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Looking at Local Government Resilience through Network Data Envelopment Analysis

Sonny N. Domingo and Arvie Joy A. Manejar

CONTACT US:

RESEARCH INFORMATION DEPARTMENT
Philippine Institute for Development Studies

18th Floor, Three Cyberpod Centris - North Tower
EDSA corner Quezon Avenue, Quezon City, Philippines

publications@mail.pids.gov.ph
(+632) 8877-4000

https://www.pids.gov.ph

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Sonny N. Domingo
Arvie Joy A. Manejar

PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES

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Abstract

The study looked into the resilience of provincial governance in the Philippines to disaster risk using World Bank (WB) socio-economic resiliency estimates and cross-sectional data generated by the Department of Interior and Local Government (DILG) and the Philippine Statistics Authority (PSA) during the period 2012-2013. Treating provincial governments as decision making units (DMUs) with bureaucratic sub-units at the provincial and city/municipal levels, composite efficiency scores were generated using an integrated Data Envelopment Approach. A World Bank generated socio-economic resiliency scorecard at the provincial level provided comparative output references for the model. It was empirically shown that disaster risk reduction and management inputs at the provincial and sub-province levels greatly contribute to improving socio-economic capacity and decreasing asset risk. However, DMU efficiency scores varied across the different sub-regional domains. A majority of provincial subDMUs also got higher efficiency ratings compared to their municipal/community subDMU counterparts, implying the need to rebalance support and disaster resilience -related initiatives at the sub-provincial levels.

Keywords: Disaster Risk Reduction and Management, Disaster Resiliency, Data Envelopment Analysis

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Looking at local government resilience through network data envelopment analysis

Sonny N. Domingo and Arvie Joy Manejar[1]

1. Introduction

1.1 Background of the study

The passage of Republic Act 10121 or the Philippine Disaster Risk Reduction and Management (DRRM) Act of 2010, established four thematic pillars namely, prevention and mitigation; preparedness; response; and rehabilitation and recovery. The Department of Interior and Local Government (DILG) co-chaired the disaster preparedness, while the Department of Social Welfare and Development (DSWD) led disaster response. However, local government units (LGUs) retained their mandated autonomy under the Local Government Code of 1991.

The DILG, together with local government units, other institutional stakeholders and civil society organizations, has been working on sub-national disaster preparedness and capacity build-up to strengthen community resilience. Particular disaster preparedness initiatives include increasing the level of awareness of the community to the threats and impacts of all hazards, and risks and vulnerabilities; equipping the community with the necessary skills to cope with the negative impacts of a disaster; and developing comprehensive national and local disaster preparedness policies, plans and systems.

Also complementing national and subnational efforts, the DSWD implements social protection programs and addresses the subsistence needs of affected populations in times of calamities. It serves as focal agency for relief and ground activity during disaster events.

While a lot of DRRM initiatives emanate at the national level, the local government code of 1991 gives LGUs autonomy and the mandate as frontline and first responders in times of disasters. It also devolved the basic services and programs of national government along with disaster operations toward self-reliant LGUs. Local governance structure and dynamics, therefore, greatly define the grounding of DRRM policy and ultimately the capacity of communities to be resilient from shocks.

Resiliency at the sub-regional level is therefore very much a function of the PCM (province/city/municipal) bureaucracy, as supported by mandated executive agencies. Inputs from PCM sub-units contribute to whatever visible resilience measure at the provincial level. This study looked into the resiliency at the level of provincial governance, treating Provincial governments as decision making units with inputs from bureaucratic sub-units at the provincial and city/municipal levels. An integrated Data Envelopment Analysis model was used to come up with efficiency estimates at the provincial and sub-provincial levels.

1.2 Motivations and Objectives of the Study

This assessment draws from two main motivations.

First, the work toward applicable measures of disaster resiliency have long been tabled among both government and non-government institutions. The literature presents a multitude of

[1] Senior Research Fellow and Research Analyst II, respectively, at the Philippine Institute for Development Studies

measurement frameworks, both applied and in theory, looking into the subject matter. But there has yet to be a seminal undertaking on disaster resilience in the Philippines that can yield direct, practical, and applicable inputs for local executives and decision-makers both at the national and subnational levels. More contributions to the body of knowledge can only further augment our understanding of the disaster risk landscape and the required action toward disaster resiliency.

The second motivation takes into account the dynamism and complexity the Philippine sub-national bureaucracy. Sixteen regions, 81 provinces, 146 cities, 1488 municipalities and 42,045 barangays present hundreds of thousands of daily local government transactions with the intention to efficiently deliver service to the citizenry and other local constituents. Optimizing the efficiency of input delivery and complementation among the different governance levels necessitate apt understanding, particularly in the context of disaster risk reduction and management.

In keeping with the above, and underscoring the importance of policy research as it relates to disaster risk reduction and management and disaster resiliency, the study seeks to apply the methodology of network data envelopment analysis in looking at sub-regional DRRM inputs toward provincial level disaster risk resiliency. Provincial governments were treated as decision making units provided with resource and material inputs through their internal institutional structures and constituent municipal local governments. The study specifically,

• looks into the inputs and resources provided to local government units under the government's disaster risk reduction and management initiatives;
• identifies decision-making stages within local decision-making units and their corresponding input-output indicators, and come-up with resilience efficiency estimates; and,
• provides recommendations on policy, resource input allocation, and decision-making processes toward improving local resilience.

1.3 Caveats

The study made use of a PSA-WB generated disaster resiliency estimate in 2016. The variable presents a computed ratio between the expected asset loses to wellbeing losses given disaster hazard projections. Provincial-level estimates were made based on the available Family Income and Expenditure Survey (FIES) dataset (2012) at the time, which technically supports regional-level validity.

The study depended on a 2012-2015 cross sectional data from PSA and DILG. This is because the DILG has yet to publish a more recent comprehensive disaster preparedness assessment for all LGUs at the provincial, municipal and city levels.

Albeit LGUs are autonomous as enshrined under the local government code, there remains administrative and development-related connections between the provincial bureaucracy and its sub-provincial counterparts. Such is the basis for framing the community-level and provincial level subDMU institutional connection.

2. Review of Related Literature

2.1 Socio-economic Resiliency to Disasters

The World Bank (2019) added to the traditional use of hazard, exposure and vulnerability indicators for disaster loss prediction by computing for the ratio of expected asset losses to wellbeing losses, which they termed "socioeconomic resilience". Risk assessments usually include hazards or natural disaster risks; exposure or the value of natural and built assets that are at risk from destruction and damage; and vulnerability or the expected consequences of asset exposure when a destructive event occurs. These three elements inform the average annual asset losses in a certain political domain or area. On the other hand, wellbeing losses were estimated from consumption losses using a "welfare function" which accounts for the value of a household's consumption at each point as it recovers from a certain shock. Wellbeing losses cover the household's consumption losses over the duration of its recovery, giving more weight to the consumption losses experienced by poor people compared to non-poor counterparts.

The United Nations Office for Disaster Risk Reduction (UNDRR) designed a scorecard for local governments to monitor implementation of Sendai Framework for Disaster Risk Reduction 2015-2030. It follows UNDRR's 10 integral indicators for making cities resilient. The scorecard has two levels; the first one is a preliminary level responding to key Sendai framework targets and indicators with critical sub-questions. It is made up of 47 indicators with a 0-3 range. The second level is a detailed assessment with a multi-stakeholder perspective. It has a much larger criteria, 117 in total with 0-5 range and may take one to four months to collect (UNDRR 2017).

Table 1. Preliminary assessment

ESSENTIAL	INDICATOR
Organize for resilience	Plan making Organization, coordination and participation Integration
Identify, understand and use current and future risk scenarios	Hazard assessment Shared understanding of infrastructure risk Knowledge of exposure and vulnerability Cascading impacts Presentation and update process for risk information
Strengthen financial capacity for resilience	Knowledge of approaches for attracting new investment to the city Financial plan and budget for resilience, including contingency funds Insurance Incentives
Pursue resilient urban development	Land use zoning New urban development Building codes and standards Application of zoning, building codes and standards

Safeguard natural buffers to enhance protective functions by natural ecosystems	Awareness and understanding of ecosystem services/functions Integration of green and blue infrastructure into city policy and projects Transboundary environmental issues
Strengthen institutional capacity for resilience	Skills and experience Public education and awareness Data sharing Training delivery Languages Learning from others
Understand and strengthen societal capacity for resilience	Community or grassroots organizations, networks, and training Social networks, leave no one behind Private sector / employers Citizen engagement techniques
Increase infrastructure resilience	Critical infrastructure overview Protective infrastructure Water – potable and sanitation Energy Transport Communications Health care Education facilities First responder assets
Ensure effective disaster response	Early warning Event management plans Staffing/responder needs Equipment and relief supply needs Food, shelter, staple goods, and fuel supply Interoperability and inter-agency working Drills
Expedite recovery and build back better	Post-event recovery planning – pre-event Lessons learnt/learning loops

Source: UNDRR (2017)

2.2 Measuring efficiency of organizations though DEA

Organizations have struggled on how to improve productivity in workplaces which geared them towards measuring efficiency. If an economy is to be concerned with certain industries, it is integral to determine the extent of the industry to increase its output without increasing its inputs (Cook & Seiford 2009). The Data envelopment analysis (DEA) presented a convenient methodological option for this.

The DEA was first introduced through Edwardo Rhodes' dissertation centered on Program Follow Through in the United States. It evaluated the educational program for disadvantaged students across the public schools with support from the government by estimating multiple inputs and outputs without the vital information about prices. This eventually led to the formulation of the Charnes, Cooper, and Rhodes (CCR) ratio.

DEA was looked upon as an instrument to measure efficiency of decision-making units (DMUs). While DMUs are usually responsible for the conversion of inputs into outputs, the general definition gives room for all the other possible applications of the unit. In order to arrive at relative comparisons, DMUs are grouped together based on their degree of managerial freedom in decision making. DEA uses a ratio of weighted outputs and inputs and labelled as relative efficiency score which falls between 0 and 1 or as a percentage (Monfared and Safi 2013).

Mathematical programming is employed by DEA to handle many variables and constraints, lessening the difficulties usually encountered when there are limitations (Cooper et al. 2007). It deviates from the single regression plane and focuses on optimizing individual observations, all the while creating a possibility frontier determined by Pareto-efficient DMUs.

In conventional DEA, DMUs are treated as a black box where inputs and outputs enter and exit respectively, but there is no further insight regarding the processes within (Lewis and Sexton 2004). In contrast, the network DEA paradigm has multi-stage processes where the internal structure of the DMUs is seen as an integral part of the efficiency assessment (Fare and Grosskopf 2000; Despotis et al. 2015).

There are various approaches in efficiency assessments in the network DEA approach, particularly in two-stage series processes. Multiplicative decomposition approach and the additive decomposition approach both assume that similar weights are used for intermediate measures even if they are outputs in the first stage and inputs in the second stage (Kao and Hwang 2008; Chen et al. 2009). The more recent approach was composition paradigm wherein estimations of the two stages are estimated first, and the overall efficiency is obtained through results rather than forecasts. A major advantage of this approach over the additive and multiplicative approaches is that it generates unbiased efficiency scores, but it cannot be readily adapted into multi-stage series processes. The two-stage DEA method was extended to a multi-stage network by Lewis and Sexton in 2004 (Despotis et al. 2015). Various models under network DEA have been introduced such as relational network DEA approach, weighted additive efficiency decomposition approach, SBM-NDEA approach, network slacks-based inefficiency (NSBI) approach and the network DEA scale and cost-efficiency approach among others (Moreno and Lozano 2014).

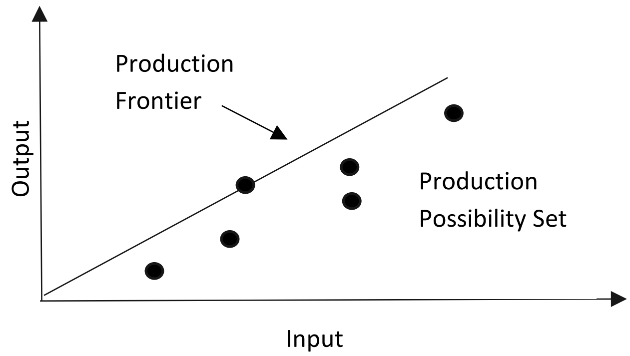
DEA models do not usually look into the operations within a DMU, thus there is no way of knowing whether any of the subDMUs is inefficient. This limitation is addressed in network DEA models as they assume that each DMU is comprised of subDMUs with corresponding inputs and contribution to the DMU output. This study applied the methodology of Network DEA in looking into sub-regional disaster resiliency among PCM decision-making units in the context of disaster risk management.

2.3 Conventional DEA Models

DEA models can be either input-oriented or output-oriented. The former minimizes inputs and satisfies the given output levels while the latter maximizes outputs without adding more inputs. Returns to scale can also be another basis for categorization by adding weight constraints. Constant returns to scale assumes that DMUs are operating at their optimum, and variable returns to scale allows the breakdown of efficiency into technical and scale ones (Ji & Lee 2010).

Charnes, Cooper, and Rhodes (CCR) model was the very first model to be developed. It follows constant returns to scale of activities and assumes that the production possibility set has the following property: if (*x,y*) is attainable, then (*tx, ty*) for any positive t is also attainable. The CCR model can also be categorized as input-oriented or output-oriented. The model is shown below observing constant returns to scale; the variables are initially restricted to be non-negative (Charnes et al. 1978).

Figure 1. Production frontier, CCR model



Source: Cooper et al. 2007

Figure 2. CCR Model

$$e_o = max \sum_r u_r y_{ro} / \sum_i v_i x_{io}$$

$$\text{s.t.} \quad \sum_r U_r \, y_{ro} - \sum_i v_i \, x_{ij} \leq 0, \text{all } j$$

$$u_r v_i \geq \varepsilon, \text{all } r, i.$$

Source: Cook & Seiford 2009

Various extensions of CCR model have been introduced since then. Examples of these are Banker-Charnes-Cooper (BCC) model, additive model, and slacks-based measure of efficiency (SBM), hybrid measure of efficiency, and Russell measure Model. BCC's production frontier follows a convex hull of existing DMUs. The frontiers first lead to variable returns to scale characterization with increasing returns-to-scale in the first line segment, decreasing returns-to-scale in the second one, and constant returns-to-scale at the junction where the transition from first to second segment is made.

Additive model has the same production possibility set as the BCC and CCR models and their variants but treats the input excesses and output shortfalls in the objective function and can discriminate efficient and inefficient DMUs. However, the model cannot measure the magnitude of inefficiency by a scalar measure. In the additive model created by Charnes, Cooper, Golany, Seiford, and Stutz, input and output orientations are combined into a single model.

Slacks-based measure of efficiency (SBM) is introduced to amplify the additive models by using a measure that makes its efficiency evaluation invariant to the measures used for the varying inputs and outputs. Introduced by Tone, SBM is a single scalar with the following features:

1. Relative to the unit of measurement of each input and output, the measure is invariant.
2. SBM has a decreasing monotone in both input and out slacks.

Another measure of efficiency found in the literature is the hybrid measure of efficiency. This measure combines radial and non-radial measures in DEA. CCR and BCC models represent the radial approach but fails to recognize non-radial input/output slacks, but this is answered for by the SBM, neglecting the radial characteristics of inputs and outputs on the other hand. With the hybrid measure, the efficiency values based on CCR and SBM models can now be compared. Moreover, the Hybrid model's inputs and outputs can be turned into radial or non-radial.

Russell Measure Model was introduced first by Fare and Lovell in 1978, developed by Pastor, Ruiz, and Sirvent and is referred to as Enhanced Russell Measure (ERM). The measure includes all inefficiencies that the model can identify, avoiding limitations set by the radial measures which cover only measures of weak efficiency.

2.4 Network Data Envelopment Analysis (DEA)

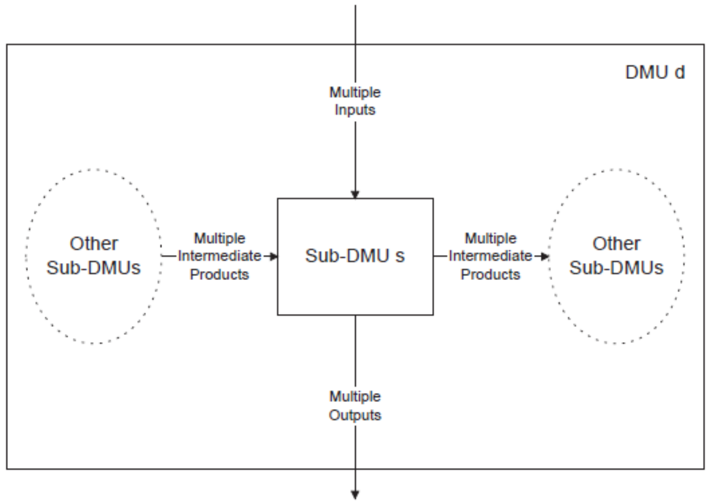
CCR and BCC models fall under conventional DEA wherein they have one-stage production processes where the relationships of the DMUs with each other are not taken into account. DMUs are treated as a black box where inputs and outputs enter and exit respectively, but there is no further insight regarding the processes within (Lewis and Sexton 2004). In contrast, the network DEA paradigm has multi-stage processes where the internal structure of the DMUs is seen as an integral part of the efficiency assessment (Fare and Grosskopf 2000; Despotis et al. 2015).

There are various approaches in efficiency assessments in the network DEA approach, particularly in two-stage series processes. Multiplicative decomposition approach and the additive decomposition approach both assume that similar weights are used for intermediate measures even if they are outputs in the first stage and inputs in the second stage (Kao and Hwang 2008; Chen et al. 2009). The more recent approach was composition paradigm wherein estimations of the two stages are estimated first, and the overall efficiency is obtained through results rather than forecasts. A major advantage of this approach over the additive and multiplicative approaches is that it generates unbiased efficiency scores, but it cannot be readily adapted into multi-stage series processes. The two-stage DEA method was extended to a multi-stage network by Lewis and Sexton in 2004 (Despotis et al. 2015). Various models under network DEA have been introduced such as relational network DEA approach, weighted additive efficiency decomposition approach, SBM-NDEA approach, network slacks-based inefficiency (NSBI) approach and the network DEA scale and cost-efficiency approach among others (Moreno and Lozano 2014).

Compared to Network DEA, traditional DEA models do not usually look into the operations within a DMU, thus there is no way of knowing whether any of the subDMUs is inefficient. There are also areas of concern towards the misleading results of efficiency scores given by a single-process DEA. A DMU with better and more efficient processes can be made worse off than a DMU with bad interventions (Kao 2014). Being able to pinpoint the sources of inefficiency within an organization could aid the DMU look for ways on how to improve its overall performance (Monfared and Safi 2013). The network DEA model assumes that each DMU is comprised of subDMUs. An input of a subDMU can be considered as external to the

DMU or is actually an output from another subDMU as seen in the figure below (Lewis and Sexton 2004).

Figure 3. Internal arrangement of a DMU in a Network DEA model



Source: Lewis & Sexton 2004

3. Framework and Methodology

3.1 Dynamic Network DEA

The methodology used in the study is patterned over the works of Tone and Tsutsui (2014) and Tran and Villano (2018), adopting the dynamic network DEA slacks-based approach:

Let n provincial DMUs $(j = 1, \dots, n)$ consist of K subDMU units$(k = 1, \dots, K)$ over time period T, mk and rk be the numbers of inputs and outputs to subDMU k, respectively. The link leading from division k to division h is denoted by $(kh)i$ and the set of links by Lkh. The inputs, outputs, linking, and carry-over variables are described as follows:

(1) $x^t_{i\,jk} \in R+$ $(i = 1, \dots, mk; j = 1, \dots, K; t = 1, \dots, T)$ is the input resource i to $DMUj$ for subDMU k in period t;

(2) $y^t_{r\,jk} \in R+$ $(r = 1, \dots, rk; j = 1, \dots, K; t = 1, \dots, T)$ is the output product r from $DMUj$, subDMU k, in period t;

(3) $z^t_{j(kh)}l \in R+$ $(j = 1, \dots, mk ; l = 1, \dots, Lkh; t = 1, \dots, T)$ is the linking intermediate products

of $DMUj$ from subDMU k to subDMU h in period t, where Lkh is the number of items in the

link from k to h; and

(4) $z^{(t,\, t+1)}jkl \in R+$ $(j = 1, \dots, mk ; l = 1, \dots, Lk ; k = 1, \dots, K; t = 1, \dots, T - 1)$ is the carryover

of $DMUj$, at subDMU k, from period t to period $t + 1$, where Lk is the number of items in the carry-over from subDMU *k*.

Let the production possibility *Pt* = {*(xtk, ytk, zt(kh), z(t,t*+1*)ik)*} *(t* = 1, . . . ,*T)* be defined

Let the objective function be defined for the following:

SubDMU efficiency

$$\delta_0^{t*} = \sum_{t=1}^{T} W^t \left[1 - \frac{1}{m_k + linkin_k + ncarry_k} \left(\sum_{i=1}^{m_k} \frac{s_{iok}^{t-}}{x_{iok}^t} + \sum_{kh_t=1}^{linkin_k} \frac{s_{o(kh)_t in}^t}{z_{o(kh)_t in}^t} + \sum_{k_t=1}^{ncarry_k} \frac{s_{ok_t carry}^{t(t+1)}}{z_{ok_t carry}^{t(t+1)}} \right) \right]$$

Overall efficiency

$$\theta_o^* = \min \sum_{t=1}^{T} W^t \times \left[\sum_{k=1}^{K} w^k \left[1 - \frac{1}{m_k + linkin_k + ncarry_k} \left(\sum_{i=1}^{m_k} \frac{s_{iok}^{t-}}{x_{iok}^t} + \sum_{kh_t=1}^{linkin_k} \frac{s_{o(kh)_t in}^t}{z_{o(kh)_t in}^t} + \sum_{k_t=1}^{ncarry_k} \frac{s_{ok_t carry}^{t(t+1)}}{z_{ok_t carry}^{t(t+1)}} \right) \right] \right]$$

Where $linkin_k$ is the number of as-input links from subDMU *k; and* $ncarry_k$ *as the* carried over link variables across subDMUs.

The network DEA model runs were supplemented with key informant discussions and focused group discussions with provincial, city and municipal stakeholders.

3.2 Dynamic network framework

This study relied on this socioeconomic resilience estimate as an indicative output measure for subregional level disaster-resilience related inputs. It must be noted though that the estimates were sourced from the applicable family income and expenditure survey (FIES), which has constrained technical validity.

Consistent with the requirements of the adopted dynamic network DEA approach, the study designated the 81 provincial governments in the country as the main decision-making units for the model. A couple of provinces failed to be included in the model because of data limitations and incompatibility. Contributing to the desired outputs and efficiency of the provincial DMU are subDMUs at the municipal or community level, as well as the bureaucracy at the provincial level.

Inputs at the municipal subDMU include: the municipal LDRRM Fund, LDRRM Plan, Contingency Plan, Local Climate Change Adaptation Plan, Standard Operation Procedures, Organized LDRRMC and LDRRMO, Early warning system, Evacuation Center, Organized Search& Rescue, and prepositioned relief operations, medical and security services.

Inputs at the provincial subDMU level include: Provincial DRRM Fund, updated PDPFP, social protection for poor people, social protection for non-poor people, access to early warning for poor people, and access to early warning for nonpoor people. Carry-over and link variables include Municipal/City Disaster Preparedness Compliance, DRRM community infrastructure, and DRRM provincial level infrastructure.

The output variables are Socio-economic Capacity Resilience and Reduced Risk to assets. Figure 4 presents the dynamic network framework for assessing provincial DMUs with regard to disaster resilience.

Figure 4. Dynamic network framework for assessing provincial DMUs and subDMUs

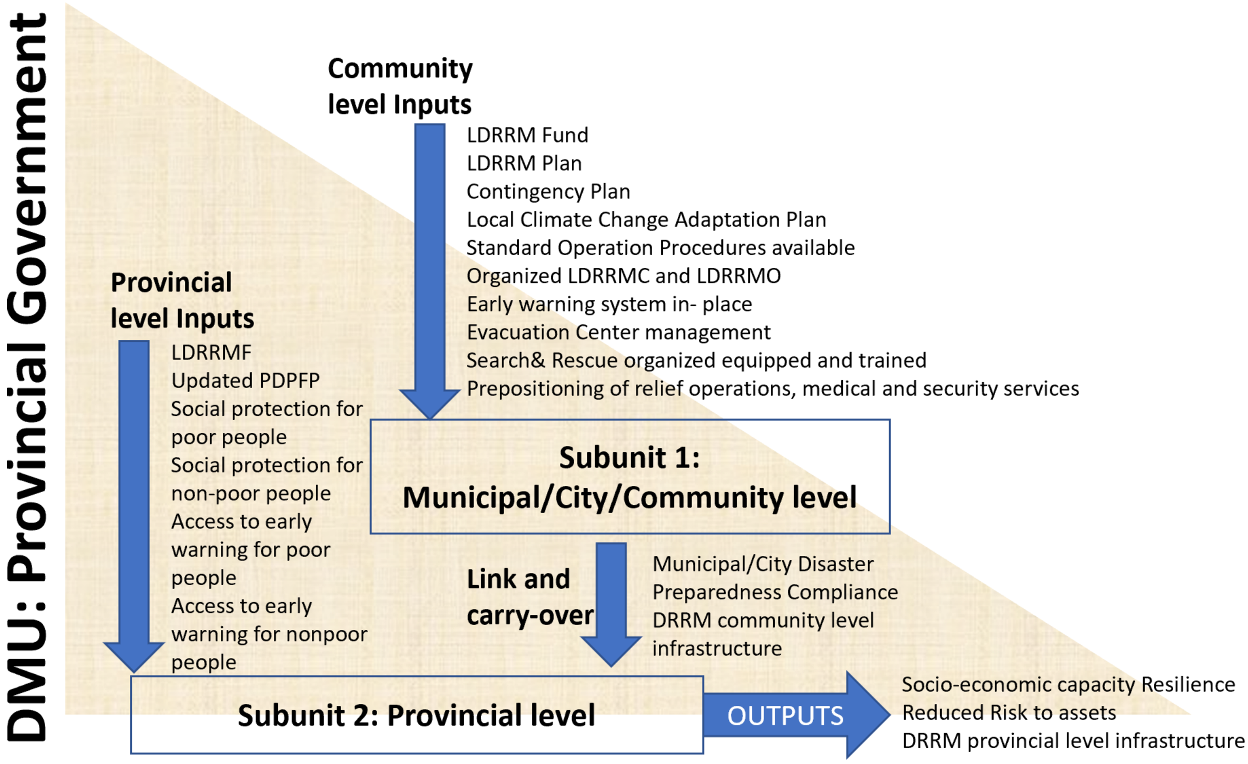


Table 2. Description of variables used in the Network DEA model

DMU: Provincial Government		
Variable		
Subunit 1: Community level Variables	Input/Output Description	Category
I1c	LDRRM Fund[2]	input
I2c	LDRRM Plan[3]	input
I3c	Contingency Plan[4]	input
I4c	Local Climate Change Adaptation Plan[5]	input
I5c	Standard Operation Procedures available[6]	input
I6c	Organized LDRRMC and LDRRMO[7]	input
I7c	Early warning system in- place[8]	input
I8c	Evacuation Center management[9]	input
I9c	Search& Rescue organized, equipped, and trained[10]	input

[2] Sourced from BLGF (2020) LGU Fiscal Data. Available at http://blgf.gov.ph/lgu-fiscal-data/#LFD
[3] Sourced from BLGS-DILG (2015). Disaster Preparedness Profile SGLG 2014 Assessment Period. Available athttps://www.dilg.gov.ph/reports-and-resources
[4] Sourced from BLGS-DILG (2015)
[5] Sourced from BLGS-DILG (2015)
[6] Sourced from BLGS-DILG (2015)
[7] Sourced from BLGS-DILG (2015)
[8] Sourced from BLGS-DILG (2015)
[9] Sourced from BLGS-DILG (2015)
[10] Sourced from BLGS-DILG (2015)

I10c	Prepositioning of relief operations, medical and security services[11]	input
L1cp	Municipal/City Disaster Preparedness Compliance[12]	link
C1c	DRRM community level infrastructure	carry-over
Subunit 2: Provincial level Variables		
I1p	Updated PDPFP[13]	input
I2p	Social protection for poor people[14]	input
I3p	Social protection for non-poor people[15]	input
I4p	Access to early warning for poor people[16]	input
I4p	Access to early warning for nonpoor people[17]	input
O1p	Socio-economic capacity Resilience[18]	output
O2p	Reduced Risk to assets[19]	output
C2p	DRRM provincial level infrastructure	carry-over

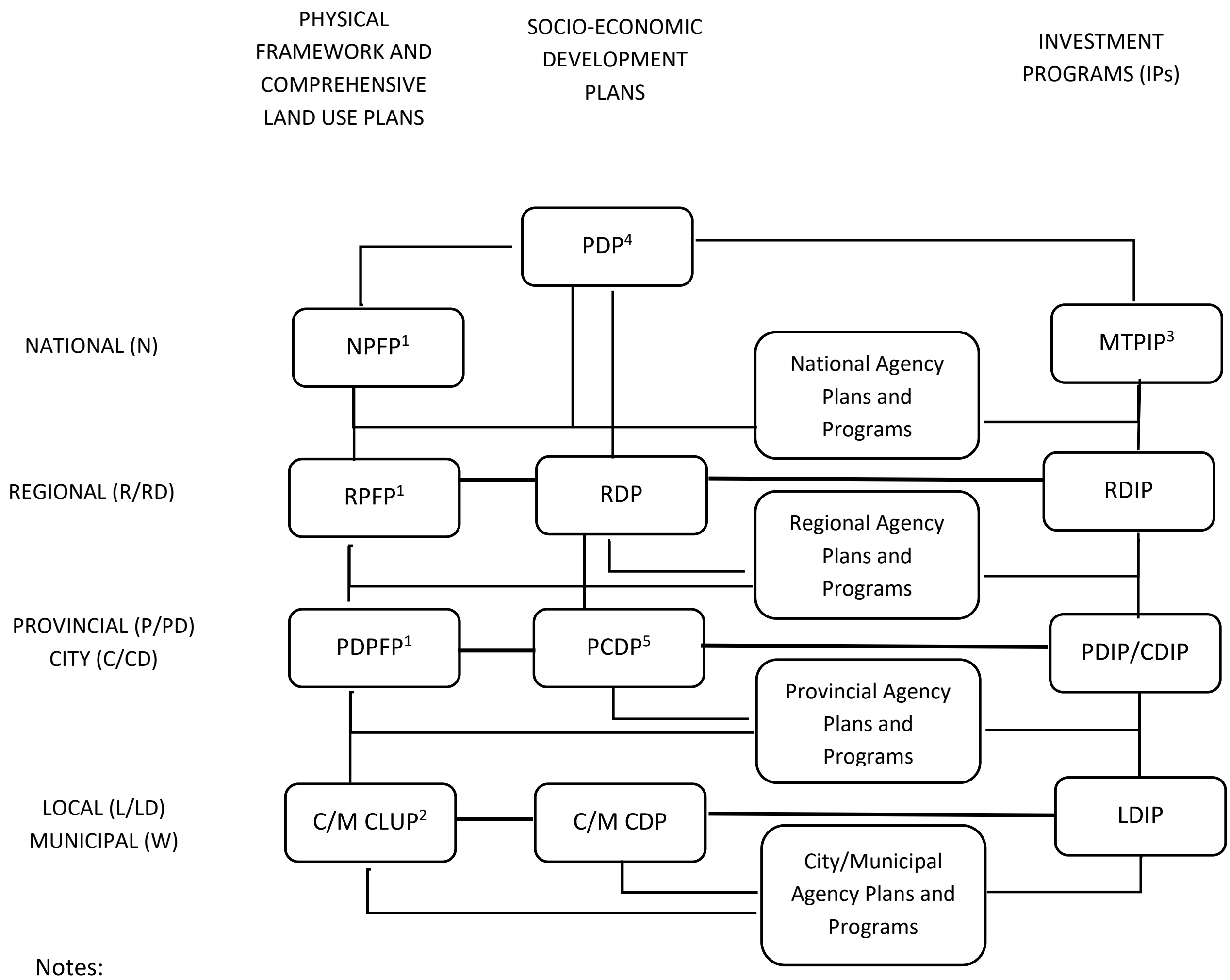
4. Results and Discussion

Local planning, budgeting, and implementation have been intertwined with national, regional, and provincial frameworks since the passage of the Local Government Code. While the policy promised autonomy and devolution of services, it maintained that there should be harmonization of plans and initiatives in all levels of the government to deliver a holistic approach in governance and development. This is better presented by Figure 5 below. As what can be observed, all plans from national to local are interlinked alongside their socio-economic development plans and investment programs.

The most important to consider were the guidelines on updating of local plans incorporated in Memorandum Circulars 2015-77 and 2016-102 issued by the DILG. It mandated for the mainstreaming of climate change and disaster risk reduction and management initiatives within local planning documents namely, Comprehensive Land Use Plan, Comprehensive Development Plan, Local Climate Change Action Plan, Contingency Plan, and Comprehensive Disaster Risk Assessment. As observed, some of these are reflected as community-level variables, and these documents, in turn, inform the community's resilience and reduced risk through the materialization of activities, equipment, and mechanisms in place.

[11] Sourced from BLGS-DILG (2015)
[12] Sourced from BLGS-DILG (2015)
[13] Sourced from BLGS-DILG (2015)
[14] PSA (2016) and World Bank (2016) Socioeconomic resilience scorecard estimate
[15] PSA (2016) and World Bank (2016) Socioeconomic resilience scorecard estimate
[16] PSA (2016) and World Bank (2016) Socioeconomic resilience scorecard estimate
[17] PSA (2016) and World Bank (2016) Socioeconomic resilience scorecard estimate
[18] PSA (2016) and World Bank (2016) Socioeconomic resilience scorecard estimate
[19] PSA (2016) and World Bank (2016) Socioeconomic resilience scorecard estimate

Figure 5. Hierarchy and linkage of plans



Notes:
[1] PFP = (N/R/P) Physical Framework Plan
[2] CLUP = (P/C/M) Comprehensive Land Use Plan
[3] MTPIP = Medium Term Philippine Investment Plan
[4] CDP = (P/C/M) Comprehensive Development Plan
[5] PDP = Philippine Development Plan

Source: Housing and Land Use Regulatory Board (2013)

A number of local government units are yet to fulfill the mainstreaming guidelines by the DILG; others are still updating their CLUP into enhanced versions of the planning document while some have not yet come up with their own. Anecdotal narratives on the ground attribute the delay in completion to the lack of coordination among the offices of the LGU, nonfunctional technical working groups, and low absorptive capacity of the institutions. The fast turnover of technical staff contributed to similar delays alongside limited fiscal resource that could have facilitated data collection, capacity building activities, database and GIS trainings, and equipment.

The targeted alignment and harmonization of plans were not reflected among the interviewed LGUs; they did not translate into similar goals and objectives for the development of the municipality. Further, vertical coordination is not evident among the involved institutions with the barangay concerns at the bottom of the hierarchy of program prioritization and sectoral representation invisible in the participation process.

Another consideration would be the fiscal aspect and the bureaucratic delays of budget programming. This was tied with the formulation of annual investment programs wherein prioritization is ultimately influenced by the local chief executive. Despite the availability of funds, local DRRM funds were observed to be unutilized, mainly due to the varying interpretations and advices from COA on how to utilize such funds and the hesitancy of some LGUs to use it for smaller PPAs. When funding was lacking, it has been observed that LGUs relied on external assistance, particularly lower class municipalities which cannot push for greater shares for DRR-related expenditures, but most of the time, they lack the mechanism and proper channels to subject the foreign aid to. What resulted were the non-turnover of results, few benefits received, and duplication of efforts. This greatly reflected the performance of LGUs in attempting to increase the resiliency of their communities and reduce their vulnerabilities. The following results show empirical data relating the strength of inputs from provincial to municipal and how they correlate to bring about efficiency in the field of disaster risk management.

In Table 3 below, the DMUs exhibit normal distribution for most of the inputs with minimal deviation, particularly for social protection and early warning access to both poor and non-poor groups. It is understandable that for early warning systems, distinction cannot be made between income classes especially during times of disasters; the alarms will be easily accessible to anyone. Social protection, on the other hand, can be discriminated against the poor people but this was not the case for the 79 DMUs. Majority of the DMUs also fulfilled documentary requirements for local planning e.g. Local DRRM Plans, Local Climate Change Action Plans, and Contingency Plans. This also meant that the programmed infrastructure and equipment reflected in those plans are present – early warning structures, evacuation centers, search and rescue operations, preparatory goods, standard of operations. However, the basis for alignment – an updated Provincial Development and Physical Framework Plan (PDPFP) – landed just half in the distribution which implies that while local planning documents are present, they do not thrust in the same direction with the provincial government. In terms of deviation, the variables municipal and provincial DRRM funds exhibited high scores for standard deviation; some DMUs may be very well endowed in terms of financial resources while others may be very limited. This is similarly echoed in the narratives gathered during field visits. Over-all, in the matters of efficiency, provincial subDMUs have higher efficiency estimates compared to the municipal subDMUs, and their overall dynamic efficiency averaged 0.48 out of 1.00.

Table 3. Summary statistics on model inputs and outputs

Variable	Label	Obs	Mean	Std. Dev.	Min	Max
dmu	Decision-making unit	79				
social_p	Social protection for poor	79	0.133763	0.045947	0.019545	0.243194
social_r	Social protection for non-poor	79	0.195065	0.064437	0.026019	0.351289
ewpoor	Early warning access for poor	79	0.145344	0.065668	0.033529	0.333425
ewnonp	Early warning access for non-poor	79	0.133763	0.045947	0.019545	0.243194
LDRRMFprov	Local DRRM Fund of province	79	40.59697	19.17747	11.05886	86.06492

office	Organized LDRRMC and LDRRMO	79	0.962025	0.192356	0	1
drrplan	Local DRRM Plan	79	0.924051	0.26661	0	1
pdpfp	Updated Provincial Development and Physical Framework Plan (PDPFP)	79	0.582279	0.496335	0	1
cp	Contingency Plan	79	0.924051	0.26661	0	1
ccplan	Local Climate Change Adaptation Plan	79	0.873418	0.334629	0	1
ewstruc	Presence of early warning system	79	0.962025	0.192356	0	1
evac	Presence of evacuation	79	0.949367	0.220648	0	1
sar	Search and rescue organized, equipped and trained	79	0.949367	0.220648	0	1
prep_goods	Prepositioning of relief operations, medical, and security services	78	0.948718	0.222	0	1
sop	Standard operation procedures available	79	0.924051	0.26661	0	1
pppasser	Provincial preparedness passer	79	0.911392	0.285992	0	1
mppasser	Municipal preparedness passer	79	0.733251	0.236336	0	1
kalasag	Gawad Kalasag awardee	79	0.025317	0.158088	0	1
resilience	Socio-economic capacity resilience	79	0.572039	0.287424	0.234577	1.7098
assets_risk	Reduced risk to assets	79	0.017486	0.025476	5.19E-05	0.108513
LDRRMFmun	Local DRRM fund of municipality	79	58.11	32.26217	4.67	145.32
proveff	Efficiency score of provincial subDMU	79	0.621086	0.242205	0.237342	1
muneff	Efficiency score of municipal subDMU	79	0.407503	0.223261	0.112131	1
provrank	Efficiency ranking of provincial subDMU	79	39.81013	23.25779	1	79
munrank	Efficiency ranking of municipal subDMU	79	39.92405	23.07556	1	79
wproveff	Weight of provincial subDMU	79	0.21738	0.084772	0.08307	0.35
wmuneff	Weight of municipal subDMU	79	0.264877	0.14512	0.072885	0.65
dynamiceff	Dynamic efficiency	79	0.482257	0.217077	0.17466	1

The same observation can be culled from Table 4 below. The DMUs have higher efficiency scores in the provincial levels compared to the municipal. Out of 79 DMUs, 12 scored a maximum 1.0 for provincial efficiency while only four (4) DMUs managed to have 1.0 for municipal efficiency. As for the dynamic efficiency which considers the carry over indicators and links from province to municipal levels, only four (4) managed to get the maximum – Basilan, Batanes, Benguet, and Guimaras. They also had the maximum scores for the previous two measures (1.0). It is interesting to note the topography and existing conditions of these DMUs. Batanes is a province frequented by typhoons – learnings from numerous experiences may have enabled a good working, collaborative environment for DRRM efforts to flourish and be successful. Another province is Benguet, also located in the northern part of the Philippines. They experience constant rainfall amid their highland areas widely cultivated with high-value crops. Guimaras, on the other hand, is a province in Western Visayas and is an island economy. This geographic characteristic alone could have put them in a disadvantage, but their efficiency scores say otherwise. For the Mindanao, it was the province of Basilan which landed first, contrary to the impression that it is often ravaged by manmade disasters and conflicts.

Table 4. Efficiency estimates

DMU	Provincial Efficiency	Municipal Efficiency	Dynamic Efficiency
dmu:Abra	0.703511	0.344018	0.46984055
dmu:Agusan_del_Norte	0.384195	0.346168	0.35947745
dmu:Agusan_del_Sur	0.41306	0.185882	0.2653943
dmu:Aklan	1	0.829783	0.88935895
dmu:Albay	0.307823	0.216348	0.24836425
dmu:Antique	0.548357	0.474017	0.500036
dmu:Apayao	0.538264	0.192909	0.31378325
dmu:Aurora	0.665655	0.352795	0.462296
dmu:Basilan	1	1	1
dmu:Bataan	1	0.744108	0.8336702
dmu:Batanes	1	1	1
dmu:Batangas	0.842315	0.310521	0.4966489
dmu:Benguet	1	1	1
dmu:Biliran	0.902247	0.771266	0.81710935
dmu:Bohol	0.360593	0.182291	0.2446967
dmu:Bukidnon	0.435658	0.188731	0.27515545
dmu:Bulacan	0.843749	0.412197	0.5632402
dmu:Cagayan	0.751384	0.29361	0.4538309
dmu:Camarines_Norte	0.744532	0.315549	0.46569305
dmu:Camarines_Sur	0.411098	0.180678	0.261325
dmu:Camiguin	0.701363	0.642501	0.6631027
dmu:Capiz	0.641818	0.337199	0.44381565
dmu:Catanduanes	0.493642	0.413746	0.4417096
dmu:Cavite	0.799969	0.479586	0.59172005
dmu:Cebu	0.538805	0.251281	0.3519144
dmu:Compostela_Valley	0.538802	0.26232	0.3590887
dmu:Cotabato	0.303068	0.128526	0.1896157
dmu:Davao	0.516674	0.325857	0.39264295
dmu:Davao_del_Sur	0.567249	0.414049	0.467669
dmu:Davao_Oriental	0.340438	0.198536	0.2482017
dmu:Eastern_Samar	0.431448	0.545033	0.50527825
dmu:Guimaras	1	1	1
dmu:Ifugao	1	0.539183	0.70046895
dmu:Ilocos_Norte	0.689961	0.500297	0.5666794

dmu:Ilocos_Sur	0.743873	0.363552	0.49666435
dmu:Iloilo	0.520746	0.268118	0.3565378
dmu:Isabela	0.878831	0.258334	0.47550795
dmu:Kalinga	0.617503	0.440574	0.50249915
dmu:La_Union	0.65792	0.344053	0.45390645
dmu:Laguna	0.736252	0.511314	0.5900423
dmu:Lanao_del_Norte	0.28611	0.258381	0.26808615
dmu:Lanao_del_Sur	0.353949	0.120721	0.2023508
dmu:Leyte	0.785156	0.59022	0.6584476
dmu:Maguindanao	0.347575	0.112131	0.1945364
dmu:Marinduque	0.547889	0.378116	0.43753655
dmu:Masbate	0.509038	0.38485	0.4283158
dmu:Misamis_Occidental	0.349332	0.24711	0.2828877
dmu:Misamis_Oriental	0.965868	0.496029	0.66047265
dmu:Mountain_Province	0.592483	0.452633	0.5015805
dmu:Negros_Occidental	0.28099	0.212684	0.2365911
dmu:Negros_Oriental	0.244409	0.162204	0.19097575
dmu:Northern_Samar	0.879951	0.775642	0.81215015
dmu:Nueva_Ecija	0.674691	0.253217	0.4007329
dmu:Nueva_Vizcaya	1	0.44643	0.6401795
dmu:Occidental_Mindoro	0.417972	0.249847	0.30869075
dmu:Oriental_Mindoro	0.405243	0.248853	0.3035895
dmu:Palawan	0.901128	0.718373	0.78233725
dmu:Pampanga	0.700274	0.488226	0.5624428
dmu:Pangasinan	0.57218	0.165664	0.3079446
dmu:Quezon	0.257915	0.136352	0.17889905
dmu:Quirino	1	0.533961	0.69707465
dmu:Rizal	1	0.73191	0.8257415
dmu:Romblon	0.649417	0.710223	0.6889409
dmu:Samar	0.446272	0.181894	0.2744263
dmu:Sarangani	0.25098	0.186631	0.20915315
dmu:Siquijor	0.940982	0.634202	0.741575
dmu:Sorsogon	0.575136	0.235303	0.35424455
dmu:South_Cotabato	0.388652	0.320412	0.344296
dmu:Southern_Leyte	0.407933	0.517184	0.47894615
dmu:Sultan_Kudarat	0.237342	0.140908	0.1746599
dmu:Sulu	1	0.520583	0.68837895
dmu:Surigao_del_Norte	0.542547	0.424879	0.4660628
dmu:Surigao_del_Sur	0.43135	0.415524	0.4210631
dmu:Tarlac	0.663894	0.487293	0.54910335
dmu:Tawi-tawi	1	0.537993	0.69969545
dmu:Zambales	0.656993	0.323313	0.440101
dmu:Zamboanga_del_Norte	0.309226	0.294876	0.2998985
dmu:Zamboanga_del_Sur	0.349956	0.235709	0.27569545
dmu:Zamboanga_Sibugay	0.572116	0.297292	0.3934804

While provincial efficiency estimates have the highest mean vis-à-vis municipal efficiency and dynamic efficiency scores, it also had the highest standard deviation at 0.24 as seen in Table 5 below. This implies that the efficiency values of the DMUs vary more widely compared to the other two and are slightly far from the figure of the mean. However, it still remains that out of 79 DMUs, 15.19 percent of them have efficient DRRM systems in the provincial level whereas only 5.06 percent of the DMUs have efficient municipalities.

The mean efficiency scores presented in Table 5 show extensive differences in subDMU performance. The mean efficiency estimates were 0.62 for the provincial subDMU, 0.41 for the municipal subDMU and 0.48 for the Dynamic network.

Provincial level subDMUs seemed to outperform their municipal subDMU counterparts in terms of aggregate efficiency. It must be noted though that the setting at the municipal level is more complex than in the province. There are currently 1488 municipalities in the country, compared to just 81 provinces. The aggregate efficiency rating of the former is therefore qualified. The dynamic efficiency score was computed by assigning weights to the two subDMUs. Given the extent of municipal subDMU operations, it was assigned a weight of 65% as opposed to 35% for the provincial subDMU. This result is indicative of the need to further augment the bureaucratic machinations, particularly on disaster resiliency- related work compliance, at both the municipal and provincial subDMU levels.

Table 5. Summary statistics on efficiency estimates

	ProvEff	MunEff	DynamicEff
Observations	79	79	79
Mean	0.6210855	0.4075026	0.4822566
Std. Dev.	0.242205	0.2232608	0.2170769
Min	0.237342	0.112131	0.1746599
Max	1	1	1
Efficient DMU Count	12	4	4
Percent Efficient	15.19	5.06	5.06

Spearman's rank correlation coefficients among the efficiencies of the municipal level and provincial level subDMUs and the overall efficiency of the dynamic network are presented in Table 6. All correlations among the efficiencies are significant at 1% level, although the correlation is smallest between the municipal and provincial subDMUs. This implies that the link between municipal and provincial subDMUs via the disaster preparedness compliance input needs to be strengthened. The overall dynamic network efficiency is strongly correlated to both municipal and provincial level subDMUs, with the municipal level efficiency contributing a bit more to the resiliency performance.

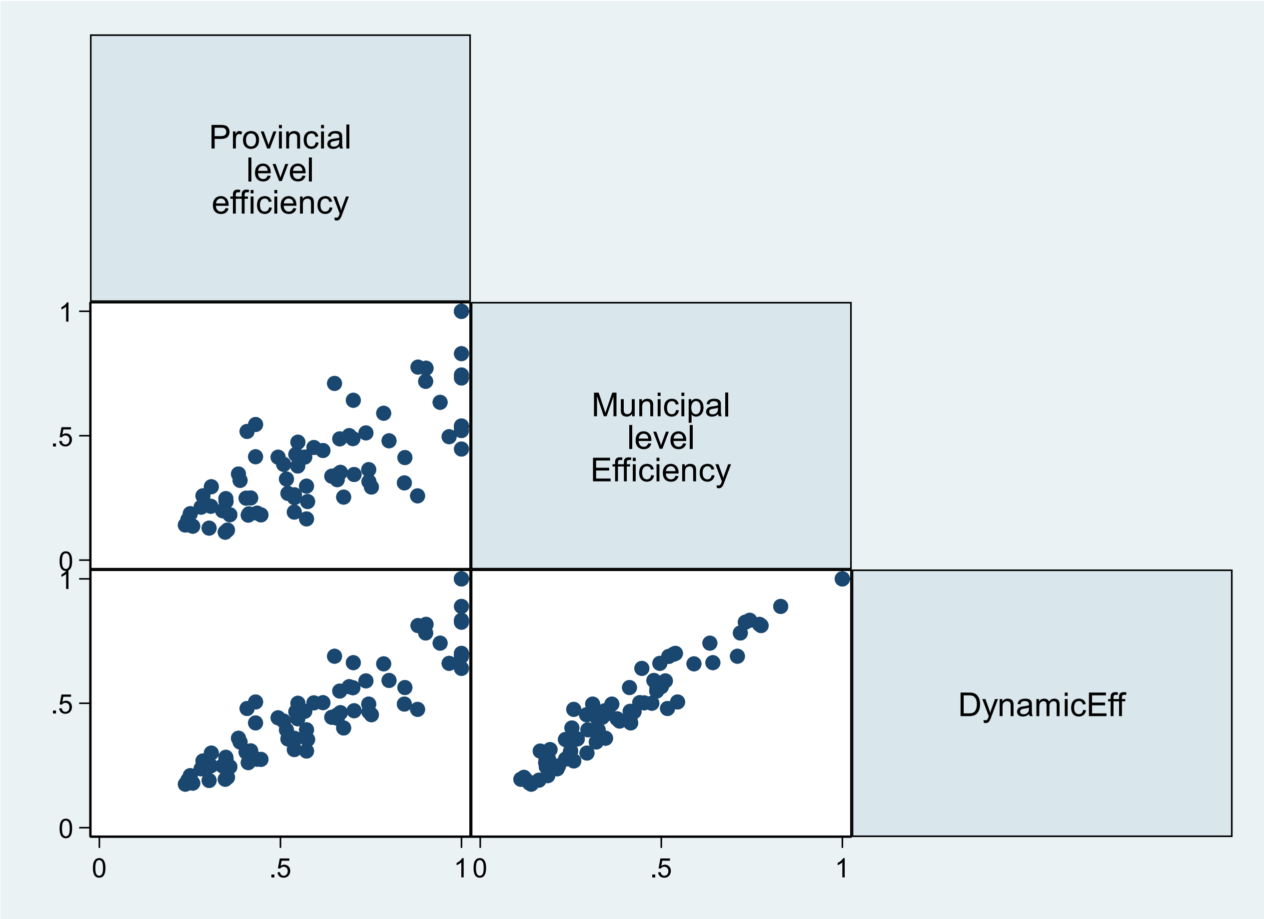
Table 6. Spearman's rank correlation tests

	Overall provincial level subDMU	Overall municipal level subDMU	Overall dynamic network
Overall provincial level subDMU	1.000		
Overall municipal level subDMU	0.779***	1.000	
Overall dynamic network	0.9153***	0.9582***	1.000

*** Significant at 1% level

The scatter plot in Figure 6 shows a strong positive linear association between dynamic network efficiencies with no obvious outliers. It can be observed however that provincial level efficiency is loosely clustered compared to the municipal level one, reflecting its slightly higher standard deviation.

Figure 6. Scatter plots of the dynamic network efficiencies showing indicative frontier

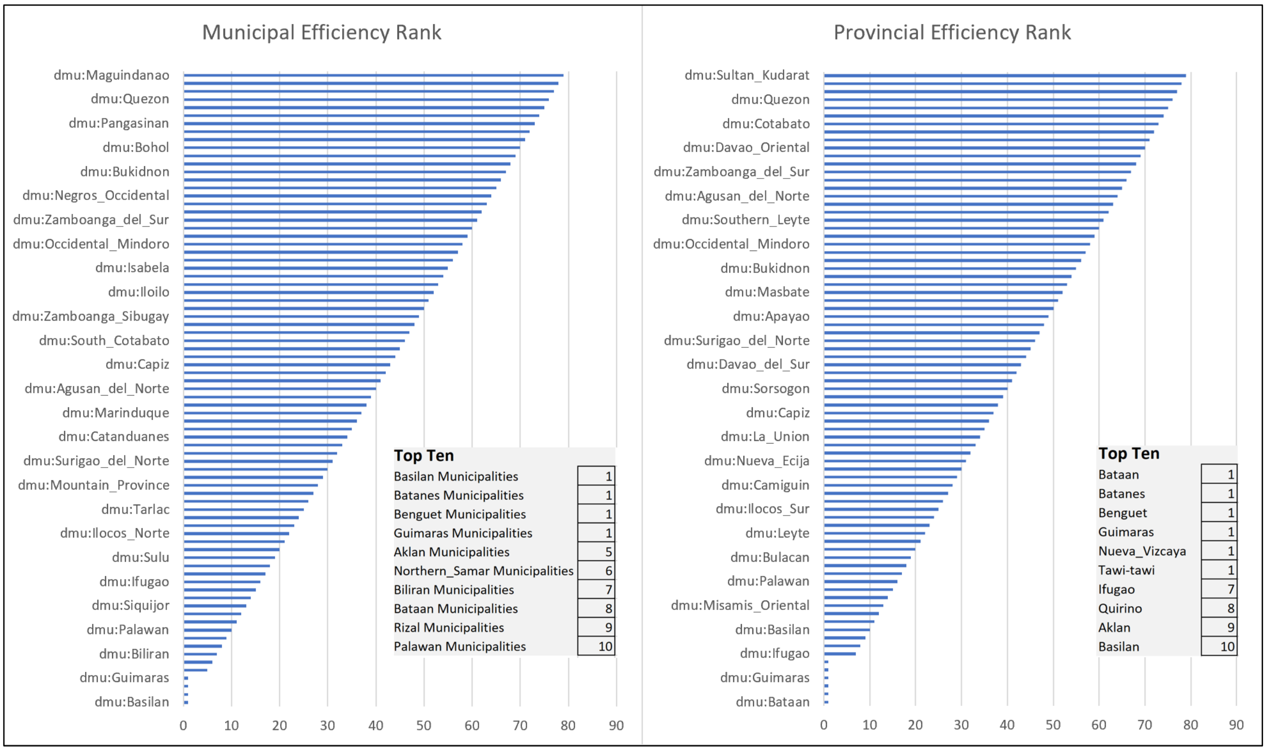


The bigger picture is seen in Figure7 where all DMUs are ranked based on their municipal and provincial efficiency estimates. Basilan, Batanes, Benguet, and Guimaras are in the Top 10 for both levels. Particularly for municipality subDMUs, they are joined by Aklan, Northern Samar, Biliran, Bataan, Rizal, and Palawan. Note that these municipalities are mostly located in Luzon and Visayas. As for the provincial level efficiency estimates, the four aforementioned DMUs are joined by Nueva Vizcaya and Tawi-Tawi which both scored the maximum 1.0, Ifugao, Quirino, and Aklan.

It must be noted though that the indicators and datasets used were from a period before super typhoon Yolanda struck. The efficiency coeficient rankings are also dependent on the input and output indicators used. The list is by no means an assertion on local government performance and related accomplishments.

The situation presents another good opportunity to validate the results of this work for a more robust output. The DILG can make available its yearly assessment of disaster preparedness compliance, and maybe the PSA can pursue the archiving of a community level database similar to that being espoused by the Community-based Monitoring System (CBMS). Certain personal and privacy protection, however must be in place. The caveat remains, the Dynamic Network model was limited by data constraints. There must be a comprehensive effort to consolidate sub-regional and sub-provincial data so that assessment platforms like the one used in the study, are made more applicable and valid. Such would have a more substantial contribution not only to disaster planning, response and resiliency, but also in its application to the bigger development landscape and nation-building initiatives.

Figure 7. Municipal subDMU and Provincial subDMU efficiency ranking



5. Conclusions

This work provides a glimpse into the differences in efficiencies among sub-regional decision-making units as applied to disaster risk management and resilience. The dynamic network DEA model approach was used to estimate provincial DMU efficiencies through the network of corresponding institutional subDMUs at both the provincial and municipal/community levels. Looking at the complementation among LGU-DMU subunits and linking their inputs and carry-over activities toward eventual disaster resiliency measures show how connected the development and governance landscapes are at the subregional level. Realizing this is important as true resilience lies in the strength and cohesion among communities and their service providers.

Results from the study, although with caveats, provide empirical contributions to the disaster risk management and resilience literature in the country. They offer substantial insights into the efficiency of local governments as regards DRRM, particularly when looking at policy augmentation, implementation and public investments. The institutional sublevels in provincial governance and decision making have inherent structural autonomy and separation, but they are compelled by strong transboundary concerns to come together and cooperate. The model output indicators of socioeconomic resilience and asset protection require cohesive inputs and actions.

Provincial governance depends greatly on institutional legwork, as well as contributions from constituent cities, municipalities and communities. Their development and physical framework plans must represent a coherent document harmonizing the aspirations and concerns of provincial constituents and stakeholders. Insulated action at the helm is never an acceptable option as disaster resilience building is beyond individuals and personalities, and more about communities and shared spaces.

The greater resource pool and spatial mandate of provincial governments as compared to the lesser endowed municipalities give them the legal and moral obligation to lead. Institutions are complementary with small and big gains at the municipal and community levels adding up toward the more visible resilience gains at the macro.

The provincial level subDMUs seemed to outperform their municipal subDMU counterparts in terms of aggregate efficiency. It must be noted though that the aggregate efficiency rating of the former is qualified as municipal subDMUs outnumber provincial subDMUs by 18 times. More telling is the strong correlation between the municipal and provincial level efficiencies, and their respective correlatissson to the overall dynamic model. The manifested empirical links are clear-- it is therefore imperative that disaster resilience initiatives are dynamic in all sub-DMU fronts. This result is indicative of the need to further augment the bureaucratic machinations, particularly on disaster resiliency- related work-compliance, at both the municipal and provincial subDMU levels.

It must be noted though that the indicators and datasets used were from a period before super typhoon Yolanda struck. This presents another good opportunity to validate the results of this work for a more robust output. The caveat remains- the Dynamic Network model was limited by data constraints. There must be a comprehensive effort to consolidate sub-regional and community-level data so that assessment platforms like the one used in the study, are made more applicable and valid. Such would have a more substantial contribution not only to disaster planning, response and resiliency, but also in its application to the bigger development landscape and nation-building initiatives.

The network DEA model at the provincial level may be academic in its wishful approach to consolidate decision-making and disaster resilience initiatives sub-regionally. But the premises behind this thinking are difficult to contest: development and thematic plans are connected and complementary, benefits from human capital and infrastructure investments cross political subdivides, and appropriate social protection is discerning but not discriminatory. Enlightened local governance and true resilience building indeed require a magnanimous frame.

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