Asia-Pacific Social Science Review

Volume 17 | Issue 2 Article 4

12-30-2017

Climate Adaptation, Technological Self-Reliance, and the Developing World: Evidence From an Emerging Economy

Rodolfo Calzado Jr.
Department of Science and Technology and De La Salle University, Philippines

Jose Santos Carandang IV
De La Salle University, Manila, Philippines, jose.santos.carandang@dlsu.edu.ph

Recommended Citation
Calzado, Rodolfo Jr. and Carandang, Jose Santos IV (2017) "Climate Adaptation, Technological Self-Reliance, and the Developing World: Evidence From an Emerging Economy," *Asia-Pacific Social Science Review*: Vol. 17: Iss. 2, Article 4.
DOI: https://doi.org/10.59588/2350-8329.1106
Available at: https://animorepository.dlsu.edu.ph/apssr/vol17/iss2/4

Asia-Pacific Social Science Review 17(2) 2017, pp. 196–213

RESEARCH ARTICLE

Climate Adaptation, Technological Self-Reliance, and the Developing World: Evidence From an Emerging Economy

Rodolfo Calzado Jr.
Department of Science and Technology and De La Salle University, Philippines

Jose Santos Carandang VI
De La Salle University, Philippines
jose.santos.carandang@dlsu.edu.ph

Abstract: Despite good intentions, development assistance from donor countries are often underutilized by recipient nations due to weak absorptive capacities. Addressing this issue has become more imperative with recent international accords engendering the rapid influx of massive climate assistance funds into the developing world. Particularly, interventions are focused on addressing exceptional vulnerabilities of developing nations to near-term climate impacts, for example, devastating typhoons and associated hazards. Fundamental to this effort is establishing the necessary technology infrastructure for generating quality climatic and environmental information, which serves as valuable logistical support for Disaster Risk Reduction and Management plans and activities. Efforts to address this in developing countries, however, are often sluggish or met with gridlocks. This is despite following internationally-prescribed best-practice roadmaps, conditioned by access to foreign aid. The Philippines' experience in implementing its technological self-reliance policy provides a possible framework for overcoming this difficulty. Contribution analysis, through dissecting and examining the policy implementation period of 2010–2015, reveals that a more cooperative sociopolitical landscape, engendered by the visibility of a program "championing" the country's drive to break away from technological dependence, can provoke rapid technological catch-up, bringing about the desired transformation.

Keywords: policy analysis, evaluation, technology catch-up, research, foreign aid, international assistance, climate change, political economy, sociopolitical change, Copenhagen accord, Philippines

Developments in consensus-driven mitigation pathways (e.g., climate justice, tragedy of commons) promoted the prioritization of adaptive capacities in the international climate change agenda (Intergovernmental Panel on Climate Change, 2014; Heltberg, Jorgensen, & Siegel, 2008; United Nations Development Programme, 2016). This led to developing countries benefiting from an upsurge of climate change assistance funds. Foremost among these is the Copenhagen Accord of 2009. Although non-binding, it commits developed countries to the goal of generating US$100 billion yearly in climate assistance funds by 2020 (United Nations Development Programme, 2016; United Nations Framework Convention on Climate Change, 2009). Although lacking a penalty system, it legally bounds all its participants to emissions reduction targets—the adherence of developing countries is dependent on the support they receive (United Nations Treaty Collections, 2016).

> While the futures of these climate agreements are largely uncertain, they engender concerns on the efficient utilization of Official Development Assistance (ODA). ODA implementation has been frequently met with significant bottlenecks, arising from sociopolitical barriers inherent to most developing countries (Cammack, 2007; Houghton, 2012), that is, the interaction of stress factors, for example, instability, lack of adaptability by the citizenry, poverty, and social inequality (Hamza & Corendea, 2012) that hinder their ability to absorb foreign grants and loans. Unproductive concessional loans, despite relaxed terms, can cumulate to a significant aggravation of an already considerable debt burden (Mirza, 2003; Ekanayake & Chatrna, 2010; Berthélemy, 2006; McKinley, 2009) resulting into a spiral of debt.

It has become increasingly apparent that addressing climate change in developing countries requires a fundamentally different approach (Chandler et al., 2002). While efforts are focused on ensuring the effective implementation of Disaster Risk Reduction and Management (DRRM) plans and activities, success heavily hinges on the accuracy and timeliness of climatic and environmental information that initiatives are based upon. This requires establishing the appropriate technology infrastructure countrywide (Heltberg et al., 2008). Although foreign assistance encourages adherence to internationally-prescribed "best-practice" roadmaps, this endeavor is still often sluggish or met with gridlocks (Houghton, 2012; Mirza, 2003; Chandler et. al., 2002; Adger, Huq, Brown, Conway, & Hulme, 2003).

It thus becomes imperative to understand why such a phenomenon persists, and how it can be overcome. The Philippines' experience, in implementing its technological self-reliance policy, provides a possible framework for overcoming this difficulty. The country's phenomenal technical amelioration (Section 4.3), in the brief period of 2010–2015, warrants investigating how the policy brought about this transformation, overcoming staple challenges in generating such capability in developing countries. Moreover, the complexity of the problem being addressed merits clarifying the exact role of the policy, and the significance of such role, in bringing about the desired change.

Policy Profile

Technological Self-Reliance

Technological self-reliance (TSR) is a public policy implemented by Philippines' science ministry, the Department of Science and Technology (DOST). It is a direction-setting policy that focuses research and development (R&D) activities on generating outputs that can competitively replace or alternate foreign products or services that the country outsources or sees an attractive potential to outsource. The policy employs a pragmatic step-wise strategy in realizing its goals. In the short-term, it aims to prove the value of R&D outputs by generating benefits in "low-hanging fruits": areas of the national agenda presenting an avenue of greatest impact, while requiring the lowest amount of effort and resources. This allows outputs to visualize benefits, attract interest, and grow in political support. In the medium-term, the policy aims for R&D outputs to play a greater and more participatory role in national development activities, continuously growing in both scope and impact. This allows the ministry to attract greater funding support for its activities in general, which will be invested into creating a more enabling environment for innovation to prosper. Lastly, the policy, throughout its lifetime, seeks to continuously increase the country's ability to assimilate technology and knowledge spillovers, building technological absorptive capacity in areas strategically relevant to the Philippine economy. In the long-term, the policy aspires for this improved technological competence to spur the creation of new industries, generate skilled jobs, and encourage greater private-sector engagement in R&D activities. The envisioned culmination of these efforts would be achieving technological mastery in development areas that further on allow the country to overcome economic dependence.

Legal Foundation

The TSR policy interprets Article XIV, Section 10 of the 1987 Philippine Constitution, which declares that the State shall "…support indigenous, appropriate, and self-reliant scientific and technological capabilities, and their application to the country's productive systems and national life." Policy enforcement is mandated to DOST by virtue of Executive Order No. 128, series 1987, or the 'Reorganization Act of the National Science and Technology Authority,' wherein Section 5 powers and functions provides: "Promote the development of indigenous technology and adaptation of suitable imported technology, and in this regard, undertake technology development up to the commercial stage, preferably in joint venture with the private sector or with public agencies." This order was granted full force of the law by virtue of the 1986 Freedom Constitution.

Methods

The present study is an analysis of the relationship between a public policy (Torjman, 2005) and a set of goals. It is thus a matter of detailing the policy–goal relationship, and determining the extent of the policy's contribution towards reaching the set goals (Nagel, 1999). As the present study is an analysis of an existing policy (Bührs & Robert, 1993), the investigation's approach is both descriptive and analytical in manner.

There were three main considerations in deciding on the methodology for policy evaluation: (i) the study is a problem of attribution, in view of other multiple interventions with similar goals, for example, other government agencies, the private sector, and international organizations through ODA; (ii) the evaluability of the goals of the policy, as no clear and measurable outcomes, target populations, and timeline for expected changes are overtly distinguishable; and (iii) the complexity of the policy, which involves multiple components, operational partners, and stakeholders, all existing within a dynamic setting. These factors rendered the design of an experiment to test cause and effect, that is, traditional positivist approaches attempting to prove casualty, impractical, and insufficient to address the present attribution problem (Wimbush, Montague & Mulherin, 2012).

The researchers applied the contribution analysis methodology to overcome the present study's limitations. This method employs an alternative process of logical argumentation, structured around a step-wise approach, to reduce uncertainty, and result in a reasonable conclusion on the contribution of a policy to a set of goals (Mayne, 2012).

Contribution Analysis

The contribution analysis approach, developed by Mayne (2001), is a theory-based form of impact evaluation designed to address some critical challenges standard in complex policy analyses. It employs a step-wise process in developing a credible performance story that describes the policy's achievements and the mode of their accomplishment (Dart & Mayne, 2004). Instead of seeking definitive proof of cause-effect, causal pathways are mapped from policy to intended outcomes, thereafter seeking supporting evidence to strengthen linkages and refute alternative theories.

The evaluation follows the contribution analysis process (Mayne, 2012): (i) identifying the attribution problem and target outcomes; (ii) describing the policy implementation process and how the desired outcomes were achieved, generally through a "logic model," then in step-by-step detail through a "results chain" (Montague, Young, & Montague, 2003), tracing linkages between the policy instruments, intermediaries if any, and the desired goals or objectives (considerations include: the policy development process, the different actors involved, their corresponding level of exposure, and the level of control or influence of the policy over the behavior of actors); and (iii) populating the results chain with relevant evidences (e.g., verifiable facts, figures, or documented cases) to strengthen linkages requiring supporting data or information.

The generated policy framework is thereafter refined through the succeeding steps: (i) reviewing the results chain in consultation with key informants (for this study, three DOST officials and two project researchers were consulted); (ii) incorporating additional outputs in the logic model, acquiring additional evidence where needed; and (iii) organizing the structure of the model to strengthen the proposed policy–goal relationship.

Finally, the derived model is checked for validity by reviewing against four criteria (Montague et al., 2003): (i) no component of the analysis goes against the basic principles of logic; (ii) all policy instruments have been or will be implemented with absolute certainty; (iii) no conflicting evidence disproves the occurrence of the chain of expected results; and (iv) other known factors that exhibit significant potential to effect the same outcomes are proven, either through logic or evidence, to have insignificant contributions or a relative role that cannot be recognized.

Data Collection Instruments

Statistical data and progress reports on programs and projects used in the study were sourced from their respective monitoring or implementing agencies, for example, the Philippine Council for Industry, Energy, and Emerging Technology Research and Development (PCIEERD); the Philippine Atmospheric Geophysical Astronomical Services Administration (PAGASA); and the Advanced Science and Technology Institute (ASTI). The DOST Planning and Evaluation Services (PES) conducted data retrieval and consolidation, thereafter checked for data consistency and structure by the DOST Office of the Secretary. Data used in the study is considered public domain. State auditing rules and regulations apply in ensuring data validity. Related policy statements, observations, and the necessary clearance to publish and analyze the data were acquired from the science minister of reviewed period (2010–2015).

Results

Subsequent sections develop the TSR policy framework. Section 4.1 describes the TSR policy development process, while identifying the attribution problem and the target outcomes. Section 4.2 describes and scrutinizes the policy process framework using the study's prescribed methodologies (Mayne, 2001; Montague et al., 2003), while also detailing the process of overcoming staple challenges for developing countries (e.g., complex bureaucratic system, sociopolitical instability). Section 4.3 describes the extent of technical amelioration, to evaluate the policy's success in achieving target outcomes. Lastly, Section 4.4 scrutinizes the significance of the policy's contribution to bringing about the desired change.

4.1 Policy Development Process

Here we describe the TSR policy development process: its target outcomes under the national DRRM framework, the reason behind its inception, and the means of its commencement.

National policy on disaster risk reduction and management: Defining target outcomes. DRRM has always been an integral part of the Philippines' national agenda, engendered by its unique geographical location and geological features that exhibit exceptional vulnerability to weather-related hazards (Yumul, Cruz, Servando, & Dimantala, 2010). More recently, the near-term impacts of climate change (Intergovernmental Panel on Climate Change, 2013 & 2014) have exacerbated this situation, resulting in the dramatic increase of the country's climate change vulnerability ranking (Kreft, Eckstein, Junghans, Kerestan, & Hagen, 2015). This prompted the country's then new government administration to issue four key policy measures in 2010: (i) the reorganization, expansion, and renaming of its disaster coordinating council into the National Disaster Risk Reduction and Management Council (NDRRMC) (Shaw, 2012); (ii) the harmonization of the government's fragmented DRRM plans and activities through a National Disaster Risk Reduction and Management Plan (NDRRMP) 2011–2028 (National Disaster Risk Reduction Council, 2011); (iii) the President's declaration of a "zero-casualty" goal during weather-related disaster events through a policy statement; and (iv) recognizing the need for access to accurate, area-specific, and time-bound weather and hazard information to reach the zero-casualty goal, a science-based approach to DRRM was emphasized by the NDRRMP.

The first of four priority areas of the NDRRMP, themed "disaster prevention and mitigation," centers on addressing the government's need for a "sound and scientific analysis of the different underlying factors which contribute to the vulnerability of the people and eventually their risks and exposure to hazards and disasters" (NDRRMP, December 2011, p. 6). Its outputs are intended for use by data users in the national DRRM framework, including the participants of other NDRRMP priority areas: disaster preparedness, disaster response, and rehabilitation and recovery. The DOST, as science ministry, is the designated overall lead for disaster prevention and mitigation. To guide the plans and activities of its members, the ministry produced the outcome statement: "[to generate] science-based weather information and climate change scenarios with associated impact assessments that enable concerned agencies to develop appropriate mitigation strategies for a disaster and climate change resilient Philippines" (Department of Science and Technology, 2016, par. 1).

Accordingly, building technical capabilities responsive to the greatest threats identified by the NDRRMP (i.e., extreme weather events and its sequential effects: flooding, landslides, and storm-surge events) were prioritized by DOST.

Barriers to implementation. The Philippine bureaucracy presented a problem for the DOST. Earlier proposals to improve climate-adaptive technological capability, filed through Congress, were already stuck in a long-term political gridlock. This created stiff financial competition on two fronts: against priority projects of other executive departments enjoying greater political support and against other budget items of the science ministry. This difficulty was compounded by the shifting political landscape arising from the recent change in leadership.

This political gridlock, however, while blocking the usual funding channels, also provided an impetus for the inception of the TSR policy. We refer to the experience of the Philippines' weather bureau, which revealed an avenue for the policy to first penetrate national development activities. These developments are described in the next Sections.

Challenges to modernizing the weather bureau. PAGASA, as the country's central weather agency, serves a significant role in the national DRRM framework. However, (i) the weather bureau lacked the necessary equipment and specialized tools to meet the level of accuracy and timeliness of weather forecasts expected by DRRM practitioners and the citizenry; and (ii) inadequate salary rates did not allow for the retention of a sufficiently competent and motivated workforce. Weather analysis leaned heavily on historical data and the forecasts of foreign weather institutions, demanding resourcefulness from PAGASA's weather scientists and technicians, who often recourse to traditional weather forecasting techniques (e.g., looking at the sky, analyzing barometric pressure, and analog pattern recognition). This difficulty was exacerbated by changing climatic patterns and frequenting weather-related occurrences (Yumul et al., 2010).

The most recognized insufficiencies include: Doppler radar facilities for more accurate typhoon tracking; automated weather instruments and stations, environmental sensors, and updated fine-scale multi-hazard maps for real-time data recording, analysis, and early warning; and high-performance computing capabilities for big-data analytics (e.g., for simulating possible hazard scenarios and predicting their respective probability of occurrence [Lagmay & Kerle, 2015]).

Legislative support to address these gaps were sought by PAGASA since 1998 and continued until 2010. In the 12-year period, at least 13 bills for the modernization of the weather bureau were filed in Congress: seven in the lower house and six in the upper house. However, none successfully passed into law. Increasing demand for reliable weather and hazard information, meanwhile, prompted the agency to recourse to ODA, such as from the Japan International Cooperation Agency (JICA) (Table 1), the biggest source of ODA loans from 2000–2010 (National Economic Development Authority, 2011).

Assistance from JICA and other international development agencies aggregate to a considerable sum-total of financial and technical support for

Table 1
JICA ODA Projects in Partnership With DOST-PAGASA (1973–2011)

Year	Project
1973–1986	Flood Forecasting and Warning System for Dam Operations (FFWS)
2004–2006	Strengthening Flood Forecasting and Warning Administration
2009	Improvement of Meteorological Radar System
2010–2012	Flood Forecasting and Warning System for Dam Operations (FFWS)
2011	Strengthening of Flood Forecasting and Warning System in Pampanga and Agno River Basins

Data source: Japan International Cooperation Agency, 2013

the country (e.g., ODA loans and grants in 2010 amount to US$10.06 billion and US$2.25 billion respectively); however, some are fragmented or underutilized in the absence of effective and productive government policies to anchor on (e.g., over 50% of total loan commitments for all effective ODA project loans recorded "poor utilization performance" in 2010 [National Economic Development Authority, 2011]). Accordingly, initiatives for building weather forecasting and hazard mitigation capabilities remained sluggish despite ODA due to policy insufficiencies in the field.

Policy commencement. The DOST in 2010 considered utilizing its research grant program "Grants-in-Aid" (GIA) as an alternative fund source. However, the terms of use of the fund restricted it to R&D activities. This provided an opportunity to implement a policy that would direct the use of GIA funds in support of the principles of the "local technology works" slogan, which in effect would allow the fund's efficient utilization. By midyear of 2011, this concept had evolved into a national science and technology policy that became TSR.

Upon implementation, the GIA funds were used to create the Nationwide Operational Assessment of Hazards (NOAH), a flagship R&D program designed to generate local technologies and expertise to address the needs of data users in the DRRM framework. Multiple synergistic project components (Project NOAH, 2013) comprise the NOAH program, all critical to its mission. Activities include: developing and distributing hydromet sensors; using remote-sensing technologies for acquiring high-accuracy digital elevation data; developing Doppler radar sub-systems; creating a flood information network; assessing storm-surge and other coastal hazards; and developing landslide sensors, among other projects that were added, expanded, or discontinued throughout the project lifetime. The NOAH program focused on building three fundamental capabilities nationwide: (i) the establishment of a network of locally-developed hydromet devices and sensors; (ii) the deployment of Doppler radar facilities; and (iii) the update and completion of fine-scale multi-hazard maps (i.e., flood, landslide, and storm-surge) (National Disaster Risk Reduction Council, 2011).

4.2 Results Chain: Linking Policy Implementation to the Target Outcomes

The policy development process provides the policy's target outcomes: (i) generally, as described by the country's DRRM framework, and further detailed by DOST's outcome statement; and (ii) more specifically, as described by the capability gaps of the weather bureau. It also identifies the NOAH program as the policy's primary agent in achieving these goals. However, before the NOAH program's products can be examined to evaluate policy performance, the linkages between policy implementation and the target outcomes should be identified and validated.

Policy ecosystem. The TSR policy identifies four general areas of intervention: (i) programs referring to the implementation of R&D programs responding to priority areas of the national agenda; (ii) emerging technologies referring to the incorporation of learnings from more advanced technology platforms of other countries into research project components; (iii) facilities referring to the establishment of science and technology infrastructure necessary for supporting government-led R&D activities, while minimizing risks for private-sector R&D activities (e.g., product design and testing, laboratory services, and gathering specialized data); and (iv) policies referring to the creation or modification of new and existing policies, within the powers of the ministry, to support other intervention areas.

Given that the GIA funds: (i) only covers research activities (i.e., basic research, applied research, developmental research, pilot testing, and technology promotion and commercialization); and (ii) capital outlay in the form of equipment but not the construction of infrastructure, special cases allow for technicalities, for example, when maintenance and operating expenses are used for retrofitting an older building.

Considering these, we proceed with the analysis using Montague's circles model (Montague et al., 2003). The model defines three circles representing the categorical environments within the policy ecosystem wherein policy actors reside (Figure 1): (i) the operational circle representing the environment under the direct control of the authority implementing the policy; (ii) the behavioral circle representing the immediate environment the policy directly influences;

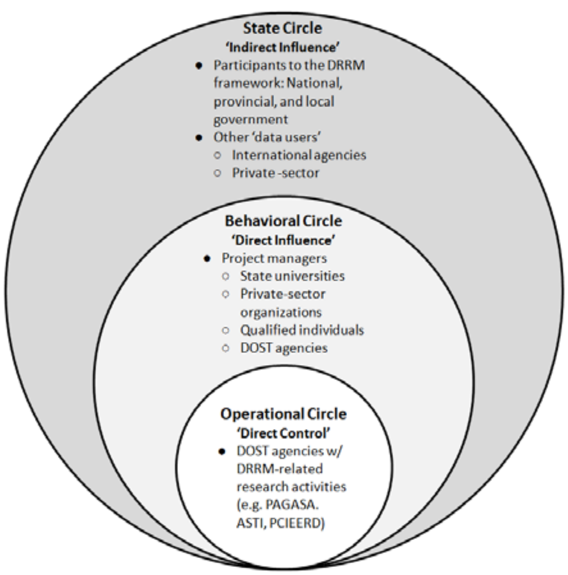


Figure 1. Montague's circles model of the technological self-reliance policy ecosystem for science-based Disaster Risk Reduction and Management. Source: Authors.

and (iii) the state circle representing the environment indirectly influenced by the policy implementation. Positions of the circles in the model, defined by their proximity to the epicenter of the ripple, describe their directness of exposure to the policy and the scope of their potential impact.

Operational circle. DOST agencies (i.e., as endorsers, proponents, or 2nd-tier managers of the GIA fund) with DRRM-related research activities populate the operational circle. The ministry exercises direct control over them through the DOST executive committee (ExeCom), as the highest body managing the fund. ExeCom functions as the final gateway before funds are released, and also hold the power to suspend or discontinue any research program or project. ExeCom is guided by the TSR policy, which influences the fund utilization in four ways (Section 4.2.1): (i) research project proposals must be aligned with the ministry programs (e.g., NOAH program); (ii) project activities must build upon learnings from more advanced emerging technology platforms; (iii) projects are encouraged to maximize the use of R&D support facilities already established by the ministry (this is the extent of the policy's effect, as GIA funds cannot be used for constructing infrastructure); and (iv) projects must adhere to policies supporting TSR principles (e.g., lead proponents must be of Filipino nationality, GIA funds cannot be used to provide counterpart funding for foreign-directed projects).

Another way control is exercised over DOST agencies is in the gate keeping of their regular budgets (i.e., GAA funds) by ExeCom. Although budget items here are less regulated, they are still subject to approval and scrutiny by ExeCom before they can be run through the annual budget cycle. This additional control mechanism is important to discourage policy loophole exploits.

Behavioral circle. Project managers leading the DOST's DRRM-related research activities populate the behavioral circle. While not necessarily sharing in DOST's mission, they are directly influenced by the policy through the GIA process, which directs the design and implementation of their research within the TSR policy principles. Its actors include a broad range of affiliates: state universities; private-sector organizations; independent contractors; and other public institutions, including the DOST agencies.

State circle. Data users of NOAH program products (e.g., DRRM practitioners both participant to and supportive of the national DRRM framework, the citizenry) populate the state circle. While not necessarily controlled or directly influenced by the TSR policy, they are indirectly influenced by its implementation as consumers of outputs derived from the policy instruments.

Results chain diagram: Identifying limitations and alternative pathways in the model. We recall the core limitations in GIA fund use (i.e., its research exclusivity, and infrastructure restriction), and review them against the target outcomes of the policy: (i) nationwide hydromet sensor network coverage for real-time weather and hazard monitoring; (ii) fine-scale multi-hazard maps (i.e., flood, landslide, and storm-surge [National Disaster Risk Reduction Council, 2011]) of vulnerable areas nationwide for operational and strategic planning; (iii) nationwide deployment of Doppler radar facilities for more accurate typhoon tracking; and (iv) high-performance computing capabilities for big-data analytics (i.e., for simulating possible hazard scenarios and predicting their respective probability of occurrence [Lagmay & Kerle, 2015]).

This allows the deduction of two important limitations in the proposed policy framework model: (i) NOAH, as a GIA-funded research program, can only be used in the development of Doppler radar sub-systems, and not for the nationwide distribution of radar facilities (the items being under the infrastructure category); and (ii) for the same reason, high-performance computing capability cannot be purchased using GIA funds (the item not falling under any research category covered by the GIA fund). Delivering these two products therefore require the use of regular or other alternative funding channels (e.g., GAA, ODA, private-sector donations). We attempt to reconcile these limitations and the policy framework in the following analysis.

Montague's circles model revealed the linkages within the policy ecosystem. We use the derived relationships and apply them using Mayne's results chain diagram model (Mayne, 2001) to summarize the interactions within the policy ecosystem, graphically representing the process flow that links operational outputs with intended outcomes (Figure 2). The arrows show how different elements of the system run, and transform, throughout the supply chain as products, services, and financial and technical support are generated and delivered to users. To reconcile the limitations in the policy framework model, the system process exhibits a feedback loop wherein funds are routed back into the system as causal inputs to the process. Feedback type (i.e., negative or positive) is dependent on the impact of DRRM activities at the grassroots level, as it determines the increase or decrease of demand for the products of the policy instruments.

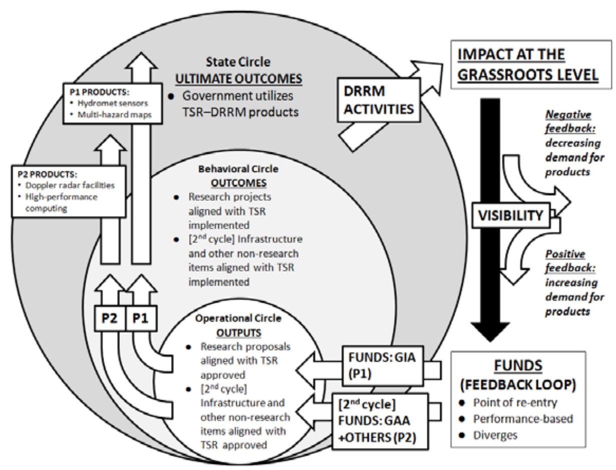


Figure 2. Results chain diagram of the Technological Self-Reliance policy ecosystem for science-based Disaster Risk Reduction and Management. Source: Authors.

The proposed structure represented in the results chain diagram links the success of the TSR policy to the ability of the NOAH program to attract political support, and thereby additional funds, for achieving the goals of the policy. System process flow thus diverges into two pathways at the point of re-entry as feedback: (i) the influx of additional GIA funds; and (ii) that of additional GAA funds, among other alternative sources. These funds, utilized by two separate conduits (i.e., NOAH program, PAGASA), also affect two different sets of policy goals (Table 2).

Table 2
Effects of Positive/Negative Feedback Loop on the TSR–DRRM Results Chain Model

Causal pathway	Conduit	TSR–DRRM policy goals affected (technological capabilities)
Pathway 1: GIA funds	NOAH program	Nationwide hydromet sensor network coverage for real-time weather and hazard monitoring
		Fine-scale multi-hazard maps (i.e., flood, landslide, and storm-surge) of vulnerable areas nationwide for operational and strategic planning
Pathway 2: GAA funds (and other alternatives)	DOST-PAGASA	Nationwide deployment of Doppler radar facilities for more accurate typhoon tracking
		High-performance computing capabilities for big-data analytics (i.e., for simulating possible hazard scenarios and predicting their respective probability of occurrence)

Source: Authors.

4.3 Country Best-Practice: Measuring Success Indicators

The results chain yielded the detailed structure and system process flow of the policy framework. Having linked the implementation of the TSR policy to the NOAH program products, we can now proceed to examine the relevant outcomes of the program (i.e., both direct and indirect effects) in evaluating the policy's performance.

Causal pathway 1: Development and distribution of hydromet devices. Hydromet devices are sensors that measure parameters related to climate interactions of water and energy balance over land (Betts, 2004). A network of interlinked sensors is critical for real-time weather and hazard monitoring. Several sensor types were used by PAGASA through time, classified into two categories for the purpose of this analysis: (i) type-1 sensors, that is, agromet and synoptic stations; and (ii) type-2 sensors, that is, automated weather stations (AWSs), automated rain gauges (ARGs), and water level monitoring systems (WLMSs).

On type-1 sensors, agromet stations collect data on fundamental weather parameters (e.g., wind speed, rainfall amount and intensity, pressure, relative humidity, temperature, solar radiation, sunshine duration, soil temperature, and soil moisture). Earlier models utilized by the weather bureau required assigned "agromet observers" to record and submit, in a prescribed format, their daily recordings. Synoptic stations, by contrast, share general characteristics with agromet stations, but function to characterize atmospheric parameters and meteorological data over a wider area. Earlier synoptic stations were able to collect and store data automatically; however, data retrieval was still done manually.

On type-2 sensors, AWS is an automated version of the agromet station, with the ability to transmit information, in real-time, to a central server for viewing over a web-based system. Other enhancements, cited by the Australian Bureau of Meteorology, includes: better measurement consistency, resilience to harsh weather, and suitability for isolated areas (due to attached solar panels, built-in internal rechargeable battery (Advanced Science and Technology Institute, 2012). ARG and WLMS, by contrast, share general characteristics with AWS, but the former functions to measure rainfall amount in specific areas over a particular timeframe, while the latter functions to measure flood waters in real-time (for the purpose of monitoring critical river basins near vulnerable communities).

The NOAH program, through proponents from DOST agencies ASTI and PAGASA, implemented the research projects "Development of Hybrid Weather Monitoring System and Production of Weather and Rain Automated Stations," the "Water Level Monitoring System," and the "Emergency Distribution of Hydro-meteorological Devices in Hard-hit Areas in the Philippines." Said projects developed new hydromet sensor designs that—through collaborations with local suppliers, manufacturers, and distributors—retained optimal specifications at lower supply chain costs (Liboro, 2015) versus foreign distributors. ASTI was able to identify other cheaper sensor models by foreign brands, however, specifications and performance failed to meet benchmarks (deficiencies include: data loss, inaccuracies, frequent maintenance, and reduced lifetime [Advanced Science and Technology Institute, 2014]).

Type-2 sensor models were deployed nationwide—in cooperation with local government, international organizations, private-sector partners, and other stakeholders—resulting in a significant increase in hydromet device distribution (721.83%) from 2010–2016 (Figure 3): from a total of 197 independent units to 1,619 interconnected units.

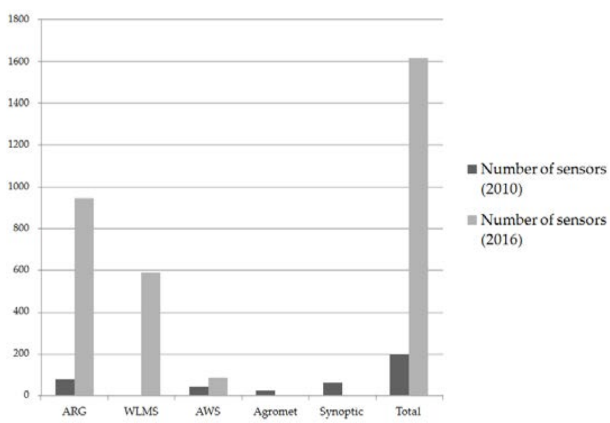


Figure 3. Graph comparing the hydromet sensor distribution in 2010 (23 agromet; 59 synoptic; 40 AWSs; 75 ARGs) versus 2016 (86 AWSs: 946 ARGs; 587 WLMSs). ARG and AWS sensors in 2010 are all foreign-sourced models. The 2016 tally excludes agromet and synoptic sensors as these units have already been converted to other sensors types. Data source: PAGASA, ASTI.

The greater hydromet sensor coverage and density allowed the NOAH program, through proponents from the Diliman campus of the University of the Philippines (UP-D), to implement the research project "Flood Information Network" (FloodNET). The project used the nationwide hydromet network in developing Automated Water Level Forecasts (AWLF), automating system processes (i.e., data gathering, modeling output, and release of flood hazard advisories with a four-hour lead time). The project, in partnership with local government, used the AWLF to establish early-warning systems in 165 flood-prone cities and municipalities nationwide.

Causal pathway 2: Multi-hazard mapping through LiDAR and other technologies. Hazard maps are visual representations of hazards and risks, geospatially superimposed over high-resolution imagery of geographical locations. Standard purposes include: planning disaster response and recovery, and land use planning (Kappes, Keiler, von Elverfeldt & Glade, 2012). Using remote-sensing survey techniques generate maps in data formats that allow integration with other data sets for producing hazard scenario projections and fine-scale multi-hazard maps (Ragettli, et. al., 2015). New remote-sensing products and capabilities have been acquired by the Philippines since July 2010: Light Detection and Ranging (LiDAR) mapping instruments; Compact Airborne Spectrographic Imager (CASI) for hyperspectral mapping; 1:10,000-scale Digital Terrain Model (DTM) and Digital Surface Model (DSM) of the country using Interferometric Synthetic Aperture Radar (IFSAR); and more recently a satellite ground receiving station; and the first of a series of Filipino co-designed microsatellites (Lagmay & Kerle, 2015) (in partnership with two Japanese universities [Perez, 2016]). Among the mentioned remote-sensing technologies, LiDAR technology was the most heavily utilized in the policy implementation period (playing a critical role in the update and generation of fine-scale multi-hazard maps).

The NOAH program, through proponents from UP-D, implemented the Disaster Risk Exposure, Assessment, and Mitigation-LiDAR (DREAM-LiDAR) research project, which involved the training of Filipino researchers and engineers in the use of LiDAR technology. This enabled the project team to gather high-accuracy digital elevation data for the country's 18 major river basins: Marikina-Pasig, Cagayan, Pampanga, Agno, Mag-asawang Tubig, Bicol, Panay, Jalaur, Ilog-Hibangan, Agusan, Agus, Cagayan, Davao, and Mindanao (accounting ~70% of the total damages nationwide from flooding events (Office of the President, 2015). Maps generated by LiDAR were at 1:5,000 scale (progenitor maps generated in 2004 were at 1:50,000 scale (Solidum & Alegre, 2011).

The gradual expansion of DREAM-LiDAR led to four other related and synergistic projects: (i) Hazard Mapping of the Philippines using LiDAR (Phil-LiDAR I) that expands the DREAM-LiDAR project coverage to 257 minor river basins (completion date: June 2017); (ii) Nationwide Detailed Resource Assessment using LiDAR (Phil-LiDAR II) that analyzes collected LiDAR data, supplemented by other survey techniques, to generate high-resolution resource maps (e.g., high-value agricultural crops, coastal resources, forest, hydrological, and renewable energy resources); (iii) Enhancing Landslide Hazard Maps through Light Detection and Ranging that updates progenitor landslide susceptibility and coastal erosion maps using the same tools as Phil-LiDAR II; and (iv) Storm-surge Modeling and Simulation that identifies, quantifies, and maps storm-surge threats to communities along coastlines, also using the same tools.

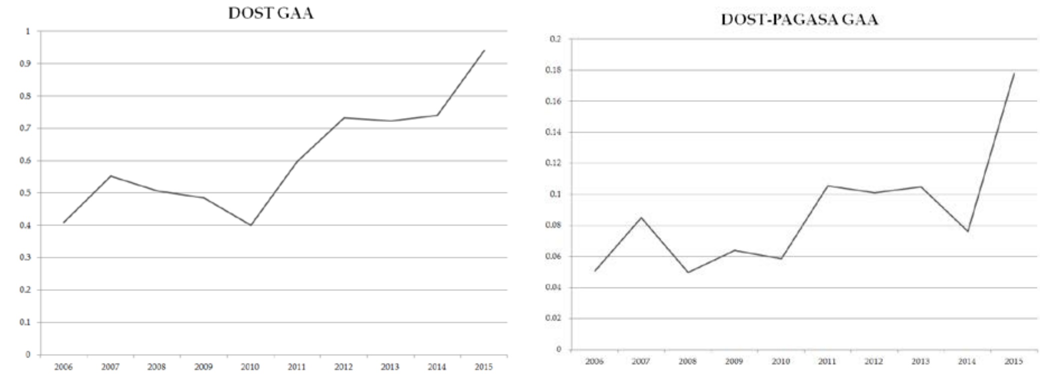
The products produced by these projects, in aggregate, include: (i) fine-scale landslide maps, that is, landslide inventory, shallow landslide, alluvial flow, debris flow, and structurally-controlled maps for all 81 landslide-prone provinces, including the megacity Metro Manila; (ii) storm-surge maps for all 67 vulnerable coastal communities; and (iii) flood-hazard maps for 170 out of the 729 or 23.3% of all flood-vulnerable communities, targeted for 100% completion by January 2017. On the mastery of LiDAR technology, the research activity in the field allowed implementation costs to go down: from ~US$350 per km^2 in 2010, it fell to ~US$78 per km^2 by 2015 (Liboro, 2015).

Causal pathway 3: Doppler radar facilities and high-performance computing. Doppler radars are specialized equipment used to measure data on the velocity of objects through the Doppler Effect. Uses in meteorology include: examining precipitation motion, measuring wind speed, typhoon tracking, and for time- and area-bound predictions of rainfall amount (Fu, et. al., 2016). Using high-performance computing systems allow for running big-data sets (integration of multiple data sets, e.g., weather information, real-time rainfall and precipitation return, topography, elevation) through analytics platforms (e.g., advanced modeling software), to produce highly-complex products: predictive models, advanced simulations, early warning, faster and more accurate weather forecasting, improved localized weather prediction, climate change scenario modeling, precision agriculture, and generally provide a platform for further research in the field.

The NOAH program, through proponents from PAGASA, initiated the research project Local Development of Doppler Radar Systems (LaDDeRS), which sought to develop local capability to design, fabricate, and operate sub-systems of Doppler radars. The project's activities and outputs, however, were centered on decreasing system maintenance costs and improving the performance of Doppler radar technicians and data analysts. This limited much of the project's contribution to improving operational efficiency, rather than the distribution of Doppler radar facilities or the acquisition of high-performance computing capabilities.

The NOAH program's growing political influence, however, managed to attract a significant roster of operational partners, both local and international (at least 43 partner organizations) (Project NOAH, 2013); its visibility capturing the attention of the legislature and creating greater demand for its products. This would have two notable effects: (i) the acquisition of an IBM Blue Gene supercomputer (Department of Science and Technology, 2013). model 1-rack Blue Gene/P (with 1,024 nodes and 4,096 processor cores); and (ii) a sharp increase in budget for both the ministry and PAGASA (Figure 4), inclusive of funds for building Doppler radar facilities.

These budget increases resulted in the vast improvement of Doppler radar distribution and coverage from 2010–2016 (Figure 5). From four Doppler radar facilities in June 2010, distribution increased by 225% for a total of 13 facilities by December 2015, their combined range covering ~85% of the landmass. Three out of the 13 radars were acquired through JICA-ODA (Virac, Aparri, and Guiuan areas); however, they were already programmed prior to the policy implementation period. Other improvements include: upgrading of earlier Doppler radars for better reliability and performance; and the addition of three "X-band" mobile Doppler radars for contingencies (units distributed in the upper, central, and southern regions of the country).



(a) (b)

Figure 4. Line graph of the annual percentage budget allocation or "slide-of-the-pie" of DOST and PAGASA out of the total national budget in 2006–2015: (a) DOST on a 0-1% scale; (b) PAGASA on a 0–0.2% scale. PAGASA allocation decreased in 2014 upon completion of some Doppler radar facilities. New constructions resumed in 2015. Data source: Department of Budget and Management, 2006, 20017, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015.

(a) (b)

Figure 5. Comparison of Doppler radar distribution nationwide in 2010 versus 2015: (**a**) location and coverage of functional Doppler radar facilities in June 2010; (**b**) location and coverage of functional Doppler radars by the end of 2015. Data source: PAGASA.

Policy milestones: Other notable secondary and tertiary effects. The vast integrated network of monitoring, early warning, and data processing systems had resulted into several milestones for the science ministry and its weather bureau. Foremost, PAGASA weather forecasting accuracy improved (i.e., by 44.61%) as average forecast track error declined from 169.85 km in 2010 to 94.08 km in 2015, the latter being within the 120-km error threshold of the World Meteorological Organization (WMO, 2014). The performance of PAGASA, and the benefits derived from the massive amount of data they generate garnered increasing recognition from the private sector between 2014–2015 (Makati Business Club, 2014, 2015 & 2016), resulting in the lobbying for and eventual passage of Republic Act No. 10692 or The

PAGASA Modernization Act of 2015 in 2015. This law was the first to guarantee a portion of the national budget—3 billion Philippine pesos (US$6.2m) for the first two years, exclusive for capital outlay, that is, infrastructure; and at least half of the amount for every succeeding year, but without the expenditure restriction—for procuring modern weather instruments and the installation of a "world-class" data center. Other benefits include: more competitive salaries for employees; the ability to avail of loans, grants, bequests, and donations from both local and foreign sources; and the right to monetize its specialized products and services.

Moreover, the enhanced capability also serves as a deterrent for corruption and ineffective adaptation projects. In 2015, the economic board of Philippines approved a flawed major flood-control project amounting to ~US$7.05 billion, upon endorsement of ODA consultants (who also based their analysis on country data). It would have proceeded; had not more robust data from the NOAH program reveal an oversight in project design (Arcilla, 2015; Rappler, 2015).

Finally, the new technology landscape served as a platform for advancing future climate change research in the country, with the potential for novel discoveries. In a study by Lagmay et. al., 2015; and Lagmay et al., 2015 for example, the analysis of Doppler data, rainfall measurements, and advanced modeling simulations revealed that the orographic effect of native volcanoes amplified regular weather patterns, turning them into devastating flooding events—a process which the researchers hypothesized has already been happening for centuries prior, but was unobservably absent from the new technical capabilities of the weather bureau.

4.4 Alternatives to the Logic Model

Here we test the validity of the derived policy framework by reviewing it against other alternative explanations to realizing the goals of the policy.

Corruption incidence. Corruption incidence is a political problem that merits significant consideration. The Philippines ranks in the lower half of the Worldwide Corruption Perceptions Index per country (Transparency International, 2012). The inspected timeframe of policy implementation in 2010–2015, however, observes a notable improvement in the country's control of corruption compared to prior years (Kaufmann, Kraay, & Mastruzzi, 2011). Furthermore, other government effectiveness indicators display a slightly rising pattern (World Bank, 2015). These factors, more considerably the corruption incidence, would be expected to significantly impact the capability of government agencies to implement policies and attract funding support. While not in entirety, this potentially decouples the effects of the TSR policy with the enhancement of specific capabilities reliant on GAA funds, for example, the distribution of Doppler radar facilities.

Several fallacies exist in the theory, however, that reasonably discredit it. Foremost, the Philippine national government is a highly complex institution: with different agents, acting on different areas of the national agenda, with vastly different scopes and mandates. While a certain level of general corruption-incidence perception exists, or of any government effectiveness indicator; this does not necessarily suggest that most NGAs will have index values along the same gradient. Moreover, the DOST, while having been considerably evasive of corruption allegations in years prior the TSR policy implementation, was implicated in one of the largest and most controversial corruption scandals in Philippine history in 2013. Its attached agency, the Technology Resource Center (TRC), was identified as a central participant to the Priority Development Assistance Fund scam or the PDAF scam (Marcelo, 2014)—an alleged defrauding of ~11 billion Philippine pesos (US$226.7m) from the lump-sum discretionary fund of Congress, in which TRC was one of the first six agencies revealed to be used in diverting funds from priority development projects into "ghost" corporations. This scandal led to several milestone events in Philippine politics, for example, the Million People March, which is a series of protests rallies in opposition to the PDAF fund scheme (De Jesus, 2013; Gagalac, 2013; Carcamo, 2013); the declaration of the PDAF fund as unconstitutional by the Supreme Court after 23 years of implementation (Aning, 2013); and the arrest of several high-ranking politicians, among whom was the chief of TRC and three Senators (Rappler, 2014). Applying the principles of the proposed alternative corruption-incidence model, it should reasonably follow that financial support will plateau or decrease in the years following the PDAF scandal. However, this was not the case: while the PDAF scandal continued to receive significant publicity in 2014 up to the end of 2015 (Matsuzawa, 2015), with arrests still ongoing in 2016, the portion of the national budget allotted to the DOST and PAGASA continued to rise (DOST, 2015). While this does not preclude potential long-term effects of corruption-incidence perception, this data proposes, at least, that there is no strong evidence to link it to near-term effects on the budget allocation. Concluding, corruption-incidence perception in the period of 2010–2015 could not have helped gather political support, and thereby the significant budget increases, for the ministry and the weather bureau—rather, it would have, at most, impeded the realization of the goals of the policy, if it had any meaningful effect at all.

Climate change perception. Another factor to consider is the role of climate change perception in fostering public awareness on the necessity of building DRRM capability. Climate change and its threats are being discussed more publicly in the Philippines following massive unprecedented disasters, prior to and during the period of policy implementation, for example, Typhoon Haiyan—one of the strongest typhoons to ever make landfall in recorded history (National Disaster Risk Reduction and Management Council, 2013)—that gathered significant attention in 2013, at both local and international levels, on account of its devastating effects (Lagmay, 2015). Climate change perception, like corruption, could therefore be assumed to attract support for improving DRRM-related capabilities. This proposes a competition of roles towards this end: between the direct effects of climate change perception versus that of the NOAH program—further suggesting that the DOST and the PAGASA could have attracted greater funding regardless of the implementation of the TSR policy.

This leads us to a key point in this analysis: heightened climate change perception also has the ability to influence government spending priorities, but it cannot affect the total pool of government funds. In contrast, the TSR policy, through its agent the NOAH program, overcomes this barrier in two ways: (i) through its R&D activities that focus on lowering supply chain costs for relevant technologies, making initiatives easier to implement at larger scales; and (ii) building upon initial success to visualize its benefits, thereafter gathering interest in its products and facilitating the expansion of activities. Therefore, improving climate change perception, by itself, cannot overcome the immense bureaucratic and political bottlenecks arising from vested interests (Yumul et al., 2010; National Disaster Coordinating Council, 2008; National Disaster Coordinating Council, 2009).

Conclusion

The Philippines' technological self-reliance policy facilitated technological catch-up in climate-adaptive technologies within a five-year period (2010–2015). This resulted to a nationwide distribution of the technology infrastructure necessary for effective response to near-term climate impacts: 225% increase in Doppler radar distribution, 721.83% increase in hydromet sensor coverage, comprehensive nationwide establishment of multi-hazard early-warning systems and corresponding hazard maps, the acquisition of high-performance computing systems, and launching the country's first microsatellite, co-developed with Japan, paving the way for further expanding the country's remote-sensing technology program. Moreover, the resulting massive pool of climatic and environmental data motivated new programs on responsive applications, for example, precision agriculture, identifying potential renewable energy sites, and accounting REDD+ natural resources.

Several assumptions derived from the Philippines' experience, may help improve foreign aid policies and developing-country development agendas address the adaptation problem:

(i) Fostering climate-adaptive technological capacities in developing countries require accelerating knowledge-flows between them and more developed countries. This involves releasing relevant technology patents, knowledge-sharing, research collaboration (e.g., Philippines-Japan co-developed microsatellite), expert exchange programs, and most importantly, incentives for scientists and engineers to continue pursuing adaptation research in their own country (discouraging emigration).

(ii) Good data also serves as a deterrent to corruption and ineffective adaptation projects. It makes the falsification of documents difficult, and allows a more accurate depiction of the technical merits of a project. The right standards for technical vetting should be emphasized, especially in developing countries as they have more to lose.

(iii) When pursuing technological catch up (e.g., climate-adaptive technologies), research outputs should not be evaluated based on their ability to find markets beyond the country, but rather by their usefulness in contributing to the national agenda. Otherwise, it will be difficult to attract political support for the technology pathway being pursued.

(iv) Self-reliant capability to generate good data on fundamental climate and environmental parameters, in response to the most prevalent climate risks, should be prioritized. It allows developing countries to address near-term climate impacts, while creating a strong foundation for pursuing the mitigation pathway.

(v) Policy robustness and stakeholder participation is insufficient to successfully reach the goals of a technology policy. A visible flagship program, as agent to the policy, is necessary to allow it to gain political ground. Visualizing the benefits of a program allows it to create demand, overcome chronic sociopolitical barriers (e.g., competing priorities, political instability, resistance to technical change), which further helps it rally financial and operational support from both local and international partners.

(vi) It is evident that international discourse on climate change should go beyond the amount of ODA to be released, and the amount of carbon emissions to be committed. Developing countries are clearly finding it difficult to pursue the mitigation pathway (e.g., green technologies), as long as their adaptation challenge remains considerable. Direct, near-term climate impacts (e.g., extreme weather events and its associated hazards), aggravated by the confluence of other sociopolitical factors, cannot be overcome conventionally. It requires a conscious paradigm shift in both the approach to foreign assistance and the developing-country mindset: from dependence on assistance' to fostering self-reliance.

Acknowledgment

The authors are grateful for the support from the Department of Science and Technology (DOST), Philippines. Comments were received from R&D Undersecretary Dr. Rowena Cristina Guevara, Planning Director Bernie Justimbaste, Dr. Dennis Erasga, Mr. Julien Carandang, Prof. Teresa Ho, and Dr. Beatrice Jayme-Tiangco. The authors gratefully acknowledge the Honorable Minister for Science and Technology Engr. Mario Montejo (2010–2016) for granting access to data and permission to publish. Finally, R.C. thanks Ms. Hazel Redrino and Ms. Hope Calzado, his inspirations. All interpretations, errors, views, opinions, and omissions are the authors', and do not necessarily reflect or express those of the DOST.

References

Adger, W. N., Huq, S., Brown, K., Conway, D., & Hulme, M. (2003). Adaptation to climate change in the developing world. *Progress in Development Studies*, *3*(3), 179–195.

Advanced Science and Technology Institute. (2012). *Philippine real-time environmental data and interpretation for climate-related tragedy prevention and mitigation (PREDICT)*. Retrieved March 25, 2016 from http://embedded.asti.dost.dost.gov.ph/category/projects/ict-for-the-environment/

Advanced Science and Technology Institute. (2014). Establishment of agro-meteorological stations in highly vulnerable areas: A tool for climate change adaptation and in the development of local early warning system (Agromet–Cum Climate Change). Retrieved March 25, 2016 from http://embedded.asti.dost.dost.gov.ph/category/projects/ict-for-the-environment/

Aning, J. (2013, September 11). SC orders release of 2013 pork stopped immediately. *Inquirer News*. Retrieved on November 14, 2016 from http://newsinfo.inquirer.net/484735/sc-stops-release-of-pork-malampaya-funds

Arcilla, C. (2015, November 1). P350-B flood control project flawed. *Inquirer.net*. Retrieved November 19, 2016 from http://opinion.inquirer.net/89953/p350-b-flood-control-project-flawed

Berthélemy, J. C. (2006). Bilateral donors' interest vs. recipients' development motives in aid allocation: Do all donors behave the same? *Review of Development Economics*, *10*(2), 179–194.

Betts, A. K. (2004). Understanding hydrometeorology using global models. *Bulletin of the American Meteorological Society*, *85*(11), 1673–1688.

Bührs, T., & Robert, B. (1993). *Environmental policy in New Zealand: The politics of clean and green.* Auckland: Oxford University Press.

Cammack, D. (2007). Understanding the political economy of climate change is vital to tackling it. *Opinion, 92*. London: Overseas Development Institute.

Carcamo, D. (2013, September 18). Groups gear up for big anti-pork barrel rally. *The Philippine Star*. Retrieved on November 14, 2016 from http://www.philstar.com/nation/2013/09/18/1224431/groups-gear-big-anti-pork-barrel-rally

Chandler, W., Secrest, T. J., Logan, J., Schaeffer, R., Szklo, A. S., Schuler, M. E., ... & Shukla, P. R. (2002). *Climate change mitigation in developing countries: Brazil, China, India, Mexico, South Africa, and Turkey*. Arlington, VA (United States): Pew Center on Global Climate Change.

Dart, J., & Mayne, J. (2004). Performance story. In S. Mathison (Ed.), *Encyclopedia of evaluation* (pp. 307–308). Thousand Oaks, California: Sage.

De Jesus, J. L. (2013, September 11). "EDSA Tayo" rally declared a "success." *Philippine Daily Inquirer*. Retrieved on November 14, 2016 from http://newsinfo.inquirer.net/485637/edsa-tayo-rally-declared-a-success

Department of Science and Technology. (2013). DOST strengthens R&D capabilities with IBM supercomputer – IBM's Blue Gene to enable improved weather prediction. Retrieved on November 5, 2016 from http://www.dost.gov.ph/knowledge-resources/news/33-2013-news/163-dost-strengthens-r-d-capabilities-with-ibm-supercomputer-ibm-s-blue-gene-to-enable-improved-weather-prediction

Department of Science and Technology. (2015). Fiscal Year 2015 Budget. Retrieved on November 5, 2016 from https://pubfiles.pagasa.dost.gov.ph/ppds/Annex65.pdf

Department of Science and Technology. (2016). Functions and DOST outcomes. Retrieved on November 3, 2016 from http://region1.dost.gov.ph/transparency/about-dost/dost-outcomes-and-regional-functions

Ekanayake, E. M., & Chatrna, D. (2010). The effect of foreign aid on economic growth in developing countries. *Journal of International Business and Cultural Studies*, *3*, 140–155.

Fu, H., Wu, X., Li, W., Xie, Y., Han, G., & Zhang, S. (2016). Reconstruction of typhoon structure using 3-dimensional Doppler radar radial velocity data with the multigrid analysis: A case study in an idealized simulation context. *Advances in Meteorology*, *2016*.

Gagalac, R. (2013, September 14). Anti-pork barrel protesters gather in Luneta [again]. *ABS-CBN News.* Retrieved on November 14, 2016 from http://www.abs-cbnnews.com/nation/metro-manila/09/13/13/anti-pork-barrel-protesters-gather-lunetaDepartment of Budget and Management. (2006). General appropriations act, FY 2006.. Retrieved on September 21, 2016 from http://www.dbm.gov.ph/?page_id=4499

Hamza, M., & Corendea, C. (Eds.). (2012). *Climate change and fragile states:* Bonn: United Nations University Institute for Environment and Human Security: UNU-EHS.

Heltberg, R., Jorgensen, S. L., & Siegel, P. B. (2008). *Climate change, human vulnerability, and social risk management*. Washington, DC: World Bank.

Houghton, K. (2012). Climate change in fragile States: Adaptation as reinforcement of the fabric of the State. In M. Hamza and C. Corendea (Eds.), *Climate change and fragile States: Rethinking adaptation* (pp. 22–42). Bonn: United Nations University Institute for Environment and Human Security: UNU-EHS.

Intergovernmental Panel on Climate Change. (2013). The physical sciences basis. Cambridge University Press. Retrieved on April 2, 2016 from http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf

Intergovernmental Panel on Climate Change. (2014). *Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects*. Cambridge University Press. Retrieved on April 2, 2016 from http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-PartA_FINAL.pdf

Japan International Cooperation Agency. (2013 August 22). JICA continues assistance to PAGASA. Retrieved on May 2, 2016 from https://www.jica.go.jp/philippine/english/office/topics/news/130822.html

Kappes, M. S., Keiler, M., von Elverfeldt, K., & Glade, T. (2012). Challenges of analyzing multi-hazard risk: A review. *Natural Hazards*, *64*(2), 1925–1958.

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The worldwide governance indicators: Methodology and analytical issues. *Hague Journal on the Rule of Law*, *3*(02), 220–246.

Kreft, S., Eckstein, D., Junghans, L., Kerestan, C., & Hagen, U. (2015). Global climate risk index 2015. Germanwatch. Retrieved on March 25, 2016 from https://germanwatch.org/en/download/10333.pdf

Lagmay, A. M. F., Agaton, R. P., Bahala, M. A. C., Briones, J. B. L. T., Cabacaba, K. M. C., Caro, C. V. C., ... & Mungcal, M. T. F. (2015). Devastating storm surges of Typhoon Haiyan. *International journal of disaster risk reduction*, *11*, 1–12.

Lagmay A. M. F., Bagtasa G., Crisologo I. A., Racoma B. A. B., & David C. P. C. (2015). Volcanoes magnify Metro Manila's southwest monsoon rains and lethal floods. *Frontiers in Earth Science. 2*,36. doi: 10.3389/feart.2014.00036

Lagmay, A. M. F., & Kerle, N. (2015). Typhoons: Storm-surge models helped for Hagupit. *Nature*, *519*, 414. doi:10.1038/519414b

Liboro, R. (2015). *Philippine case: Project NOAH*. Paper presented for the Country Experience during the Regional Training Workshop in Asia and the Pacific: Sustainable Development and Disaster Risk Management Using E-Government. United Nations Office for Sustainable Development. Retrieved on November 2, 2016 from http://www.unosd.org/content/documents/1109songdo%20philippines%20ppt%20final.pdf

Makati Business Club. (2014, August 11). *MBC executive outlook survey: Business gives positive marks to 43 agencies in Year 4 of PNoy's administration*. Retrieved on March 30, 2016 https://philippineprivatepublicpartnership.blogspot.com/2014/08/mbc-executive-outlook-survey-business.html

Makati Business Club. (2015, August 14). *Second semester 2015 MBC EOS: Business recognizes improvement in 31 agencies; BSP, PEZA, DOT remain top 3*. Retrieved on March 30, 2016 from http://www.philembassy.no/news-item/second-semester-2015-mbc-eos-business-recognizes-improvement-in-31-agencies-bsp-peza-dotMakati Business Club. (2016). *Corporate members*. Retrieved on November 5, 2016 from http://www.mbc.com.ph/corporate-members/

Marcelo, E. (2014, December 23). Sandigan Bayan denies Dennis Cunanan's motion to travel to US. *GMA News Online.* Retrieved on November 6, 2016 from http://www.gmanetwork.com/news/story/394776/news/nation/sandiganbayan-denies-dennis-cunanan-s-motion-to-travel-to-us

Matsuzawa, M. (2015, September 3). 20 lawmakers accused of malversation in new PDAF scam. *CNN Philippines.* Retrieved on November 8 2016 from http://cnnphilippines.com/news/2015/09/02/PDAF-pork-barrel-scam-complaint-fake-NGOs-not-operated-by-Janet-Napoles.htmlMayne, J. (2001). Addressing attribution through contribution analysis: Using performance measures sensibly. *Canadian Journal of Programme Evaluation*, *16*(1), 1–24.

Mayne, J. (2012). Contribution analysis: Coming of age? *Evaluation*, *18*(3), 270–280.

McKinley, T. (2009). Why is "the Dutch disease" always a disease?* The macroeconomic consequences of scaling up ODA. In McKinley, T. (Ed.), *Economic alternatives for growth, employment and poverty reduction* (pp. 85–99). UK: Palgrave Macmillan.

Mirza, M. M. Q. (2003). Climate change and extreme weather events: Can developing countries adapt? *Climate Policy*, *3*(3), 233–248.

Montague, S., Young, G., & Montague, C. (2003). Using circles to tell the performance story. Retrieved April 22, 2016 from http://www.pmn.net/wp-content/uploads/Using-Circles-to-Tell-the-Performance-Story.pdf

Nagel, S. S. (Ed.). (1999). *Policy analysis methods.* Commack, N.Y.: Nova Science Pub Incorporated.

National Disaster Coordinating Council. (2008). *Situation report no. 33 on the effects of Typhoon "FRANK" (Fengshen)*. Retrieved on March 25, 2016 from http://reliefweb.int/report/philippines/philippines-ndcc-update-typhoon-frank-situation-report-no-33

National Disaster Coordinating Council. (2009). *Final report on Tropical Storm "ONDOY" {Ketsana} (Glide No. TC-2009-000205-PHL) and Typhoon "PEPENG" {Parma} (Glide No. TC-2009-000214-PHL) (September 24–27 and September 30–October 10, 2009)*. Retrieved on March 25, 2016 from http://www.ndrrmc.gov.ph/attachments/article/92/Narrative_Report_re_Tropical_Storm_Ondoy_(KETSANA)_and_Typhoon_Pepeng_(PARMA)_2009.pdfNational Disaster Risk Reduction Council. (2011). *National disaster risk reduction and management plan (NDRRMP) 2011–2028*. Retrieved September 8, 2016 from http://faolex.fao.org/docs/pdf/phi152518.pdf

National Disaster Risk Reduction and Management Council. (2012). I. Final report on the effects and emergency management re Tropical Storm "SENDONG" (Washi). II. Status of early recovery programs in Region X (Cagayan de Oro and Iligan Cities). Retrieved on March 25, 2016 from http://www.ndrrmc.gov.ph/index.php/21-disaster-events

National Disaster Risk Reduction and Management Council. (2013). NDRRMC update: Final Report re effects of Typhoon "YOLANDA" (HAIYAN). Retrieved on March 25, 2016 from http://www.ndrrmc.gov.ph/index.php/21-disaster-events.

National Disaster Risk Reduction and Management Plan. (2011). NDRRMP Report. Retrieved on March 21, 2016 from http://www.dilg.gov.ph/PDF_File/reports_resources/DILG-Resources-2012116-420ac59e31.pdf

National Economic Development Authority. (2011). *2010 ODA portfolio review*. Retrieved on November

15, 2016 from http://www.neda.gov.ph/wp-content/uploads/2016/08/CY-2010-ODA-Portfolio-Review-Report.pdf

Office of the President. (2015). *The 2015 state of the nation address: Technical report, Philippines*. Retrieved on April 16, 2016 from http://www.gov.ph/2015/07/27/2015-sona-technical-report/

Perez, A. (2016, March 23). First Filipino-made satellite "Diwata-1" launched into space. *CNN Philippines.* Retrieved April 22, 2016 from http://cnnphilippines.com/news/2016/03/22/diwata-in-space.html

Philippine Atmospheric, Geophysical, and Astronomical Services Administration. (2008). About PAGASA Regional Services. Retrieved November 2016 from http://www.pagasa.dost.gov.ph/index.php/45-regional-services.

Project NOAH. (2013). About Project NOAH [Blog post]. Retrieved October 4, 2016 from http://blog.noah.dost.gov.ph/about/

Ragettli, S., Pellicciotti, F., Immerzeel, W. W., Miles, E. S., Petersen, L., Heynen, M., … Shrestha, A. (2015). Unraveling the hydrology of a Himalayan catchment through integration of high resolution in situ data and remote sensing with an advanced simulation model. *Advances in Water Resources*, *78*, 94–111.

Rappler. (2014, June 23). LIVE BLOG: PDAF scam arrests. Retrieved on November 14, 2016 from http://live.rappler.com/Event/PDAF_scam_arrests?Page=4

Rappler. (2015, November 4). NEDA Chief: Mega Manila flood masterplan subject to "refinements." Retrieved November 19, 2016 from https://www.rappler.com/business/industries/208-infrastructure/111684-neda-metro-manila-flood-control-masterplan-refinement

Republic Act No. 10692 or The PAGASA Modernization Act of 2015 in 2015. Retrieved November 12, 2016 from http://www.officialgazette.gov.ph/2015/11/03/republic-act-no-10692/

Shaw, R. (2012). *Community-based disaster risk reduction.* Bingley: Emerald Group Pub.

Solidum, R., & Alegre, L. D. (2011). Hazard mapping and assessment for effective community-based disaster risk management (READY) Project. *Asian Journal of Environment and Disaster Management*, 3(1), 79–92.

Torjman, S. (2005). *What is policy?* Ottawa, Canada: Caledon Institute of Social Policy.

Transparency International. (2012). *Worldwide corruption perceptions index*. Retrieved November 10, 2016 from https://www.transparency.org/country/#PHL_DataResearch

United Nations Development Programme. (2016). Sustainable development goals – Goal 13: Take urgent action to combat climate change and its impacts. Retrieved on November 18, 2016 from http://www.un.org/sustainabledevelopment/climate-change-2/

United Nations Framework Convention on Climate Change. (2009). *MEETINGS: Copenhagen Climate Change Conference–December 2009*. Retrieved November 17, 2016 from http://unfccc.int/meetings/copenhagen_dec_2009/meeting/6295

United Nations Treaty Collections. (2016). *Paris agreement*. Retrieved November 18, 2016 from https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en

Wimbush, E., Montague, S., & Mulherin, T. (2012). Applications of contribution analysis to outcome planning and impact evaluation. *Evaluation*, *18*(3), 310–329.

World Bank. (2015). *Worldwide governance indicators (WGI): country data report for Philippines, 1996–2014*. Retrieved on November 14, 2016 from http://info.worldbank.org/governance/wgi/index.aspx#countryReports

World Meteorological Organization. (2014). Topic 3.1 Effective warnings: Forecast validation. Retrieved from http://www.wmo.int/pages/prog/arep/wwrp/new/documents/Topic3.1.pdf

Yumul, G. P., Cruz, N. A., Servando, N. T., & Dimantala, C.B. (2010). Extreme weather events and related disasters in the Philippines, 2004–08: A sign of what climate change will mean? *Disasters, 35*, 362–382. doi: 10.1111/j.1467-7717.2010.01216