TCFD-oriented Budget Planning, Risk Analysis, and Performance Index for National Climate Resilience Strategy

TCFD 導向之國防氣候調適策略預算規劃、風險分析與績效指標探討

楊志豪
銘傳大學會計學系教授兼系主任

永續發展與氣候相關風險爲軍事部門需要重視的議題。在政府責任、透明度及效能之情境下，國防氣候調適策略規劃應考量氣候相關財務揭露，同時國防預算規劃之遠見與長期資金支持亦爲重要關鍵。本研究提出「TCFD導向之國防氣候調適策略預算規劃、風險分析與績效指標」概念架構，以協助國防部管理決策單位提出合適之國防氣候調適策略組合以降低氣候變遷對於軍事行動之影響，達成有效戰力發揮。本概念架構主要建議：

1. 建構TCFD導向之決策架構，優化國防永續預算投資規劃。
2. 運用風險分析思維，精準掌握國防氣候調適因應策略。
3. 建構多維績效衡量指標與數學規劃模型，合理評估投資效益。
4. 培育氣候與環境素養，激發創新思維模式。
5. 國防跨部門資源整合，達成淨零減碳目標。

關鍵字：2050淨零目標、氣候相關財務揭露、國防氣候調適策略預算規劃、風險分析、績效指標評估

Abstract

Sustainable development and the integration of climate-related risks and opportunities are crucial for the military sector. To enhance transparency, efficiency, and government responsibility, it is essential to incorporate Task Force on Climate-related Financial Disclosures (TCFD) considerations into the national defense climate resilience strategy. Adequate foresight in national defense budgeting and long-term funding support is vital for advancing climate information disclosures. This study proposes an integrated framework for national defense climate resilience strategy budget planning, risk analysis, and performance evaluation, oriented around TCFD principles. This framework aims to assist the Ministry of National Defense (MND) management in addressing climate change threats related to national defense climate resilience strategy investment and performance monitoring.

The main recommendations are as follows:

I. Implementation of TCFD-oriented decision infrastructure to optimize national sustainable budget planning
II. Application of risk analysis concepts to address the national defense climate resilience strategy
III. Development of a multidimensional performance evaluation index using a mathematical goal programming to assess the benefits of national defense investments
IV. Cultivation of climate and environmental literacy cultivation to inspire innovative thinking
V. Coordination of national defense cross-sector resource to achieve the net-zero emission goal

Keywords: 2050 net-zero emission goal; Task Force on Climate-related Financial Disclosures (TCFD); National Defense Climate Resilience strategy budget planning; risk analysis; performance index evaluation

1. Introduction

The emergence of sustainable development represents a transformative era for governments, industries, and academics, characterized by climate-related challenges such as new energy sources, carbon emissions, and resource recycling. Many countries are committed to mitigating climate change and implementing effective climate strategies to achieve carbon reduction goals and enhance resilience in sustainable supply chains (Raihan, 2023).

In response to sustainable development trends and challenges, the Ministry of National Defense (MND) prioritizes a net-zero emission transition strategy to meet national sustainable development goals. Climate change also increases the risks for military operations, necessitating climate adaptation strategies that simultaneously address sustainable development and warfighting requirements. The national defense financial management should consider sustainable decision-making information through budget achievement and benefit analysis, aiming to optimize national defense resource management. Simultaneously,

managing climate risks and enhancing operational resilience are crucial for ensuring damage recovery and military readiness.

The climate risks associated with military operations are becoming increasingly complex, making developing adequate responses to climate change essential. From the national defense financial management perspective, climate risks impose financial burdens and operational challenges. The Financial Stability Board (FSB) introduced the "Task Force on Climate-related Financial Disclosures (TCFD)" in 2015 to help organizations establish a framework for climate-related financial risks and opportunities. TCFD guidelines identify significant climate risks across four categories: Governance, Strategy, Risk Management, and Metrics and Targets.

The defense net-zero emission transition strategy contributes to achieving sustainable development and enhances resilience in defense warfighting capabilities. Given the constraints on national defense financial resources, achieving a reasonable and sustainable national budget scale is challenging. The Taiwanese government has proactively committed to achieving net-zero emissions by 2050, focusing on greenhouse gas reduction and management. It has proposed advanced solutions to reach this target. The four main strategic implementations include secure energy transition, competitive industry transition, sustainable lifestyle transition, and resilient society transition. Therefore, MND is dedicated to addressing the impacts of climate hazards on military missions, operations, and infrastructures and incorporating climate literacy into budget planning processes.

This study focuses on developing a TCFD-oriented model for sustainable budget and performance evaluation for the National Climate Resilience Strategy. Additionally, applying a multi-criteria decision methodology is proposed to enhance transparency in the decision-making process. This study is organized into four sections. Section 2 reviews literature on sustainable development and the TCFD-oriented budget concept. Section 3 presents the conceptual framework, and Section 4 provides the main conclusions and management implications.

2. Literature Review

This section reviews relevant literature on TCFD-oriented sustainable budget planning and the multiple-dimension performance decision evaluation framework.

2.1 TCFD-oriented national sustainable budget planning

Sustainable development and the integration of climate-related risks and opportunities are crucial for the military sector. To ensure transparency, efficiency, and government responsibility, it is essential to incorporate TCFD considerations into the national defense climate resilience strategy. Adequate national defense budgetary foresight and long-term funding support are critical for advancing climate information disclosures.

Generally, the potential impact of climate-related factors on the military sector is complex and varied (Ding et al., 2023). Decision-makers in the military sector must identify climate

impacts on defense logistics and infrastructure, assess vulnerabilities in climate-related strategies, and conduct cost-benefit analyses to ensure precise investment planning for national defense installation resilience. Climate-related risks are categorized into transition risks and physical risks. Transition risks encompass societal transformation due to climate change, including policy and legal changes, technological advancements, market shifts, and reputational impacts. Physical risks include acute and chronic weather-related events (O'Dwyer & Unerman, 2020). From the national defense sustainable budget planning perspective, evaluating climate-related risks is essential for creating resilience opportunities that promote sustainable development.

2.2 Multiple dimension performance decision evaluation

This study primarily proposes a set of multidimensional performance criteria based on the TCFD framework. It aims to identify the national defense climate resilience strategies in the context of net-zero emission transition policies and national sustainable development objectives. The TCFD framework comprises four main perspectives: Governance, Strategy, Risk Management, and Metrics and Targets.

Governance is a crucial evaluation perspective in the decision-making problem of the national defense climate resilience strategy. Decision-makers in the MND play a crucial role in the net-zero transition, particularly in integrating climate-related risks and setting climate goals. Schmidt et al. (2022) emphasized that management must ensure that decisions related to national defense climate policies fully consider the sustainable development objectives and enhance initiatives to reduce carbon emissions and improve resource efficiency.

Strategy is another key evaluation perspective in formulating a national defense climate resilience strategy. It is essential to consider climate risk, opportunity matrix planning, financial impact, and climate scenario analysis. The MND can develop a climate risk and opportunity matrix to identify climate risks and evaluate the cost and benefit of climate resilience strategies, thereby optimizing budget planning. Incorporating climate scenario analysis helps address uncertainties and supports informed decision-making (Huiskamp et al., 2022).

Risk Management is critical in the planning process for national defense climate resilience strategy. By employing a comprehensive risk integration assessment, the MND can proactively identify transition and physical risks related to climate resilience and recognize potential challenges in technology integration and warfighting requirements. Söder (2023) noted that climate risk analysis should be integrated into all operations and activities as a coordinated process to assess risk levels and identify opportunities for climate resilience decisions.

In developing the national defense net-zero emission policy, evaluating the metrics and targets of the national defense climate resilience strategy is essential. This evaluation ensures that the net-zero emission targets are met and supports the benefits of carbon disclosure risk assessment. Maji and Kalita (2022) argued that the net-zero

emission goal must be embedded in the evaluation infrastructure. Conducting carbon disclosure risk assessments is crucial for identifying potential risks. The MND should establish a net-zero emission target to manage objectives and performance effectively, including reducing carbon emissions, improving energy efficiency, and promoting the use of renewable energy.

2.3 Mixed MCDM with mathematical programming method

The main advantage of decision science methods lies in their ability to integrate both qualitative and quantitative evaluations. By constructing an evaluation hierarchy, these methods can link and strengthen the relationship between national net-zero transition policies and national climate resilience strategies. This study proposes using a mixed decision methodology combined with mathematical programming. Various well-established decision methods have been applied in military operation research. This study applied the VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) methodology to the decision framework. VIKOR, introduced as a practical technique within multi-criteria decision-making (MCDM) (Opricovic, 1998), employs a compromise ranking method to determine the best and worst rating values for all criteria. The VIKOR method is described by the following steps:

- Calculate the data's normalized value and the criteria weights using the expert questionnaire method in accordance with the decision framework.
- For each criterion in the national defense climate resilience strategy evaluation, calculate the maximum and minimum values and determine the strategies' distance from the ideal solution, as shown in Eqs. (1) and (3):

$$w_j^* = Max\ v_{ij}, j = 1,2,\cdots,m$$

$$w_j^- = Min\ v_{ij}, j = 1,2,\cdots,m$$

- Compute the values of concordance (S_j) and discordance (R_j), which represent group utility and individual regret measures for strategy , respectively, using the following relations:

$$S_j = \sum_{i=1}^{n} w_i(f_j^* - f_{ij})/(f_j^* - f_j^-)$$

$$R_j = Max\left[w_i(f_j^* - f_{ij})/(f_j^* - f_j^-)\right]$$

Computing the aggregate value (Q_j).

$$Q_j = v\left[(S_j - S^*)/(S^- - S^*)\right] + (1-v)\left[(R_j - R^*)/(R^- - R)\right]$$

for $j = 1,2,\cdots,m$

In ranking the strategies by sorting each S, R, and Q value in increasing order, three ranking lists are generated, denoted as S*, R*, and Q*. The best strategy, according to the Q_j, is the one with the minimum value Q_j. Decision-makers may accept this compromise solution as it provides a maximum "Group Utility" of the "majority" (measured by S_j, representing "concordance") for the majority and a minimum individual regret for the "opponents" (measured by R_j, representing "discordance").

To address real-world multi-objective problems, Charnes and Cooper (1955) used Zero-One Goal Programming to handle various resource constraints planning. This model focuses on achieving optimal objectives and simultaneously satisfying multiple resource limitations. For the national defense climate resilience strategy, it

is essential to identify resource requirements, such as budget, carbon emission reduction, and implementation period, and to understand the deviations between various resource inputs.

The ZOGP model is described as follows:

Minimize $NDCR = P_k(w_j d_i^+, w_j d_i^-)$

Subject to:

$$\sum_{j=1}^{n} r_{ij} x_j + d_i^- - d_i^+ = h_i \quad \text{for } i = 1,2,\cdots,m \quad j = 1,2,\cdots,n$$

$$x_j + d_i^- = 1 \quad \text{for } i = m+1, m+2, \cdots, m+n; \; j = 1,2,\cdots,n$$

$$d_i^+ \geq 0, \; d_i^- \geq 0 \quad \text{for } \forall_i$$

$$x_j = 0 \text{ or } 1 \quad \text{for } \forall_j$$

where $NDCR$ represents the sum of derivation variables from m goals considered; i denotes m restricted resources; j represents n selected strategies; P_k indicates the preemptive priority (P1>P2>P3>>>P_k) for the goal $NDCR$; x_j is a binary variable for the j^{th} strategy; w_j represents the aggregate value obtained from the VIKOR results for the j^{th} strategy; r_{ij} is the parameter for strategy j regarding selection resource I; and h_i denotes the available resources or limiting factors that must be considered in decision-making and evaluation.

2.4 Conceptual Framework

To align with the National Sustainable Development Goal and optimize the national defense net-zero transition reform, the MND aims to enhance the defense sustainable budget and incorporate a TCFD-oriented performance index evaluation to maximize the effectiveness of the budget. This study presents a process divided into four key areas: Resource Management, Energy Management, Operational Management, and Carbon Management. The conceptual framework for TCFD-oriented National Sustainable Budget Planning is illustrated in Figure 1.

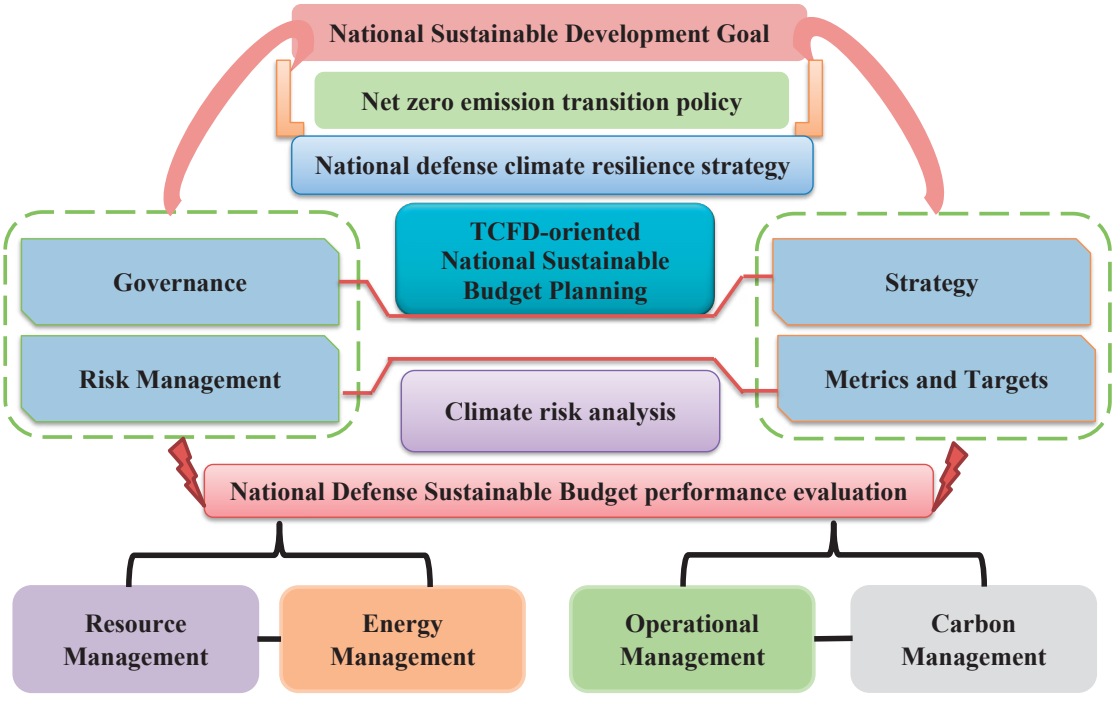

Figure 1. The concept framework of TCFD-oriented National Sustainable Budget Planning

3. Integrated Climate Risk Analysis with Multiple Dimension Performance Evaluation Process

Chen et al. (2024) emphasized that risk management is crucial for addressing the impacts and threats posed by climate change. Therefore, the military sector should implement various strategies tailored to its vulnerabilities and capacities. First, the MND can proactively identify both transition and physical risks associated with its climate resilience strategy. The analysis framework is divided into risk probability and operation impact levels to assess climate-related risks within the military sector, as detailed in Table 1 and Figure 2.

Table 1. National defense climate threat risk analysis (example)

Risk Category	Risk Factor	Risk Period	Risk Probability
Physical	Temperature variations	Long-term	Low/Medium/ High
Transition	Policy regulation	Medium-term	Low/Medium/ High
Physical	Severe weather	Short-term	Low/Medium/ High
Physical	Technology	Medium-term	Low/Medium/ High
Transition	Market	Medium-term	Low/Medium/ High

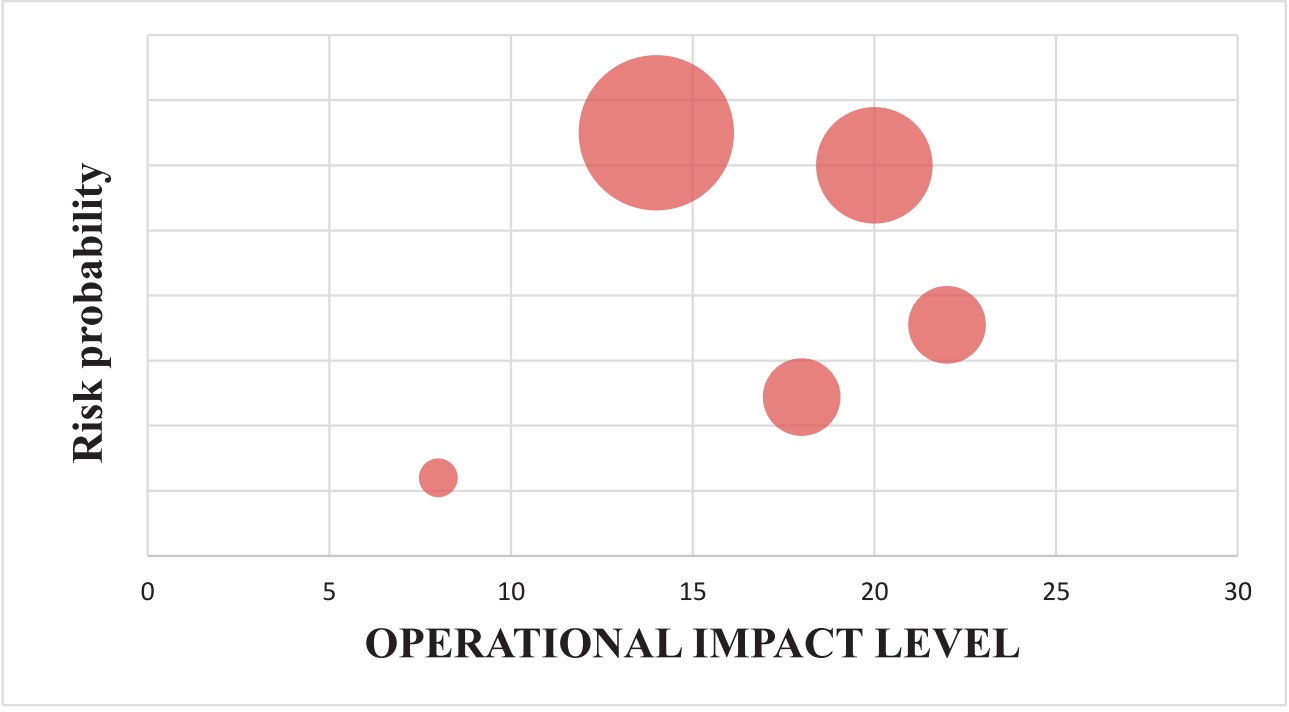

Figure 2. Bubbles diagram for national defense climate threat risk analysis (example)

Evaluating multiple dimensions of the national defense climate resilience strategy is crucial from the TCFD perspective. This includes Governance, Strategy, Risk Management, and Metrics and Targets, which are essential for ensuring the performance of the national defense climate resilience strategy beyond just the budget execution rate. The National Defense Comptroller Bureau will continue to review and assess approaches to addressing climate change and apply data analysis to monitor these processes. Additionally, the national defense climate resilience strategy must effectively allocate resources. The developed mathematical optimization model considers related resources—such as budget amount, carbon emission reduction, and implementation period—and utilizes the VIKOR weights derived from decision science methodology, as illustrated in Figure 3 and Table 2.

Figure 3. National defense climate resilience strategy performance index (example)

Table 2. National Defense Climate Resilience Strategy Decision

Resource Constraints	VIKOR Weight	Budget Amount	Reduction Carbon emission	Implementation Period
Strategy 1	-	-	-	-
Strategy 2	-	-	-	-
Strategy 3	-	-	-	-
Strategy 4	-	-	-	-

4. Conclusions and Management Implications

This study proposes an integrated TCFD-oriented framework for national defense climate resilience strategy budget planning, risk analysis, and performance evaluation. This framework is designed to assist the MND in addressing climate change threats related to national defense climate investments and performance monitoring. The key findings of applying this conceptual model are as follows:

I. TCFD-oriented Decision infrastructure to optimal the national sustainable budget planning

TCFD considerations are essential for planning the national defense climate resilience strategy. Additionally, national defense budgetary foresight and long-term funding support are critical for promoting climate information disclosures. The MND should assess both physical and transition risks related to the impact of weather on military infrastructure and operations. Effective national defense budget planning should incorporate climate-related risk evaluations to foster opportunities for climate resilience and support sustainable development.

II. Application of Risk analysis concept to address national defense climate resilience strategy

Risk Analysis is crucial in integrating climate resilience considerations into strategic decision-making. It involves identifying risk categories (physical and transition) and understanding their probability and vulnerabilities. This analysis enhances transparency in climate-informed decision-making and supports the management in planning climate resilience installations and infrastructure.

III. Multiple Dimension Performance Evaluation index with Mathematical Goal Programming to evaluate national defense investment benefits

The evaluation of the national defense climate resilience strategy should align with the TCFD framework, which includes Governance, Strategy, Risk Management, and Metrics and Targets. The National Defense Comptroller Bureau should advance the integration of performance indices and mathematical programming models to address current and future climate change challenges. Data analysis will aid in optimizing national resource allocation.

IV. Climate and environmental literacy cultivation to inspire innovative thinking

The MND must cultivate climate and environmental literacy to prepare a climate-ready force. This involves integrating climate resilience training programs and addressing climate and environmental literacy, data analysis technologies, and innovation. Such initiatives are crucial for enhancing strategic planning and inspiring innovative approaches to climate resilience.

V. National defense cross-sector resource coordination to achieve the net-zero emission goal

Climate strategy collaboration to enhance adaptation and resilience is progressing across the military sector. The National Defense Comptroller Bureau plays a crucial role in coordinating cost-benefit analyses to develop an optimal national defense climate resilience strategy. To leverage national financial management advantages, TCFD-oriented national sustainable budget planning offers effective and efficient guidelines to support the achievement of national sustainable development goals and the net-zero emission target.

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