Utilization of Goal Programming (GP) and AHP Model in Planning for the Implementation of DOST-PCHRD Capacity Building Programs

Vanessa Neillizzle B. Bartolome
Department of Science and Technology – National Capital Region

Paula Jane A. de Leon
Philippine Council for Health Research and Development
Department of Science and Technology

Rex Aurelius C. Robielos
School of Industrial Engineering and Engineering Management
Mapua University
Intramuros, Manila, Philippines
racrobielos@mapua.edu.ph

Abstract

This study aims to develop a GP and AHP model which aids in planning the distribution of capacity building projects and activities across the regions. The strategy applied to ensure equitable distribution of projects and activities is through regional clustering. The goal programming (GP) model was utilized to aid in realizing the feasibility of target number of projects and activities set for each regional cluster. Results showed that the targets set per regional cluster during the planning stage were only achieved for the Awards and Fellowship program. Further, the AHP model was also created to help the Council in prioritizing the recipients of capacity building programs to ensure alignment with the Council's objective.

Keywords
Goal Programming, Analytical Hierarchy Process, Capacity Development Program

1. Introduction
The global public health research system has long been challenged by physical, political, and financial constraints that severely affect health research and development (R&D) initiatives contributing to efforts to improve humanity's health and quality of life. Looking into the aspects of human resources and facilities for health R&D, limitations due to gaps in capacity building unravel untapped and often wasted potential to pursue a better, healthier, and more fulfilling lives of people worldwide.

Indeed, capacity building empowers scientists and R&D organizations to contribute to the achievement of the global health agenda.[1] Capacity building, as defined by various sources, is an ongoing process of creation, obtaining, adapting, strengthening, and maintaining the sets of capabilities of workers, organizations, and societies to effectively utilize their resources to achieve the goals.[2] R&D investments provide much-needed assistance for the continuous improvement of the capacity of individuals and research institutions,[3] which improves their responsiveness in addressing pressing public health concerns in developing countries. [4]

In many parts of the world, especially in developing nations, R&D promotion is policy-driven, mainly under the leadership and support of national agencies. Such institutions are responsible for fostering a research-friendly environment in their respective countries through policy development, priority setting, and capacity-building. R&D investment is the priority of capacity building, such as in the case of funding for education and research are dependent on government investments.[5]

In the Philippines, the Department of Science and Technology – Philippine Council for Health Research and Development (DOST-PCHRD), the Department of Health (DOH) and the University of the Philippines Manila (UPM), collectively lead the Philippine National Health Research System (PNHRS), has streamlined the agenda-setting, funding, and implementation of health R&D initiatives in the Philippines. In this regard, the PNHRS puts a premium on the crucial role of Filipino researchers, and significant initiatives have been done to level up the capacity of the country's experts, science professionals, and science students. In 2018, around 419 Million Pesos was allocated by the three organizations to support initiatives to develop the capacity of health researchers and research organizations in the country.
The DOST-PCHRD, one of PNHRS' lead agency and the focal agency that develops and strengthens the nation's human and infrastructure resources of the health research network. DOST-PCHRD is at the forefront of the movement to create an enabling environment to enhance and level up the capacity of researchers to conduct timely, responsive, and relevant health research initiatives in the country. With its mandate to formulate policies, plans, programs, projects, and strategies for health S&T development, the Council develops, funds, and leads capability building initiatives in the health sector.

The DOST-PCHRD, through its Institution Development Division (IDD), operates to ensure the availability of high-quality research addressing the national/regional health research priorities of the country. A lot of research capacity building programs at the individual, organizational, or regional networks have already been implemented. These interventions have been carried out through different strategies falling under two (2) main categories: Human Resource Development and Network and Institution Development.

The initiatives of the Council to enhance the research capacity in the regions has been running for decades. However, in a commissioned study of the Council, results revealed that researchers' and institutions' research capacity was very low on the national level. Also, the research capacities of institutions were either poor or fair.

To address the gaps, IDD's main strategic objective for 2015-2019 was to develop capacities for conducting, managing, and utilizing health research. Annual plans reflect that every year there were target projects and activities for a specific program. Reported achievements were cumulative, therefore shifting IDD's focus on achieving first the target rather than the implementation of its program and how well the regions received it.

2. Literature Review

To provide insights on the national R&D systems, the United Nations (UN) identified (a) financial investment and (b) human resource working in R&D as important parameters for evaluating a comprehensive picture of a national innovation system of a country. These indicators are used to assess a nations' achievements of its national targets, identify strengths and weaknesses of a national innovation system, recognize needed policies that can best support a country's R&D, determine partnership needs between the government, academe, the private sector and other non-profit research institutes, and assist with development of tax incentives to stimulate R&D and related policies and strengthen innovations in public and private sectors.[6]

The capability of nations to support a robust and dynamic national research system is strongly linked to available funding sources. Countries with the lowest scores in Human Development Index (HDIs) tended to show remarkably low outcomes in health research capacity, further aggravating the capacity of these nations' health research systems to address local health problems and needs.[7] Uneven financial support across countries in a region results in poor regional outcomes in strengthening capacity for R&D in national levels. Concentration of training institutions to a few countries that can fund such institutions causes inequity in the distribution of training resources resulting in limited research capacity building activities in a region.[8]

As for human resource working in R&D, lack of experience among individual lead/head researchers creates a general lack of a research culture in organizations and an impediment for career growth of new or young researchers due to inability of these lead researchers to provide much needed guidance and mentorship. Limited experience in collaboration with policymakers is also a barrier in translation, dissemination, and utilization of health results.[9]

Utilizing these indicators to create a picture of the Philippine R&D system, it is evident that the Philippines follows the investment trend worldwide with the government, the private sector, and the academe constantly consuming the biggest investments for R&D.[10] The Philippines R&D scene is primarily being fueled by the private sector which

shared 36.88% of the P 21,869,000 of the country's Gross Domestic Expenditure (GERD) on R&D. Most of these GERD were utilized to fund research on engineering and technology, which received 43.76% of the investment for R&D. In comparison, research on Medical Sciences was only given 4.56% of the total GERD for R&D. The financial investments coming from the private sector is in parallel with the number of researchers they hired, which accounted for more than half (51.2%) of all employed health research personnel in the Philippines. As many as 198 researchers are serving for every 1,000,000 Filipinos. The sectors of higher education come in second with investment accounting for 36.74% of GERD for R&D and hiring 28.59% of the country's researchers. The public sector comes in third with 24.25% of the country GERD in R&D and after employing 17.15% of the country's pool of active researchers.[11]

3. Methodology

Capacity building programs implemented were identified based on IDD's business process in reference to the Council's Quality Management System (QMS). Gathered documents for review were the annual plans, accomplishment reports, procedures manual, and work instructions manual. Through the Finance and Administrative Division (FAD), all financial transactions of the Council stored in the enhanced New Government Accounting System (enGAS) database for the year 2015-2017 were requested. The data extracted were subjected to data cleaning and processing.

The number of projects and activities and expenditures were filtered according to region. Each data entry was categorized into the following:(1) type of capacity building strategy, (2) type of capacity building program, and (4) region. The number of projects and activities, as well as the expenditure for each program, was determined. Cross tabulation was performed to determine the distribution of expenses and activities per program across the regions. The results of the cross-tabulation were used in strategizing a way to ensure equitable distribution of capacity building projects and activities in the country. Appropriate analysis tools such as Goal Programming and Analytical Hierarchy process were used in planning the targets and realizing the current strategies of IDD.

Figure 1 shows the methodology flowchart of this study.

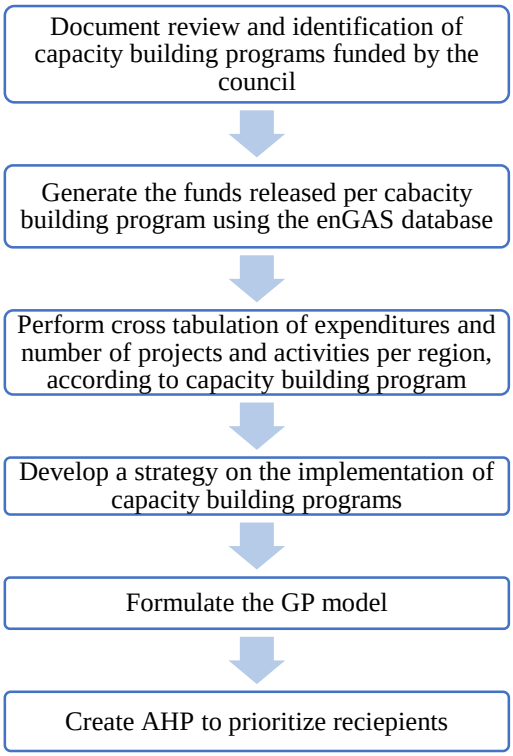

Figure 1. Methodology Flowchart

4. Results and Discussion

4.1.Descriptive Statistics

Table 1 shows the regional distribution of projects and activities expenditures per program Majority (78%) of the of the agency for capacity development was focused on the RHRDC, 12% to Scholarship, 9.6% to RFF, less than 1% to Awards and no allocation for Fellowship. Form this table, it can also be determined which among regions have the have the highest and least expenditure according to program. The overall top spending region was NCR (13.6%) with highest expenditure under the scholarship and awards program. On the other hand, the least spending region was Bicol Region (1.6%).

For the top spending regions in capacity building program, RHRDC recorded its highest expense in Ilocos Region (11.7%) followed by Central Luzon (9.6%) and CAR (9.2%). The least spending regions were Bicol Region (1.7%), CARAGA (2.2%) and CALABARZON (3.4%).

For the scholarship program, NCR has 45% of the total scholarship expenditures followed by CALABARZON (23.5%) and Central Luzon (7.8%). No expenditures were reported for the Regions (CAR, Ilocos Region,Central Visayas, Zamboanga Pen, Socksargen, CARAGA, BARMM).

Though there were no expense recorded for Socksargen, it was the top spender under the RRF program covering 28.9% of the total expenditure followed by Central Luzon (15.2%) and NCR (10.8%).

Results suggest that the highest expenses per capacity building program were mostly from the regions of Luzon except for the RRF program.

Table 1. Regional Distribution of Budget per Capacity Development Program, 2015-2017

REGION	SCHOLARSHIP	AWARDS	FELLOWSHIP	RRF	RHRDC	TOTAL
NCR	5,454,795.68	252,600.00	-	1,025,639.20	6,720,980.97	13,454,015.85
CAR	-	-	-	999,857.00	7,021,282.15	8,021,139.15
Ilocos Region	-	-	-	496,810.00	8,956,600.25	9,453,410.25
Cagayan Valley	237,165.03	-	-	-	5,102,414.38	5,339,579.41
Central Luzon	948,660.12	-	-	1,443,923.50	7,367,869.77	9,760,453.39
Calabarzon	2,845,980.35	-	-	-	2,608,693.16	5,454,673.51
Mimaropa	711,495.09	-	-	-	4,822,038.54	5,533,533.63
Bicol Region	237,165.03	-	-	-	1,313,774.28	1,550,939.31
Western Visayas	237,165.03	-	-	-	5,787,407.94	6,024,572.97
Central Visayas	-	-	-	-	4,690,262.45	4,690,262.45
Eastern Visayas	711,495.09	-	-	885,232.00	2,697,982.29	4,294,709.38
Zamboanga Pen	-	-	-	400,652.50	5,517,644.30	5,918,296.80
Northern Mindanao	237,165.03	-	-	-	3,677,852.67	3,915,017.70
Davao Region	474,330.06	-	-	503,803.40	3,292,456.42	4,270,589.88
Soccsksargen	-	-	-	2,750,000.00	2,704,212.00	5,454,212.00
Caraga	-	-	-	996,740.00	1,682,622.39	2,679,362.39
BARMM	-	-	-	-	2,490,650.00	2,490,650.00
TOTAL	12,095,416.51	252,600.00	0.00	9,502,657.60	76,454,743.96	98,305,418.07

Table 2 shows that majority of the projects and activities were consumed mostly by NCR (13.3%) followed by Eastern Visayas (11.4%) and BARMM (7.6%). Regions with the least number of projects and activities were Cagayan Valley (1.9%), Socksargen (3.3%) and CARAGA (3.8%). Regions with the greatest number of projects and activities per capacity building program; NCR for Scholarship and Awards, Eastern Visayas and Central Luzon for RRF and Eastern Visayas for RHRDC.

Results showed that regions with high expenditure do not necessarily follow that it has a lot of projects and activities. On the other hands, quantifying the number of projects and activities indicated the Visayas dominated 2 out of 5 programs implemented for capacity building.

Table 2. Regional Distribution of Projects and Activities per Capacity Development Program, 2015- 2017

REGION	SCHOLARSHIP	AWARDS	FELLOWSHIP	RRF	RHRDC	TOTAL
NCR	23	1	-	2	2	28
CAR	-	-	-	2	9	11
Ilocos Region	-	-	-	2	13	15
Cagayan Valley	1	-	-	-	3	4
Central Luzon	4	-	-	3	3	10
Calabarzon	12	-	-	-	1	13
Mimaropa	3	-	-	-	6	9
Bicol Region	1	-	-	-	8	9
Western Visayas	1	-	-	-	8	9
Central Visayas	-	-	-	-	13	13
Eastern Visayas	3	-	-	3	18	24
Zamboanga Pen	-	-	-	1	10	11
Northern Mindanao	1	-	-	-	10	11
Davao Region	2	-	-	1	10	13
Socksargen	-	-	-	1	6	7
Caraga	-	-	-	1	7	8
BARMM	-	-	-	-	16	16
TOTAL	51	1	0	16	143	211

4.2. Clustering of Regions

Regional clustering was determined based on the historical performance of the regions in conducting projects and activities for capability building on health research. In planning for the implementation of projects and activities through regional clustering, the following were considered: (1) Equitable distribution of capacity building program's project and activities, (2) clustering of regions based on performance to focus IDD's assistance and (3) setting of targets to ensure projects and activities are implemented per program based on a predefined budget.

Regional clusters were defined as follows:
Cluster 1: Non-performing to low performing regions
Cluster 2: Moderately performing regions
Cluster 3: High performing regions
Cluster 4: Extremely high performing regions

With these initial classification, the target number of PAP's assigned for each regional cluster aims to upgrade the performance of regions under Cluster 1 to moderately performing regions; while regions from Cluster 2 to high performing regions; regions from Cluster 3 to extremely high performing regions; and regions from Cluster 4 shall maintain its performance.

For the scholarship program, majority of the regions were in Cluster 1 since there were no recorded accomplishments in Regions CAR, Ilocos Region, Central Visayas, Zamboanga Peninsula, Sockargen, Caraga, and BARMM. NCR and Calabarzon were in Cluster 4 while the rest of the regions were categorized under Cluster 2 or 3.

Figure 2 shows the distribution of regions per cluster. Results suggests that IDD's intensive assistance to implement projects and activities should shift in parts of Luzon and Mindanao.

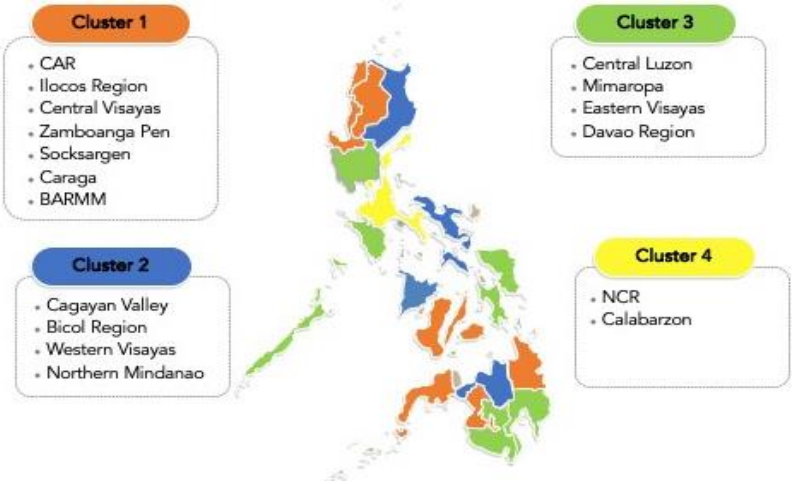

Figure 2. Clustering of Regions for the Scholarship Program

The target number of projects and activities for the scholarship program was derived from setting an increase of 20% in PAPs across the regions. Historically, there are 51 projects and activities conducted which will result into 61 total targets of projects and activities to be distributed per regional cluster. Table 3 shows the distribution of targets for the scholarship program.

Table 3. Target number of projects and activities per regional cluster, Scholarship program

CLUSTER	REGION	TARGET
I	CAR Ilocos Region Central Visayas Zamboanga Pen Socksargen Caraga BARMM	3
II	Cagayan Valley Bicol Region Western Visayas Northern Mindanao	5
III	Central Luzon Mimaropa Eastern Visayas Davao Region	15
IV	NCR Calabarzon	38

Under the fellowship program, 10 regions are equally distributed in Cluster 1 and 3 while 4 of the regions in Luzon (NCR, CAR, Ilocos Region and Central Luzon) are in Cluster 4 (See Figure 4). Since there were no recorded projects and activities, the target was set to 1 per region and the clustering was based from the RHRDC program regional clustering. RHRDC is the longest program implemented by IDD which may serve as a reliable source on how to gauge the capability of the regions in implementing projects and activities. Table 4 shows the target number of projects and activities per regional cluster.

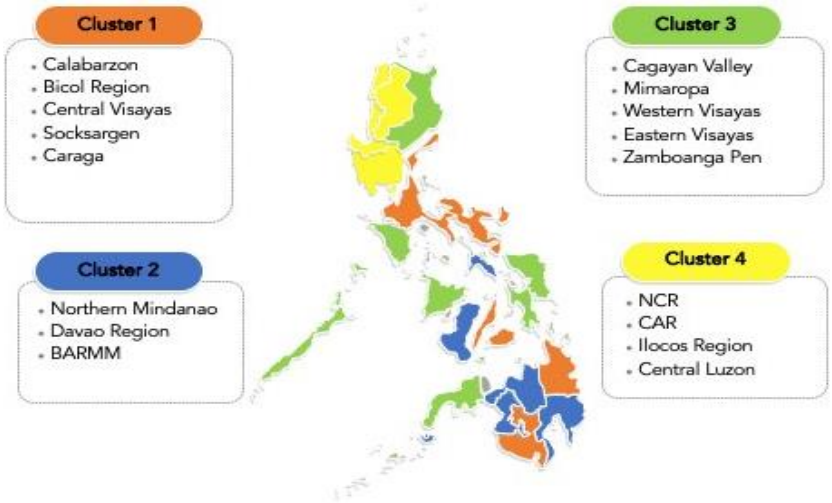

Figure 3. Clustering of Regions for the Fellowship Program

Table 4. Target number of projects and activities per regional cluster, Fellowship program

CLUSTER	REGION	TARGET
I	Calabarzon Bicol Region Central Visayas Socksargen Caraga	5
II	Northern Mindanao Davao Region BARMM	3
III	Cagayan Valley Mimaropa Western Visayas Eastern Visayas Zamboanga Pen	5
IV	NCR CAR Ilocos Region Central Luzon	4

The clustering for Awards program followed the clustering of regions created by IDD for the evaluation of Awards entries. The clustering was Luzon, Visayas, Mindanao and NCR. Figure 4 shows the distribution of regions per cluster. In targeting the number of projects and activities for the Awards program, it followed the targets of the Fellowship program since it only recorded 1 projects/activities for 2015-2017. Table 5 shows the distribution of targets per regional cluster wherein the highest target was set for Cluster 1.

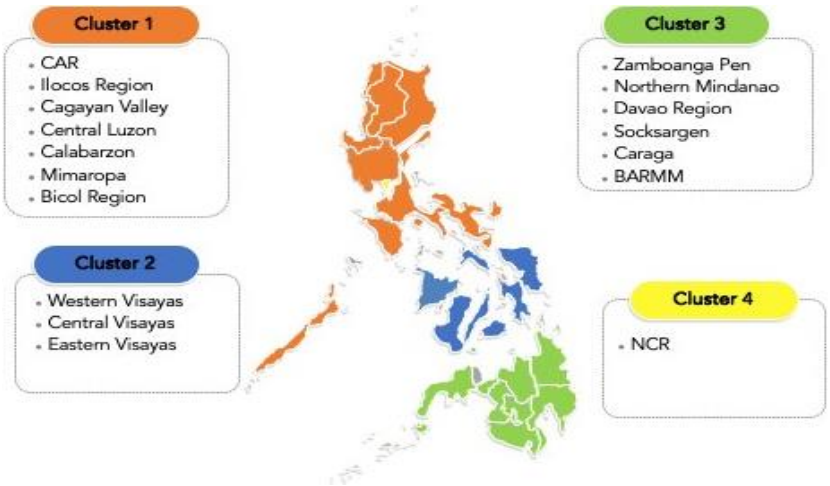

Figure 4. Clustering of Regions for the Awards Program

Table 5. Target number of projects and activities per regional cluster, Awards program

CLUSTER	AWARDS	TARGET PAPs
I	CAR Ilocos Region Cagayan Valley Central Luzon Calabarzon Mimaropa Bicol Region	7
II	Western Visayas Central Visayas Eastern Visayas	3
III	Zamboanga Pen Northern Mindanao Davao Region Socksargen Caraga BARMM	6
IV	NCR	1

Regional clustering for RHRDC program was based on the absorptive capacity of the region in utilizing the funds for the programs projects/activities vis-à-vis number of accomplished projects and activities.

Figure 5 shows that most of the high performing regions (NCR, CAR, Central Luzon, Ilocos Region) were in Luzon. Moreover, 10 regions were equally distributed in Cluster 1 and Cluster 3. The regions on Cluster 2 were all from Mindanao.

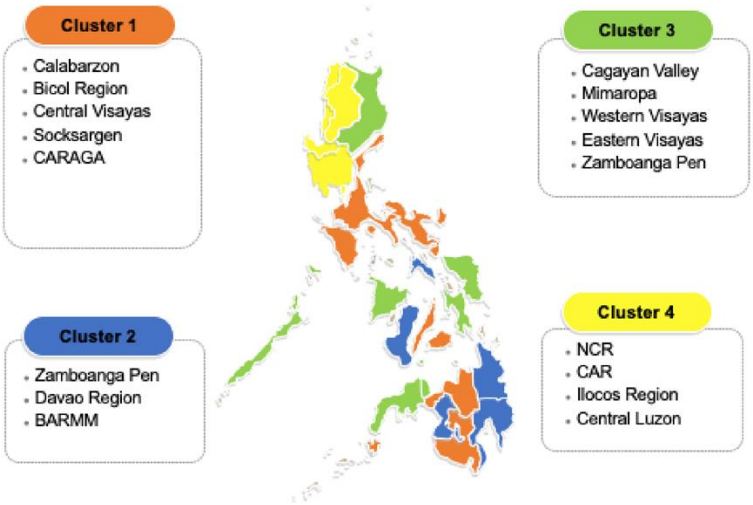

Figure 5. Clustering of Regions for the Regional Health Research and Development Consortium Program

The targets set for RHRDC is shown in Table 6. Target setting was based on equitable target distribution per regions multiplied by the number of regions in the cluster.

The high performing regions were assigned with high targets since the records showed that these regions can possibly keep up with the targets. However, IDD is operating with 7 regional program officers to manage the RHRDCs. Based on the distribution of targets, the same RPO will be assigned to the regions with very low performance, thus may possible affect the quality of assistance provided to these regions.

Table 6. Target number of projects and activities per regional cluster,
Regional Health Research and Development Consortium Program

CLUSTER	REGION	TARGET
I	Calabarzon Bicol Region Central Visayas Socksargen Caraga	25
II	Northern Mindanao Davao Region BARMM	18
III	Cagayan Valley Mimaropa Western Visayas Eastern Visayas Zamboanga Pen	50
IV	NCR CAR Ilocos Region Central Luzon	80

Figure 6 shows the regional clustering for the RRF program. The clustering of regions was based from the number of RRF projects/activities conducted. It can be noted that Cluster 1 regions have no existing RRF projects/activities and majority of the regions were from Luzon (4) followed by regions from Visayas (2) and Mindanao (2).

Logically, RRF projects and activities should be directly proportional to the RHRDC projects and activities since one of the indicators that gauges the impact of RHRDC operation is the submission of RRF projects from the researchers trained by RHRDC. Comparing the results, Ilocos Region was labeled as the top spender for RHRDC projects and activities, however, was categorized in Cluster 3 for RRF program.

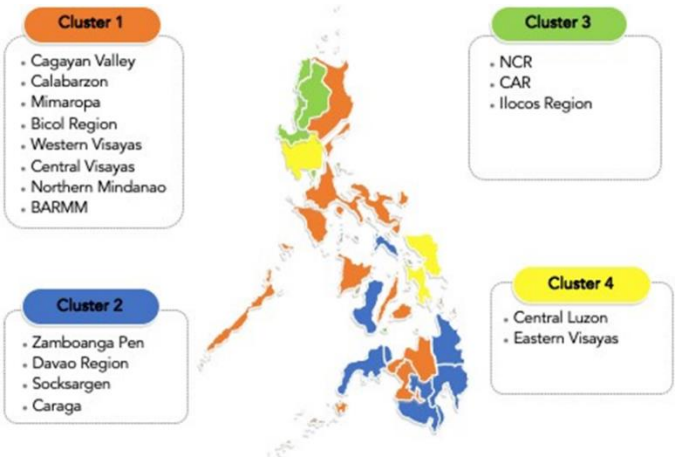

Figure 6. Clustering of Regions for the Regional Research Fund (RRF) Initiative Program

Table 7 shows the distribution of projects and activities per regional cluster. The distribution of target number of projects and activities went down as the regional cluster number went up. For Cluster 1, the target number of projects and activities was 24, 12 for Cluster 2, 9 for Cluster 3 and 6 for Cluster 4.

In targeting the number of RRF projects/activities, regions with on-going projects and unliquidated funds were considered. Based on Table 2, Eastern Visayas and Central Luzon which were both in Cluster 4 have already 3 projects/activities each. Targeting to increase the number of projects may be too risky for the Council since it will increase the chance of having unsettled project funds due to piling up of projects. Also, this will be an added concern to RHRDC apart from its target projects/activities.

Table 7. Target number of projects and activities per regional cluster
Regional Research Fund (RRF) Initiative Program

CLUSTER	REGION	TARGET
I	Cagayan Valley Calabarzon Mimaropa Bicol Region Western Visayas Central Visayas Northern Mindanao BARMM	24
II	Zamboanga Pen Davao Region Socksargen Caraga	12
III	NCR CAR Ilocos Region	9
IV	Central Luzon Eastern Visayas	6

4.3. Goal Model

A GP model is an ideal decision-making methodology that can be used to make an optimal selection of regional cluster that can achieve the target projects and activities per capacity building program. A GP model considers the resource limitations (i.e. budgetary limitations) and other selection limitations (i.e. mandated projects) which should be rigidly observed during the selection decision.

In order to determine the optimal project and activities in each regional cluster according to programs, the goals are:

Goal 1: Increase number projects and activities for scholarship program by 61 (at least 20% of the total accomplishment from prior years), equitably distributed per cluster
Goal 2: Have at least one projects and activities for awards program per region per cluster
Goal 3: Have at least one projects and activities for fellowship program per region per cluster
Goal 4: Increase number of projects and activities for RRF by 51, equitably distributed per cluster
Goal 5: Increase number of projects and activities for RHRDC program by 173 (at least 20% of the total accomplishment from prior years), equitably distributed per region per cluster

In this regard, the GP model for can be stated as follows:
Minimize:

$$z = \sum_{k=1}^{K} \sum_{i=1}^{m} w_{ki} P_k \left(d_i^- + d_i^+ \right) \tag{1}$$

Subject to:

$$\sum_{i=1}^{m} a_{ij} x_j + d_i^- - d_i^+ = b_i \qquad (j = 1, 2, \ldots, n) \tag{2}$$

x_j, d_i^-, d_i^+ = non-negative integers (*i* = 1, 2, …, m; *j* = 1, 2, …, n)

where:
z = the sum of the weighted deviational variables
w_{ki} = the relative weight assigned to *k* priority level for the *i*th goal constraint
P_k = the kth preemptive priority
d_i^- = a negative deviational variable describing under-achievement of the *i*th goal
d_i^+ = a positive deviational variable describing over-achievement of the *i*th goal
a_{ij} = technical coefficient for the decision variable x
x_j = the *j*th of variable x
b_i = the right-hand-side value for the *i*th goal constraint

Decision variables
For this study, there are four decision variables per program. They are:

x1, x2, x3, x4 = number of PAPs for scholarship program in Cluster 1 (x1), Cluster 2 (x2), Cluster 3 (x3) and Cluster 4 (x4)
x5, x6, x7, x8 = number of target nominees for award in Cluster 1 (x5), Cluster 2 (x6), Cluster 3 (x7) and Cluster 4 (x8)
x9, x10, x11, x12 = number of fellows in Cluster 1 (x9), Cluster 2 (x10), Cluster 3 (x11) and Cluster 4 (x12)

x13, x14, x15, x16 = number of RRF funded projects in Cluster 1 (x13), Cluster 2 (x14), Cluster 3 (x15) and Cluster 4 (x16)
x17, x18, x19, x20 = number of PAPs for RHRDC in Cluster 1 (x17), Cluster 2 (x18), Cluster 3 (x19) and Cluster 4 (x20)

Constraints

The formulation of a GP model assumes that all problem constraints become goal from which to determine the best possible solution. To achieve balance distribution of PAPs and/or targets per cluster, the identified constraints are showed on the following equations:

$$x_1 + x_2 + x_3 + x_4 = 61 \quad (4)$$
$$x_5 + x_6 + x_7 + x_8 = 17 \quad (5)$$
$$x_9 + x_{10} + x_{11} + x_{12} = 17 \quad (6)$$
$$x_{13} + x_{14} + x_{15} + x_{16} = 51 \quad (7)$$
$$x_{17} + x_{18} + x_{19} + x_{20} = 173 \quad (8)$$

Equation (4) determines the desired number of PAPs for scholarship program; equation (5) specifies the desired number of award nominees; equation (6) for the desired number of fellows; equation (7) for the desired number of RRF funded projects; equation (8) for the number of PAPs to be implemented under the RHRDC program, in which all of these are in Cluster 1, 2, 3, & 4, respectively. All these constraints as stated in equations (4), (5), (6), (7), and (8) ensures that the target value is met. Constraint, as showed in equation (3), ensures that all the decision variables are non-negative.

Deviation variables
The objective function of the model is to minimize the deviation variables corresponding to various goals. Therefore, deviation variables are shown as follows:

d_1^+, d_2^+, d_3^+, d_4^+ = the deviation variables of overachievement of the Goal 1 in Cluster 1 (d_1^+), Cluster 2 (d_2^+), Cluster 3 (d_3^+) and Cluster 4 (d_4^+)
d_1^-, d_2^-, d_3^-, d_4^- = the deviation variables of underachievement of the Goal 1 in Cluster 1 (d_1^-), Cluster 2 (d_2^-), Cluster 3 (d_3^-) and Cluster 4 (d_4^-)
d_5^+, d_6^+, d_7^+, d_8^+ = the deviation variables of overachievement of the Goal 2 in Cluster 1 (d_5^+), Cluster 2 (d_6^+), Cluster 3 (d_7^+) and Cluster 4 (d_8^+)
d_5^-, d_6^-, d_7^-, d_8^- = the deviation variables of underachievement of the Goal 2 in Cluster 1 (d_5^-), Cluster 2 (d_6^-), Cluster 3 (d_7^-) and Cluster 4 (d_8^-)
d_9^+, d_{10}^+, d_{11}^+, d_{12}^+ = the deviation variables of overachievement of the Goal 3 in Cluster 1 (d_9^+), Cluster 2 (d_{10}^+), Cluster 3 (d_{11}^+) and Cluster 4 (d_{12}^+)
d_9^-, d_{10}^-, d_{11}^-, d_{12}^- = the deviation variables of underachievement of the Goal 3 in Cluster 1 (d_9^-), Cluster 2 (d_{10}^-), Cluster 3 (d_{11}^-) and Cluster 4 (d_{12}^-)
d_{13}^+, d_{14}^+, d_{15}^+, d_{16}^+ = the deviation variables of overachievement of the Goal 4 in Cluster 1 (d_{13}^+), Cluster 2 (d_{14}^+), Cluster 3 (d_{15}^+) and Cluster 4 (d_{16}^+)
d_{13}^-, d_{14}^-, d_{15}^-, d_{16}^- = the deviation variables of underachievement of the Goal 4 in Cluster 1 (d_{13}^-), Cluster 2 (d_{14}^-), Cluster 3 (d_{15}^-) and Cluster 4 (d_{16}^-)
d_{17}^+, d_{18}^+, d_{19}^+, d_{20}^+ = the deviation variables of overachievement of the Goal 5 in Cluster 1 (d_{17}^+), Cluster 2 (d_{18}^+), Cluster 3 (d_{19}^+) and Cluster 4 (d_{20}^+)
d_{17}^-, d_{18}^-, d_{19}^-, d_{20}^- = the deviation variables of underachievement of the Goal 5 in Cluster 1 (d_{17}^-), Cluster 2 (d_{18}^-), Cluster 3 (d_{19}^-) and Cluster 4 (d_{20}^-)
d_{21}^+, d_{22}^+, d_{23}^+, d_{24}^+ = the deviation variables of overachievement of the Goal 6 in Cluster 1 (d_{21}^+), Cluster 2 (d_{22}^+), Cluster 3 (d_{23}^+) and Cluster 4 (d_{24}^+)
d_{21}^-, d_{22}^-, d_{23}^-, d_{24}^- = the deviation variables of underachievement of the Goal 6 in Cluster 1 (d_{21}^-), Cluster 2 (d_{22}^-), Cluster 3 (d_{23}^-) and Cluster 4 (d_{24}^-)

After identifying the desired variables, the identified goal should be translated to mathematical equation, aligned to the GP model's objective function, and based on the:

(a) desired number of PAPs for scholarship program in Cluster 1, 2, 3 & 4

$$x_1 - 3 + (d_1^-) - (d_1^+) = 0 \quad (9)$$
$$x_2 - 5 + (d_2^-) - (d_2^+) = 0 \quad (10)$$
$$x_3 - 15 + (d_3^-) - (d_3^+) = 0 \quad (11)$$
$$x_4 - 38 + (d_4^-) - (d_4^+) = 0 \quad (12)$$

(b) desired number of award nominees in Cluster 1, 2, 3 & 4

$$x_5 - 7 + (d_5^-) - (d_5^+) = 0 \quad (13)$$
$$x_6 - 3 + (d_6^-) - (d_6^+) = 0 \quad (14)$$
$$x_7 - 6 + (d_7^-) - (d_7^+) = 0 \quad (15)$$
$$x_8 - 1 + (d_8^-) - (d_8^+) = 0 \quad (16)$$

(c) desired number of fellows in cluster 1, 2, 3, & 4

$$x_9 - 5 + (d_9^-) - (d_9^+) = 0 \quad (17)$$
$$x_{10} - 3 + (d_{10}^-) - (d_{10}^+) = 0 \quad (18)$$
$$x_{11} - 5 + (d_{11}^-) - (d_{11}^+) = 0 \quad (19)$$
$$x_{12} - 4 + (d_{12}^-) - (d_{12}^+) = 0 \quad (20)$$

(d) desired number of RRF funded projects in cluster 1, 2, 3, & 4

$$x_{13} - 24 + (d_{13}^-) - (d_{13}^+) = 0 \quad (21)$$
$$x_{14} - 12 + (d_{14}^-) - (d_{14}^+) = 0 \quad (22)$$
$$x_{15} - 9 + (d_{15}^-) - (d_{15}^+) = 0 \quad (23)$$
$$x_{16} - 6 + (d_{16}^-) - (d_{16}^+) = 0 \quad (24)$$

(e) desired number of PAPs for RHRDC in cluster 1,2,3, & 4

$$x_{17} - 25 + (d_{17}^-) - (d_{17}^+) = 0 \quad (25)$$
$$x_{18} - 18 + (d_{18}^-) - (d_{18}^+) = 0 \quad (26)$$
$$x_{19} - 50 + (d_{19}^-) - (d_{19}^+) = 0 \quad (27)$$
$$x_{20} - 24 + (d_{20}^-) - (d_{20}^+) = 0 \quad (28)$$

Lastly, the objective function's goal weights will change depending on the requirements of each specific program. These weights are assigned based upon the goal precedence listed above and the relative importance of each goal to the others. Part of this model's flexibility is that, in addition to changing which goals are considered, the relative properties of the goals can easily be modified simply by changing the weights.

The GP Model was solved using the Excel Solver with the inputs detailed above, and the solution yields the following results as shown in Tables 8-12.

Results in Table 8 showed that targeting an increase of 20% from the baseline was not achieved for most of the Cluster in the scholarship program. The target number of projects and activities were not achieved for Cluster 1, 3 and 4. There was an underachievement of 12 and 35 for Cluster 3 and 4, respectively

On the hand, there was an over achievement of 6 targets for Cluster 2.

Table 8. Summary of Results for Goal 1

Program per Cluster		Goal / Targets	Decision Variable		Over achievement deviation variable (+)		Under achievement deviation variable (-)		Goal Achievement
Scholarship	Cluster 1	3	x1	0	d1	0	d1	3	Not achieved
	Cluster 2	5	x2	11	d2	6	d2	0	Over achieved
	Cluster 3	15	x3	3	d3	0	d3	12	Not achieved
	Cluster 4	38	x4	3	d4	0	d4	35	Not achieved
Total		61		17		6		50	

For the Awards program, all of the targets for each cluster were achieved. There was an over achievement of 9 targets for Cluster 4 while targets in Cluster 1,2 and 3 were fully achieved as shown in Table 9.

Table 9. Summary of Results for Goal 2

Program per Cluster		Goal / Targets	Decision Variable		Over achievement deviation variable (+)		Under achievement deviation variable (-)		Goal Achievement
Awards	Cluster 1	7	x5	7	d5	0	d5	0	Fully achieved
	Cluster 2	3	x6	3	d6	0	d6	0	Fully achieved
	Cluster 3	6	x7	6	d7	0	d7	0	Fully achieved
	Cluster 4	1	x8	10	d8	9	d8	0	Over achieved
Total		17		17		9		0	

Table 10 shows that all related deviational variables were zero, thus, the targets set for each regional Cluster under the Fellowship program were fully achieved.

Table 10. Summary of Results for Goal 3

Program per Cluster		Goal / Targets	Decision Variable		Over achievement deviation variable (+)		Under achievement deviation variable (-)		Goal Achievement
Fellowship	Cluster 1	5	x9	5	d9	0	d9	0	Fully achieved
	Cluster 2	3	x10	3	d10	0	d10	0	Fully achieved
	Cluster 3	5	x11	5	d11	0	d11	0	Fully achieved
	Cluster 4	4	x12	4	d12	0	d12	0	Fully achieved
Total		17		17		0		0	

For the RRF program, results showed in Table 11 satisfies all the targets for Cluster 1, 3 and 4. However, the target set for Cluster 2 (12) was unmet with as deviational variable of 11.

Table 11. Summary of Results for Goal 4

Program per Cluster		Goal / Targets	Decision Variable		Over achievement deviation variable (+)		Under achievement deviation variable (-)		Goal Achievement
RRF	Cluster 1	24	x13	24	d13	0	d13	0	Fully achieved
	Cluster 2	12	x14	1	d14	0	d14	11	Not achieved
	Cluster 3	9	x15	9	d15	0	d15	0	Fully achieved
	Cluster 4	6	x16	6	d16	0	d16	0	Fully achieved
Total		51		40		0		11	

All the regional cluster targets for the RHRDC program were not achieved as shown in Table 12. The deviation variable for the unmet targets were 24 for Cluster 1, 18 for Cluster 2, 50 for Cluster 3 and 80 for Cluster 4.

Table 12. Summary of Results for Goal 5

Program per Cluster		Goal / Targets	Decision Variable		Over achievement deviation variable (+)		Under achievement deviation variable (-)		Goal Achievement
RHRDC	Cluster 1	25	x17	1	d17	0	d17	24	Not achieved
	Cluster 2	18	x18	0	d18	0	d18	18	Not achieved
	Cluster 3	50	x19	0	d19	0	d19	50	Not achieved
	Cluster 4	80	x20	0	d20	0	d20	80	Not achieved
Total		173		1		0		172	

4.4. AHP Model

After ensuring that all regions were considered in the implementation of capacity building programs and the clustering of regions provided an overview to IDD where to shift its focus and resources, there is a high possibility of increase in researchers/scholars availing the program.

With this, the AHP model was created to prioritize the recipients of capacity building programs considering that the Council operates in a budget released quarterly by the Department of Budget and Management (DBM). Also, this will serve as a framework that will identify recipients that will really contribute to the over-all objective of the Council, which is to capacitate researchers and institutions.

The AHP model, is a systematic procedure for representing the elements of a problem in the form of a hierarchy. At the top level of the hierarchy, criteria are evaluated and at the next levels the alternatives are evaluated by each criterion. In the evaluation, pairwise comparisons are used to provide a subjective evaluation of the alternatives based on multiple criteria. The comparisons are made using Saaty's preference scale.

4.4.1. Criteria used in the AHP Model

To determine the criteria and sub-criteria for each level, IDD's programs heads were consulted. Review of existing procedures and work instructions were reviewed to determine the essential information in determining the sub-criteria for each program.

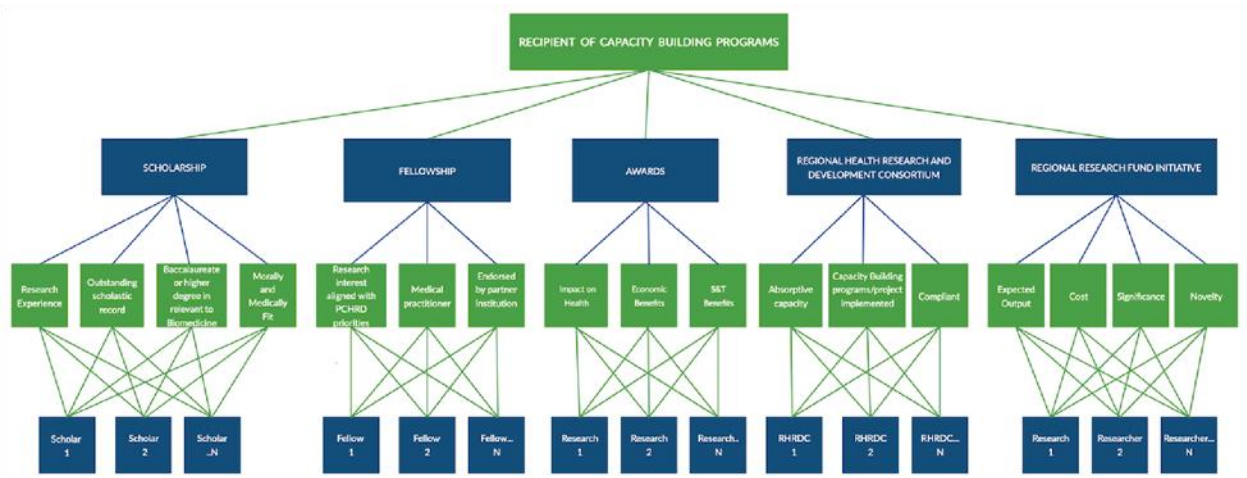

Figure 7. Structure of the AHP Model

Figure 7 shows the 5 layers of the AHP with the goal of determining the recipient of capacity building programs. The second layer presents the 5 major criteria: Scholarship, Fellowship, Awards, Regional Health Research and Development Consortium and Regional Research Fund Initiative. The third layer depicts the sub-criteria while the last layer are the alternatives for each program.

For the scholarship criterion, the sub-criteria were the research experience, outstanding scholastic record, baccalaureate or higher degree relevant to Biomedicine and morally and medically fit.

For the fellowship criterion, the sub-criteria were research interest aligned with PCHRD priorities, medical practitioner and endorsed by partner institution.

Regarding awards criterion, the sub-criteria were impact on health, economic benefits and S&T benefits.

For the RHRDC criterion, its sub-criteria were absorptive capacity, capacity building programs/projects implemented and compliant to the requirements for funding.

For RRF criterion, the sub-criteria were expected output, cost, significance and novelty.

4.4.2. Pairwise Comparison of Criteria

The sub-criteria and Saaty's preference scale (Table 13) were used in the development of the questionnaire. Questions were administered through Google forms to 10 individuals acting as program heads or planning officers of the Council.

Table 13. Saaty's Preference Scale

Importance Scale	Definition of Importance Scale
1	Equally Important
2	Equally to Moderately Important
3	Moderately Important
4	Moderately to Strongly Important
5	Strongly Important
6	Strongly to Very Strongly Important
7	Very Strongly Important
8	Very Strongly to Extremely Important
9	Extremely Important

Scholarship pairwise comparison result (Table 14) shows that the highest criterion was the Baccalaureate or higher degree in Biomedicine while the least was the research experience. The consistency ratio is computed at 0.029 which indicates that the comparison matrix is relatively consistent.

Since the Council offers a specialized scholarship in Biomedicine, it was reported that the main reason for the dropout of 2 MS scholars is the realization of recipients that Biomedicine is not their field of interest. This reason resulted to poor performance of the scholar that eventually led to discontinuance of scholarship. With the highest criteria given to Baccalaureate or higher degree in Biomedicine, the priority will be given to scholars with higher chances of completing the program.

Table 14. Summary of Pairwise Comparison for Scholarship

	Research Experience	Outstanding Scholastic Record	Baccalaureate or higher degree in Biomedicine	Morally and Medically Fit	4th root of product	priority vector
Research Experience	1.000	0.571	0.400	1.000	0.691	0.165
Outstanding Scholastic Record	1.778	1.000	0.667	1.667	1.186	0.282
Baccalaureate or higher degree in Biomedicine	2.500	1.571	1.000	1.286	1.499	0.357
Morally and Medically Fit	1.000	0.600	0.778	1.000	0.827	0.197
Sum	6.278	3.743	2.844	4.952	4.203	1.000
Sum*PV	1.033	1.056	1.015	0.974	4.077	
Lambda max	4.077					
CI	0.026					
CR	0.029 (relatively consistent)					

For the fellowship program in Table 15, the highest criterion was research interest aligned with PCHRD priorities (0.052) while the lowest is that he/she should be a medical practitioner (0.170). The consistency of the comparison matrix is 0.014 which is relatively consistent.

The highest criterion given to this program is consistent with the program's objective which is to develop competency and expertise in health research on PCHRD's priority areas.

Table 15. Summary of Pairwise Comparison for Fellowship

	Research interest aligned with PCHRD priorities	Medical Practitioner	Endorsed by partner institution	3rd root of product	Priority Vector
Research interest aligned with PCHRD priorities	1.000	2.833	3.000	2.041	0.592
Medical Practitioner	0.333	1.000	0.600	0.585	0.170
Endorsed by partner institution	0.333	1.667	1.000	0.822	0.238
Sum	1.667	5.500	4.600	3.448	1.000
Sum*PV	0.987	0.933	1.097	3.016	
Lambda max	3.016				
CI	0.008				
CR	0.014 (relatively consistent)				

For the Awards program as shown in Table 16, the highest criterion was impact on health (0.556), followed by S&T benefits (0.282) and economic benefits (0.163). There was relative consistency on the comparison matrix (CR=0.012).

The Council's Awards program was advertised as "*giving recognition to individuals and groups for their exemplary research efforts and contributions in enhancing health research capabilities*". However, since 2017, the submitted entries hardly passed during the evaluation of research entries. With the resulting criterion in the AHP model, it is

quite misleading since the IDD prioritizes impact rather than the expected benefits which the Call for Awards was specifically based on.

Table 16. Summary of Pairwise Comparison for Awards

	Impact on Health	Economic Benefits	S&T Benefits	3rd root of product	Priority Vector
Impact on Health	1.000	4.000	1.667	1.882	0.556
Economic Benefits	0.250	1.000	0.667	0.550	0.163
S&T Benefits	0.600	1.444	1.000	0.953	0.282
Sum	1.850	6.444	3.333	3.386	1.000
Sum*PV	1.028	1.047	0.939	3.014	
Lambda max	3.014				
CI	0.007				
CR	0.012 (relatively consistent)				

Table 17 showed that the highest priority criterion for the RHRDC program was capacity building programs/project implemented (0.498) and the lowest was compliant to the requirements for funding (0.141). The consistency matrix was relatively consistent and was computed at CR=0.006.

The priority criterion for the RHRDC program showed consistency with the Council's objective in establishing the regional consortium. To date, the Council is maintaining the health consortium in all the regions including BARMM.

Table 17. Summary of Pairwise Comparison for RHRDC

	Absorptive Capacity	Capacity building programs/projects implemented	Compliant	3rd root of product	Priority Vector
Absorptive Capacity	1.000	0.833	2.250	1.233	0.362
Capacity building programs/projects implemented	1.222	1.000	4.000	1.697	0.498
Compliant	0.444	0.250	1.000	0.481	0.141
Sum	2.667	2.083	7.250	3.411	1.000
Sum*PV	0.964	1.037	1.022	3.022	
Lambda max	3.022				
CI	0.011				
CR	0.006 (relatively consistent)				

As shown in Table 18, the RRF program prioritized the criterion on cost (0.394) followed by expected output (0.392) and novelty (0.127). The least priority criterion was significance of the research (0.087). The computed CR is 0.017 which showed relative consistency in the pairwise matrix.

The weights given to expected output and cost were almost equal. This only shows that IDD is particular in the amount of financial support given to new health researchers. With this, the financial support should support the long term goal of IDD for the researchers which is to develop capability in utilizing their researches. With the low weights given to the significance and novelty criteria, majority of the RRF programs implemented were not translated either into policy briefs or academic journals.

Table 18. Summary of Pairwise Comparison for RRF

	Expected Output	Cost	Significance	Novelty	3rd root of product	Priority Vector
Expected Output	1.000	1.333	4.111	2.500	1.924	0.392
Cost	0.750	1.000	4.800	3.875	1.933	0.394
Significance	0.250	0.200	1.000	0.667	0.427	0.087
Novelty	0.400	0.250	1.500	1.000	0.622	0.127
Sum	2.400	2.783	11.411	8.042	4.906	1.000
Sum*PV	0.941	1.096	0.994	1.020	4.051	
Lambda max	4.051					
CI	0.017					
CR	0.009 (relatively consistent)					

5. Conclusion

Revisiting the projects and activities per capacity building program vis-a vis the expenditure, it was realized that IDD's financial and human resources were not equitably distributed in the regions. The use of clustering method provided a mechanism to balance the assistance to be provided to the regions without compromising the opportunities of the performing regions as well as the required tangible outputs of IDD in general. It provided a systematic way to plan the targets compared to the usual practice of simply putting numbers based on judgment.

The planned target number of projects and activities per program was only achieved for Awards, Fellowship and RRF. The goal programming model provided an opportunity to identify all the factors which should be considered in realizing the feasibility of the target number of project/activities per capacity building program. Further, application of GP model in planning provided an insight whether the targets will be achieved or not which is helpful in revisiting and updating the plans.

For several years, IDD operates passively in a "first come, first serve" basis for managing its financial resources and was evident since there were no criteria used for prioritizing the capacity building programs. With the creation of AHP model, the priority criterion for each program were identified as follows: (1) Baccalaureate or higher degree in Biomedicine for Scholarship program, (2) research interest aligned with PCHRD priorities for fellowship program, (3) impact on health for the Awards program, (4) capacity building programs/project implemented and (5) cost for RRF. The consistency of the prioritized criterion with the program's objectives were also determined and were found conflicting for Awards and RRF.

Based on the results, the following were recommended:

- Inclusion of other capacity building programs implemented in the region to provide a clearer view of the human resource requirement needed for the implementation of the programs;
- Revisit existing plans to update the strategies regarding the implementation of capacity building programs to;
- Recognize the potential risks of implementing capacity building program and taking suitable measures to identify them;
- Assess potential partners and co-operators in implementing capacity building program; and
- Plan measures in the design phase of projects and activities that will lead to sustainability

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Biographies

Rex Aurelius C. Robielos is the Dean of the School of Industrial Engineering and Engineering Management at Mapua University. Before joining Mapua, he was Section Manager of Operations Research Group, Analog Devices General Trias. He has a BS in Applied Mathematics from the University of the Philippines Los Baños, and a Diploma and MS in Industrial Engineering from the University of the Philippines Diliman. He is pursuing Ph.D in Industrial Management (candidate) at National Taiwan University of Science and Technology in Taiwan. He is the current Secretary of Human Factors and Ergonomics Society of the Philippines and Director of the Philippine Institute of Industrial Engineers and Operations Research Society of the Philippines.

Vanessa Neillizzle B. Bartolome is an Administrative Officer V at the Department of Science and Technology – National Capital Region (DOST-NCR). She received her bachelor's degree in Chemical Engineering from the Technological Institute of the Philippines, Quezon City. She is currently pursuing her Masters in Business Analytics at Mapua University, Manila.

Paula Jane A. de Leon is a Senior Science Research Specialist at the Philippine Council for Health Research and Development of the Department of Science and Technology under its Institution Development Division. She is responsible for the strategic planning of the division and is also involved in the management of capacity building programs in the regions. She received her bachelor's degree in Public Health from the University of the Philippines-Manila and currently pursuing her Masters in Business Analytics at Mapua University, Manila.