

Adaptive Governance For El Niño Risk Reduction: Comparative Lessons from Bulacan and Metro Manila, Philippines

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ARTICLE INFORMATION	ABSTRACT
Article history: Published: October 2026 Keywords: Adaptive Governance Disaster Risk Reduction El Niño Bulacan Metro Manila Drought Water Security Climate Resilience	This study compared adaptive governance and disaster risk reduction (DRR) practices in Bulacan and Metro Manila during the 2023-2024 El Niño episode. Adaptive governance was examined through anticipatory risk intelligence, interagency and multilevel coordination, decision flexibility, resource mobilization, organizational learning, and risk communication and participation. A comparative cross-sectional design involved 368 respondents from local DRRM, planning, engineering, environment, health, social welfare, barangay administration, utility, civil society, and institutional partner groups, with equal representation from Bulacan and Metro Manila. The instrument contained 24 adaptive-governance statements, six DRR-performance statements, and a 12-item checklist of concrete El Niño measures. Internal consistency was strong across the six governance dimensions (Cronbach's alpha = .894-.908) and the DRR-performance scale (alpha = .932). Welch tests with Holm adjustment and Hedges' g were used for continuous comparisons; chi-square tests with Holm adjustment and Cramer's V were used for action uptake; Spearman's rho assessed associations; and multiple linear regression with HC3 robust standard errors estimated the independent contribution of governance dimensions. Metro Manila recorded a higher anticipatory-risk score after multiplicity adjustment, while overall DRR performance did not significantly differ between the two settings. Concrete measures, however, showed pronounced contextual specialization: Metro Manila more frequently reported water-conservation campaigns, leak and demand management, continuity adjustments, and utility partnerships, whereas Bulacan more frequently reported agriculture and livelihood protection. Overall adaptive governance was strongly associated with DRR performance (rho = 0.636, p < .001). In the multivariable equation, all six governance dimensions remained positive predictors, while location itself was not significant; the equation explained 46.0% of DRR-performance variance. The findings indicated that effective El Niño governance depended less on copying identical interventions across jurisdictions than on combining early climate intelligence, coordinated authority, context-specific resource deployment, transparent communication, and institutional learning. A comparative adaptive-governance framework was proposed for drought, heat, water-security, livelihood, and service-continuity planning.

1. Introduction

The 2023-2024 El Niño episode posed a governance problem as much as a climatic one. PAGASA confirmed in July 2023 that unusual warming in the equatorial Pacific had developed into a weak El Niño and warned that below-normal rainfall could generate dry spells and drought in climate-sensitive sectors such as water resources, agriculture, energy, health, and public safety.¹ By 7 June 2024, PAGASA declared the episode ended as oceanic and atmospheric indicators returned to ENSO-neutral conditions, although it cautioned that warmer-than-usual temperatures and below-normal rainfall could continue in some areas.² The event therefore created an extended period in which government institutions had to act under evolving forecasts rather than wait for a single disaster impact point.

National consequences demonstrated why El Niño required anticipatory management. By mid-May 2024, the Department of Agriculture estimated agricultural losses at about PHP 9.5 billion, affecting more than 163,000 hectares and over 175,000 farmers and fisherfolk, with rice, corn, and high-value crops carrying most of the recorded losses.³ At the same time, government agencies monitored water supply, electricity, food prices, health effects, wildfire risk, and extreme heat. The hazard did not behave like a sudden-onset typhoon. Its effects accumulated across weeks and months, crossed administrative and sectoral boundaries, and demanded repeated recalibration as forecasts, dam levels, water demand, crop conditions, and heat indices changed.

The Philippine policy architecture already required this kind of integrated response. Republic Act No. 10121 established a proactive, comprehensive, multi-sectoral DRRM system that mainstreamed disaster risk reduction and climate risk in development planning, budgeting, public infrastructure, health, education, agriculture, water, and local governance.⁴ Republic Act No. 9729 similarly required climate change to be integrated into national and local planning and defined adaptive capacity as the ability of ecological, social, or economic systems to adjust to climatic variability and extremes.⁵ In January 2024, Executive Order No. 53 reactivated the

Task Force El Niño and directed it to update the national action plan, monitor short- and long-term interventions, expedite water-related infrastructure, and coordinate across the critical areas of water, food, energy, health, and safety.⁶

These legal mandates reflected the broader Sendai Framework principle that disaster losses are reduced not only through response capacity but through risk understanding, stronger risk governance, investment in resilience, and preparedness for effective action.⁷ For El Niño, the governance challenge was especially pronounced because decisions had to be distributed across national agencies, metropolitan institutions, provinces, cities, municipalities, barangays, utilities, schools, health offices, farmers' organizations, private firms, and households. No single office controlled the entire risk system.

Adaptive governance offered a useful conceptual lens for this problem. Folke and colleagues described adaptive governance as institutional arrangements capable of responding to complex and changing social-ecological conditions through networks, learning, collaboration, and flexible organization.⁸ Chaffin, Gosnell, and Cosens later synthesized adaptive-governance scholarship around interactions among actors, organizations, and institutions that enable adjustment under uncertainty and environmental change.⁹ In disaster research, Djalante, Holley, and Thomalla linked adaptive governance to resilience through polycentric and multilayered institutions, participation and collaboration, self-organization and networks, and learning and innovation.¹⁰ Djalante further emphasized multi-stakeholder platforms as mechanisms through which organizations operating at different scales can coordinate DRR action.¹¹

These ideas were directly relevant to the Philippines. Local governments possess legal responsibilities for DRRM, but drought and metropolitan water risk routinely cross jurisdictional boundaries. A study of Metro Manila DRRM plans found relatively strong integration of governance and risk-identification attributes but also identified gaps in city-to-city learning and argued that metropolitan coordination was central to resilient planning.¹² Research on Philippine metropolitan disaster management likewise showed that hazards whose impacts cross city boundaries expose tensions between local political jurisdictions and the larger functional scale at which infrastructure and risk must be managed.¹³ Adaptive governance therefore required both local discretion and coordination beyond the local boundary.

Bulacan and Metro Manila provided a particularly instructive comparison because they were linked by water and economic systems while facing different immediate manifestations of El Niño. Bulacan contains agricultural areas, irrigation demands, fisheries and livelihood systems, expanding urban settlements, and major water infrastructure. Metro Manila is a densely urbanized metropolitan system in which drought risk is strongly connected to potable water continuity, demand management, public health, heat exposure, school and work continuity, and coordination among multiple local governments and metropolitan agencies. The two settings were not independent: the Angat system located in Bulacan has long been central to Metro Manila's raw-water supply, creating a shared resource context in which water allocation and drought preparedness have implications both upstream and downstream.^{16,23}

Official records showed that Bulacan's 2024 interventions were strongly oriented toward local water access and livelihood protection. In February 2024, Project LAWA at BINHI was launched in Doña Remedios Trinidad through a DSWD-local government partnership to address water scarcity and food-security risks among vulnerable sectors.¹⁷ In March, the Department of Agriculture and the provincial government inaugurated a PHP 12-million small water impounding project in Angat designed to support approximately 35 hectares of agricultural land.²⁰ By June, the provincial government reported rehabilitation assistance to 1,069 farmers and fisherfolk from San Miguel, Obando, and San Rafael who had been affected by El Niño-related crop and fisheries impacts.¹⁸ A July government report further noted that 1,835 hectares of rice land in San Miguel were among the areas most severely affected, with provincial DRRM funds used for farmer and fisher assistance.¹⁹

Metro Manila's documented response had a different operational emphasis. In March 2024, the Metro Manila Council urged LGUs to adopt measures that included rainwater harvesting, catchment systems, reduced nonessential water use, wastewater or gray-water reuse, leak repair, and water filtration initiatives.²¹ The National Water Resources Board separately called on village and condominium property managers to enforce water-conservation practices, detect leaks, limit discretionary water use, and collect rainwater where possible.²² Water-sector institutions also relied on supply diversification, system readiness, demand management, and operational monitoring. Manila Water's 2024 reporting described El Niño risk controls that included source development, infrastructure repair, dam-flow monitoring, supply augmentation, demand management, and improved system readiness.²⁵

The contrast between these two settings made a comparative governance study more useful than a simple ranking exercise. Bulacan's adaptive challenge included agriculture, livelihood recovery, localized water access, and provincial-municipal coordination; Metro Manila's challenge centered more heavily on dense urban demand, water-system reliability, utility coordination, heat exposure, and service continuity. Both, however, required early warning, interorganizational action, flexible decisions, resources, public communication, and learning. The relevant question was therefore not which locality had a universally superior response, but which governance capacities were associated with stronger DRR performance and how those capacities translated into context-specific measures.

Prior Philippine studies had already suggested that local resilience depended on institutional capacity, community participation, partnerships, and financing. Research in a small-island community in Hagonoy, Bulacan found that community leadership, partnerships, DRR funding, inclusion, and local participation could either strengthen or constrain resilience.¹⁴ Work on institutional resilience in Aurora demonstrated the importance of building local-government capacity for climate adaptation planning through multi-actor engagement.¹⁵ These studies supported an interpretation of disaster governance that went beyond the presence of plans and focused on whether institutions could learn, coordinate, mobilize, and adapt in practice.

The study addressed that need by comparing adaptive-governance capacities and El Niño DRR performance in Bulacan and Metro Manila. It operationalized adaptive governance through six dimensions: anticipatory risk intelligence; interagency and multilevel coordination; decision flexibility; resource mobilization; organizational learning; and risk communication and participation. It also examined whether concrete response measures differed between the two settings and whether governance capacity explained DRR performance after locality was taken into account.

1.1 Objectives of the Study

The study generally examined adaptive governance and disaster risk reduction during the 2023-2024 El Niño episode in Bulacan

and Metro Manila. Specifically, it sought to: (1) describe the respondent and institutional profile of the two study settings; (2) determine the level of anticipatory risk intelligence, coordination, decision flexibility, resource mobilization, organizational learning, risk communication and participation, and overall DRR performance; (3) test whether these governance dimensions and DRR performance differed between Bulacan and Metro Manila; (4) compare the prevalence of concrete El Niño measures across the two settings; (5) determine the associations between adaptive-governance dimensions and DRR performance; and (6) identify which governance dimensions independently explained DRR performance when the other dimensions and locality were considered simultaneously.

1.2 Research Hypotheses

At the .05 level of significance, the study tested the following null hypotheses: H01: the distributions of adaptive-governance dimensions and DRR performance did not differ between Bulacan and Metro Manila; H02: the prevalence of concrete El Niño risk-reduction measures did not differ between the two settings; H03: adaptive-governance dimensions were not significantly associated with DRR performance; and H04: none of the adaptive-governance dimensions independently explained DRR performance after the other dimensions and locality were considered.

1.3 Conceptual Framework

Adaptive governance was treated as a capacity for organized adjustment under uncertainty rather than as a single program. The first dimension, anticipatory risk intelligence, referred to the use of forecasts, heat and drought advisories, water and agricultural monitoring, and scenario-based planning before severe impacts occurred. The second, coordination, referred to horizontal cooperation among sectoral offices and vertical linkages among national agencies, metropolitan or provincial institutions, local governments, barangays, utilities, and community partners. The third, decision flexibility, referred to the ability to modify schedules, operating rules, service modes, or resource priorities as conditions changed.

The fourth dimension, resource mobilization, captured the ability to move funds, equipment, water-related assets, relief goods, agricultural inputs, health resources, and personnel toward emerging needs. The fifth, organizational learning, covered monitoring, documentation, after-action review, updating of procedures, and the incorporation of experience into subsequent preparedness. The sixth, risk communication and participation, included timely advisories, understandable public information, feedback channels, and engagement of relevant stakeholders. These dimensions reflected recurring characteristics in adaptive-governance and DRR scholarship.^{8,9,10,11}

DRR performance was operationalized as the perceived capacity of the participating institution or local system to reduce disruption and protect water security, livelihoods and food systems, health, vulnerable groups, and continuity of essential services during El Niño. The framework did not equate high perception scores with absence of loss. A jurisdiction could experience serious exposure while still demonstrating adaptive capacity, and a jurisdiction with lower exposure could still show weak governance. The focus was on the quality of the governance response under the conditions that existed.

2. Methods

The study employed a comparative, cross-sectional quantitative design. The comparative component examined differences between Bulacan and Metro Manila in adaptive-governance capacities and specific El Niño measures. The correlational component assessed the relationship between adaptive-governance dimensions and DRR performance, while the multivariable component estimated the unique contribution of each governance dimension after shared variance and locality were taken into account.

The analytic window covered the 2023-2024 El Niño episode from the PAGASA declaration in July 2023 through the final El Niño advisory in June 2024.^{1,2} Respondents evaluated the actions and institutional practices they had observed or participated in during that period. The two study settings were selected because they shared important water-security linkages but differed in land use, sectoral exposure, density, administrative scale, and dominant service-continuity concerns.

The target respondent pool consisted of personnel and stakeholder representatives with direct knowledge of local El Niño preparedness, coordination, mitigation, service continuity, or recovery actions. These included local DRRM personnel; planning, engineering, and environmental personnel; health and social welfare personnel; barangay and local administration representatives; and utility, civil society, or institutional partners. The design sought perspectives from both core emergency-management offices and the sectoral units that convert climate information into operational decisions.

An a priori two-group power calculation using a two-sided alpha of .05, statistical power of .80, and a small-to-moderate standardized difference of $d = .30$ required approximately 176 respondents per group. The final analytic sample contained 368 respondents, with 184 from Bulacan and 184 from Metro Manila, exceeding the minimum requirement. Equal group allocation improved the precision and interpretability of the comparative tests.

The instrument had four parts. Part I recorded locality, institutional role, and years of service. Part II contained 24 adaptive-governance statements, with four indicators each for anticipatory risk intelligence, interagency and multilevel coordination, decision flexibility, resource mobilization, organizational learning, and risk communication and participation. Part III contained six statements on DRR performance during El Niño. Parts II and III used a five-point response scale from 1 (strongly disagree) to 5 (strongly agree). Part IV contained a 12-item yes/no checklist of concrete measures that could be implemented during drought, heat, water-supply, livelihood, and continuity risks.

Instrument content was aligned with the Philippine DRRM and climate-policy framework, Task Force El Niño priorities, the Sendai Framework, and adaptive-governance literature.^{4,5,6,7,10} Items were written as observable institutional practices rather than personality judgments. Anticipatory items asked about the use of forecasts and pre-impact triggers; coordination items examined cross-office and cross-level working arrangements; flexibility items captured adjustment of operations and priorities; resource items assessed the mobilization of funds, equipment and personnel; learning items assessed monitoring and revision; and communication items assessed public information and stakeholder engagement.

Internal consistency was estimated using Cronbach's alpha. Coefficients for the six governance dimensions ranged from .894 to .908, while the DRR-performance scale yielded alpha = .932. These coefficients supported the computation of multi-item composite scores. Composite means were interpreted using the following descriptive intervals: 4.21-5.00, very high; 3.41-4.20, high; 2.61-3.40, moderate; 1.81-2.60, low; and 1.00-1.80, very low. The labels were used only as descriptive summaries and did not replace inferential analysis.

For continuous composite comparisons, Welch's independent-samples *t* test was used because it did not require equal group variances. Hedges' *g* quantified standardized effect size, with positive values indicating higher Metro Manila scores and negative values indicating higher Bulacan scores. Because eight related comparisons were examined, Holm adjustment controlled the familywise error rate. Mann-Whitney sensitivity checks were also performed and did not materially alter the direction of the comparative conclusions.

For the 12 yes/no intervention measures, Pearson chi-square tests compared proportions between Bulacan and Metro Manila. Holm adjustment was again applied across the family of comparisons, and Cramer's *V* summarized association strength. Spearman's rho was used to assess monotonic relationships between governance dimensions and DRR performance. This rank-based coefficient was selected because the composites were derived from ordered response categories and because it was less sensitive to minor departures from interval-level measurement.

A multiple linear regression equation with HC3 heteroscedasticity-robust standard errors was used to estimate the independent relationship of the six adaptive-governance dimensions with DRR performance, together with a locality indicator for Metro Manila. Composite scores were considered appropriate for this analysis because each construct was measured through multiple internally consistent items. Variance inflation factors were inspected for multicollinearity. A supplementary interaction analysis tested whether the association between overall adaptive governance and DRR performance differed by locality. All tests were two-sided at alpha = .05.

Participation procedures emphasized informed consent, voluntary participation, confidentiality, and reporting at aggregate level. Respondents were not asked to evaluate political affiliation, electoral preference, or individual politicians. The unit of analysis was the respondent's experience of institutional processes and measures. No names of individual respondents were retained in the analytic file.

3. Results

Results are presented in the order of the objectives: respondent profile, scale performance, locality comparisons, concrete El Niño measures, associations, and multivariable analysis.

Table 1. Respondent profile by locality

Respondent role	Bulacan n	%	Metro Manila n	%	Total
LDRMO/DRRM personnel	45	24.5	49	26.6	94
Planning, engineering, or environment personnel	45	24.5	38	20.7	83
Health or social welfare personnel	27	14.7	32	17.4	59
Barangay/local administration representatives	38	20.7	36	19.6	74
Utility, CSO, or institutional partners	29	15.8	29	15.8	58

The sample was deliberately distributed across both core DRRM functions and sectoral or community-facing roles. Local DRRM personnel and barangay/local administration representatives together formed a substantial share of respondents, but planning, engineering, environment, health, social welfare, utility, civil society, and institutional perspectives were also represented. This distribution was important because El Niño decisions were not confined to emergency operations centers; they also affected water, infrastructure, welfare, health, communications, community coordination, and continuity of public services.

Table 2. Descriptive statistics and internal consistency

Scale	Mean	SD	Cronbach alpha	Descriptor
Anticipatory risk intelligence	3.71	1.12	0.908	High
Interagency and multilevel coordination	3.82	1.07	0.898	High
Decision flexibility	3.65	1.10	0.894	High
Resource mobilization	3.68	1.11	0.906	High
Organizational learning	3.46	1.13	0.895	High
Risk communication and participation	3.64	1.12	0.896	High
Overall adaptive governance	3.66	0.75		High
Overall DRR performance	3.81	1.04	0.932	High

Across the complete sample, overall adaptive governance was rated high ($M = 3.66$, $SD = 0.75$), and DRR performance was also rated high ($M = 3.81$, $SD = 1.04$). Coordination had the highest pooled mean among the governance dimensions, while organizational learning had the lowest pooled mean. The pattern suggested that institutions were more confident about working across offices during the El Niño period than about systematically converting experience into revised procedures, documented lessons, and future triggers.

Reliability coefficients were uniformly strong. Anticipatory risk intelligence, coordination, flexibility, resource mobilization, organizational learning, and communication all exceeded alpha = .89, and DRR performance exceeded .93. The results supported the interpretation of the multi-item scores as coherent constructs and reduced the likelihood that observed locality differences were merely the result of unstable item combinations.

Table 3. Comparative tests for governance and DRR performance

Measure	Bulacan M (SD)	Metro Manila M (SD)	D	95% CI	Hedges g	p	Holm p
Anticipatory risk intelligence	3.51 (1.20)	3.91 (1.00)	0.40	[0.17, 0.63]	0.36	<.001	0.004
Interagency and multilevel coordination	3.71 (1.09)	3.93 (1.04)	0.22	[0.01, 0.44]	0.21	0.045	0.180

Measure	Bulacan M (SD)	Metro Manila M (SD)	D	95% CI	Hedges g	p	Holm p
Decision flexibility	3.51 (1.12)	3.78 (1.06)	0.27	[0.05, 0.49]	0.25	0.018	0.107
Resource mobilization	3.70 (1.14)	3.67 (1.08)	-0.03	[-0.26, 0.20]	-0.03	0.796	0.796
Organizational learning	3.40 (1.16)	3.53 (1.10)	0.14	[-0.09, 0.37]	0.12	0.239	0.718
Risk communication and participation	3.51 (1.10)	3.77 (1.12)	0.26	[0.03, 0.48]	0.23	0.028	0.140
Overall adaptive governance	3.56 (0.79)	3.77 (0.71)	0.21	[0.06, 0.36]	0.28	0.007	0.052
Overall DRR performance	3.76 (1.06)	3.86 (1.03)	0.10	[-0.12, 0.31]	0.09	0.365	0.731

Before multiplicity adjustment, Metro Manila recorded higher means for anticipatory risk intelligence, coordination, decision flexibility, communication, and overall adaptive governance. After Holm correction across the eight comparisons, the clearest retained difference was anticipatory risk intelligence. Metro Manila's anticipatory score ($M = 3.91$) exceeded Bulacan's ($M = 3.51$), with a small-to-moderate standardized effect ($g = 0.36$). The adjusted results cautioned against describing the two settings as categorically different across every governance domain.

Overall DRR performance did not significantly differ between the settings: Bulacan $M = 3.76$ and Metro Manila $M = 3.86$. This was substantively important. It indicated that comparable overall performance could emerge from different governance configurations and intervention portfolios. The result supported a context-sensitive interpretation: adaptive governance was not defined by identical actions, but by the capacity to select and coordinate actions appropriate to the risk environment.

Table 4. Comparative prevalence of reported El Niño measures

Reported measure	Bulacan %	Metro Manila %	Chi-square	Cramer's V	p	Holm p
El Niño/drought contingency plan reviewed	82.1	84.2	0.17	0.02	0.676	0.840
Interagency task force or coordinated monitoring	79.3	84.2	1.17	0.06	0.280	0.840
Water-conservation advisories/campaigns	70.1	95.1	38.30	0.32	<.001	<.001
Rainwater harvesting or alternative-source measures	70.1	78.8	3.21	0.09	0.073	0.438
Leak control/demand-management measures	46.2	82.1	49.91	0.37	<.001	<.001
Agriculture or livelihood protection measures	88.6	27.7	137.58	0.61	<.001	<.001
Heat-health protection protocols	82.1	87.5	1.71	0.07	0.191	0.766
Service/class/work continuity adjustments	59.8	86.4	31.84	0.29	<.001	<.001
Relief/resource prepositioning	77.7	69.6	2.74	0.09	0.098	0.488
Post-event review/monitoring mechanism	49.5	67.4	11.46	0.18	<.001	0.005
Targeted measures for vulnerable groups	82.6	77.7	1.09	0.05	0.296	0.840
Utility/private-sector partnership	56.0	88.6	47.21	0.36	<.001	<.001

The action checklist revealed sharper contextual differences than the composite ratings. Metro Manila respondents much more frequently reported water-conservation campaigns, leak-control or demand-management measures, service/class/work continuity adjustments, post-event monitoring, and utility or private-sector partnerships. The largest urban difference involved leak and demand management, followed by utility/private-sector partnership and water-conservation communication. These measures matched the operational characteristics of a dense metropolitan water system, where demand reduction, system efficiency, alternative sources, and coordination with regulated utilities can protect continuity without waiting for reservoir conditions to become critical.^{21,22,25}

Bulacan respondents, in contrast, much more frequently reported agriculture or livelihood protection measures. The association between locality and this measure was large by Cramer's V, reflecting the importance of crop, fisheries, and livelihood exposure in the provincial setting. This pattern was consistent with documented 2024 interventions in Bulacan, including water-access projects, small water impounding infrastructure, and direct rehabilitation assistance to farmers and fisherfolk.^{17,18,19,20} The result showed why a comparative analysis should distinguish governance capacity from the sectoral content of the response.

Several measures were common rather than differentiating. Both settings reported high levels of contingency-plan review, interagency coordination or monitoring, heat-health protocols, resource prepositioning, and targeted measures for vulnerable groups. The absence of large locality differences in these actions suggested a shared national DRRM architecture and common exposure to heat, water stress, and public-safety concerns, even when the implementation details differed.

Table 5. Associations with DRR performance

Adaptive-governance measure	Spearman rho with DRR performance	p
Anticipatory risk intelligence	0.524	<.001
Interagency and multilevel coordination	0.527	<.001
Decision flexibility	0.440	<.001
Resource mobilization	0.337	<.001
Organizational learning	0.392	<.001
Risk communication and participation	0.425	<.001
Overall adaptive governance	0.636	<.001

All six adaptive-governance dimensions were positively associated with DRR performance. The strongest bivariate relationships were coordination ($\rho = 0.527$) and anticipatory risk intelligence ($\rho = 0.524$), while resource mobilization showed a smaller but

still significant relationship ($\rho = 0.337$). The overall adaptive-governance index correlated strongly with DRR performance ($\rho = 0.636$, $p < .001$). The coefficients supported the theoretical expectation that DRR performance during a slow-onset climate hazard was linked to the combined ability to anticipate, coordinate, adjust, mobilize, learn, and communicate.

The relative strength of coordination and anticipation was especially consistent with El Niño governance. Forecast information alone has limited value if it does not change decisions, while coordination without credible risk information can become reactive. Research using Metro Manila's water-supply system has shown that ENSO information can have operational value when incorporated into adaptive water-management decisions rather than treated as background climate information.¹⁶ Likewise, adaptive-governance scholarship has repeatedly placed networks, learning, multi-level institutions, and collaboration at the center of resilience under uncertainty.^{8,10,11}

Table 6. Robust multiple regression explaining DRR performance

Predictor	B	HC3 SE	Standardized beta	p	VIF
Anticipatory risk intelligence	0.196	0.046	0.209	<.001	1.49
Interagency and multilevel coordination	0.246	0.050	0.253	<.001	1.49
Decision flexibility	0.139	0.047	0.146	0.003	1.36
Resource mobilization	0.129	0.044	0.137	0.003	1.26
Organizational learning	0.103	0.044	0.112	0.019	1.36
Risk communication and participation	0.118	0.044	0.126	0.007	1.39
Metro Manila locality indicator	-0.113	0.083	—	0.175	1.05

The regression equation explained 46.0% of the variance in DRR performance (adjusted R-squared = 0.450). All six adaptive-governance dimensions retained positive independent coefficients when entered simultaneously. Coordination had the largest standardized coefficient ($\beta = 0.253$), followed by anticipatory risk intelligence ($\beta = 0.209$). Decision flexibility, resource mobilization, communication, and organizational learning also contributed significant unique information. The results indicated that no single governance capability was sufficient; performance was strongest where several capacities worked together.

After the six governance dimensions were included, the Metro Manila locality indicator was not significant ($B = -0.113$, $p = 0.175$). This result was central to the comparative interpretation: the setting in which a respondent worked did not independently explain performance once governance capacity was considered. Variance inflation factors were low, indicating that the regression coefficients were not distorted by problematic multicollinearity.

A supplementary analysis also found no significant locality-by-overall-adaptive-governance interaction ($p = 0.442$). Thus, the positive relationship between adaptive governance and DRR performance operated in a broadly similar direction in both settings. Bulacan and Metro Manila differed more in the content and emphasis of specific interventions than in the basic governance mechanism linking adaptive capacity with perceived performance.

4. Discussion

The study demonstrated that El Niño governance was best understood as a problem of adaptation under changing information rather than as a sequence of fixed emergency procedures. The 2023-2024 episode evolved over many months, and PAGASA advisories progressively changed the probability and timing of expected impacts.^{1,2} Effective local systems therefore needed to convert climate signals into anticipatory decisions, revisit those decisions as conditions changed, and coordinate across sectors whose thresholds were not identical. Water managers, health offices, schools, agriculture offices, social welfare units, utilities, and local executives did not experience the same risk at the same moment.

The strongest retained locality difference in the composite comparisons concerned anticipatory risk intelligence, where Metro Manila scored higher after multiplicity adjustment. This result was plausible in a metropolitan system whose water continuity depends heavily on continuous reservoir monitoring, regulated allocations, demand projections, concessionaire operations, and alternative-source development. Metro Manila institutions also had access to metropolitan coordination mechanisms and water-sector actors with dedicated monitoring capabilities. During the 2024 episode, metropolitan authorities explicitly urged LGUs to adopt conservation and water-crisis measures before widespread supply interruption occurred.^{21,22}

However, higher anticipatory scores did not translate into significantly higher overall DRR performance. The absence of a performance difference suggested that Bulacan used a different mix of adaptive mechanisms to address its risk profile. Resource mobilization was statistically comparable between the two settings, while Bulacan's concrete action profile was strongly oriented toward agriculture and livelihoods. This was consistent with the province's documented response: vulnerable communities received water-access interventions, farmers benefited from irrigation infrastructure, and affected farmers and fisherfolk received rehabilitation assistance.^{17,18,19,20} In other words, adaptive governance did not require Bulacan to resemble Metro Manila; it required Bulacan to deploy resources toward the sectors most exposed in its own context.

The contrast illustrated a key principle of adaptive governance: institutional capacity should generate context-appropriate action rather than procedural uniformity. Folke and colleagues emphasized learning, networks, and flexible institutions as foundations for managing social-ecological change.⁸ Chaffin and colleagues likewise situated adaptation in the interactions among actors and institutions responding to uncertainty.⁹ The present findings extended that logic to Philippine El Niño governance. Similar DRR performance could emerge through different combinations of measures when the underlying governance capacities remained functional.

Coordination emerged as the strongest multivariable predictor of DRR performance. This finding was unsurprising but consequential. El Niño risk is fragmented administratively: PAGASA generates climate information; water agencies manage allocation and infrastructure; agriculture offices monitor crops; health agencies address heat and disease; social welfare agencies support vulnerable households; schools make continuity decisions; and local governments translate national guidance into place-specific action. Coordination determines whether these separate mandates become a coherent response. The Task Force El Niño

structure itself reflected this need by bringing together defense/civil defense, science and technology, environment, agriculture, health, and planning institutions around shared critical sectors.⁶

The coordination finding also resonated with research on Metro Manila disaster planning. Ner and colleagues found strong governance integration in local plans but identified city-to-city learning and metropolitan coordination as areas requiring greater attention.¹² Gera similarly argued that disaster risks often operate at a metropolitan scale that does not align neatly with political boundaries.¹³ The El Niño case sharpened this issue because water systems and heat effects do not stop at city borders. Metropolitan institutions can reduce fragmentation by providing shared data, common triggers, coordinated advisories, and platforms for joint learning without eliminating the discretion of individual cities.

Bulacan faced a related but differently structured coordination problem. Its provincial government had to link municipalities, barangays, agriculture and fisheries offices, DRRM structures, irrigation and water actors, social welfare programs, and national agencies. Community-level resilience research in Hagonoy has shown that partnerships, funding access, leadership, and participation can strengthen or hinder resilience depending on how they are organized.¹⁴ The present findings reinforced that local and provincial adaptive capacity is partly relational: resources become useful when institutions know who can act, under what authority, and through what mechanism.

Anticipatory intelligence was the second strongest predictor in the multivariable analysis. This dimension represented more than receiving a PAGASA bulletin. It involved translating information into thresholds for action: when to intensify conservation messaging; when to inspect leaks or alternative sources; when to shift crop calendars or provide irrigation support; when to activate heat-health protocols; when to adjust classes or work arrangements; and when to protect vulnerable groups. DepEd's 2024 guidance on extreme heat, for example, explicitly allowed school heads to suspend in-person classes or shift to alternative delivery modes based on localized conditions.²⁶ Such discretion becomes adaptive only when decision makers have timely, credible information and clear authority.

Decision flexibility independently predicted DRR performance even after anticipation and coordination were controlled. Slow-onset hazards create a particular need for reversible and staged decisions. Overreacting too early can impose unnecessary costs, while acting too late can lock institutions into crisis response. Flexible governance can use escalating measures: conservation advisories before rationing; voluntary demand management before compulsory restrictions; crop and irrigation adjustments before severe production loss; alternative service arrangements before heat creates unsafe conditions. This principle is consistent with adaptive-governance theory, which treats learning and adjustment as normal features of decision making rather than signs that the original plan failed.^{9,10}

Resource mobilization also remained independently important. Plans and forecasts do not protect communities unless they can be converted into personnel, funds, equipment, water infrastructure, relief resources, health interventions, or livelihood support. The Bulacan cases illustrated this conversion from risk recognition to tangible support. At the metropolitan level, water-sector adaptation similarly required physical infrastructure and system investments. Manila Water reported that El Niño preparedness involved supply augmentation, alternative sources, critical infrastructure repair, and improved system readiness, demonstrating that adaptive governance has a material as well as an institutional dimension.²⁵

Organizational learning showed the lowest pooled governance mean but still contributed independently to DRR performance. This dimension may be one of the most important long-term lessons from the 2023-2024 episode. El Niño is recurrent. The value of a response is therefore not limited to whether it reduced immediate disruption; institutions should preserve what they learned about forecast triggers, vulnerable communities, water-use behavior, procurement timelines, interagency bottlenecks, crop exposure, heat protocols, and public communication. Without documentation and after-action review, each El Niño episode risks being managed as if it were unprecedented.

Learning was also the bridge between the two localities. Metro Manila's experience with water-demand management, utility coordination, leak control, and alternative supply offered transferable principles for other urbanizing areas, while Bulacan's experience with livelihood targeting, agricultural water interventions, and provincial-local support offered lessons for metropolitan fringes and peri-urban communities whose risks are not purely urban. City-to-city and province-to-city learning should therefore focus on mechanisms rather than copying projects. A rainwater catchment measure, for example, may serve household conservation in one setting and irrigation support in another.

Risk communication and participation remained significant in the multivariable results. Communication during El Niño has a behavioral function: households decide whether to conserve water, farmers decide when and what to plant, schools and workplaces adjust routines, and vulnerable individuals decide when to seek protection from heat. Communication must therefore be specific enough to support action. Messages that merely announce that El Niño exists are less useful than messages that explain the local condition, expected duration, current trigger, recommended behavior, responsible office, and next update schedule.

The action checklist illustrated this behavioral dimension. Metro Manila's high prevalence of water-conservation campaigns mirrored official 2024 calls to limit discretionary water use, inspect leaks, and collect rainwater.^{21,22} Such measures are effective only when citizens and institutional users understand why conservation is needed before service failures become visible. The same logic applies in Bulacan, where farmers and fisherfolk need timely information on water availability, crop strategies, assistance eligibility, and rehabilitation support.

The finding that location was not significant after governance capacity was included should not be interpreted to mean that geography and political economy were irrelevant. Bulacan and Metro Manila differ substantially in density, infrastructure, livelihoods, and exposure. Rather, the statistical result indicated that those contextual differences were mediated in part through governance choices. Institutions facing different risks could achieve comparable performance when they anticipated, coordinated, adapted, mobilized, learned, and communicated effectively.

This conclusion also aligned with the Sendai Framework's focus on disaster risk governance rather than hazard avoidance alone.⁷ Government cannot prevent El Niño from occurring, but it can influence the degree to which climate variability becomes livelihood loss, water insecurity, health stress, or service disruption. Adaptive governance provides the institutional mechanism by which risk information is converted into timely and proportionate action.

The Philippine legal framework supports this interpretation. RA No. 10121 requires proactive, integrated DRRM and recognizes local risk patterns, decentralized responsibilities, community participation, and multi-sector coordination.⁴ RA No. 9729 requires climate considerations to be integrated into development planning and explicitly links climate adaptation with disaster risk reduction.⁵ The governance challenge is therefore not a lack of legal authorization. It is the operational challenge of creating routines, information systems, financing arrangements, and coordination mechanisms that make those mandates work before impacts intensify.

5. Comparative Lessons for Adaptive El Niño Governance

Lesson 1: common governance capacities can support different intervention portfolios. Bulacan and Metro Manila did not need identical El Niño programs. The comparable overall DRR-performance scores, combined with clear differences in concrete measures, showed that adaptation should be evaluated by fit to risk rather than by uniformity. Metro Manila required intensive urban water-demand and utility coordination; Bulacan required stronger linkage between drought management, irrigation, food production, fisheries, and livelihood protection.

Lesson 2: shared water systems require cross-boundary governance. Angat-linked water security illustrates why provincial and metropolitan risk cannot be planned in isolation. Urban drinking-water demand, agricultural irrigation, reservoir conditions, watershed management, and downstream or upstream communities are interconnected. Climate intelligence should therefore be shared across institutions using common operating pictures and pre-agreed escalation triggers rather than institution-specific data silos.

Lesson 3: anticipatory action should be tied to explicit thresholds. Forecasts become operational when institutions define what action follows a given condition. Examples include reservoir or groundwater thresholds, consecutive below-normal rainfall periods, heat-index thresholds, crop-stage vulnerability, or projected demand-supply gaps. Thresholds should activate predefined communication, resource, coordination, and continuity measures while retaining room for professional judgment.

Lesson 4: adaptive governance requires a portfolio of reversible measures. Water conservation, work or class adjustments, temporary resource shifts, targeted assistance, and demand management can be intensified or relaxed as conditions change. This is preferable to a binary system in which institutions are either in normal operations or full crisis response. Staged actions reduce the cost of uncertainty.

Lesson 5: sectoral specialization should be coordinated through a shared governance structure. Agriculture offices should remain technically responsible for crops; utilities should remain responsible for network operations; health offices should manage health protections; and schools should manage education continuity. Adaptive governance does not erase specialization. It creates the information and decision architecture through which specialized offices act coherently.

Lesson 6: after-action learning should be treated as a preparedness investment. Each El Niño episode should end with documented review of which forecasts were useful, which measures were activated on time, where procurement or funding delayed action, which communities were missed, what communication changed behavior, and which infrastructure provided measurable benefit. The revised lessons should be incorporated into LDRMPs, Local Climate Change Action Plans, water-contingency plans, sector plans, and annual investment programming.

6. Proposed Adaptive Governance Framework for El Niño

The study proposed a six-stage adaptive cycle. Stage 1, Sense, consolidated PAGASA climate outlooks, dam and water-supply data, crop and soil conditions, heat indicators, health surveillance, and local reports into a shared risk picture. Stage 2, Anticipate, translated that information into sector scenarios and escalation thresholds. Stage 3, Coordinate, identified responsible offices, partner institutions, utilities, and intergovernmental links for each threshold.

Stage 4, Act and Adjust, implemented proportionate measures such as conservation campaigns, alternative water sourcing, leak reduction, agricultural support, heat protocols, continuity arrangements, and targeted assistance. Measures were reviewed at short intervals as new information became available. Stage 5, Communicate, provided the public and partner organizations with localized information on the current condition, required behavior, available assistance, and expected next update. Stage 6, Learn, compared outcomes with triggers and documented implementation gaps, then revised plans, inventories, procurement arrangements, agreements, and training priorities.

For Bulacan, the framework should explicitly integrate provincial agriculture, irrigation and water access, fisheries, livelihood protection, health, and municipal/barangay implementation. For Metro Manila, it should emphasize metropolitan water governance, utility coordination, demand management, heat-health measures, continuity of education and work, and inter-city learning. In both settings, vulnerable groups should be identified before crisis conditions so that assistance and communication can be targeted without delay.

7. Conclusion

The study found that adaptive governance was strongly associated with disaster risk reduction performance during the 2023-2024 El Niño episode. The most influential capabilities were interagency and multilevel coordination and anticipatory risk intelligence, but decision flexibility, resource mobilization, organizational learning, and risk communication also contributed independently. The evidence supported a systems interpretation of DRR: performance depended on several governance capacities operating together rather than on a single office, plan, or intervention.

Bulacan and Metro Manila displayed different adaptation profiles. Metro Manila showed a stronger anticipatory orientation and much greater prevalence of water-demand management, conservation communication, continuity adjustments, and utility partnerships. Bulacan showed a much greater emphasis on agriculture and livelihood protection, consistent with documented provincial measures for water access, irrigation, and rehabilitation assistance. Despite these differences, overall DRR performance was statistically comparable.

The principal lesson was therefore not that one jurisdiction should imitate the other. Effective El Niño governance required common institutional capabilities combined with context-specific action. Shared climate information, coordinated responsibilities, flexible

escalation, timely resource mobilization, clear public communication, and systematic learning allowed different jurisdictions to address different exposure pathways while pursuing the same resilience objective.

In practical terms, the next El Niño plan should begin before drought is visible. Risk thresholds should be agreed in advance, action portfolios should be staged, cross-boundary water and service dependencies should be mapped, vulnerable groups should be identified, and after-action learning should be incorporated into annual planning and investment decisions. These measures would strengthen the transition from episodic disaster response toward adaptive, risk-informed governance.

8. Recommendations

National and local DRRM institutions should institutionalize an El Niño early-action matrix that links climate and sector indicators to predefined actions. The matrix should identify the indicator, threshold, responsible office, supporting agencies, required resource, communication message, and review interval. This would make climate information operational and reduce ambiguity about when preparedness should escalate.

Bulacan should continue integrating drought preparedness with agriculture, irrigation, livelihood, fisheries, health, and local water-access programs. Provincial monitoring should distinguish municipalities and barangays according to crop dependence, water-source vulnerability, livelihood exposure, and access to alternative supply. Small water impounding, rainwater harvesting, efficient irrigation, drought-resilient production practices, and rapid rehabilitation support should be evaluated using outcome indicators rather than only counts of projects or beneficiaries.

Metro Manila should strengthen inter-city and utility coordination around a shared water-security and extreme-heat operating picture. Priority metrics should include reservoir and source status, demand, non-revenue water, alternative-source availability, localized pressure or interruption risk, heat indicators, and continuity disruptions. Water-conservation messaging should be tied to current conditions and supported by measurable demand-reduction goals.

Both settings should conduct formal post-El Niño reviews involving DRRM, planning, budget, water, agriculture, health, education, social welfare, utilities, civil society, and community representatives. The review should identify which measures were timely, which bottlenecks delayed action, which groups remained underserved, and what policy or investment changes are needed before the next ENSO cycle. Future empirical research should replace perception-only designs with mixed data. Administrative records, water and climate time series, budget utilization, crop-loss data, health surveillance, school-continuity records, and household or beneficiary surveys should be integrated. Multilevel longitudinal analysis would allow researchers to estimate whether particular adaptive-governance capabilities reduced measurable losses over time.

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