Appropriate Resource Allocation of Korea's ICT ODA to Africa: Using Optimization Simulation

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Abstract
This study concerns the allocation of resources aimed at maximizing the effectiveness of aid projects for Africa provided by Korea. It aims to discover how desirable it is to allocate ICT ODA project aid provided by Korea to Africa by business type in order to achieve the optimal resource allocation status. A meaningful result was derived through a simulation process for optimizing resource allocation using POWERSIM software. The conclusion is that the ICT-related aid which has been provided to African countries to date has not been allocated in a desirable way, and it is necessary to re-organize resource allocation in a new way by business type. It is suggested that greater resources should be allocated to the dissemination of ICT systems and infrastructure construction in the future.

Keywords: ICT ODA, optimization, simulation.

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1 Introduction

The amount of aid that Korea provided to the African continent over the ten years from 2009 to 2018 amounted to about $500 million. This is equivalent to around 1% of the $30.4 billion of aid provided to Africa by the OECD Development Assistance Committee (DAC) over the same period. In the future, the amount of aid supplied by Korea to African countries is expected to continue to increase. However, the Corona pandemic, which began in January 2020 and is continuing around the world, is requiring a reconsideration of the strategic direction of Korean aid to Africa. Because of the Corona pandemic, most countries in Africa have restricted face-to-face activities and have imposed restrictions on external activities. These restrictions on external activities have made people reliant on non-face-to-face contact, and have been accompanied by various restrictions in public facilities such as schools and hospitals.

In addition, since the prohibition or restriction of face-to-face activities leads to an increase in the role of Information and Communication Technology (ICT), it is necessary to re-establish the direction of the ODA provided by Korea, an advanced country in the ICT sector. The aim of this study is to provide the necessary information regarding how to establish an ICT-related aid strategy for Korea so that it can provide aid to African countries in the future given awareness of this problem. In particular, it aims to establish what type of business should be selected for providing ICT-related aid to Africa, and how to allocate appropriate resources for each type of business. For this purpose, an optimization simulation method is employed.

2 Theoretical Discussion: Support for Africa

A number of studies have been conducted relating to Korean aid to African countries, but not many on ICT aid. Most of the studies on Korea's ICT aid to Africa concern the effectiveness, or the general evaluation, of ICT aid. However, for policymakers, specific and practical research results are more important than generalised research that merely suggests broad directions. In the case of research related to ICT aid, what is particularly needed is an examination of how to allocate resources so as to maximize the effectiveness of the entire ODA project when trying to allocate resources for various types of ICT aid projects (Adil et al., 2013;

Tunio et al., 2014; World Bank, 2013).

Business types that can be selected for conducting ODA projects include: education and training using ICT, fostering business using ICT, supplying ICT-related systems, building ICT infrastructure, dispatching ICT-related volunteers to Africa, and employing ICT-related specialists (Swan & Hofer, 2011; Esselaar & Adam, 2013. They may also involve inviting human resources to Korea for training, and consultancy on ICT-related policies. Among these various types of projects, it is necessary to examine which types will be suitable for African countries in the future.

Table 1 shows the amount of aid provided to African countries by Korea and the OECD DAC member countries. The unit is a million US dollars. The amount of aid provided by all OECD DAC members in 2018 was around $30.4 billion, and the amount of aid provided over the past decade around $293.5 billion. Korea provided around $500 million in 2018, and the total amount of aid it has provided over the past ten years is around $3 billion. Korea accounts for around 1% of the total aid provided by the OECD DAC.

Table 1 OECD DAC and Korea's Aid to Africa by Year (Unit: USD million)

Donor	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
OECD DAC	28192.37	29140.29	32523.06	30271.15	30054.85	29050.13	26877.31	27213.43	29776.38	30423.84	293522.81
Korea	95.01	139.88	178.36	261.01	271.72	332.72	358.76	415.64	408.01	504.44	2965.55
Korea Ratio	0.34%	0.48%	0.55%	0.86%	0.90%	1.15%	1.33%	1.53%	1.37%	1.66%	1.01%

Table 2 shows the amount of ICT-related aid provided by Korea to African countries by year. As Table 2 shows, the total amount of ICT-related aid that Korea provided to Africa over the ten years from 2009 to 2018 was around $1.5 million.

Table 2 Korea's ICT support to Africa (Unit: USD million)

Recipient_Name	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Africa Total	13.80	16.71	12.04	6.17	5.66	7.09	7.89	11.02	10.10	14.62	**105.09**
Africa, regional	**0.00**	**0.01**	**0.00**	**0.04**	**0.28**	**0.00**	**0.03**	**0.00**	**0.00**	**0.00**	**0.37**
Angola	**9.96**	**1.46**	**4.33**	**1.38**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**17.14**
Botswana	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.10**	**0.00**	**0.01**	**0.00**	**0.00**	**0.11**
Burkina Faso	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**
Burundi	**0.00**	**0.02**	**0.00**	**0.01**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.05**
Cabo Verde	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Chad	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**
Egypt	**0.35**	**0.10**	**0.03**	**0.32**	**0.10**	**0.03**	**0.11**	**0.16**	**0.05**	**0.00**	**1.25**
Ethiopia	**0.09**	**0.01**	**0.55**	**0.87**	**0.67**	**0.54**	**2.17**	**2.90**	**1.05**	**0.47**	**9.32**
Gabon	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.07**	**0.00**	**0.00**	**0.00**	**0.07**
Ghana	**0.03**	**0.15**	**0.03**	**0.09**	**0.06**	**0.06**	**0.14**	**0.24**	**0.07**	**0.24**	**1.10**
Guinea	**0.00**	**0.01**	**0.01**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**
Kenya	**0.08**	**0.11**	**0.08**	**0.10**	**0.07**	**0.28**	**0.10**	**1.46**	**1.40**	**1.90**	**5.58**

Liberia	0.01	0.03	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Morocco	0.90	0.92	0.02	0.68	0.11	0.18	0.45	0.49	0.43	0.26	4.44
Mozambique	0.00	0.04	0.05	0.02	0.00	0.05	0.06	0.10	0.51	0.27	1.10
Niger	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01
North of Sahara, regional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rwanda	1.25	2.38	0.08	0.74	0.77	0.23	0.80	1.62	2.13	5.00	14.99
Senegal	0.29	10.71	4.99	0.55	0.17	0.00	0.07	0.28	0.34	0.48	17.89
South Africa	0.25	0.06	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.35
South of Sahara, regional	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Sudan	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Tanzania	0.38	0.11	1.22	0.40	0.06	0.07	0.09	0.46	0.27	0.34	3.41
Tunisia	0.10	0.05	0.04	0.29	0.00	0.04	0.18	0.22	0.18	0.20	1.30
Uganda	0.00	0.09	0.04	0.08	0.00	0.55	0.17	1.38	0.21	0.24	2.76
Zambia	0.01	0.02	0.02	0.01	0.00	0.00	0.01	0.00	0.00	0.04	0.12
Zimbabwe	0.02	0.05	0.05	0.06	2.05	3.82	1.16	0.05	0.47	0.26	8.00
Algeria	0.00	0.05	0.00	0.02	0.00	0.00	0.06	0.00	0.00	0.03	0.16
Benin	0.00	0.00	0.01	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.05
Cameroon	0.01	0.05	0.04	0.11	0.00	0.00	0.57	0.57	0.66	0.04	2.06
Cote d'Ivoire	0.01	0.17	0.01	0.01	0.00	0.00	0.01	0.16	0.94	2.50	3.80
Democratic Republic of the Congo	0.01	0.01	0.05	0.00	0.00	0.05	0.15	0.00	0.15	0.08	0.51
Libya	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.11
Mali	0.01	0.00	0.01	0.00	0.03	0.00	0.01	0.00	0.00	0.00	0.06
Nigeria	0.03	0.07	0.07	0.07	1.04	0.87	1.43	0.95	1.02	1.71	7.25
Lesotho	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Malawi	0.00	0.03	0.20	0.19	0.00	0.00	0.00	0.00	0.00	0.53	0.94
Mauritania	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sierra Leone	0.00	0.00	0.02	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.06
Congo	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Eritrea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Djibouti	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Eswatini	0.00	0.00	0.01	0.02	0.00	0.09	0.00	0.00	0.00	0.00	0.12
Namibia	0.00	0.00	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.05
Somalia	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
South Sudan	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Madagascar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.20
Togo	0.00	0.00	0.00	0.00	0.01	0.10	0.00	0.00	0.00	0.00	0.12
Comoros	0.00	0.00	0.00	0.00	0.03	0.00	0.04	0.00	0.00	0.00	0.07
Guinea-Bissau	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central African Republic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

By contrast, Table 3 shows the scale of ICT-related ODA aid by project type. ICT training is highes t at 19.75%, and type of ICT volunteers lowest at 5.95%.

Table 3 Current budget ratio by the type of project

Type	Amount	Ratio
ICT training	$ 18,680,940	19.75%
ICT-related business	$ 7,980,579	8.44%
ICT system provision	$ 11,732,154	12.40%
ICT infra establishment	$ 16,221,200	17.15%
ICT volunteers	$ 5,631,877	5.95%
ICT invitation	$ 18,013,020	19.05
ICT consulting	$ 16,319,057	17.26
Total	$ 94,578,827	100

3 Survey Design

This study is based on the premise that resource allocation has not been optimized when ICT-related aid provided by Korea to Africa over the last ten years has been reviewed by project type. To solve this problem, it is necessary to derive an optimization value for resource allocation using an optimization simulation method. The data required here are: the previously-obtained performance score for each type of project; the future necessity for each type of project; the ripple effect for each type of project; the feasibility of each type of project; and the current resource allocation data for each type of project.

In order to collect these data, five experts were selected and the necessary data were obtained from them. These five experts have experience in conducting ICT ODA as a project in Africa, or have experience in evaluating these projects. From these five experts, data on the degree of need, feasibility, and ripple effect in Africa by project type were collected. These data are presented in Table 4.

Table 4 Scores of the evaluation criteria

Project type	necessity	feasibility	impact	performance	budget	budget ratio
ICT-training	8.75	9	9.5	7.5	18,680,940	0.20
ICT-business	6.75	5.75	7.25	5	7,980,579	0.08
ICT-system provision	9	7.75	8.5	6.25	11,732,154	0.12
ICT-infra	8.5	7.25	9.5	6	16,221,200	0.17
ICT-volunteering	7.25	8.25	8	7.75	5,631,877	0.06
ICT-invitation	7.5	8.75	6.5	7.5	18,013,020	0.19
ICT-consulting	8.75	8.75	9	6.75	16,319,057	0.17
Total				46.75	94,578,827	1

Note. Unit: scale is 1 to 10 points, budget is dollars

Using these data, this study attempts to derive the optimal resource allocation status for each

project type in order to maximize performance within limited resources.

The simulation process derives, first, the feasib ility score for each project, then the necessity and ripple effect for each business type, and fi nally, a formula that can predict the performan ce score for each project type. After this proc ess is complete, it is decided to derive the opt imal resource allocation status for each project type.

4 Analysis and Implications

First, we will try to find a prediction equation for the feasibility score for each project type. It was assumed that the feasibility score was d etermined by the budget for each project type. Therefore, an optimization simulation was perf ormed for this, the results of which are shown in Figure 1.

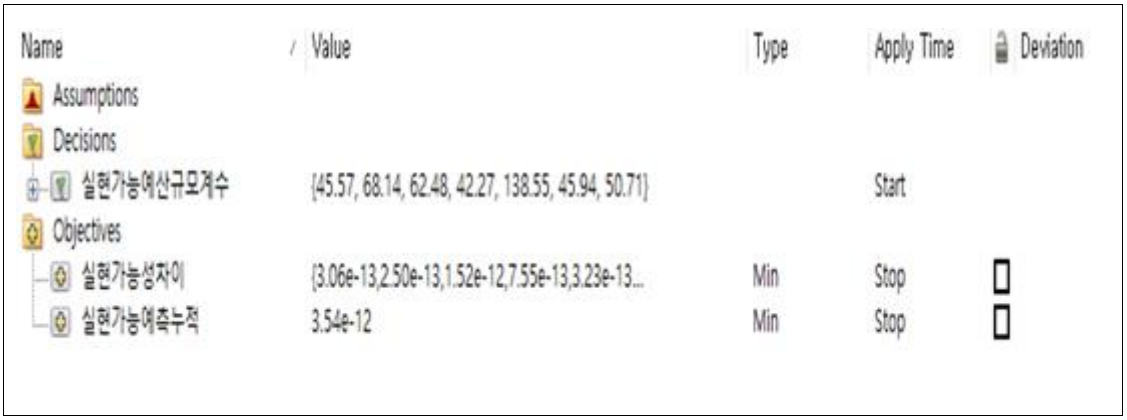

Figure 1 Feasibility prediction coefficient of feasibility by type of ICT project

As Figure 1 indicates, the feasibility score for ICT education and training is determined by the budget ratio of the ICT education and training sector = 45.57 * ICT education and training sector, and the feasibility score for other fields can be calculated using the same logic. The difference between the predicted value and the actual value estimated by this prediction equation is very weak in decimal units. In other words, it can be seen that the feasibility prediction formula for each project type estimates the actual value by more than 99%.

The next step is to derive a necessity prediction equation for each type of ICT project. It is assumed that the necessity of each project type is influenced by the impact score of each.

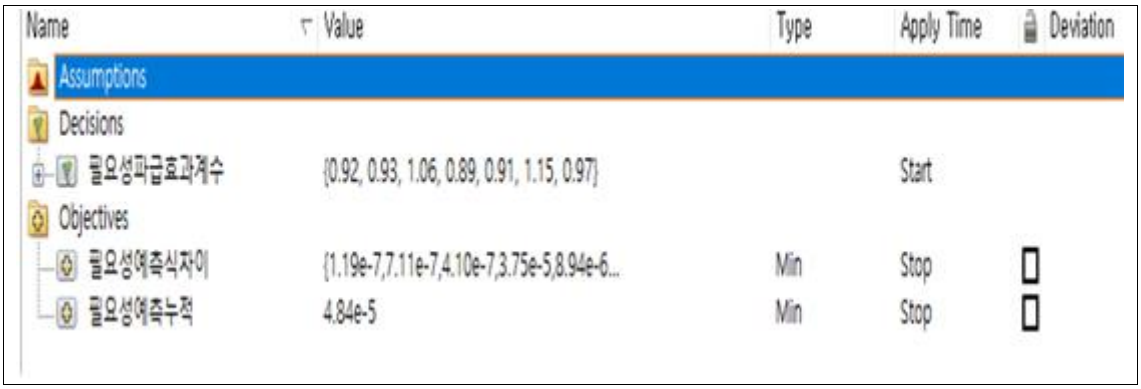

Figure 2 Necessity prediction coefficient by type of ICT project

As Figure 2 shows, the ICT project type necessity score is affected by the ripple effect score for each project type, and the coefficient of ripple effect is represented in 7 fields, from 0.92 to 0.97.

Next, it is assumed that the ripple effect for each type of ICT project is affected by the budget for each project type. The formula for predicting this is shown in Figure 3.

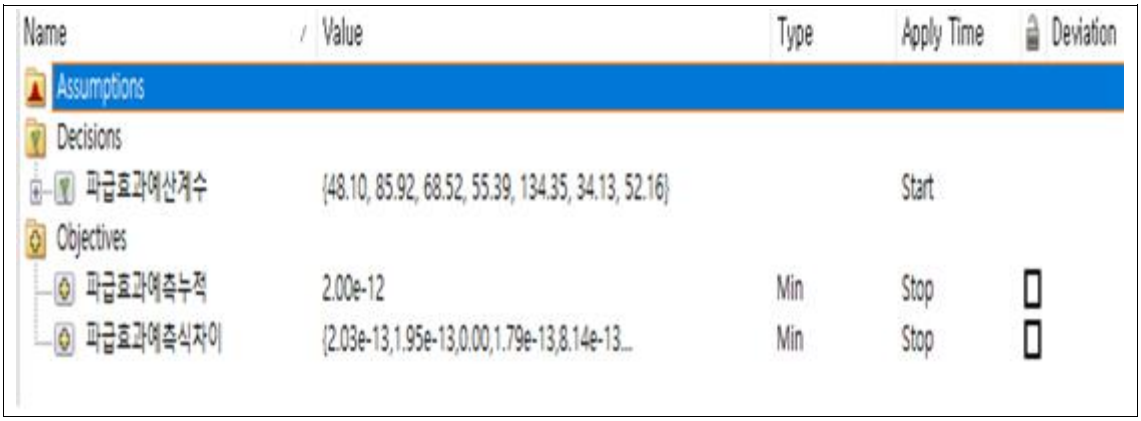

Figure 3 Prediction coefficient of ripple effect by type of ICT project

Next, we need to find an equation with which to predict the performance score for each type of ICT ODA project. This performance score is assumed to be affected by feasibility, budget size, ripple effect and necessity. In this relationship, the estimating equation is as shown in Figure 4.

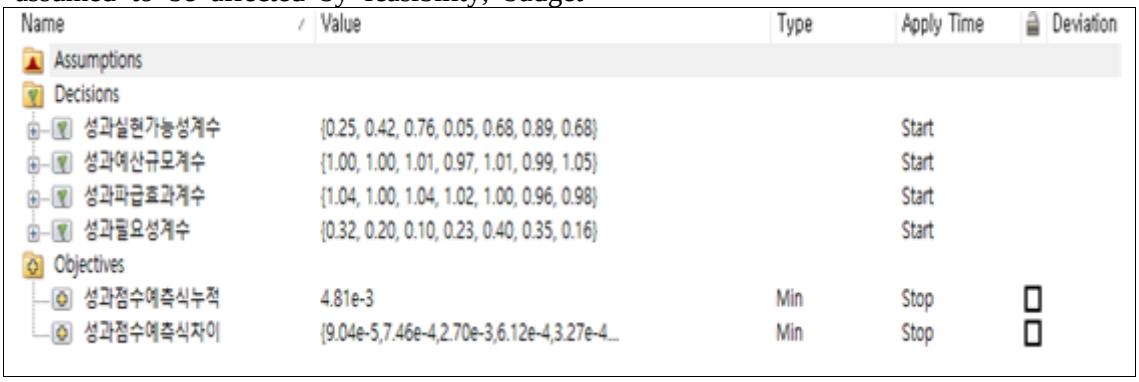

Figure 4 Performance score prediction coefficient by ICT field

The coefficients listed above can be summarized by combining the simulation equations, as follows. In other words: prediction of performance score for each type of ICT project (Y) = (budget ratio by sector * budget scale factor by sector) * 0.3 + (feasible factor * feasibility prediction score) * 0.3 + (ripple effect coefficient * ripple effect prediction score). It is expressed as an equation of 0.4 + (necessity coefficient * need prediction score). Therefore, for example, the performance score for the type of ICT education and training project = (budget ratio of education and training project * budget scale factor of education and training project) * 0.3 + (the feasibility coefficient of education and training project * feasibility prediction score) *. It can be expressed by the formula 0.3+ (the ripple effect coefficient of education and training projects * the predicted score of the ripple effect of education and training projects) * 0.4+ (the necessity coefficient of education and training projects * the predicted score of education and training projects).

As the above objectives indicate, as shown in the minimization of variables, it minimizes the difference between the actual performance score and the performance score prediction formula created by the prediction formula (Warwick & Kershner, 2008; William, 2003; Durrant & Green, 2000), and at the same time minimizes the accumulated difference between the performance score prediction formula and the actual value for each project type. It shows the values of each coefficient possible in the condition. Figure 5 shows the ratio of resource allocation by project type where the performance score is calculated as the maximum. The combined performance score for the current seven project types is 46.75. The purpose of this optimization simulation is to obtain the newly re-adjusted budget ratio so that the sum of the budget ratios of each project type does not exceed 1, while maximizing the performance score

corresponding to the objective function.

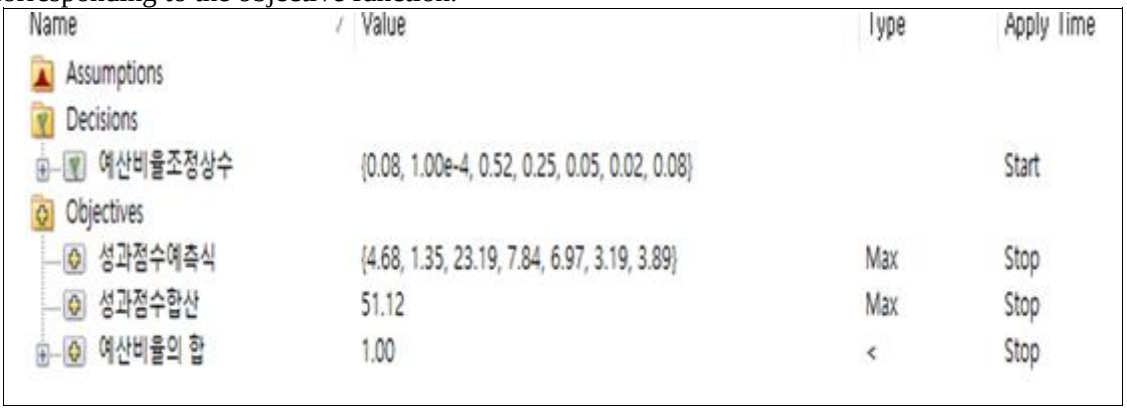

Figure 5 Optimization simulation results

In Figure 5, seven budget ratio adjustment constants are listed, and the first-occurring 0.08 is the adjusted budget ratio for the type of ICT education and training project. This is lower than the existing budget ratio of 0.2. The second project type is the ICT business type; this is currently 0.08, but the adjusted ratio is 0.0004. The third value is the ICT system supply budget ratio, which is currently 0.12, whereas the optimized budget ratio is high, at 0.52. The ICT infrastructure construction ratio is currently 0.17, but it appears that the adjusted ratio must be increased to 0.25 for a desirable state to be reached.

As regards the volunteer service dispatch project, the adjusted value is currently 0.06, which should be slightly lower at 0.05, and the figure for invitational training is currently high at 0.19, but the adjusted value needs be adjusted much lower, at 0.02. Finally, ICT consulting is currently 0.17, but it appears that it should be adjusted as low as 0.08. When the budget ratio of the project type is adjusted in this way, the sum of the performance scores is 51.12, which results in a performance score improvement around 9.4% higher than the sum of the performance scores (46.75) before the adjustment.

In summary, the contents presented in Table 5 are as follows. It can be seen that the existing budget ratio for the seven ICT-related business types is 20% in respect of education and training and 8% in respect of business development. However, as a result of deriving a new budget ratio, which can increase the total sum of performance scores by fixing the sum of the budget ratios at 1, the budget ratio between project types was newly adjusted.

Table 5 Re-allocated budget ratio by the type of project

project type	current budget ratio	current performance score	re-allocated budget ratio	estimated performance score
ICT training	0.20	7.5	0.08	4.68
ICT business	0.08	5	1.00e-4	1.35
ICT system	0.12	6.25	0.52	23.19
ICT infra	0.17	6	0.25	7.84
ICT volunteers	0.06	7.75	0.05	6.97
ICT invitation	0.19	7.5	0.02	3.19
ICT consulting	0.17	6.75	0.08	3.89
	1.00	46.75	1	51.12

5 Conclusion

A meaningful result was derived through a simulation process for optimizing resource allocation using POWERSIM software. It is important that the ICT-related aid which is currently being provided to African countries resets the

allocation of resources by business type. This has an important meaning from the viewpoint of optimization of resource allocation. From a microscopic point of view, the direction of res ource allocation for maximizing business perfor mance for each type of ICT project is differen t from that of the existing budget allocation di rection. In other words, when considering, in t he future, the necessity for the project in the l ight of the coronavirus, local feasibility and ri pple effects (etc.), increasing the distribution ra tio for the spread of the ICT system and the establishment of the ICT infrastructure appears to increase the overall performance score.

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