation resources.

7. Scientific and practical significance

- *Scientific significance:* The dissertation has successfully developed and applied a methodological framework for the quantitative evaluation of climate change adaptation effectiveness. The novelty of this method is the establishment of a Climate Risk Baseline and the measurement of effectiveness based on the degree of risk reduction when implementing adaptation measures, as expressed by the formula: Effectiveness = $Risk_{baseline} - Risk_{post\text{-}adaptation}$. This approach contributes to filling a current research gap, which lacks a formal, unified assessment framework capable of explicitly quantifying adaptation effectiveness.

- *Practical significance:* The research findings of the dissertation provide a strategic decision-support toolkit for management agencies and policymakers in Quang Nam province. Specifically, the set of detailed climate risk maps for the timelines of 2020, 2030, and 2050, along with the risk zonation results, help to visualize and identify high-risk areas ("hotspots"). This serves as a robust scientific basis for developing action plans, prioritizing resource allocation, and designing intervention measures tailored to the specific context of each locality.

8. Thesis layout

In addition to the introduction and conclusion, the thesis consists of 3 chapters as follows:

Chapter 1. Overview of studies in the world and in Vietnam on climate change adaptation baselines and assessment of climate change adaptation effectiveness.

Chapter 2. Approaches and research methods for development climate change adaptation baselines and evaluating the effectiveness of climate change adaptation actions.

Chapter 3. Results of developing the adaptation baseline and assessing climate change adaptation effectiveness in the Mid-Central Coastal Region.

CHAPTER 1. OVERVIEW OF STUDIES IN THE WORLD AND IN VIETNAM ON CLIMATE CHANGE ADAPTATION BASELINES AND ASSESSMENT OF CLIMATE CHANGE ADAPTATION EFFECTIVENESS

1.1. Overview of climate change adaptation baselines

A climate change adaptation baseline refers to a reference line or the current state of natural, economic, social, environmental, and institutional systems, established to serve as the foundation for assessing the effectiveness of adaptation actions and measures implemented over time [33], [41], [37], [38], [51], [61].

Numerous international studies have clarified the methodology for establishing climate change adaptation baselines. For instance, a study by Burton et al. (2005) in China developed a baseline for water resources based on economic, management, and cultural indicators [33]. Similarly, Giordano et al. (2013) in the Ancona region (Italy) utilized factors such as weather trends, socio-economic conditions, and current policies [41]. A study by the FAO (2017) on agriculture in

Kyoto (Japan) also focused on four groups of factors: natural resources, production systems, institutions, and socio-economics [39].

Regarding implementation methods, Dublin's Action Plan (2017) established its baseline through in-depth workshops and the collection of national data [38]. Meanwhile, a 2021 report from New Zealand's Ministry for the Environment compiled feedback from nearly 400 agencies and organizations to assess nationwide adaptation readiness.

In Viet Nam, several studies have examined the impacts, V, risks, losses, and damage caused by climate change. However, there remains a lack of in-depth quantitative research on the development of climate change adaptation baselines, especially when applied to a specific region or locality.

1.2. Overview of climate change adaptation effectiveness assessment

Whether an adaptation to climate change is considered effective depends on its long-term goals and the extent to which it is achieved [45]. The objectives of adaptation to climate change often revolve around two key areas: (1) Minimizing impacts on development; (2) Adapting to climate change now and in the future [36]. Therefore, depending on the socio-economic context, the focus and objectives of adaptation to climate change will differ.

Globally, national Monitoring and Evaluation (M&E) systems evaluate climate change adaptation effectiveness through diverse approaches. Germany's M&E system, for instance, uses the DPSIR framework [54] to develop impact and response indicators. Another system assesses institutional Adaptive Capacity (AC) from over 300 adaptation actions using 63 national indicators [55]. Morocco's system focuses on sectors like water resources and agriculture, emphasizing

vulnerability (V) changes resulting from adaptation [46]. An IIED (2016) study proposed a scorecard methodology with criteria on processes, outcomes, and policy integration [45], while GIZ (2013) outlined principles for effective M&E and conducted case studies in the Philippines, Germany, and Morocco [42].

In Vietnam, Huynh Thi Lan Huong et al (2015) has developed a scientific basis, proposed a set of indicators to evaluate climate change adaptation activities and pilot applied in the CCA management for a locality [6]. Vu Duc Dam Quang and Huynh Thi Lan Huong (2022) identified two bottom-up and top-down approaches and proposed three sets of M&E indicators as follows: (1) National-level M&E index set; (2) Provincial-level M&E index set and (3) Project-level M&E index set [31]. In the Technical Report for the National Strategy on Climate Change for the period up to 2050, the criteria for monitoring and evaluating the content of climate change adaptation in the Strategy are comprehensive criteria, aiming to monitor and evaluate the implementation, the level of achievement of goals as well as enhance the capacity and effectiveness of climate change adaptation management of the country [1] .

1.3. Gaps in research

Although there have been some studies on baseline development and assessment of climate change adaptation effectiveness, significant gaps in research remain. There is no official guidance from the UNFCCC or other international organizations on the development of climate change adaptation baselines. Furthermore, many methods are qualitative in nature, rendering objective comparison and assessment difficult. There are many challenges in the collection and synthesis of climate change adaptation indicators due to the lack of

synchronization between data sources. In addition, natural, social and climate change factors have complex impacts, making it a challenge to accurately quantify the effectiveness of adaptation measures. The lack of studies on long-term effectiveness is also a limitation. Most studies only develop baselines for a specific period and assess climate change adaptation effectiveness for a short period, so the assessment is not complete and comprehensive with long-term impacts. The assessment results are often general, making it difficult to clearly identify areas at high risk of climate change at a detailed level, or often only focus on one area or sector in the assessed area, so the final results are not appropriate for generalization.

1.4. Determine the research direction of the thesis on development baselines and evaluating the effectiveness of climate change adaptation

The thesis focuses on developing a unified set of indicators and an integrated methodology to construct baselines and evaluate climate change adaptation effectiveness. This approach aims to overcome the limitations in uniformity, quantification and spatial analysis in previous studies.

CHAPTER 2. RESEARCH APPROACHES AND METHODS FOR DEVELOPING CLIMATE CHANGE ADAPTATION BASELINES AND EVALUATING THE EFFECTIVENESS OF CLIMATE CHANGE ADAPTATION ACTIONS

2.1. Approaches

2.1.1. Climate risks

The climate risk assessment index set in the Thesis is based on the concept of climate risk of the Intergovernmental Panel on Climate

Change (IPCC) [50] in which risk is a combination of three main components: H, E and V [47].

2.1.2. Approach to risk assessment and baseline development for climate change adaptation

Based on the IPCC approach, the thesis has developed a climate change risk assessment process including six steps as follows:

Step 1: Determine the purpose and scope of the research. The scope of the study was conducted in the Mid- Central Coastal Region, specifically a pilot for Quang Nam province, with the smallest administrative units considered being the district level.

Step 2: Identify the types of climate H that need to be studied. An overview of the research area shows that for Quang Nam province, the main types of climate H include storms, floods, droughts, sea level rise, flash floods, temperature increases and changes in rainfall.

Step 3: Identify H. H is the likelihood of a physical event or natural or human-induced trend occurring that can lead to losses in life, health, property, infrastructure, livelihoods, service provision, ecosystems and environmental resources [64]. To quantify H, the thesis focuses on the intensity, frequency and extent of the identified H.

Step 4: E assessment. E is the presence of people, livelihoods, species/ecosystems, environmental functions, services, resources, infrastructure, economic, social and cultural assets in places or conditions that may be adversely affected by H [64]. To assess E, the thesis uses the following groups of indicators: For human factors, E is expressed through population density in risky areas. Regarding agriculture, indicators include the proportion of agricultural land area, the number of livestock and labor in the agricultural sector that may

be affected. Water resources are assessed through the total dry season flow and river density, reflecting water accessibility or flood risk. Finally, infrastructure is assessed through the proportion of residential land area, the proportion of land for infrastructure development at national, provincial and district levels located in dangerous areas.

Step 5 assesses Vulnerability (V), which comprises three main components: Sensitivity (S), Coping Capacity (CC), and Adaptive Capacity (AC). Sensitivity (S) reflects a system's inherent susceptibility to harm, measured by social indicators (e.g., elderly/child populations, poverty rate), agricultural output, water stress, and infrastructure deficits like the lack of clean water and hygienic latrines. Next, Coping Capacity (CC) is assessed by disaster response resources, including personnel, equipment, and hydro-meteorological networks. Finally, Adaptive Capacity (AC) is reflected in activities like training and awareness-raising; technical factors such as adapted agriculture, VietGAP production, reservoir safety, and water infrastructure; and economic factors like average income and capital disbursement rates.

Step 6: Assess the risk of climate change without implementing additional adaptation measures (Building a climate change adaptation baseline). After clearly identifying the risk factors (H, E, V - including S, CC, AC), a climate change adaptation baseline will be established. The baseline is a quantitative and multidimensional result of the initial climate change risk status of the study area.

2.2. Research methods

2.2.1. Building upon previous research

The thesis has inherited the overall methodological framework for disaster risk assessment, specifically the detailed index set to

assess risk components, notably the H index group in Huynh Thi Lan Huong et al (2021) [7]. The approach in selecting, proposing and quantifying indicators such as the number of storms, rainfall, wind speed from this project has provided a verified scientific foundation. This allows the thesis not to have to rebuild the H assessment methodology from scratch and to focus on adjusting, applying and further refining it for the specific context of the research area. In addition, the thesis also inherits other important data sources such as socio-economic statistics, hydrometeorological data, and climate change scenarios.

2.2.2. Method of collecting and synthesizing documents and data

This method collects and synthesizes documents and data for research and evaluation. The data that needs to be collected includes:

- Data related to H: Some H analysis results related to (1) Storm; (2) Flood; (3) Drought; (4) Sea level rise; and (5) Flash flood are taken from the State -level project code KC.08.24/ 16-20. Data on changes in (1) temperature and (2) rainfall such as average annual temperature and total rainfall of the two stations Tam Ky and Tra My are collected from the province's Statistical Yearbook and the Technical Report on Updating the Climate Change Action Plan for Quang Nam Province for the period 2021-2030, with a vision to 2050.

- Data rela2050; E: Data are collected from the provincial Statistical Yearbook; Master plan for socio-economic development of 18 cities, districts and towns in the Quang Nam Provincial Planning for the period 2021-2030, with a vision to 2050; Plan to respond to natural disasters according to risk levels in Quang Nam province ; Plan for Prevention and Control of Natural Disaster and Irrigation Development of Quang Nam province for the period 2021-2030, with

a vision to 2050; Provincial land use planning and Land use planning of cities, districts and towns.

- Data related to V: Data are collected from the results of the population census, the Provincial Statistical Yearbook and documents related to the Population Arrangement Plan and Production Organization Plan for natural disaster hotspots, especially high-risk areas, border areas, islands, and migration areas; the Overall Socio-economic Plan of the province's cities, districts, and towns; Provincial Disaster Prevention and Control Plan; and the Plan for Developing the Specialized Meteorological and Hydrological Network Serving Disaster Prevention and Control in the Province.

2.2.3. Method of calculating indexes

- Standardization of index values: The thesis uses two main standardization methods: Min- Max standardization and threshold standardization with the selected standardization range from 0 to 1.

- Determine the weight: Due to time and resource limitations, the thesis assumes equal weighting for all indicators.

- Calculation of the values of the main indicators: The thesis calculates based on the average value of the component indicators.

- Determine climate risk index and risk value threshold: Climate risk is determined by the formula: R=(H+E+V)/3. The risk will then be classified according to percentile.

2.2.4. Geographic Information System (GIS)

The thesis has built a map showing climate risks from low to high levels for both scenarios when no additional adaptation measures are implemented and when additional adaptation measures are implemented.

2.2.5. The Method of Consultation through Workshops

The workshop consultation method was implemented to gather in-depth opinions from climate change experts and to verify and validate the reliability of the collected information. Within the framework of this dissertation, the PhD candidate organized two scientific workshops to consult with management agencies, research institutes, and relevant experts in order to refine the methodology for establishing the baseline, the set of indicators, and the results of the climate risk assessment in Quang Nam.

2.3. Hypothesis for adaptive solutions

The thesis has built calculation hypotheses for 16 adaptation options, as follows: (1) Reducing E: Option 1 - Change in the number of people affected by natural disasters and Option 2 - Change in the total flow in the dry season; (2) Reducing S: Option 3 - Reduce the rate of poor households; Option 4 - Change in water resources (dry season scarcity coefficient and dry season pressure coefficient); Option 5 - Change the rate of households not using clean water and Option 6 - Change the rate of households not using hygienic toilets; (3) Strengthening CC: Option 7 - Enhance some rescue means and equipment and Option 8 - Strengthen hydrometeorological stations and (4) Strengthening AC: Option 9 - Increase propaganda to raise awareness of climate change; Option 10 - Increase agricultural area applying adaptation solutions; Option 11 - Increase the area of VietGAP production areas; Option 12 - Increase the area of concentrated livestock farming on a large scale; Option 13 - Increase the proportion of reservoirs with flood prevention plans ; Option 14 - Scale of implementation of water storage and saltwater intrusion

projects; Option 15 - Increase average income and Option 16 - Increase disbursement rate.

CHAPTER 3. RESULTS OF DEVELOPMENT ADAPTATION BASELINES AND EVALUATING THE EFFECTIVENESS OF ADAPTATION TO CLIMATE CHANGE IN THE MID-CENTRAL COASTAL REGION

3.1. Results of developing a set of indicators to assess the level of climate risk

The H index was constructed using the H-based response to climate change approach, focusing not only on extreme events such as storms (number, rainfall, wind speed) but also covering regional-specific H conditions such as floods, droughts, sea level rise, and flash floods.

The E index identifies the targets directly affected by H due to climate change. The selected indicators measure the concentration of people (population density, number of affected people), key economic assets (agricultural area, number of livestock), essential natural resources (dry season water resources), and infrastructure systems (ratio of residential land, land for infrastructure development).

V index includes: (1) Sensitivity (S): This reflects the extent to which a system will be negatively affected by climate impacts, measured through indicators such as the poverty rate, the share of elderly and children, and dependence on sensitive resources such as agricultural output or dry season water resources. (2) Resilience capacity (CC): This represents the ability to respond to and handle impacts at the time H occurs. This component is assessed through on-site human and material resources such as disaster prevention

personnel, rescue means and tools. (3) Adaptive capacity (AC): This demonstrates the ability to adjust, learn and change to minimize risks in the long term. AC indicators include awareness raising activities, adoption of advanced production techniques, financial capacity (average income) , and investment levels in strategic infrastructure.

3.2. Results of climate risk assessment under current conditions in Quang Nam

3.2.1. Climate hazards

The synthesis results showed an increasing trend of H across Quang Nam province from 2020 to 2050. The average H of the province is expected to increase from 0.32 (2020) to 0.35 (2030) and continue to 0.37 (2050). Dien Ban town consistently showed the highest H in the period from 0.43 (2020) to 0.49 (2050). Localities in the midland and coastal plains such as Tam Ky city, Hoi An city, Dai Loc district, Duy Xuyen district, Thang Binh district and Nui Thanh district also had high H and a clear increasing trend. For mountainous districts notably Nam Giang district and Phuoc Son district, although the synthesis H was lower than that of the plains, it still showed an increasing trend.

3.2.2. Exposure level under current conditions

The exposure level (E) due to climate change in Quang Nam shows a clear increasing trend from 2020 to 2050, reflecting the expansion of population, economic and infrastructure factors in the risk areas. The average E of the province has increased from 0.74 (2020) to 0.81 (2030) and is expected to reach 0.87 (2050). Districts, towns and cities in the midland and delta regions such as Tam Ky City, Hoi An City, Dai Loc District, Dien Ban Town, Duy Xuyen District, Que Son District, Thang Binh District, Nui Thanh District, Phu Ninh

District all have had high E since 2020 which has increased significantly since. For the 09 mountainous districts, despite E in 2020 being lower than that in the delta region, there is a stronger increase in the rate in the period 2020-2050.

3.2.3. Level of vulnerability under current conditions

The general trend of Quang Nam province is an increase in V due to the impact of climate change and natural disasters from 2020 to 2050. The average V of the whole province increased from 0.19 (2020) to 0.21 (2030) and is calculated to increase to 0.22 (2050). For mountainous districts, V tends to be higher since 2020 and has maintained or had small fluctuations. Some cases such as Phuoc Son and Tay Giang District have seen a slight decrease. Meanwhile, V in Quang Nam province shows a clear increase in many localities, especially the developing midland and coastal plain areas.

3.2.4. Climate risks under current conditions

Overall, risks in Quang Nam are expected to increase continuously from 2020 to 2050 in all H types. Changes in rainfall and temperature are the factors with the highest risk levels and a significant increasing trend. The combined risk level in Quang Nam province is expected to increase continuously from 2020 to 2050. The average combined risk level of the whole province has increased from 0.42 (2020) to 0.46 (2030) and is expected to reach 0.49 (2050). Most districts, towns and cities show an increase in the combined risk level. Other midland and delta localities such as Thang Binh, Duy Xuyen and Nui Thanh also show increasing combined risk levels. Mountainous districts such as Nam Giang and Nong Son also show high combined risk levels and a significant increase.

3.3. Results of development climate change adaptation baselines for Quang Nam province

The climate change adaptation baseline for Quang Nam province is developed based on the results of the aggregate risk quantification, reflecting the level of impact without additional adaptation measures. The aggregate risk level of each locality was classified into 5 levels: Very Low (0 – 0.33); Low (0.33 – 0.38); Medium (0.38 – 0.44); High (0.44 – 0.47); and Very High (> 0.47). During the detailed classification process, raw, unrounded values were used to ensure the highest accuracy. The risk classification results show a significant increase in risk levels over time.

3.4. Results of assessment of the effectiveness of climate change adaptation measures

In baseline, the average risk level of Quang Nam province will increase continuously from 0.42 in 2020 to 0.46 (in 2030) and reach 0.49 (in 2050). However, when adaptation options are applied, the province 's overall risk level is significantly improved. Specifically, the average risk level of the province has decreased to 0.33 (in 2030) and continues to be maintained at 0.33 (in 2050).

The implementation of 16 adaptation measures has effectively mitigated climate change risks in Quang Nam, helping to reverse the increasing trend and enhance the province's resilience to natural disasters.

When performing the risk classification, the majority of localities (13/18) are at the Medium risk level, with 5 localities at the High level at the baseline in 2020. However, by 2030, the number of localities at the Very High level increases to 5, 9 localities at the High level and only 4 localities at the Medium level. By 2050, the baseline

predicts 13 localities will be at Very High risk , 4 localities at the High level and only 1 locality remaining at the Medium level. However, when applying the 16 adaptation options, the risks have changed In both 2030 and 2050, there are no localities at High or Very High risk levels.

3.5. Results of assessing the adaptation effectiveness of each group of measures

3.5.1. Comparison of the effectiveness of groups of measures

The sixteen measures are grouped into six categories: Public Safety (Group 1), Water Management (Group 2), Living Conditions/Infrastructure (Group 3), Forecasting/Response (Group 4), Sustainable Agriculture (Group 5), and Economic/Investment Management (Group 6).

Analysis shows Group 3 is the most effective, maintaining risk at a Medium level until 2050. Group 1 is also effective, slowing the rate of risk increase. In contrast, Groups 2, 4, 5, and 6 show little improvement over the baseline, with risks remaining High to Very High.

This result indicates that individual groups are insufficient to reverse the rising risk trend. Maximum effectiveness is achieved only through an integrated implementation of all 16 measures, creating a synergistic effect that significantly reduces risk (from 0.42 to 0.32 by 2050).

Notably, Group 3 (Improving Living Conditions) has the greatest independent potential for risk reduction. This highlights that poverty reduction and access to clean water and sanitation are foundational to enhancing community resilience and adaptive capacity.

3.5.2. Comparison of the effectiveness of each solution

Under the "No Action" scenario, risk progressively increases, reaching 0.4861 by 2050. Among individual measures, Measure 1 (reducing affected populations) is most effective, lowering the 2050 risk to 0.4456.

Conversely, several measures show little improvement, including those related to dry-season flow (2), VietGAP production (11), rescue equipment (7), water stress (4), adapted agriculture (10), livestock farming (12), and income (15). The remaining measures offer moderate risk reduction (2050 risk: 0.4688–0.4792), such as improving reservoir safety (13), water infrastructure (14), poverty reduction (3), hydro-met stations (8), awareness (9), and capital disbursement (16).

Overall, the effectiveness of individual measures varies significantly. This underscores the need for an integrated and coordinated approach to optimize climate adaptation.

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

1) This thesis presents a quantitative method for developing an adaptation baseline and evaluating its effectiveness, demonstrated in Vietnam's Mid-Central coastal region via a case study of Quang Nam province (pre-merger). The methodology assesses climate risk (H, E, V) to establish an "Adaptation Baseline" (pre-adaptation risk) and an "Adaptation Effectiveness Line" (post-adaptation risk), which are then used to evaluate individual and grouped measures. Due to similar natural conditions and climate impacts, this method is applicable across the entire region.

2) Key quantitative findings on Climate Risk, Baseline and Adaptation Effectiveness in Quang Nam:

- The Adaptation Baseline shows an increasing trend of the province's Aggregate Climate Risk, from Medium (0.42) in 2020 to High (0.46) in 2030 and reaching Very High (0.49) in 2050. The province's total climate risk increases due to the impact of climate change (from 0.32 in 2020 to 0.35 in 2030 and 0.37 in 2050). The province's E increases from 0.74 (in 2020) to 0.87 (in 2050) due to the increase in population, assets and structures, especially in coastal and delta areas. The combined resources (CC and AC) remain unchanged and remain low (0.20) from 2020 to 2050, indicating that the self-responsibility will not improve without adaptation measures. The areas with the highest risk levels are Dien Ban town, Thang Binh district, Duy Xuyen and mountainous districts such as Nam Giang, Nong Son, which will have a Very High risk level in 2050 according to the baseline.

- The Adaptation Efficiency Path shows the effectiveness of adaptation measures: the synchronous implementation of all 16 adaptation options will bring about significant effectiveness, significantly reducing the province's risk level, from 0.42 (in 2020) to 0.33 (in 2030 and 2050), bringing the entire province to Low or Very Low risk levels. The resource value on the efficiency path increases significantly, from 0.20 (in 2020) to 0.48 (in 2030) and 0.51 (in 2050), demonstrating a major improvement in the province's resilience and adaptation capacity when the measures are implemented.

Effectiveness of each solution group: Group 3 (improving living conditions and basic social infrastructure) is the most effective group, helping to stabilize the risk at Medium level (0.43) by 2050.

This confirms that investing in poverty reduction, clean water and basic sanitation is a key strategy to reduce V. Group 1 (improving people's safety - reducing the number of people affected) is also effective, bringing the risk to a level significantly lower than the Baseline. Other measure Groups (water resources management, sustainable agricultural development, economic capacity building) when implemented individually still show High or Very High risk levels by 2050, not enough to cope with the increasing trend of climate change risks on their own.

Overall assessment: The optimal climate change adaptation strategy for Quang Nam must be comprehensive and integrated, taking improving the quality of life and CC of the community as the foundation, combined with solutions to reduce E and enhance response capacity.

3) New Contributions of the Dissertation:

a) New Scientific Contributions:

Established the scientific basis for developing an Adaptation Baseline and evaluating quantified adaptation effectiveness. This was achieved by assessing the change in climate risk resulting from the implementation of adaptation measures in comparison to the Baseline. This method successfully quantifies risk reduction through the formula: Effectiveness = Baseline Risk - Post-adaptation Risk. This represents a significant advancement, addressing a critical gap, as previous studies in Vietnam lacked a formal, unified, and quantifiable guidance framework.

Successfully developed a Climate Change Adaptation Baseline for Quang Nam province using a set of climate risk indicators. The use of climate risk as the primary metric for constructing the baseline is a

central tenet of this dissertation. This approach creates a quantitative and objective reference line, overcoming the limitations of previous research, which was often confined to a qualitative level. This methodology was successfully applied to Quang Nam and is deemed appropriate and widely applicable to other coastal areas in Central Vietnam.

Evaluated adaptation effectiveness for both individual measures and groups of measures. This evaluation helps delineate zones with varying risk levels and identify priorities for adaptation activities, thereby contributing to the formulation of an optimal and integrated adaptation strategy.

b) New Practical Contributions:

Provided a strategic reference tool for management agencies concerning detailed levels of vulnerability and climate risk in localities within the former administrative boundaries of Quang Nam province. The Climate Risk Maps (for the years 2020, 2030, and 2050) and the risk classification results help to visualize and identify high-risk areas ("hotspots"). This serves as a solid basis for the effective allocation of resources and prioritization of implementation efforts.

Assessed the adaptation effectiveness of Quang Nam province upon implementing individual or groups of adaptation measures. These findings serve as a crucial reference document for planning, management, as well as for adjusting and refining the province's socio-economic development plans to ensure sustainable development in the context of climate change. In particular, the comparison of the effectiveness of different solution groups provides an evidence-based rationale for prioritizing investments in areas that yield the highest adaptation benefits.

B. Recommendations

One of the limitations of this dissertation is that the evaluation focused solely on the effectiveness of climate change adaptation activities, without quantifying the co-benefits related to mitigation, due to constraints in time and resources. This research direction should be a focus of subsequent studies by developing a framework for assessing the co-benefits between adaptation and mitigation. Specifically, this would involve incorporating mitigation indicators such as the area of new afforestation, the proportion of renewable energy use, or the amount of GHG emissions reduced from sustainable agricultural models. This approach would enable a more comprehensive analysis of the synergistic relationships as well as potential trade-offs involved in implementing climate change response actions.

In the pilot study on assessing the effectiveness of climate change adaptation activities in Quang Nam, the dissertation only considered indicators for which data were available, owing to limited data availability. In subsequent research, it is necessary to consider additional indicators, such as those measuring contributions to reducing community vulnerability, as data availability improves.

Due to time and resource constraints, the dissertation assumed that all measures have equal weights when calculating the composite effectiveness—an assumption that may not fully reflect the relative importance and priority of each measure in practice. To address this limitation, future research should focus on developing a specific set of weights for each group of measures. Determining these weights will help make the effectiveness assessment results more accurate and reliable, and provide a solid foundation for local policy-making.

LIST OF PUBLISHED WORKS OF THE AUTHOR RELATED TO THE THESIS

1. Vu Duc Dam Quang, Huynh Thi Lan Huong (2020), "*Development of a framework for climate change adaptation actions' effectiveness evaluation*", VN J. Hydrometeorology, 6, 46–56; doi:10.36335/VNJHM.2020(6).46–56.

2. Vu Duc Dam Quang, Huynh Thi Lan Huong (2022), *"Set of indicators for monitoring and evaluating climate change adaptation activities"*, *Journal of Climate Change Science* 22/2022; doi:10.s55659/2525-2496/22.71063.

3. Vu Duc Dam Quang (2025), "*Developing a baseline and assessing the effectiveness of climate change adaptation in the Mid-Central Coastal Region*". Journal of Environmental and Natural Resources Science (ISSN 0866 - 7608) No. 58 (Special Issue 2025).