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Strategic environmental assessment of Thai river basins: Incorporating climate change considerations

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ABSTRACT

It is globally recognized that climate change is increasingly affecting sustainable development. Given these challenges, it is imperative to incorporate climate change considerations as part of Strategic Environmental Assessment (SEA), a tool used for sustainable development and planning strategies. The Thai government is in the process of developing river basin management schemes and updating SEA for all the river basins in the country. Considering climate change in future development planning processes would ensure that the outcomes enable more sustainable development. In this article, SEA reports for Thai river basins that have been completed were examined to determine if climate change was considered and how it was done. Analyses were conducted for each of the four phases of SEA, i.e., establishing the context for SEA, implementing SEA, informing, and influencing decisions, monitoring and evaluating plans. The checklist criteria were used to analyze climate change impacts in the river basin SEA reports, focusing specifically on climate change or global warming impacts that lead to serious disasters in the river basins. The results showed that 7 out of the 9 reports currently consider climate change impacts, but not in all phases of the SEA. The linkage of climate change impact analyses between the different phases was weak. There were only 4 reports that sufficiently considered climate change impacts in the second phase of the SEA. These reports used both qualitative and quantitative tools that were appropriate for predicting climate change impacts and with a link to the third and fourth phases. As a result, most of the SEA reports were insufficient in considering climate change impacts.

Keywords: Climate change, Global warming, River basin management, Strategic environmental assessment, Water resources management

INTRODUCTION

Climate change is the change in the state of the climate that can be detected (e.g., by statistical tests) and that change persists over an extended period of time, usually decades or longer [1, 2]. The impacts of climate change are now global and unprecedented in scale. The headquarters of the UN just issued a warning that the era of global warming has ended and "the era of global boiling has arrived" because July 2023 was on track to be the warmest month ever [3]. The World Meteorological Organization (WMO) scientists indicate that long-term warming is continuing and that the likelihood of a temporary exceedance of the 1.5 °C upper limit set by the Paris Agreement is increasing over time [4].

Regarding the impacts on river basins, climate change has significant impacts on the hydrological cycle that lead to serious environmental problems and disasters in river basins. Globally, rivers have experienced dramatic changes in their discharge, reducing their natural ability to adapt to and absorb disturbances. Given the expected changes in global climate change and water demand, this may lead to the loss of native biodiversity and risks to ecosystems and people from increased flooding or water scarcity [5].

Thailand ranks 9th in the world as the country with the highest risk of climate change. In addition, Thailand's ability to cope with disasters is quite low (39th out of 48 countries) [6]. In 2011, Thailand was damaged by floods. The damage amounted to around 1.43 trillion baht, which corresponds to 12.6 percent of the GDP. This does not take into account the opportunity cost of investing in other activities that could be more productive for the economy than repair and rehabilitation work [7]. Thus, if drastic actions are not taken, adaptation to these impacts will be even more difficult and costly in the future [2, 8, 9].

Strategic Environmental Assessment (SEA) is

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a systematic and internationally recognized process used in strategic planning for the future to propose a policy, plan, or program (PPP) that serves sustainability. It was developed in the late 1960s and first applied in the United States of America with the National Environmental Policy Act of 1969. It has evolved and is now used in a variety of sectors to assess and predict potential impacts, achieve sustainability, and make adequate adaptation decisions [9-14].

Thailand has been making efforts to promote the concept of sustainability. In 2009, the 10th National Plan for Economic and Social Development (2007-2011) published the first general guideline for SEA practitioners [15]. In 2017, a general guideline was published under the 12th National Plan for Economic and Social Development (2017-2022) and the National Strategy 2018-2037 [16]. The Office of National Water Resources (OWNR), a government agency responsible for the nation's water policy, commissioned a committee composed of experts from all relevant departments and consulting firms to prepare SEA reports for 22 major river basins for sustainable water management. The plan was to publish the SEA reports starting in 2020 and complete them by 2027. At this stage (August 2023), there are SEA reports available for 9 river basins, as shown in Figure 1.

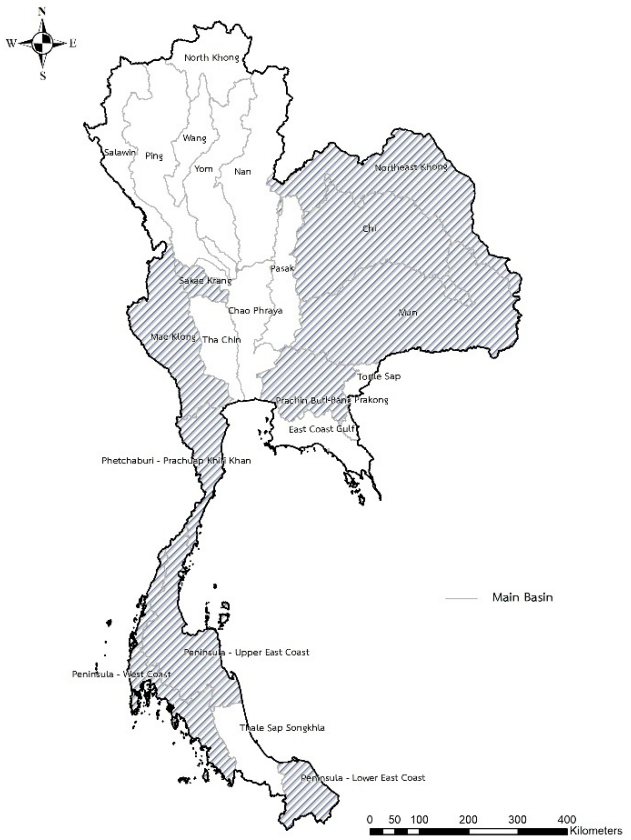

Figure 1 The current publications of river basin SEA reports (shaded areas).

Basically, SEA should include four phases [9, 16-26]. The first phase (i.e., establishing the context for the SEA) is reviewing the need for the SEA, scanning for targets, and initiating the preparatory tasks. Identifying the main issues of focus (extreme or exceptional events) from climate change and defining the objectives of SEA, i.e., how to improve the planning process, as well as, identifying interested and affected stakeholders [27] and planning their participation [28].

In the second phase (i.e., implementing the SEA), historical data on floods, droughts, extreme weather events, and water demand are collected. The observed (historical) data or scenario model is scoped and used to determine the extent of water stress and forecast the potential impacts of climate change on river basins [12, 29-31]. Climate change mitigation strategies are then formulated (i.e., identify actions to reduce adverse impacts or improve resilience) [32], as well as reports on policy reforms and potential environmental linkages.

In the third phase (i.e., informing and influencing decisions), the presentation of the final report, policy summary, and infographics that are important for influencing key decisions, are prepared. A clear, understandable, and concise briefing or issue paper can help ensure that decision makers are aware of the key environmental issues related to the PPP, particularly the climate change impacts analyzed.

In the fourth phase, monitoring and evaluation plans are established to minimize the climate change impacts of implementing the strategic policy, plan, or program, and to ensure that the goals of the SEA are met. These mechanisms allow for the timely detection of adverse impacts and the implementation of corrective actions.

The consideration of climate change is to ensure that future development outcomes of policy plans and programs can withstand climate change and protect the ecosystems of the basin and the welfare of the people to achieve sustainable water management. This article investigated whether climate change was adequately considered in the assessment process, and examined how climate change was considered and presented in the Thai river basin SEA process.

MATERIALS AND METHODS

The 9 SEA reports published on Thai River Basins were reviewed to determine the extent to which climate change was addressed. The reports, i.e., Chi [33], Sakae Krang [34], Prachin Buri-Bang Pakong [35], Peninsula-East Coast [36], Mun [37], Phetchaburi-Prachuap Khiri Khan [38], Peninsula-West Coast [39], Mae Klong[40], and Northeast Kong[41], were published by the Office of the National Water Resources (ONWR) between 2020 and 2022. They can be downloaded online at http://sea.nesdc.go.th.

Climate change impacts addressed in the river basin SEA reports focus specifically on climate change or global warming impacts, such as seasonal fluctuations in water balance, inadequate water supplies for

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consumption, and the frequency and severity of droughts and floods [42-44]. Content analyses were conducted in all the main SEA phases. Checklists were used to rate climate change impacts considered in the reports as 'Y' (yes - the criterion was met) or 'N' (no - the criterion was not met) to determine whether the stated criteria were met (Figure 2). There were 3 levels of outcome:

1. Does not consider; none of the criteria were met.
2. Insufficient; some criteria were met.
3. Sufficient; all criteria were met.

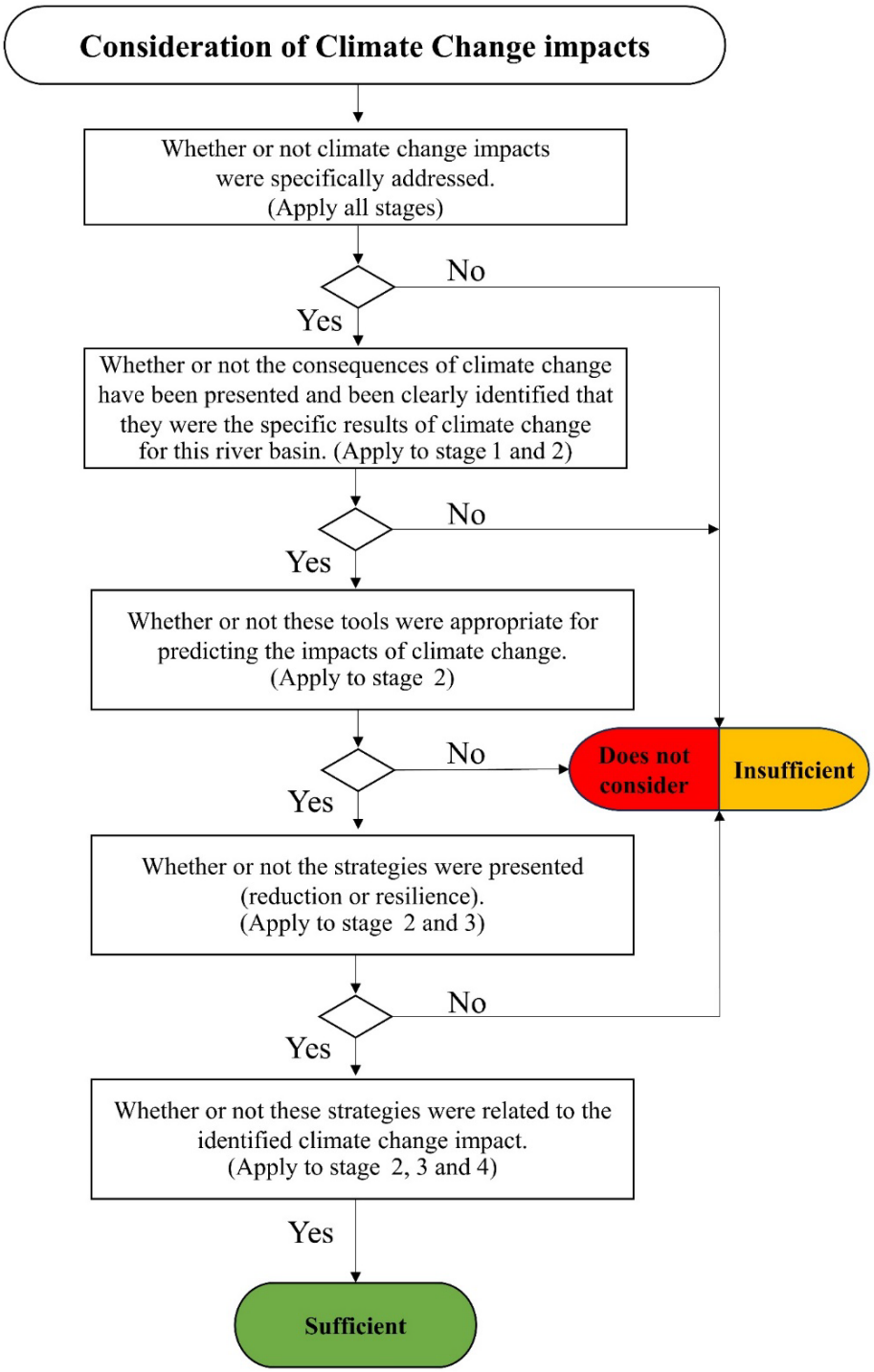

Figure 2 Criteria for consideration of climate change impacts in the SEA.

The first screening criterion was to inspect the content in all phases of the SEA to determine whether or not climate change impacts were specifically addressed. This was done by looking up specific words or contexts that explicitly mentioned climate change, greenhouse gases, greenhouse effects, global warming, climate anomaly, and their effects on river basins. If climate change was specifically addressed, this criterion would be rated "yes". Otherwise, it would be rated "no".

The second criterion, only applying to phases 1 and 2, was to examine whether or not the consequences of climate change had been presented and clearly

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identified, such that they were the specific impacts of climate change for those particular river basins. If the general consequences of climate change were presented but they were not clearly identified and were specific to those river basins, this criterion would be rated "no".

The third criterion, only applying to phase 2, was to identify whether or not there were tools applied to predict the impacts of climate change. The usage of study tools, e.g., data gathering-spatial and temporal data in the form of databases or reviews, physical/conceptual/mathematical (stochastic/deterministic) models, risk or consequences assessment matrices, or expert judgements, must be appropriate to evaluate the climate change impacts, and the corresponding quantitative or qualitative results must be presented. If there were no applications of tools or the applied tools were not appropriate to evaluate the impacts, this criterion would be rated "no".

The fourth criterion, applying to phases 2 and 3, was to examine whether or not the strategies were presented. The specific strategies for that particular river basin that resulted from the SEA to mitigate or reduce climate change or create resilience to climate change must be presented. If the presented strategies were gathered from other sources, this criterion would be rated "no".

The fifth criterion, applying to phases 2, 3, and 4, was to examine whether or not the presented strategies were related to the identified climate change impact of that particular river basin. If there were no related strategies presented or the presented strategies were not related to the identified impacts, this criterion would be rated "no".

For all the criteria, if there were no relevant information or data presented, that criterion would be rated "does not consider".

RESULTS AND DISCUSSION

Overall, all the reports were structured and formulated according to the general SEA guide for Thailand [16]. The results of the review are presented in Table 1 and summarized in Figure 3. The results showed that 7 out of the 9 SEAs included climate change impact considerations, but these were not sufficient in all the phases.

It was noticeable that none of the reports considered climate change in the first phase of establishing context for the SEA. For the second phase of the implementation of SEA, the results showed that there were 4 reports that sufficiently considered climate change, including the Prachin Buri-Bang Pakong, Peninsula East Coast, Mun, and Northeast Khong River Basins. It was insufficiently considered in the Chi, Peninsula-West Coast, and Mea Klong River Basins. However, the Phetchaburi-Prachuap Khiri khan river basin was insufficiently considered, but not in the form of a climate change impact analysis as part of the SEA process, as the climate change strategies originate from the existing water management plans. The rest of the reports did not consider climate change at all. For the third phase on informing and influencing decisions, the results showed that there were 3 reports that sufficiently considered climate change, including the Prachin Buri-Bang Pakong, Mun, and Northeast Khong River Basins, while it was insufficiently considered for the Mea Klong River Basin. The other reports did not consider climate change. For the fourth phase of the monitoring and evaluation plans, the results showed that there were 4 reports that sufficiently considered climate change, including the Prachin Buri-Bang Pakong, Peninsula East Coast, Mun, and Northeast Khong River Basins, while the other reports did not consider it.

Table 1 The consideration of climate change impacts in the SEA reports for the Thai River Basin.

SEA Reports	Criteria	SEA Process*			
		1	2	3	4
1. Chi River Basin (Jan-2020)	1. Whether or not climate change impacts were specifically addressed. (Apply to all phases)	N	Y	N	N
	2. Whether or not the consequences of climate change were presented and they were clearly identified to be the specific results for this river basin. (Apply to phase 1 and 2)	N	Y		
	3. Whether or not the tools used for predicting the impacts of climate change were appropriate. (Apply to phase 2)		Y		
	4. Whether or not reduction or resilience-related strategies were presented. (Apply to phase 2 and 3)		N	N	
	5. Whether or not the strategies identified were related to the climate change impacts assessed. (Apply to phase 2, 3 and 4)		N	N	N
	Result**	DC	IS	DC	DC

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SEA Reports	Criteria	SEA Process* 1	2	3	4
2. Sakae Krang River Basin (Jan-2020)	1. Whether or not climate change impacts were specifically addressed. (Apply to all phases)	N	N	N	N
	2. Whether or not the consequences of climate change were presented and they were clearly identified to be the specific results for this river basin. (Apply to phase 1 and 2)	N	N		
	3. Whether or not the tools used for predicting the impacts of climate change were appropriate. (Apply to phase 2)		N		
	4. Whether or not reduction or resilience-related strategies were presented. (Apply to phase 2 and 3)		N	N	
	5. Whether or not the strategies identified were related to the climate change impacts assessed. (Apply to phase 2, 3 and 4)		N	N	N
	Result**	DC	DC	DC	DC
3. Prachin Buri-Bang Pakong River Basin (Mar-2020)	1. Whether or not climate change impacts were specifically addressed. (Apply to all phases)	N	Y	Y	Y
	2. Whether or not the consequences of climate change were presented and they were clearly identified to be the specific results for this river basin. (Apply to phase 1 and 2)	N	Y		
	3. Whether or not the tools used for predicting the impacts of climate change were appropriate. (Apply to phase 2)		Y		
	4. Whether or not reduction or resilience-related strategies were presented. (Apply to phase 2 and 3)		Y	Y	
	5. Whether or not the strategies identified were related to the climate change impacts assessed. (Apply to phase 2, 3 and 4)		Y	Y	Y
	Result**	DC	S	S	S
4. Peninsula-East Coast River Basin (Sep-2020)	1. Whether or not climate change impacts were specifically addressed. (Apply to all phases)	N	Y	N	Y
	2. Whether or not the consequences of climate change were presented and they were clearly identified to be the specific results for this river basin. (Apply to phase 1 and 2)	N	Y		
	3. Whether or not the tools used for predicting the impacts of climate change were appropriate. (Apply to phase 2)		Y		
	4. Whether or not reduction or resilience-related strategies were presented. (Apply to phase 2 and 3)		Y	N	
	5. Whether or not the strategies identified were related to the climate change impacts assessed. (Apply to phase 2, 3 and 4)		Y	N	Y
	Result**	DC	S	DC	S

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SEA Reports	Criteria	SEA Process* 1	2	3	4
5. Mun River Basin (Mar-2021)	1. Whether or not climate change impacts were specifically addressed. (Apply to all phases)	N	Y	Y	Y
	2. Whether or not the consequences of climate change were presented and they were clearly identified to be the specific results for this river basin. (Apply to phase 1 and 2)	N	Y		
	3. Whether or not the tools used for predicting the impacts of climate change were appropriate. (Apply to phase 2)		Y		
	4. Whether or not reduction or resilience-related strategies were presented. (Apply to phase 2 and 3)		Y	Y	
	5. Whether or not the strategies identified were related to the climate change impacts assessed. (Apply to phase 2, 3 and 4)		Y	Y	Y
	Result**	DC	S	S	S
6. Phetchaburi-Prachuap Khiri Khan (Sep-2021)	1. Whether or not climate change impacts were specifically addressed. (Apply to all phases)	N	N	N	N
	2. Whether or not the consequences of climate change were presented and they were clearly identified to be the specific results for this river basin. (Apply to phase 1 and 2)	N	N		
	3. Whether or not the tools used for predicting the impacts of climate change were appropriate. (Apply to phase 2)		N		
	4. Whether or not reduction or resilience-related strategies were presented. (Apply to phase 2 and 3)		N***	N	
	5. Whether or not the strategies identified were related to the climate change impacts assessed. (Apply to phase 2, 3 and 4)		N	N	N
	Result**	DC	IS	DC	DC
7. Peninsula-West Coast River Basin (Sep-2021)	1. Whether or not climate change impacts were specifically addressed. (Apply to all phases)	N	Y	N	N
	2. Whether or not the consequences of climate change were presented and they were clearly identified to be the specific results for this river basin. (Apply to phase 1 and 2)	N	Y		
	3. Whether or not the tools used for predicting the impacts of climate change were appropriate. (Apply to phase 2)		Y		
	4. Whether or not reduction or resilience-related strategies were presented. (Apply to phase 2 and 3)		N	N	
	5. Whether or not the strategies identified were related to the climate change impacts assessed. (Apply to phase 2, 3 and 4)		N	N	N
	Result**	DC	IS	DC	DC

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SEA Reports	Criteria	SEA Process* 1	2	3	4
8. Mae Klong River Basin (May-2022)	1. Whether or not climate change impacts were specifically addressed. (Apply to all phases)	N	Y	Y	N
	2. Whether or not the consequences of climate change were presented and they were clearly identified to be the specific results for this river basin. (Apply to phase 1 and 2)	N	Y		
	3. Whether or not the tools used for predicting the impacts of climate change were appropriate. (Apply to phase 2)		N		
	4. Whether or not reduction or resilience-related strategies were presented. (Apply to phase 2 and 3)		N	Y	
	5. Whether or not the strategies identified were related to the climate change impacts assessed. (Apply to phase 2, 3 and 4)		N	N	N
	Result**	DC	IS	IS	DC
9. Northeast Khong River Basin (May-2022)	1. Whether or not climate change impacts were specifically addressed. (Apply to all phases)	N	Y	Y	Y
	2. Whether or not the consequences of climate change were presented and they were clearly identified to be the specific results for this river basin. (Apply to phase 1 and 2)	N	Y		
	3. Whether or not the tools used for predicting the impacts of climate change were appropriate. (Apply to phase 2)		Y		
	4. Whether or not reduction or resilience-related strategies were presented. (Apply to phase 2 and 3)		Y	Y	
	5. Whether or not the strategies identified were related to the climate change impacts assessed. (Apply to phase 2, 3 and 4)		Y	Y	Y
	Result**	DC	S	S	S

*SEA Process number 1 is establishing the context for SEA, 2 is implementing SEA, 3 is informing and influencing decisions, and 4 is the monitoring and evaluation phase.

**DC stands for Does not consider, IS for Insufficient, and S for Sufficient.

***The strategies related to climate change come from the existing water management plans, not from the SEA.

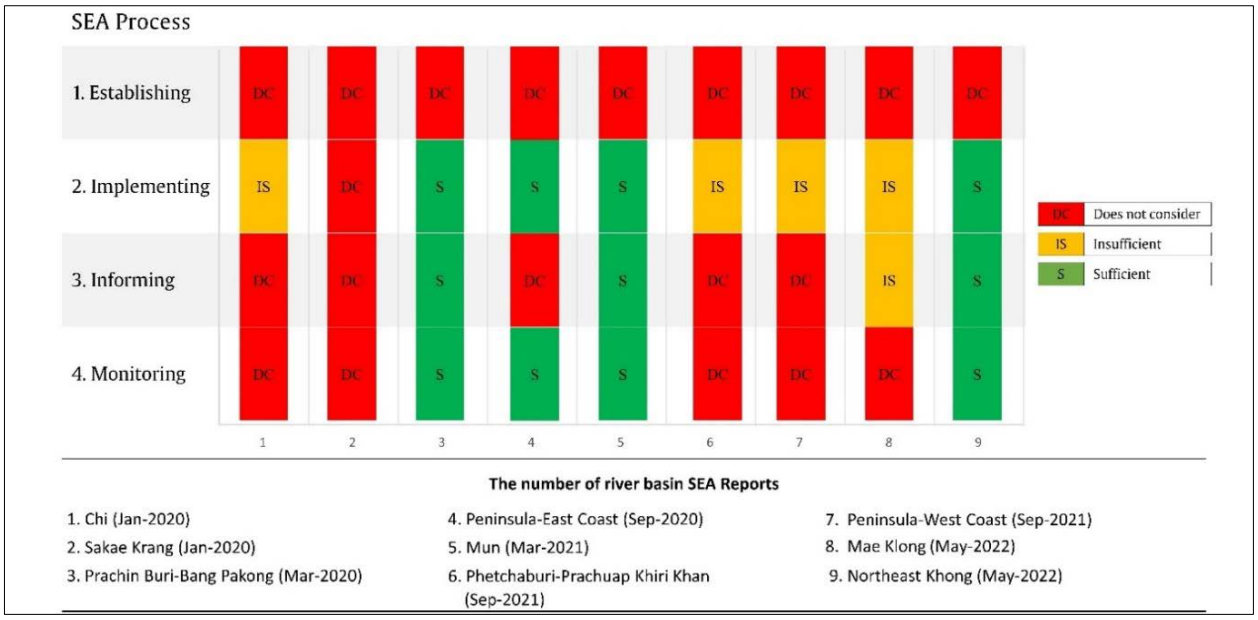

Figure 3 The summary result of addressing climate change impacts in the SEA reports for the Thai river basin.

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In the first phase of SEA, climate change impacts were not specifically addressed in all the reports investigated because there was no clear distinction between the scanning task in the first phase and the scoping task in the second phase. The purpose of the scanning process, described in public guidance documents, was to target what was likely to have significant impacts on or be significantly affected by climate change, to consider whether the context for SEA was comprehensive in the first phase [2]. The scoping task in the second phase was to collect data to predict climate change impacts and identify relevant actions. All these reports integrated the scanning task of the first phase with the scoping task of the second phase, and most of them considered climate change impacts in the context of the scoping task. Therefore, all reports were rated "do not consider".

The second phase, implementation of SEA, begins with the scoping task and the prediction of future climate change impacts and the development of a policy plan or program. All tasks should be sufficiently considered and linked to each other's. In particular, the identification of climate change impacts has been analyzed through the choice of assessment tools [45, 46]. Both qualitative and quantitative tools should be chosen for comprehensive tools [47, 48], especially the quantitative tools with statistical data analysis and scenario modeling for future prediction of climate change impacts [49].

It was found that 4 SEA reports for the Prachin Buri-Bang Pakong, Peninsula-East Coast, Mun, and Northeast Khong River Basins fully considered the impacts of climate change and were linked to each task, producing sufficient results. These reports first used qualitative tools such as literature reviews, expert judgment, and public workshops to identify the most important issues. Then, quantitative tools such as GIS, basic statistical data analysis, climate modeling, or scenario modeling were used to assess climate change impacts. Then qualitative tools were used again, including analysis of strengths, weaknesses, opportunities, and threats (SWOT), analysis of strengths, opportunities, aspirations, and results (SOAR), multi-criteria decision making (MCDM), expert judgment, and public workshops for priority setting, action, and policy program creation. Thus, these 4 reports were rated "sufficient". In addition, two of these reports, the Prachin Buri-Bang Pakong and Mun River Basins, used scenario modeling instead of statistical data analysis. It was developed by the IPCC [30] to assess the impacts of climate change, taking into account changes in the hydrological cycle, and to present representative concentration pathways (RCPs) of the climate change scenarios to provide a reliable and comprehensive prediction [50].

For the 4 reports, including the Chi, Peninsula-West Coast, Phetchaburi-Prachuap Khiri Khan, and Mea Klong River Basins, the considerations were not presented for every task in the second phase; the result was "insufficient". The Chi and Peninsula-West Coast River Basin reports addressed climate change impacts and used both qualitative and quantitative tools, particularly, the Peninsula-West Coast River Basin report used IPCC scenario models, but neither report assessed the link to policymaking. The Mea Klong River Basin report examined climate change impacts using only qualitative tools such as SWOT, TOWS, MCDM, expert judgement, and public workshops, which were less comprehensive and not linked to next tasks. The report for the Phetchaburi-Prachuap Khiri Khan River Basin did not specifically address climate change impacts as the first task and the use of statistics based on satellite imagery (area-based mapping) was addressed as part of the task to develop strategies that came from the existing water management plans and not from the SEA.

For the rest of the report, the Sakae Krang River Basin, the result was "does not consider" because it did not specifically address climate change impacts. Only the main problems (floods and droughts) were addressed and analyzed using statistics based on satellite imagery (area-based mapping) and did not compare to climate modeling. There were no linkages between each task.

In the third phase, strategic summaries in the form of reports or infographics were prepared for decision-makers who needed to know how climate change would affect future development, the impact of their decisions, and the consequences of not making such decisions. It was determined that 3 reports, the Prachin Buri-Bang Pakong, Mun, and Northeast Khong River Basins, were "sufficient" as they comprehensively analyzed the climate change impacts associated with the above phase and presented their significance. Climate change mitigation and resilience measures were presented in both summary reports and infographics. The report on the Mae Klong River Basin was "insufficient" because, although it presented climate change impacts, these were only from existing water management plans and not from SEA. The other reports were rated "does not consider" because they did not present climate change impacts and related actions in their summaries.

The final phase reviewed reports on monitoring and evaluation plans to track progress on climate change mitigation or resilience strategies described in the reports from SEA. It was found that 4 reports, the Prachin Buri-Bang Pakong, Peninsula East Coast, Mun, and Northeast Khong River Basins, were rated "sufficient" as they presented the measures to monitor the impacts of climate change and identified the agencies responsible for the plans. In the other reports, climate change impacts were not presented at all in the monitoring plans, which resulted in a rating of "does not consider".

In addition, if climate change impacts are more effectively addressed, the policy plan or program established during the SEA process, particularly in the informing and monitoring phases, should develop rapporteurs and make open data resources available

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to the private sector. These strategies would provide early warning of climate change impacts to local people and give them time to prepare, adapt, or build networks that could provide information more quickly. In this way, they could be helped, and losses and damages could be reduced [50-52].

CONCLUSIONS

The results showed that 7 of the 9 SEA reports on Thai River Basins consider the impacts of climate change, but not for all the phases. All the reports that consider climate change impacts were found to start with the second phase, i.e., the implementation of the SEA. In the SEA reports for the Prachin Buri-Bang Pakong, Mun, and Northeast Khong river basins, climate change impacts were found to be fully considered and to be linked to the next phases, leading to sufficient outcomes in phases 2, 3, and 4. Two of these reports, the Prachin Buri-Bang Pakong and Mun River Basins, used both qualitative and quantitative tools to analyze the impacts of climate change. They used scenario models developed by the IPCC to assess the impacts of climate change, which were more reliable and appropriate in comparison to the statistical data analyses.

Based on the results of this study, the government should pay more attention to the impacts of climate change in the SEA process, e.g., by publishing guidelines for the SEA of Thai river basins for practitioners that incorporate climate change impacts. The guidelines should consider the impacts of climate change from the initial phase and focus on systematic analyses in all subsequence phases.

The findings can be applied to the development of the SEA guidance document for Thai river basins and contribute to a more comprehensive consideration of climate change impacts in SEA reports to ensure more sustainable development results.

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