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The Development Aid for the Agricultural Sector of African, Caribbean and Pacific Countries—Determinants and Allocation

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Abstract: We propose a method for allocating Official Development Assistance (ODA) to the agricultural sector of African Caribbean and Pacific (ACP) countries based on objectively measured indicators of the development of the economies determined for the period of 2010–2022. These indicators are calculated from statistical data using factor analysis. They are then implemented in a linear programming model to allocate the budget for ACP agriculture. The results show that the proposed approach allocates funds according to the assumed logic, supporting countries in the low and very low development classes. The research conducted can contribute to the discussion on the allocation of development support to the agricultural sector by potential donors while analyzing different assumptions. This study can also serve as a prelude to researching the phenomenon of increasing efficiency in the agricultural sector in the context of potential economic development paths for the analyzed countries.

Keywords: developing countries; Official Development Assistance; development assistance efficiency; agricultural productivity factor analysis; agricultural economic growth; linear programming; resource allocation

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1. Introduction

Developing countries form one of the largest groups of countries around the world, which is of key importance in terms of their development potential. Research on their situation and the possible opportunities and barriers to development are among the key aspects of development economics.

Development economics, a discipline that analyzes today's problems related to gaps between countries, methods for narrowing them, and growth models in the context of progressing globalization processes, is a topic of interest to many authors. Research in this field focuses on finding the reasons for differences between countries [1–4], analyzing the situation in developing countries [5–7], proposing possible development paths [8–10], and analyzing the impact of agriculture on economic development levels [11–13].

Often, developing countries form groupings to provide a source of cooperation and mutual support for socioeconomic development. One example of international cooperation is the Organisation of African, Caribbean and Pacific States (ACP), which was established under the 1975 Georgetown Agreement. The partnership provided preferential access to European markets for ACP countries and allowed them to protect their local markets. Initially comprising 46 countries, the group now consists of 79. It comprises countries with low per capita incomes, most of which are characterized by a high share of agriculture in GDP and a high share of people employed in agriculture. The establishment of cooperation

between the EEC and the ACP followed the social and economic situation in the world. The relationship was influenced by the progressive process of European integration, the colonial past of European countries, the independence movements of overseas territories, and the geopolitical situation after the Second World War, including, above all, the growing rivalry between the USA and the USSR. Importantly, the group is a partner of the European Union and represents a kind of response to the Schuman Declaration, which emphasized the need for cooperation with the region. Through the Cotonou Agreement, cooperation was to be based on three main pillars: economic cooperation, political cooperation, and development assistance [14]. The agreement was concluded for 20 years, but it was eventually decided to extend its provisions until 30 June 2022. In place of the Cotonou Agreement, a so-called 'post-Koton' agreement is to be introduced, which, as of 2021, is awaiting final approval by both parties.

Developing countries, including the ACP, face many problems, such as low levels of education, high levels of poverty, a flawed structure of economies, and high unemployment. In the structure of developing countries' economies, the agricultural sector is crucial, representing one of the main sources of employment and a high share of GDP. The problems of agricultural development and efficiency, underinvestment, defective agrarian structure, and inconsistent agricultural policies remain significant. It is assumed that as economic development increases, there is a tendency for the role of agriculture in the national economy to diminish, but this occurs while the efficiency of this sector increases [12,15]. However, increasing the efficiency of the agricultural sector in developing countries requires agricultural policy support that many of these countries cannot afford.

The usual response to the problems and needs of developing countries is assistance offered by developed countries in various forms, including subsidies, loans or capital investments under Official Development Assistance (ODA), or private aid schemes to which many countries contribute. Also, there are many institutions and groups of countries established to provide direct assistance to developing countries, including the Development Assistance Committee (DAC, 30 countries), EU institutions, the International Monetary Fund, regional development banks (including the African Development Bank and Asian Development Bank), United Nations (including FAO, WHO, and UNICEF), World Bank Group (IBRD and IDA), other arrangements, and private donors [16]. In this context, special emphasis should be placed on the aid offered by the DAC, as it accounts for approximately 45% of total aid funds to developing countries [17,18] and amounted to USD 15,382 million in the years under review. Research findings suggest that this is the sole source that allows the countries to move to a higher level of development or, in extreme cases, address their basic needs of survival. Note also that each year, more and more ODA aid funds are delivered to developing countries, and as much as 76% of total funds are allocated to agricultural support.

The optimum allocation of these funds (and, as a consequence, their efficient use) is a big challenge for decision makers. Hence, the question arises of how much the allocation of aid funds between ACP countries takes into account the differences in their development condition and what criteria are used in the allocation process. The research problem addressed is relevant for several reasons. Firstly, the support system is inefficient and ineffective. The problem is the flow fluctuation from donors. In addition, countries receiving support often show limited systemic capacity.

Optimization modeling is one possible method of fund allocation assessment [19–21]. Its purpose is to confer some transparency to decision-making processes in a formal manner consistent with the predefined method. In the case of political allocation decisions, modeling makes it possible to track the impact of changes in allocation on the degree to which objectives are achieved and to analyze the dependencies between objectives. According to [22], optimiza-

tion allows the structuring of a problem, proposes some methods for aggregating the decision makers' preferences, and enables combining quantitative and qualitative criteria, which is essential when making political decisions. Ref. [23] points out that the use of optimization methods should contribute to alleviating tensions and conflicts. Ref. [24] believes optimization modeling to be the most promising and fastest-developing method of supporting political decision-making processes.

The main objective of this paper is to propose an allocation of ODA funds in ACP countries using an optimization model based on socioeconomic determinants of development.

As shown by the literature review, although much research effort has been devoted to analyzing the efficiency of development assistance, no attempt has yet been made to use the optimization model in assessing the allocation of development assistance funds based on socioeconomic development indexes. Meeting the objective of this paper will allow us not only to learn more about the conditions for the efficiency of agricultural development assistance but also to assess the allocation of assistance funds between ACP countries. The literature provides examples of optimization methods used in the public sector. For instance, Ref. [25] indicates its practical use in the Finnish public sector, and Ref. [26] discusses its effectiveness in analyzing the budget process in Porto Alegre, Brazil. Refs. [27–30] propose optimization methods to be used by the public sector in structuring their decision-making processes related to access to natural resources. Ref. [31] proposed optimization modeling in the context of energy systems. Also, multicriteria optimization methods were used in addressing a variety of agricultural policy issues by [21,32–36]. However, Refs. [23,25] emphasize that despite the development and considerable utility of multicriteria methods, their practical uses in the public sector continue to be rare. Therefore, using optimization modeling in assessing the allocation of agricultural development assistance in ACP countries seems justified.

The outline of the article is as follows. Firstly, the method of the study is described. Next, using factor values, the level of development of ACP countries is determined in order to give them their respective typological classes, which becomes the starting point in modeling the optimal allocation of development assistance to agriculture. Finally, the article concludes with a discussion of the possibilities of budget modeling for ACP countries.

2. Materials and Methods

Due to the wide range of data characterizing ACP countries, the article uses the factor analysis method to identify the main determinants of development in ACP countries. Ref. [37] was the first to introduce the term general factor when studying intelligence tests. Thurstone, in turn, generalized this theory, laying the theoretical foundations of multivariate analysis methods, which include factor analysis. The method is used in many scientific fields, including regional, geographical, medical, and agricultural research [38–41]. Factor analysis provides the possibility to divide a data set into subsets, analyze multivariate phenomena, classify them, and build indexes. From an accounting point of view, factor analysis is a linear model that describes a group of study variables. It involves transforming n observable variables into m new factors that are not correlated with each other. The process is described by the following formula [42,43]:

$$z_j = a_{j1}F_1 + a_{j2}F_2 + a_{j3}F_3 + \ldots + a_{jm}F_m + d_jU_j$$

where z_j—j—a variable (j = 1, 2, 3, . . ., n).

F_m—common factors;
$a_{j1}, \ldots, a_{jm}$—loads of common factors;
U_j—specific factor;

d_j—specific factor load.

The creation of a model involves going through several stages. Firstly, appropriate input variables are selected for analysis, as the final structure is a function of the variables selected. An inadequate number and quality of features entered into the model may result in poor factors that are difficult to interpret [44]. In the case of this study, the initial number of variables was 38, describing the socioeconomic situation of the ACP countries.

The second stage of the study was the construction of a correlation matrix and its preliminary analysis. The use of factor analysis is valid if there are sufficiently large values of correlation coefficients between the variables under study. It is assumed that all coefficients should reach values greater than 0.3. This level is often indicated in the literature [45]. If the set of primary variables includes complete variables that are uncorrelated or very weakly correlated with other variables, they should be removed from further analysis. Otherwise, difficult-to-interpret or unreliable results may result. The selection of variables for the study describing the ACP countries was dictated by the availability of data, as well as arbitrary decisions by the author. The situation of the countries was studied from 2010 to 2022, which implied taking the mean value of the indicator for the factor analysis. Taking into account the above guidelines, a systematization of the indicators identifying the development factors in each ACP country was carried out. The research relied heavily on publicly available data, including, primarily, the OECD database, the World Bank, Faostat, and the International Country Risk Guide. We collected a total of 38 variables characterizing the level of socioeconomic development of ACP countries.

The choice of development indicators is always associated with a certain degree of subjectivity. Different authors [46,47] qualify in a different way the activities that are to lead to the achievement of the set goals and assign them appropriate measures. Refs. [46,48] used similar variables to study the level of development of countries as in this paper. Ref. [49] analyzed the level of development exclusively from the point of view of social factors. Refs. [50–52] added strictly political factors, while Ref. [53] additionally pointed to environmental indicators.

The indicators covered social, economic, agricultural, and political aspects. We then removed correlated variables to obtain a range of 27 variables.

A total of 27 indicators characterizing ACP countries qualified for this stage of the research:

X1—share of population of working age (% of population).
X2—urbanization rate (%).
X3—share of exports of goods and services (% of GDP).
X4—urban population growth (%).
X5—share of employees in services (%).
X6—share of employees in industry (%).
X7—share of employees in agriculture (%).
X8—current account balance (% of GDP).
X9—life expectancy (years).
X10—gross national product per capita (USD/person).
X11—gross domestic product per capita (USD/person).
X12—annual growth of gross domestic product (%).
X13—quality of bureaucracy.
X14—crops and livestock products (USD 1000).
X15—food Excluding Fish products(USD 1000).
X16—CO_2 emissions (kg/person).
X17—population growth (%).
X18—infant mortality (per 1000 live births).
X19—dependency ratio (% of working age population).

X20—unemployment rate (%).
X21—share of agriculture in GDP (%).
X22—share of industry in GDP (%).
X23—total fertility rate (births per woman aged 15–49).
X24—number of births per 1000 women aged 15–19.
X25—internal conflict.
X26—corruption.
X27—religious tension.

The next stage of the research was related to the construction of an indicator for the development of ACP countries based on the results of the factor analysis obtained. For this purpose, the average value of factor scores for all determined factors in the analyzed countries was calculated to obtain a relative index of socioeconomic development.

In our exemplary model, we assumed that the allocation would be performed in typological groups of countries differing in socioeconomic development. Thus, we used the index values to identify four typological groups of ACP countries.

The study used the division adopted by [54], who linearly ordered the values of the development index according to non-increasing values, and, on this basis, typological groups of units were distinguished. A method of division into four groups was applied, which uses the arithmetic mean q- and standard deviation sq-, calculated from the indicator values:

- Class I: qi~ $\geq$ q- + sq.
- Class II: q- + sq > qi~ $\geq$ q-.
- Class III: q- > qi~ $\geq$ q--sq.
- Class IV: qi~ < q—sq.

By ranking countries according to their development index and placing them in typological groups, the coefficients of the objective function and the model's boundary conditions were determined. The Statistica 13.3 package and the Excel-Solver add-on were used to carry out the analysis. The last (and essential) consisted of a model-based analysis of different allocation options of agricultural development assistance in ACP countries and checking how they compare to the actual allocation. Depending on initial assumptions, it is possible to obtain an optimum allocation of amounts of aid between ACP countries covered by this analysis. The actual allocation is assessed based on how it compares to the model results. The use of linear programming in modeling economic policies was pioneered by [55]. He introduced the objective function that is to be maximized, defined the restrictions, and considered the problem of contradictory political and economic objectives. The authors who developed that concept include [20,21]. They used linear programming as an enabling tool in analyzing specific decision-making problems of public finance. In the linear optimization model, both the objective function and all restrictions are linear functions. The integral parts of building a linear programming model are defining the objective function; setting the restrictions that specify the possible decision-making options; and defining a way of comparing the decisions and choosing the one that best meets the objective. The decisions can be described as a series of variables that take numeric values; the conditions as a system of equations or inequalities; and the degree of objective attainment as a value of the function referred to as the objective function. Whether that function is maximized or minimized depends on the optimization criterion used [56].

The essence of linear programming, therefore, is to build relatively simple decision-making models that can be understood by decision makers and help them to make policy decisions. These models are built to enable the analysis of the consequences of different decision options, the interdependencies between decisions, and the response of the system to changes and thus to obtain decision guidelines that allow a better understanding of the

nature of the problem and the consequences of making certain decisions [57–61]. In the proposed design, following [20,39], the linear objective function can be defined as follows:

$$\max_{B_1,\ldots B_n} Z = \sum_{i=1}^{n} Z_i \cdot B_i$$

with the following definitions:

Z—objective function;
B_i—budgetary expenses for a typological group of countries i;
i = 1, . . ., n—index of considered groups of countries;
z_i—coefficient of the objective function (values of socioeconomic index).

The equation is subject to the following: $\sum_{i=1}^{n} a_{ri} \cdot B_i \left\{ \begin{array}{c} \leq \\ = \\ \geq \end{array} \right\} b_r$ for r = 1, . . ., m and Bi $\geq$ 0 for i =1, . . ., n

Here, the definitions are as follows:

r = 1, . . ., m—is the index of restrictions (equations or inequations);
a_{ri}—is the coefficient of restriction r for group i;
b_r—is the value of restriction r.

In the approach proposed above, the zi are indicators of the level of development of the typological classes of ACP countries calculated in the previous stage of this study. Maximizing the objective function, the model allocates the total budget for agricultural development assistance among the four ACP country groups under certain constraints. The main constraints are the budget constraint and upper and lower allocation limits for each group. The budget constraint ensures that the total budget for all ACP groups does not exceed a certain value. The upper and lower limits, i.e., the maximum and minimum amount, were calculated based on actual (original) ODA allocation values for the countries. In the model, the upper limit is assumed to be 1.2 of the original budget, while the lower limit is assumed to be a minimum of 0.2 of the upper limit. The Excel-Solver add-on program was used for this stage of the research.

3. Results

Under Bartlett's test of sphericity, the *p*-value was 0.0481 (*p*-value less than 0.05), which means that the hypothesis that the correlation matrix is a unitary matrix should be rejected, which is the rationale for performing principal component analysis. It is reasonable to reduce the dimension. On the other hand, the overall KMO criterion for the variables was 0.521, which can also be considered as a rationale for conducting further analysis. Based on the eigenvalue and % explained variance of the analyzed variables, we determined five main factors (Table 1). Each main factor adopted consisted of a set of variables that were calculated based on statistical data. The adopted approach captured 79% of the total variance in the data, with the greatest impact from factor one (explaining over 48% of the total variance). Importantly, factors with eigenvalues of factors below 1 were not included in the study.

Table 2 shows the factor loadings for the first five socioeconomic development factors (varimax normalized rotation). These express the relationship between each variable and the underlying factor. Eight variables relating to the economic snapshot were correlated with the first factor, which is why we called the first factor the economic factor (X8, X10, X11, X12, X16, X20, X21, and X22). Then, the nine variables correlated with the second factor relating to demographics and social phenomena were included as the social factor (X2, X4, X9, X13, X17, X18, X19, X23, and X24). The remaining three factors were named, in

turn, the agricultural factor (X14 and X15), the labor factor (X1, X5, X6, and X7), and the political factor (X25, X26, and X27), which resulted from the thematic assignment to the individual factors. Within the framework of the research, the factors obtained characterize the level of socioeconomic development of ACP countries, and the scores determined the level of individual countries. The results were then averaged across countries to obtain the ACP socioeconomic development index, which made it possible to carry out further analysis by typological groups of ACP countries (Table 3).

Table 1. Eigenvalue and magnitude of variance explained by individual factors.

Factor	Eigenvalues Extracting: Principal Components			
	Eigenvalue	% of Total Variance	Cumulative Eigenvalue	Cumulative % of Variance
1	13.074	48.424	13.074	48.424
2	2.972	11.007	16.046	59.431
3	2.218	8.215	18.264	67.646
4	1.729	6.405	19.994	74.051
5	1.321	4.893	21.315	78.944

Source: Own calculations with the use of Statistica software (v13.3).

Table 2. Factor loading matrix.

	Factor Loadings (Varimax Normalized Rotation) Extraction: Principal Components (Labeled Charges > 0.5)				
	Factor I	**Factor II**	**Factor III**	**Factor IV**	**Factor V**
X1—share of population of working age (% of population)	0.104	−0.525	0.000	**0.953**	0.022
X2—urbanization rate (%)	−0.121	**0.651**	−0.025	0.051	0.307
X3—share of exports of goods and services (% of GDP)	−0.056	0.239	0.041	0.094	−0.084
X4—urban population growth (%)	−0.156	**0.649**	−0.008	0.084	0.065
X5—share of employees in services (%)	0.016	−0.062	−0.021	**−0.855**	0.252
X6—share of employees in industry (%)	0.039	0.040	0.102	**−0.754**	0.095
X7—share of employees in agriculture (%)	−0.024	0.035	−0.014	**0.615**	−0.221
X8—current account balance (% of GDP)	**−0.596**	0.220	0.052	−0.121	0.024
X9—life expectancy (years)	0.113	**0.749**	−0.023	−0.003	−0.100
X10—gross national product per capita (USD/person)	**0.547**	0.121	−0.024	−0.015	−0.057
X11—gross domestic product per capita (USD/person)	**0.599**	0.149	−0.033	−0.022	−0.101
X12—annual growth of gross domestic product (%)	**−0.617**	0.021	0.097	0.147	−0.114
X13—quality of bureaucracy	0.160	**0.582**	−0.003	0.021	−0.312
X14—crops and livestock products (USD 1000)	0.014	−0.022	**−0.571**	0.079	−0.048
X15—food Excluding Fish products (USD 1000)	0.010	−0.018	**−0.564**	0.064	−0.046
X16—CO_2 emissions (kg/person)	**−0.813**	−0.148	0.005	0.102	0.218
X17—population growth (%)	0.143	**−0.870**	−0.036	0.006	0.001
X18—infant mortality (per 1.000 live births)	0.053	**0.695**	0.051	0.069	−0.083
X19—dependency ratio (% of working age population)	0.095	**−0.673**	0.004	0.018	0.051
X20—unemployment rate (%)	**0.756**	0.501	−0.071	0.042	−0.372
X21—share of agriculture in GDP (%)	**−0.685**	0.181	0.014	0.037	0.076
X22—share of industry in GDP (%)	**0.938**	−0.309	0.025	−0.011	0.062
X23—total fertility rate (births per woman aged 15–49)	0.089	**−0.709**	0.018	−0.034	0.072
X24—number of births per 1000 women aged 15–19	0.102	**−0.835**	0.003	0.054	0.024
X25—internal conflict	0.028	0.047	0.086	−0.440	**0.665**
X26—corruption	0.108	−0.071	−0.057	−0.352	**0.522**
X27—religious tension	−0.016	0.084	0.118	−0.352	**0.556**

Source: Own calculations with the use of Statistica software. Bold values reflect statistically significant variables with factor loadings over 0.5.

Table 3. Factor values for individual countries and classes within the extracted factors.

Class	Country	Factor Values Rotation: Varimax Normalized Extraction: Principal Components					
		Economic Factor	Social Factor	Agricultural Factor	Labor Factor	Political Factor	Average
Class I—high level of development	South Africa	0.888	0.220	1.817	−0.001	2.111	1.007
	Botswana	0.192	1.003	0.055	1.996	0.829	0.815
	Gabon	−0.722	2.094	−0.142	0.228	1.430	0.578
	Suriname	1.521	0.615	−0.048	0.237	0.507	0.566
	Trinidad and Tobago	3.099	2.654	−0.481	−0.884	−1.701	0.537
	Namibia	0.104	0.035	−0.116	1.620	0.921	0.513
	Cote d'Ivoire	−0.716	0.348	3.471	−1.367	0.755	0.498
	Dominican Republic	0.803	−0.136	−0.479	0.901	1.149	0.448
Class II—average level of development	Ghana	0.191	−0.074	0.892	0.974	−0.326	0.332
	Jamaica	2.083	−0.734	−0.553	0.636	0.224	0.331
	Zambia	−1.197	0.860	0.378	1.442	0.029	0.302
	Congo. Rep.	−0.578	1.632	0.041	−0.937	1.083	0.248
	Guyana	2.072	−0.654	0.201	0.037	−0.420	0.247
	Cameroon	−0.637	0.091	0.159	0.640	0.117	0.074
Class III—low level of development	Burkina Faso	−0.674	−0.055	0.463	0.037	0.216	−0.002
	Papua New Guinea	0.678	0.289	0.255	0.190	−1.531	−0.024
	Togo	−0.198	−0.557	0.176	0.295	0.100	−0.037
	Madagascar	−0.334	−0.396	0.105	1.012	−0.702	−0.063
	Senegal	−0.306	−0.184	−0.263	−0.330	0.661	−0.084
	Nigeria	0.568	−1.416	−1.091	−0.285	1.628	−0.119
	Tanzania	−0.757	−0.043	0.494	0.376	−0.789	−0.144
	Liberia	−0.227	−1.501	−0.224	0.264	0.292	−0.279
	Kenya	0.463	−0.780	0.324	−0.518	−0.941	−0.290
	Angola	−1.260	1.723	−2.035	0.078	−0.039	−0.307
	Mozambique	−0.762	−0.861	−0.594	1.561	−0.995	−0.330
	Guinea-Bissau	−0.122	−1.040	−0.031	−0.242	−0.391	−0.365
	Guinea	−0.362	0.022	−0.170	−0.352	−0.983	−0.369
	Sierra Leone	−0.148	−1.884	−0.383	0.693	−0.222	−0.389
	Uganda	−0.608	0.267	0.682	−1.046	−1.256	−0.392
	Congo. Dem. Rep.	−1.091	0.760	−0.381	−0.793	−0.489	−0.399
	Mali	−1.074	−0.205	0.005	−0.633	−0.154	−0.412
Class IV—very low level of development	Malawi	0.048	−0.679	0.415	−0.352	−1.593	−0.432
	Sudan	0.511	−1.285	−0.022	−2.883	1.403	−0.455
	Niger	−0.874	−0.027	0.146	−0.937	−1.664	−0.671
	Haiti	−0.576	−0.103	−3.064	−1.657	0.745	−0.931

Source: own elaboration (Cronbach's alpha turnss is 0.908).

In the method adopted, the higher the value of the development index, the more favorable the socioeconomic situation of the country compared to other ACP countries. In relation to the calculated development index of individual ACP countries, four typological groups were distinguished (Class I—high level of development, Class II—average level of development, Class III—low level of development, and Class IV—very low level of development).

Countries with a high development index value (0.441) were concentrated in the first class. This group included South Africa, Botswana, Gabon, Suriname, Trinidad and Tobago, Namibia, Cote d'Ivoire, and the Dominican Republic. In group two, the countries with a medium development index, the index value ranged from 0.441 to 0 and clustered Ghana, Jamaica, Zambia, Congo, Rep, Guyana, and Cameroon. The most numerous group was

group III—countries with a low value of the development index—including Burkina Faso, Papua New Guinea, Togo, Madagascar, Senegal, Nigeria, Tanzania, Liberia, Kenya, Angola, Mozambique, Guinea-Bissau, Guinea, Sierra Leone, Uganda, Congo, Dem. Rep., and Mali, and the value of the index ranged from 0 to −0.441. Countries with a very low value of the development index were concentrated in group IV. The index value was below −0.441, which clustered Malawi, Sudan, Niger, and Haiti in one class (Table 3, Figure 1).

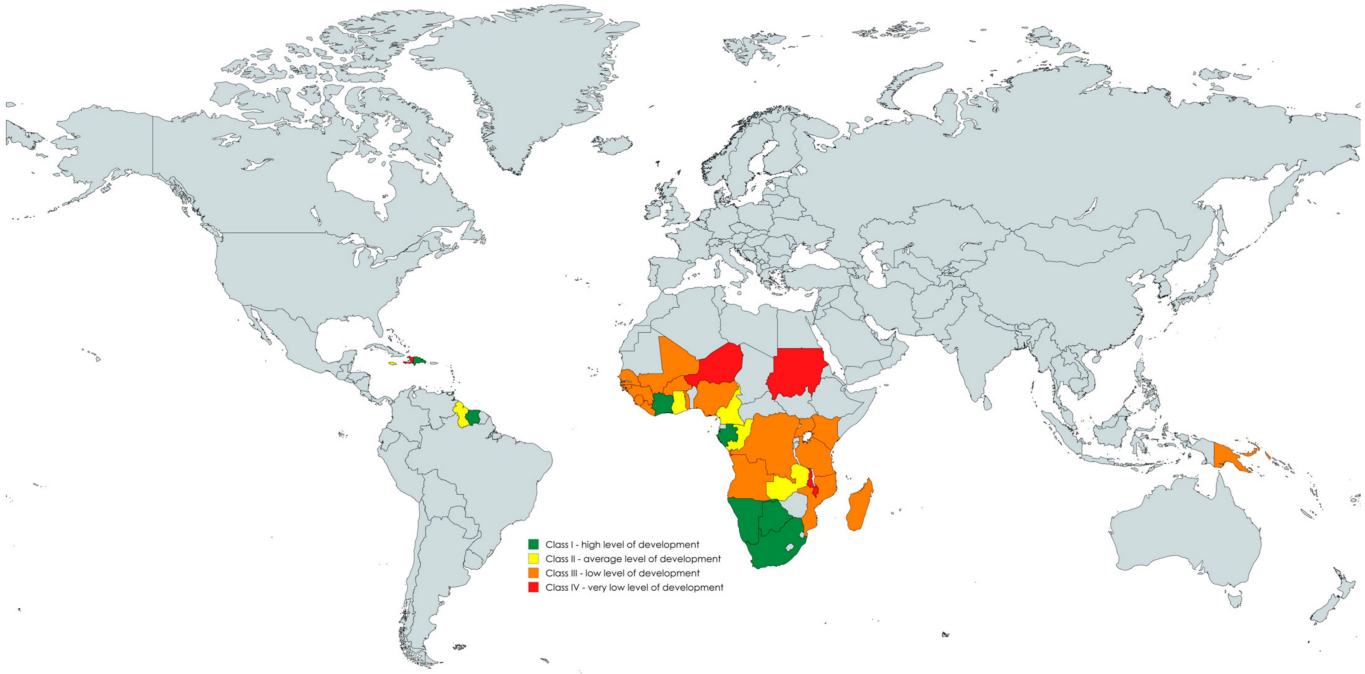


Figure 1. Development level of ACP countries by designated socioeconomic development index. Source: own elaboration.

The results show the differentiation of socioeconomic development between the typological classes. In Class I, practically all factors were better developed than average and even the most developed (with the labor factor being the exception), and the significance of the agricultural sector (measured by the share of agriculture in GDP and the share of those employed in agriculture) was notably lower than in the other groups. In Class II, the economic factor, the social factor, the agricultural factor, the labor factor, and the political factor have taken positive values, which means that their level is above the average for ACP countries. In addition, the class with a medium development index value showed an advantage for all factors over countries with low and very low development index values. In Class II, a gradual decrease in the importance of agriculture in the economy can be observed, while the share of industry remained stable and the importance of services increased. Negative factor values, below the average for ACP countries, characterized class III (labor factor exception). The last class—countries with a very low value of the development index—was characterized by relatively high values of the economic factor and political factor (higher values than in Class III), while the other factors assumed the lowest values, well below the average (Figure 2). In Classes III and IV, the agricultural sector played a key role in the economies (Class III: 54% employed in agriculture, 26% GDP; Class IV: 56% employed in agriculture, 25% GDP).

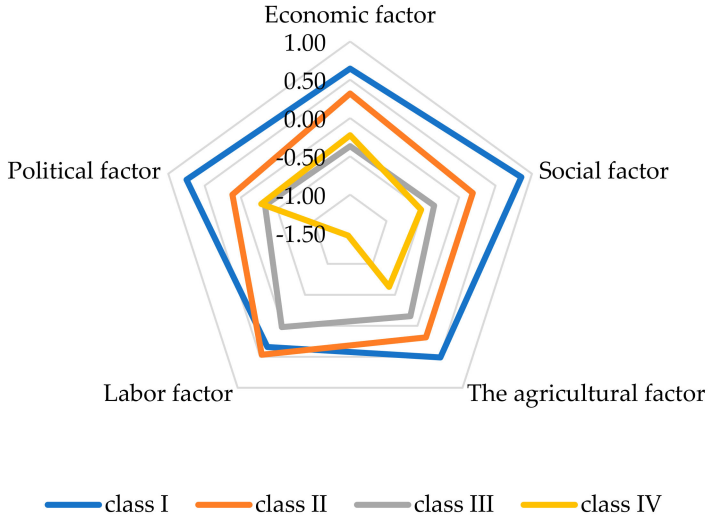


Figure 2. Values of development factors in the analyzed typological groups of ACP countries. Source: own elaboration.

The next step was to build an optimization model to allocate development aid to agriculture. In the proposed model, we used the coefficients of the objective function for the average level of development of countries in the designated typological classes of ACP countries (Table 4). The indicated objective function for the linear optimization model was constructed so that it maximizes (Figure 3) and minimizes (Figure 4) the sum of the objective function coefficients (socioeconomic development index) multiplied by the allocation values for the analyzed typological groups of countries.

Table 4. Values of factors on socioeconomic development index for ACP country classes.

Class	Factor Values Socioeconomic Development Index
Class I—high level of development	0.620
Class II—average level of development	0.256
Class III—low level of development	−0.236
Class IV—very low level of development	−0.622

Source: own elaboration.

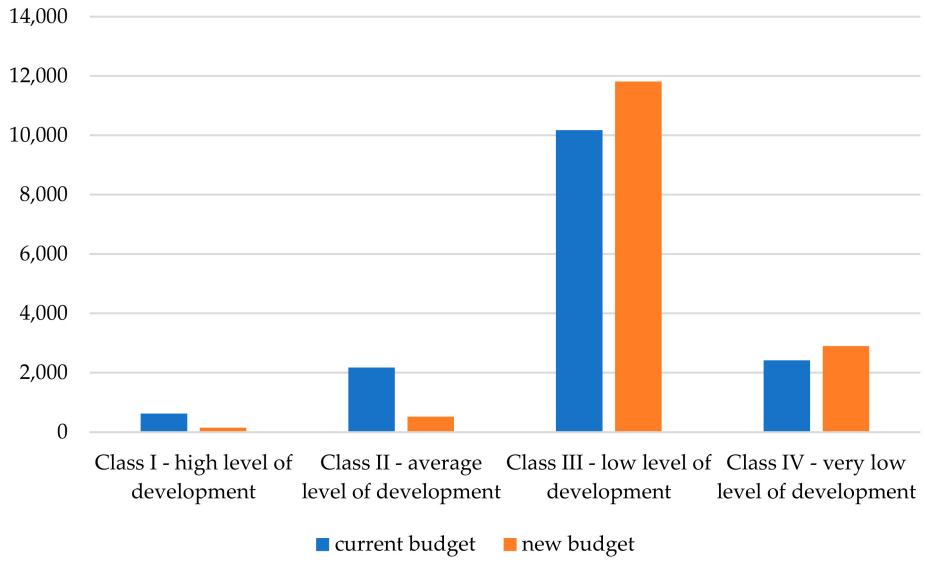


Figure 3. Proposed allocation model versus actual allocation implemented by DAC countries for the agricultural sector in ACP countries (USD million) (max). Source: own elaboration.

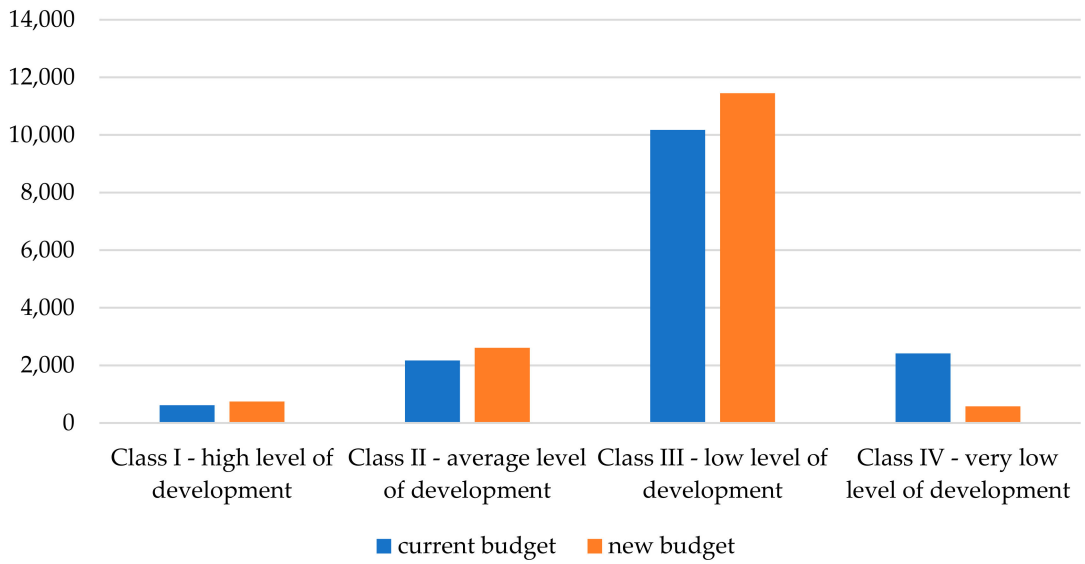


Figure 4. Proposed allocation model versus actual allocation implemented by DAC countries for the agricultural sector in ACP countries (USD million) (min). Source: own elaboration.

In the first model, we assumed that when maximizing the objective function, groups of countries with lower levels of development would be more supported. Conversely, when minimizing the function, more developed (better performing) countries should be supported. In addition, budget constraints (lower and upper limits) were also assumed. The upper limit was assumed to be 1.2 of the current budget, while the lower limit was assumed to be a minimum of 0.2 of the upper limit. Ref. [21] adopted similar limits.

By maximizing and minimizing the objective function under a given constraint, the model allocates the entire development assistance budget for the agricultural sector among the four selected classes of countries. Figure 3 shows the allocation structure of the model under the assumption of maximization of the objective function. According to the logic of the model, the model then allocates larger values of support to groups of countries with lower-than-average indicators. The result of the model allocation is compared with the current (actual) allocation from 2010 to 2022.

Under the assumption of budget minimization, support will be channeled toward more developed countries. The results show that higher than current development support goes to Classes I, II, and III. The largest increase in support in relation to the actual allocation was for Class III (Class III should receive approximately 12.5% more funding than the current budget). In turn, for the class of countries with the lowest level of development, funding was reduced by 24% compared to the current allocation. In the situation of minimizing the constructed objective function, countries with a relatively better socioeconomic situation are supported more. Class I received relatively high funding. Classes I and II should have their new budget increased by an average of 20% (Figure 4).

The two initial approaches are summarized in Figure 5. Class III in both approaches should be more strongly funded. Several facts support this. For the most part, countries in this class are characterized by high average employment in the agricultural sector (over 53%) and a high share of agriculture in GDP (26%). Furthermore, this class is the most numerous, which translates into the highest funding. For other groups, the differences in the model allocation of the two allocation options are greater.

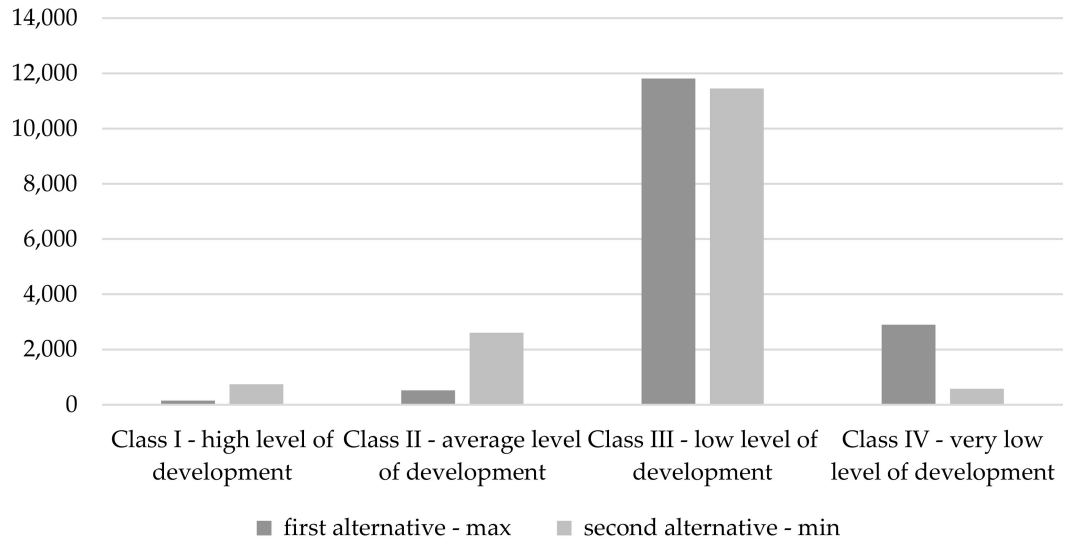


Figure 5. Proposed allocation models vs. actual allocation implemented by DAC countries for the ACP agricultural sector (in USD million) (min and max). Source: own elaboration.

4. Discussion

These ACP countries face many development problems; nevertheless, the biggest one seems to be inefficient agriculture, which can directly translate into food problems as well. Ref. [6] argues that development aid can provide a source of capital to help countries get on the path to developing the agricultural sector; however, for this to happen, the system needs to be much clearer and more standardized. As Ref. [62] points out, adequate financing is a key factor in achieving the desired goals in developing countries. The agricultural sector in ACP countries suffers from underinvestment, a flawed agrarian structure, and low productivity. One attempt to overcome the problems of the agricultural sector in developing countries is the absorption of international development aid. Research on the volume and effectiveness of aid to developing countries has been conducted, among others, by [18,63–65]. They pointed to the need for efficient fiscal and monetary policies by beneficiaries to effectively absorb aid funds [18] and to ensure aid continuity [64–66] and the need to target aid to countries most in need [63].

Agriculture in ACP countries needs external support on its way to development [67]. Ref. [68] argues that agriculture, like other industries, is entering a new era, based on knowledge. With development assistance, developing country agriculture can become more competitive and market-driven. This will increase efficiency on small farms and minimize the problem of food insecurity in developing countries [69–71]. Development assistance can be a source of capital needed to increase agricultural productivity [6]. As highlighted in the literature, development disparities in developing countries should be a determinant of the amount of assistance provided.

The approach of using factor analysis and linear programming modeling presented in this paper allows the allocation of agricultural development assistance according to the assumed logic of supporting countries. Assuming that higher support is to go to economically and socially underdeveloped countries, the objective function is maximized. By contrast, under the assumption that countries with already higher levels of development should receive higher support, the objective function can be minimized. The results show that the allocation obtained using the model is consistent with the imposed logic. In the first variant (maximization of the objective function), the model allocates more than it currently does to countries with very low development indicators. In the second, on the other hand, the class that brings together countries with relatively higher development rates benefits

from funding. The choice of allocation option may be up to policy makers. Guided by the criterion of bridging development gaps, Option 1 should be used, while Option 2 could be chosen to support countries that are initially more developed and where the efficiency of fund utilization may be higher.

The allocation model proposed in this paper is the initial stage of research into developing a workable agricultural support mechanism in developing countries that takes into account the socioeconomic situation of the beneficiaries. Several discussion points should be acknowledged.

First, the degree of analysis was limited by the availability of statistical data. For the group of countries analyzed, a set of 38 indicators was collected, defining the socioeconomic situation with a particular focus on variables characterizing the agricultural sector. Their selection was based on factual considerations and data availability. The selection of development indicators is always associated with a certain subjectivity. Various authors [46,47] qualify the activities aimed at achieving the set objectives in a different way and assign appropriate measures to them, but the concept of including socioeconomic aspects in the study with emphasis on the agricultural and political sectors was adhered to. Thus, in this paper, the selection of variables was based on literature studies. However, as the proposed model is only exemplary, other measurable and comparable features can be considered when applying the model.

Second, the paper proposes an author's index of socioeconomic development, created on the basis of statistical data using factor analysis. However, it should be emphasized that other development indicators can also be used in the construction of the objective function. These could be indicators such as HDI or GDP. The advantage of our measure is that it takes into account indicators describing the agricultural sector in the countries analyzed.

Third, a typological grouping is not necessary. In fact, the model allocation is made at the country level—the total available budget for a given period is divided by country. Each country, under given constraints and with given development indicators, therefore, receives an optimized allocation amount. The typology used was merely a means of simplifying the presentation of the results (instead of 30 countries, the allocation is presented for four classes).

5. Conclusions

The attempt made in this article to propose a model for the allocation of development assistance to ACP countries using the value of a socioeconomic development indicator should contribute to broadening the discussion on the objectification of development assistance allocation, which is essential for developing countries in the context of their further development. It should be emphasized that the model created is only exemplary and provides a basis for further development. It provides the direction of support, which is focused on countries in the low and very low development classes based mostly on unproductive and inefficient agriculture. However, different allocation criteria (e.g., productivity indexes) could be taken into account. Their choice might be left to the decision makers, but the allocation performed by the model will still be objective according to the chosen allocation criterion.

An optimized distribution of budget allocations to agriculture at the level of individual economies can be an important source of information for policy makers in the international arena including international organizations providing Official Development Assistance. It should also provide a rationale for structuring a framework for rationalizing decision making in the budgeting of regional agricultural development programs, which should focus on modernizing the sector. Considering the complexity of the phenomenon presented,

it seems justified to address this issue at the national level, using indicators related to agricultural productivity.

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