

A Multi-Objective Model for the Optimal Allocation of Development Funds among the Counties of Fars Province, with Emphasis on Spatial Justice, Reducing Regional Disparities, and Balanced Development

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ABSTRACT

The optimal allocation of development funds at the regional level is one of the most critical decision-making issues in public planning systems, as government financial resources are limited, while regional development needs differ considerably in terms of their magnitude, nature, and urgency. This study aims to develop a model for allocating development funds among 11 counties in Fars Province based on deprivation indicators for the year of 2021 (1400) and approved budget data for 2022 (1401). Data on eight key indicators across economic, infrastructural, educational, health, digital, and social dimensions were collected from the Statistical Center of Iran, the Ministry of Health and Medical Education, the Ministry of Cooperatives, Labour, and Social Welfare, the Ministry of Energy, the Ministry of Petroleum, and the Planning and Budget Organization of Fars Province. The indicators were weighted using a hybrid approach combining the subjective Analytic Hierarchy Process (AHP), based on the judgments of 15 experts with a consistency ratio of 0.072, and the objective Shannon entropy method. The deprivation index was then calculated using the numerical taxonomy method. The allocation model was solved using goal programming in LINGO, and the results were compared with the approved budget. The findings indicate that the proposed model reallocates the total budget of IRR 92,396,600 million in a manner that increases allocations to the most deprived counties. Arsanjan and Khorrambid receive the largest increases, by 60.7% and 39.1%, respectively, whereas Shiraz, as the most developed county, experiences a 17.6% reduction in its budget allocation. Inequality indicators show that the Gini coefficient decreases from 0.418 to 0.312, representing a 25.4% improvement, while the Theil index decreases from 0.342 to 0.244, representing a 28.7% improvement. In addition, the service gap in deprived counties decreases by an average of 36%. Scenario analysis indicates that the deprivation-oriented scenario, with a Gini coefficient of 0.28, performs best in reducing inequality, although the combined scenario provides a more balanced trade-off between equity and efficiency. Overall, the proposed model demonstrates that need- and deprivation-based allocation can significantly improve spatial equity. However, successful implementation requires careful consideration of absorptive capacity and analysis of alternative budget scenarios.

Keywords: Spatial Justice, Optimal Resource Allocation, Goal Programming, Deprivation Index, Numerical Taxonomy, Hybrid Weighting Method, Analytic Hierarchy Process, AHP, Shannon Entropy, Fars Province.

1. INTRODUCTION

The allocation of public resources is one of the most important responsibilities of governments in the process of economic and social development. Through public budgets and investments in infrastructure, education, healthcare, transportation, communications, agriculture, industry, and public services, governments influence the development trajectories of different regions. The importance of this issue becomes even more pronounced when public resources are limited while regional needs are unevenly distributed. At the regional level, the allocation of development funds is

not merely an accounting issue; rather, it is a multi-criteria and multi-objective decision-making problem, as counties may differ simultaneously in terms of infrastructure, employment, human capital, access to services, and capacity to absorb financial resources. Therefore, decisions regarding the amount of funding allocated to each county cannot be based on a single indicator. Recent literature on regional development also emphasizes this necessity. The OECD *Regional Outlook 2023* indicates that regional disparities remain substantial in many countries and that differences in access to public services can contribute to persistent

cycles of stagnation and declining productivity [1]. Place-based policies are likewise founded on the principle that regions are not homogeneous and that public policy should be designed in accordance with the specific characteristics, capacities, constraints, and opportunities of each place [2]. The OECD's 2025 report further highlights this approach in the context of technological and demographic transformations, globalization, and climate change [2]. In addition, the role of public investment in reducing regional inequalities and enhancing resilience to future shocks has been emphasized [3–5]. This issue is particularly important in Iran. Bayramzadeh et al. (2025) demonstrated that regional inequalities remain one of the major challenges in resource allocation in Iran and that the use of development indicators can enhance the transparency and defensibility of budgetary decisions [6]. Persian-language studies on development-level classification in Fars Province have also confirmed substantial disparities among its counties. For example, Zangiabadi and Akbari, using 43 indicators as well as factor and cluster analyses, demonstrated significant disparities in the levels of development across the counties of Fars Province [7]. Moreover, a recent policy review on the identification of deprived areas in Iran indicates that the use of composite indicators, attention to the severity of deprivation, and the integration of deprivation identification into resource-allocation policies remain among the central issues of the country's regional planning system [8]. These findings reinforce the need to move beyond purely administrative or single-criterion allocation towards multi-criteria and traceable decision-making frameworks.

Fars Province, owing to its geographical extent, economic and demographic diversity, and disparities in access to public services across its counties, provides an appropriate setting for examining this issue. Under traditional approaches, budgets may be allocated based on population size or the previous year's budget performance. However, reliance on past performance can create a self-reinforcing cycle for areas that have experienced lower levels of budget absorption in previous years due to inadequate infrastructure or limited implementation capacity. Conversely, population alone is not a sufficient indicator of development needs, while allocating excessive resources to deprived areas without considering their capacity to implement projects may lead to an increase in unfinished projects and reduce the effectiveness of public investment. Therefore, the central question of this study is how the limited development funds of Fars Province can be allocated among its counties in a manner that, while complying with the overall budget constraint, reduces deprivation and service gaps while simultaneously taking efficiency, absorption capacity, and balanced development into account. The importance of this issue can be examined from four perspectives. From an economic perspective, directing funds toward

infrastructure gaps and areas with greater potential for impact can increase the social productivity of public investment. From a social perspective, reducing disparities in access to education, healthcare, transportation, water, communications, and social support services is closely linked to quality of life and regional equity. From a spatial perspective, justice does not necessarily imply an equal distribution of resources; rather, it may require differentiated allocations to bring regions closer to an acceptable level of service provision. From a managerial perspective, a decision-support model can enable policymakers to anticipate the implications of changes in resource levels, criterion weights, and priorities before actual implementation. Accordingly, the main objective of this study is to develop a multi-objective model for the optimal allocation of development funds among the counties of Fars Province, with an emphasis on reducing regional disparities, promoting spatial justice, improving investment efficiency, and achieving balanced development. To this end, the study identifies indicators affecting levels of development, calculates a composite deprivation index, ranks the counties, determines allocation priorities, develops a goal programming model, compares the model results with the approved allocations, examines the effects of changes in objective weights and budget levels, incorporates absorption capacity, and analyzes alternative scenarios. The novelty of this study lies in integrating multiple decision-making stages within a unified framework: hybrid weighting of indicators using AHP and Shannon entropy, measurement of deprivation using Numerical Taxonomy, conversion of the assessment results into an allocation-priority index, multi-objective optimization using goal programming, and evaluation of decision stability through sensitivity and scenario analyses. Thus, the study goes beyond merely ranking regions and seeks to narrow the gap between the “identification of deprivation” and the “operational decision-making process for budget allocation.” The simultaneous use of expert-based and data-driven weighting, together with the incorporation of absorption capacity alongside deprivation and service gaps, enables a more transparent balance between equity and implementability. Consequently, the proposed framework can serve as a decision-support tool for comparing allocation alternatives and enhancing the transparency of budgetary decisions.

2. Theoretical Foundations of the Study

Spatial Justice: Spatial justice refers to the equitable distribution of opportunities, services, and resources across geographical space. In public policy, spatial justice does not necessarily imply an equal allocation of resources; rather, it aims to reduce unjustified disparities among regions. Therefore, if one county is significantly disadvantaged in terms of access to services, allocating the same level of resources to that county and to a more developed county is not

necessarily equitable. In recent literature, spatial justice has been associated not only with the distribution of resources but also with the capacity of regions to benefit from opportunities and shape their own development trajectories [9].

Place-Based Policies: Under the place-based policy approach, one-size-fits-all policies are replaced by approaches that take the specific characteristics of each region into account in decision-making. In its 2025 report, the OECD emphasizes that spatial disparities are influenced by technological, climatic, demographic, and globalization-related changes, and that regional policies must be able to adapt to these changes [2]. Moreover, in his examination of developments in place-based policies, McCann argues that such approaches should be designed according to the nature of the problem, the geographical scale, and local capacities [10]. This perspective highlights the need to consider local needs, institutional capacity, and the ability to translate financial resources into development outcomes simultaneously [9].

Public Resource Allocation: Public resource allocation refers to the process of distributing government budgets, funds, and capital among different regions and sectors of a country. This process is one of the most critical instruments through which governments pursue development objectives and reduce regional inequalities. However, experience has shown that the uneven distribution of public resources not only fails to reduce existing inequalities but can also deepen spatial disparities by reinforcing more developed regions while neglecting disadvantaged areas. Therefore, the optimal allocation of public resources requires models that can anticipate the spatial consequences of budget distribution and prevent the exacerbation of regional inequalities.

Equity–Efficiency Trade-Off: One of the fundamental challenges in public policy is the trade-off between equity and efficiency. On the one hand, equity requires resources to be distributed in a manner that provides greater support to deprived and disadvantaged regions in order to reduce existing disparities. On the other hand, economic efficiency requires resources to be allocated to areas where the returns on investment are higher, which are generally more prosperous and developed regions. This trade-off is particularly evident in regional budget allocation, as efforts to reduce inequality are typically accompanied by some loss of efficiency, and vice versa. Therefore, policymakers are continually confronted with the question of how to establish a sustainable and acceptable balance between these two objectives.

Regional Development: Regional development refers to the process of improving the economic, social, cultural, and environmental conditions of different geographical regions, with the ultimate goals of reducing spatial disparities, improving residents' quality of life, and creating the conditions for sustainable growth across all. Regional development is a multidimensional concept that goes beyond

economic growth alone and encompasses factors such as spatial justice, local participation, institutional capacity building, environmental sustainability, and the quality of public services. Under a place-based approach to regional development, uniform and general policies for all regions are replaced by planning based on the unique characteristics of each region, such as its natural resources, comparative advantages, development level, and specific needs, with the aim of achieving balanced and equitable development across the country.

Goal Programming: Goal programming is an effective operations research method designed to address problems involving multiple conflicting objectives. Unlike classical linear programming, in which a single objective function is optimized, goal programming defines multiple objectives as goals with different priorities and introduces deviation variables, representing underachievement and overachievement, to measure the extent to which each goal is achieved. This approach enables decision-makers to identify an optimal allocation that satisfies, to the greatest extent possible, a set of potentially conflicting objectives, such as equity and efficiency. The flexibility of goal programming in assigning priorities to objectives and its ability to analyze different scenarios make it a powerful tool for addressing complex resource-allocation problems in regional planning.

3. Literature Review

The literature can be broadly classified into three main groups: studies on regional inequality, studies on budget allocation, and studies on multi-objective optimization. Bayramzadeh et al. (2025) conducted one of the recent studies related to Iran. Their study examined 47 development indicators across three dimensions—economic and infrastructural, educational and cultural, and health—and emphasized equity in the allocation of budgetary resources among the provinces of Iran [6]. In the field of goal programming, Lozano and Contreras (2022) employed lexicographic goal programming for centralized resource allocation [11]. Pratyusha et al. (2023) also proposed a goal programming model for budget allocation [12]. These studies demonstrate that goal programming continues to have considerable potential for addressing resource-allocation problems, particularly when multiple and sometimes conflicting objectives must be incorporated simultaneously into a model. In addition, Ojo et al. (2020) developed a modified goal programming model for budget allocation under inflationary conditions, demonstrating the flexibility of this approach in dealing with unstable economic conditions [13]. At the provincial level, Izadi et al. (2024) used multi-criteria analysis to assess disparities in development across Fars Province, and their findings confirmed substantial differences among the counties of the province [14]. An analytical review of the literature reveals three major gaps that remain to be addressed. First, some studies are limited to calculating deprivation indices or

ranking regions and do not explicitly demonstrate how these assessments can be translated into an operational allocation framework. Second, in some allocation models, one of the two objectives—equity or efficiency—receives greater emphasis than the other, while resource absorption capacity receives less attention as an implementation constraint. Third, sensitivity analyses and budget scenarios have not been systematically reported across all studies. Accordingly, the present study seeks to bridge the gap between deprivation assessment and the operational allocation of resources by integrating deprivation, need, service gaps, and absorption capacity within a goal programming framework. It also seeks to assess the robustness of the resulting decisions through sensitivity and scenario analyses.

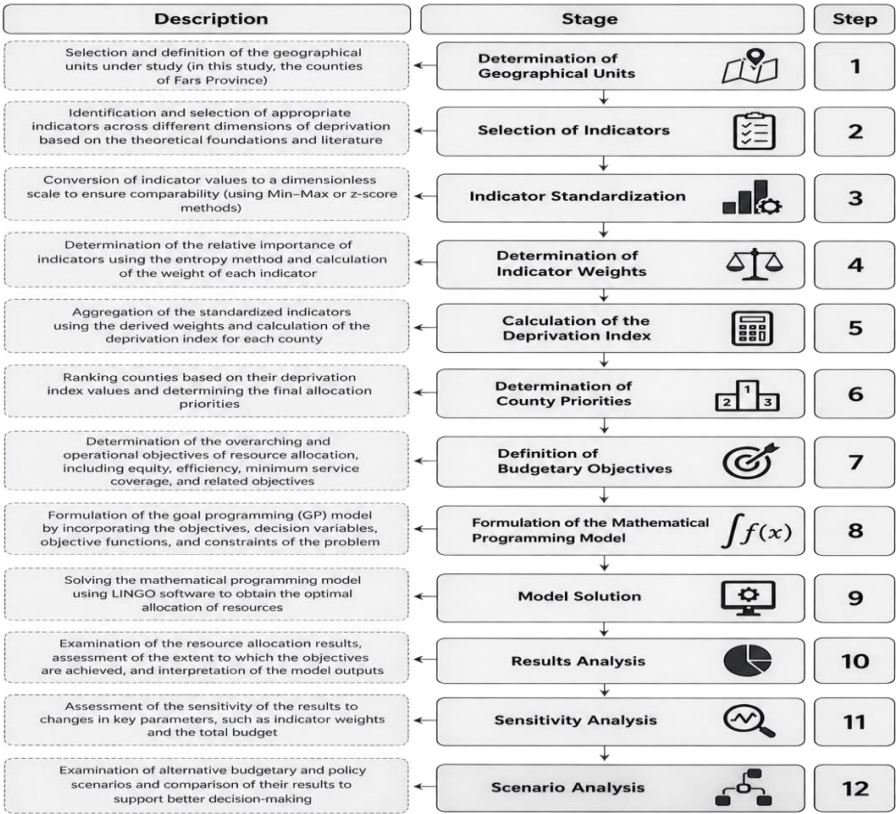
To complement this body of literature, Kazemi and Amini (2024), in their examination of the spatial concentration of deprivation in Iran, demonstrated that deprivation is multidimensional and spatial in nature and that its concentration can be perpetuated at the regional level [15]. Similarly, Mousavi et al. (2024), through an analysis of development barriers and inequality in Iran's border provinces, emphasized the role of differences in territorial capacities and unequal access to resources in perpetuating development disparities [16]. From a methodological perspective, an interdisciplinary review of algorithmic approaches to public resource allocation indicates that allocation models should simultaneously account for multiple objectives, transparent criteria, flexibility, and equity considerations [17]. These findings reinforce the need

for a multi-objective decision-support framework capable of balancing deprivation, need, absorption capacity, and allocation efficiency. Alongside these studies, Zangiabadi and Akbari, in a Persian-language study of the counties of Fars Province, used 43 indicators along with factor and cluster analyses to demonstrate the existence of development imbalances and significant differences in the level of development among the counties [7]. This finding, particularly its emphasis on the multidimensional nature of development and the need for spatial classification, provides domestic evidence supporting the adoption of a multi-indicator approach in the present study. Furthermore, a research report by the Research Center of the Islamic Consultative Assembly on the history of identifying deprived areas in Iran indicates that numerical taxonomy and composite indicators have a long history of use in assessing regional inequality in the country. However, the central challenge has consistently been translating the identification of deprivation into a clear and defensible mechanism for policymaking and resource allocation [8]. From this perspective, the distinguishing feature of the present study is its shift from assessment and ranking towards multi-objective, scenario-based resource allocation.

4. Research Methodology

This study is applied in terms of its purpose and is a methodological, quantitative, analytical, and model-based approach. The following stages of the proposed framework have been given in Figure 1.

Figure 1. Proposed methodological framework.



The research process begins with defining the geographical units and selecting the development indicators. Following the standardization and weighting of indicators, the deprivation index is calculated, and the counties are prioritized. Subsequently, the objectives and budgetary constraints are incorporated into the goal programming model, and the model is solved. Finally, the results are evaluated, and the robustness and efficiency of the model are assessed through sensitivity analysis and alternative scenarios. Table 2 presents a broader set of indicators that can be used to assess development and deprivation. However, in the final implementation of the model, eight indicators were selected for which complete and comparable data were available for the 11 selected counties. These indicators include the unemployment rate, the proportion of the population below the poverty line, the illiteracy rate, the infant mortality rate, the percentage of households without piped water, the percentage of households without access to urban natural gas, physician density per capita, and educational space per capita. The indicator data pertain to 2021 (1400), and the data sources include the Statistical Center of Iran, the Ministry of Cooperatives, Labour and Social Welfare, the Ministry of Health and Medical Education, the Ministry of Energy, the Ministry of Petroleum, the Ministry of Education, and the Planning and Budget Organization of Fars Province. The approved budget used for comparison pertains to 2022 (1401). To enhance replicability, the direction of each indicator was specified prior to standardization. Accordingly, positive-direction indicators representing higher levels

Table 1. Evaluation Indicators.

Dimension	Indicator	Operational Definition	Unit	Proposed Data Source
Economic	Unemployment	Ratio of the unemployed population to the total economically active population aged 15–64 years	%	Statistical Center of Iran, Labour Force Survey
	Value Added	Value added generated in different sectors of the county's economy (agriculture, industry, and services) at constant prices	Billion IRR	Provincial Management and Planning Organization, Regional Accounts
	Per Capita Income	Total household income in the county divided by the total population	Million IRR	Statistical Center of Iran, Household Income and Expenditure Survey (alternative indicator: per capita value added)
	Investment	Volume of approved or realized investment in the county during a fiscal year	Billion IRR	Provincial Management and Planning Organization, Investment Performance Reports
Infrastructure	Water	Percentage of the urban and rural population covered by a safe and reliable piped-water network	%	Ministry of Energy (Provincial Water and Wastewater Company), Annual Performance Reports
	Electricity	Ratio of households with an electricity meter to the total	%	Ministry of Energy (Provincial Electricity

of well-being and negative-direction indicators representing deprivation were incorporated into the calculations. In the subjective weighting stage, the AHP consistency ratio was 0.072, which is below the conventional threshold of 0.10; therefore, the consistency of the experts' judgments was considered acceptable. Objective weights were also calculated using the Shannon entropy method based on the information dispersion of indicators and, following normalization, were incorporated into the process of determining the final indicator weights. In the optimization stage, the constraint requiring the sum of allocations to equal the total budget, together with minimum and maximum allocation bounds and absorption-capacity considerations, restricted the feasible solution space, thereby ensuring that the model output remained practically interpretable.

Population and Unit of Analysis

The study population comprises the 37 counties of Fars Province in 2021 (1400). Of these, 11 counties were included in the analysis based on the availability of complete and reliable data for the selected indicators and their representation of different levels of deprivation. The remaining 26 counties were excluded from the final analysis because data for some key indicators, including the unemployment rate, poverty rate, and physician density, were incomplete. Therefore, the empirical findings of this study are limited to the 11 counties, and their generalization to the entire province should be undertaken with caution. The deprivation-indicator data pertain to 2021 (1400), whereas the approved county-level budget data pertain to 2022 (1401) [18].

		number of households in the county		Distribution Company), Consumer Statistics
	Wastewater	Percentage of the population covered by urban and rural wastewater collection and treatment networks	%	Ministry of Energy (Provincial Water and Wastewater Company), Performance Reports
	Roads	Rate of access to paved roads (ratio of the length of paved main and secondary roads to the total road length in the county)	km or %	Ministry of Roads and Urban Development, Provincial Road Maintenance and Transportation Department
Education	School Dropout Rate	Ratio of the number of school-age children who have dropped out of education (aged 6–18 years) to the total population in this age group	%	Ministry of Education, Provincial Department of Education (Student Statistics System)
	Educational Space per Capita	Ratio of existing educational space (square meters of built-up area) to the total number of students in the county	m ² per student	Ministry of Education (School Renovation Organization), Educational Space Statistics
	Skills	Ratio of graduates of technical and vocational education and the <i>Kār-Dānesh</i> program to the total number of upper-secondary graduates	%	Ministry of Education, Educational Affairs Department and Technical and Vocational Training Organization
Health	Physicians	Ratio of general practitioners and specialists employed in the public and private sectors to the county population	per 10,000 population	Ministry of Health and Medical Education (Health Workforce Statistics System), Annual Report
	Hospital Beds	Ratio of active hospital beds to the county population	per 1,000 population	Ministry of Health and Medical Education, Provincial University of Medical Sciences, Hospital Statistics
	Access Time	Average travel time to healthcare centers and hospitals in the county, based on distance and road conditions	minutes	Health Department of the Provincial University of Medical Sciences, calculated based on the road network
Digital	Internet Coverage	Percentage of the population covered by high-speed Internet networks (3G, 4G, and 5G) or ADSL	%	Ministry of Information and Communications Technology, Communications Infrastructure Monitoring System
	Internet Speed	Average Internet speed provided in the county, based on operator data	Mbps	Communications Regulatory Authority, Provincial Communications Quality Report
	Household Internet Access	Ratio of households with Internet access (fixed or mobile) to the total number of households in the county	%	Statistical Center of Iran, Household Income and Expenditure Survey (or operator data)
Social	Poverty	Ratio of the population below the absolute poverty line, based on minimum food and non-food expenditures	%	Ministry of Cooperatives, Labour and Social Welfare, Provincial Poverty Indicators Report
	Aging	Ratio of the population aged 65 years and over to the total county population	%	Statistical Center of Iran, Census Results and Population Estimates

	Social Protection Coverage	Ratio of the population covered by social protection institutions (Imam Khomeini Relief Foundation, State Welfare Organization, and Martyrs and Veterans Affairs Foundation) to the total county population	%	Imam Khomeini Relief Foundation, State Welfare Organization, and other provincial social protection institutions
Environment	Water Stress	Ratio of water withdrawals to the county's renewable water resources (water resource exploitation indicator)	% or ratio	Ministry of Energy (Iran Water Resources Management Company), Provincial Water Balance Report
	Drought	Standardized Precipitation Index (SPI) or number of dry years during the past decade	SPI value or years	Islamic Republic of Iran Meteorological Organization, Provincial Synoptic Stations
	Vulnerability	Composite score of flood, earthquake, land subsidence, and other natural-hazard risks in the county	Score (0–100)	National Disaster Management Organization, Spatial Planning Studies and Natural Hazard Assessments
Capacity	Budget Absorption	Ratio of absorbed funds to allocated funds in the previous fiscal year	%	Provincial Planning and Budget Organization, County Budget Performance Reports
	Project Delays	Average Percentage Delay in the Completion of County Development Projects Relative to the Scheduled Completion Time	% (days or months)	Planning and Budget Organization, Development Project Progress Reports (Sajjad System)
	Unfinished Projects	Ratio of unfinished projects to the total number of projects defined in the county	%	Planning and Budget Organization, Development Project Management System

The eight dimensions presented in Table 1 cover a substantial range of aspects related to development and deprivation, including economic conditions; access to basic infrastructure; education and healthcare; access to digital technologies; social and support conditions; environmental challenges; and the region's implementation and managerial capacity to absorb and utilize budgetary resources. Given the limited availability of complete county-level data, the final implementation of the model focused on eight key and comparable indicators. This distinction between the “comprehensive indicator framework” and the “indicators available for empirical implementation” helps prevent overgeneralization of the findings.

Mathematical Formulation

Data Standardization: Standardization refers to transforming the values of different indicators, which are measured in different units, into a common range (typically 0 to 1) so that they can be compared and combined.

For Positive Indicators:

$$Z_{ij} = \frac{X_{ij} - X_j^{\min}}{X_j^{\max} - X_j^{\min}} \quad (1)$$

For Negative Indicators:

$$Z_{ij} = \frac{X_j^{\max} - X_{ij}}{X_j^{\max} - X_j^{\min}} \quad (2)$$

where:

- X_{ij} : Value of indicator j for county i
- Z_{ij} : Standardized value
- $X_j^{\max}$: Maximum value of the indicator
- $X_j^{\min}$: Minimum value of the indicator

Calculation of the Distance from the Ideal Condition: After standardization, the distance of county i from the ideal condition is defined as follows:

$$D_i = \sqrt{\sum_{j=1}^p w_j (1 - Z_{ij})^2} \quad (3)$$

The higher the value of D_i , the greater the distance of county i from the ideal condition.

Deprivation Index: The relative deprivation index is defined as follows:

$$DI_i = \frac{D_i}{\sum_{i=1}^m D_i} \quad (4)$$

where DI_i denotes the share of county i in total deprivation. This index can serve as an initial basis for determining allocation priorities.

Combined Allocation Priority Index: To enhance the model, deprivation alone is not considered the sole

basis for decision-making. The combined index is proposed as follows:

$$P_i = \alpha DI_i + \beta Gap_i + \gamma Need_i + \delta Res_i - \theta Capacity_i \quad (5)$$

where:

- DI_i : Deprivation Index
- Gap_i : Service Gap
- $Need_i$: Development Need
- Res_i : Vulnerability and Resilience Need
- $Capacity_i$: Absorptive Capacity
- $\alpha, \beta, \gamma, \delta, \theta$: Objective Weights

Multi-Objective Goal Programming: The decision variable represents the budget share allocated to county i from funding category j , subject to constraints on the total budget, minimum and maximum allocations, and deviations from the specified objectives. The model is defined as follows:

$$MinZ = \sum_{k=1}^K P_k (w_k^- d_k^- + w_k^+ d_k^+) \quad (6)$$

In this equation:

- d_k^- : Negative deviation from the target
- d_k^+ : Positive deviation from the target
- P_k : Goal priority
- w_k^- and w_k^+ : Deviation weights

Total Budget Constraint:

$$\sum_{i=1}^m \sum_{j=1}^n x_{ij} \leq B \quad (7)$$

where:

- x_{ij} : Allocated budget
- B : Total available budget

Budget Constraint for Each Sector:

$$\sum_i x_{ij} + d_j^- - d_j^+ = B_j \quad (8)$$

This constraint ensures that the total funds allocated to each sector are consistent with the available budget for that sector.

Minimum and Maximum Allocation Constraints:

To prevent the exclusion of deprived areas, the following relations should be met:

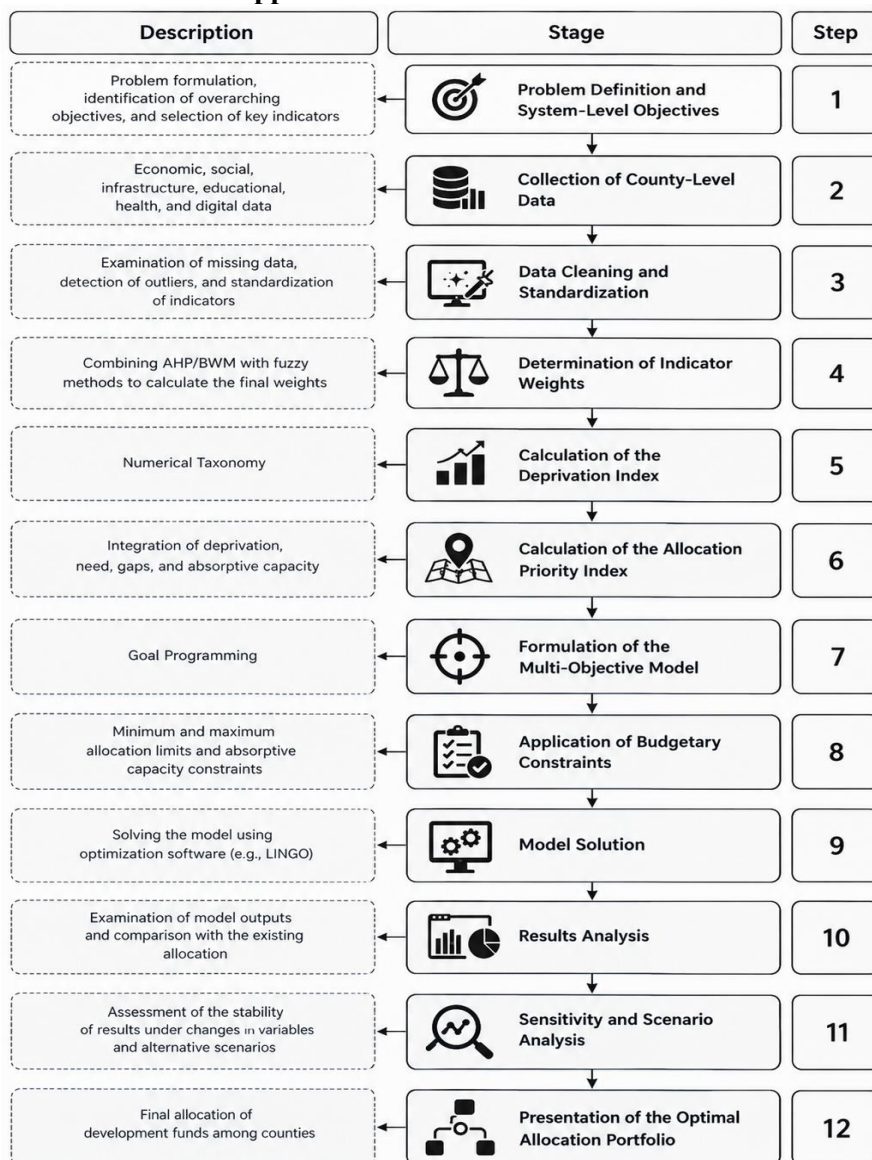
$$L_{ij} \leq x_{ij} \leq U_{ij} \quad (9)$$

Here, L_{ij} denotes the minimum and U_{ij} denotes the maximum amount of funding that can be allocated.

Flowchart of the Proposed Model

The proposed framework comprises a systematic, multi-stage process designed to optimize the allocation of development funds among counties. The process begins with defining the problem and establishing the overarching objectives, followed by the collection, cleaning, and standardization of relevant and diverse datasets. These steps provide the foundation for assigning composite weights to the indicators using AHP and Shannon entropy methods. Subsequently, a deprivation index is constructed using numerical taxonomy, which is then integrated with measures of need, development gaps, and absorptive capacity to derive the allocation priority index. In the next stage, a multi-objective goal programming model is formulated and subject to budgetary constraints, including minimum and maximum allocation limits and absorptive capacity constraints. The resulting optimization problem is solved using LINGO software. The model outputs are then evaluated through results, sensitivity, and scenario analyses to assess the robustness of allocation outcomes under alternative assumptions and policy conditions. Finally, the analysis produces a proposed allocation portfolio for the counties. By integrating deprivation assessment, multi-objective optimization, and scenario-based evaluation, the framework enables policymakers to examine the implications of alternative assumptions and priorities while improving the transparency, consistency, and evidence base of the resource allocation process (see Figure 2).

Figure 2. Conceptual Model/Decision-Support Architecture.



5. Discussion and Results

The results of applying the model to the 2021 data indicate that the proposed allocation pattern differs substantially from the approved budget. This difference does not, in itself, imply that the administrative allocation is inappropriate; rather, it

indicates that when deprivation, need, and absorptive capacity are explicitly incorporated into the model, a different pattern of resource allocation emerges. Based on the indicators defined in this study, this alternative allocation places greater emphasis on reducing spatial inequality.

Table 2. Differences between the approved budget and the model-based allocation.

County	Approved budget	Model-based budget	Difference (Model approved)	Deprivation level
Abadeh	4,004,800	4,550,000	545,200	High
Arsanjan	3,608,800	5,800,000	2,191,200	Very High
Estahban	3,257,200	4,200,000	942,800	High
Eqlid	6,115,800	6,950,000	834,200	High
Bavanat	4,157,700	5,100,000	942,300	High
Jahrom	9,299,800	8,350,000	-949,800	Moderate
Khorrambad	3,955,400	5,500,000	1,544,600	Very High
Darab	10,788,400	9,800,000	-988,400	Moderate
Sepidan	6,446,800	7,650,000	1,203,200	High
Shiraz	31,567,600	26,000,000	-5,567,600	Low
Fasa	9,194,500	8,496,600	-697,900	Moderate
Total	92,396,600	92,396,600	0	—

The results presented in Table 2 indicate that, relative to the approved allocation, the proposed model assigns higher budget shares to counties such as Arsanjan and Khorrambad, while recommending lower allocations for counties such as Jahrom and Shiraz. This finding highlights an important theoretical distinction: spatial equity should not necessarily be equated with equal monetary allocations. When regions differ in their levels of development and access to resources, uniform allocations or the continuation of historical allocation patterns may perpetuate existing disparities. Under the deprivation-oriented model, counties that are farther from the desired level of development are given greater priority in resource allocation. However, deprivation alone cannot serve as the sole basis for decision-making, because a region may be deprived while having limited implementation capacity to absorb and effectively utilize additional funding. Accordingly, integrating spatial equity with absorptive capacity and efficiency can result in a more realistic and context-sensitive allocation of resources.

In comparison with the existing literature, the overall direction of these findings is consistent with those reported by Bayramzadeh et al. [6]. Both studies indicate that reliance solely on administrative or historical allocation patterns does not necessarily contribute to reducing spatial inequality and that incorporating development indicators into resource allocation mechanisms can redirect public resources toward less-advantaged areas. The present findings are also consistent with evidence on the spatial concentration of deprivation in Iran [15], reinforcing the view that deprivation cannot be adequately explained by a single demographic or financial variable. At the same time, the model's emphasis on absorptive capacity is important because spatial equity cannot be achieved simply by increasing the budget share of deprived areas. The institutional and implementation capacity of regions to translate financial resources into public services and infrastructure should also be considered an integral component of spatial equity and regional development capacity [9]. The findings of Zangiabadi and Akbari [7] concerning Fars Province, although based on a different time period and a distinct set of indicators, likewise confirm the existence of substantial development disparities among the province's counties. Thus, the overall direction of the present findings is consistent with domestic evidence concerning spatial imbalances in Fars Province. However, the contribution of the present study extends beyond identifying and measuring these disparities by incorporating them directly into the budget allocation mechanism (see Tables 3-9).

Table 3. Weights of deprivation indicators (Entropy method).

Rank	Indicator	Weight
1	Unemployment Rate	0.187
2	Proportion of Population Below the Poverty Line	0.165
3	Illiteracy Rate	0.142
4	Infant Mortality Rate	0.128
5	Percentage of Households Without Piped Water	0.119
6	Percentage of Households Without Access to Natural Gas	0.105
7	Physician-to-Population Ratio	0.094
8	Educational Space per Capita	0.060

Table 4. Deprivation index and county rankings.

Rank	County	Deprivation Index	Level
1	Arsanjan	0.872	Very High
2	Khorrambid	0.835	Very High
3	Estahban	0.781	High
4	Bavanat	0.754	High
5	Sepidan	0.728	High
6	Abadeh	0.702	High
7	Eqlid	0.684	High
8	Fasa	0.512	Moderate
9	Darab	0.478	Moderate
10	Jahrom	0.443	Moderate
11	Shiraz	0.215	Low

Table 5. Final priority index (Combined deprivation + Absorptive capacity + Resilience).

Rank	County	Priority index
1	Arsanjan	0.634
2	Khorrambid	0.625
3	Estahban	0.615
4	Bavanat	0.608
5	Sepidan	0.604
6	Abadeh	0.598

7	Eqlid	0.592
8	Fasa	0.512
9	Darab	0.502
10	Jahrom	0.498
11	Shiraz	0.490

Table 6. Goal programming model output (Final allocation).

County	Approved budget	Model-based budget	Difference (Model – approved)	Change
Arsanjan	3,608,800	5,800,000	2,191,200	+60.7%
Khorrambid	3,955,400	5,500,000	1,544,600	+39.1%
Estahban	3,257,200	4,200,000	942,800	+28.9%
Bavanat	4,157,700	5,100,000	942,300	+22.7%
Sepidan	6,446,800	7,650,000	1,203,200	+18.7%
Abadeh	4,004,800	4,550,000	545,200	+13.6%
Eqlid	6,115,800	6,950,000	834,200	+13.6%
Fasa	9,194,500	8,496,600	-697,900	-7.6%
Darab	10,788,400	9,800,000	-988,400	-9.2%
Jahrom	9,299,800	8,350,000	-949,800	-10.2%
Shiraz	31,567,600	26,000,000	-5,567,600	-17.6%
Total	92,396,600	92,396,600	0	—

Table 7. Scenario analysis.

Scenario	Description	Gini coefficient	Minimum coverage
1	Administrative/Approved allocation (Baseline for comparison)	0.42	80%
2	Deprivation-oriented	0.28	85%
3	Efficiency-oriented	0.38	75%
4	Combined (Equity + Efficiency)	0.31	82%
5	20% Increase in budget	0.25	90%
6	10% Reduction in budget	0.35	78%

Best-Performing Scenario: Scenario 2 (Deprivation-oriented), with a Gini coefficient of 0.28.

Table 8. Sensitivity analysis.

Parameter	Change	Impact on allocation
Unemployment rate weight	+10%	Increased budget allocation to Arsanjan and Khorrambid
Illiteracy rate weight	+10%	Increased budget allocation to Estahban and Bavanat
Total budget	+20%	90% coverage across all counties
Total budget	-10%	Reduction in coverage to 78%

Table 9. Key improvement indicators.

Indicator	Before Allocation	After Allocation	Improvement
Gini Coefficient	0.42	0.31	-26%
Service Gap (Most Deprived)	0.65	0.40	-38%
Minimum Service Coverage	75%	82%	+7%
Theil Index	0.342	0.244	-28.7%

The model results show that budget allocation based on the deprivation index leads to substantial changes in the pattern of resource distribution. Arsanjan and Khorrambad, which have the highest levels of deprivation, experience budget increases of 60.7% and 39.1%, respectively, whereas Shiraz, the most affluent county among the units examined, experiences a 17.6% reduction in its proposed share. This reallocation is accompanied by a reduction in the Gini coefficient from 0.418 to 0.312, representing a 25.4% improvement, and a decrease in the Theil index from 0.342 to 0.244, representing a 28.7% improvement. In addition, the service gap in deprived counties decreases by an average of 36%. The 38% reported in Table 9 refers to the most deprived group and therefore differs from the overall average. Among the different scenarios, the deprivation-oriented scenario, with a Gini coefficient of 0.28, performs best in

reducing inequality, although the combined equity-and-efficiency scenario, with a Gini coefficient of 0.31, provides a more balanced trade-off among the different objectives. Sensitivity analysis also shows that the model is more sensitive to the weights assigned to the unemployment and illiteracy rates. Therefore, transparency in determining indicator weights is important for interpreting the results and applying them in policymaking.

Scenario and sensitivity analyses enhance the policy relevance of the model compared with a simple ranking approach, as decision-makers can assess the consequences of changing the weights assigned to objectives or the budget ceiling before actual implementation. This feature is consistent with recent literature on public resource allocation, which emphasizes the importance of transparent objectives, the comparison of alternative scenarios, and the

management of the distributional consequences of decision-support models [17]. Recent budgeting practices likewise indicate that analyzing the distributional effects of public expenditure decisions can help incorporate inequality considerations into the budgeting process [19]. Therefore, the main advantage of the proposed framework lies not merely in generating a single allocation figure but in providing a basis for policy comparison across equity, efficiency, and feasibility.

6. CONCLUSION

The allocation of development funds among counties is a multi-objective problem in which spatial equity, deprivation reduction, economic development, improvement of public services, investment efficiency, and resilience interact with one another. The findings from Fars Province show that combining numerical taxonomy with goal programming can produce an allocation pattern that differs from the approved allocation and reveal the distributional consequences of alternative budgetary options. In this study, 11 counties and eight key indicators were incorporated into the model, and the proposed allocation was determined based on deprivation, need, and implementation constraints.

The main theoretical implication of the study is that spatial equity should not be equated with equal monetary allocations. When regions differ in their levels of development and access to resources, allocations proportional to development gaps may be more justifiable from an equity perspective, provided that the capacity to convert resources into development outcomes is also considered in the decision-making process. The added value of the proposed framework lies in linking deprivation assessment with a multi-objective allocation mechanism that allows for scenario analysis and sensitivity testing. From a practical perspective, the model can serve as a decision-support tool for comparing allocation options rather than as a substitute for policymakers' judgment and implementation assessments.

7. Research Limitations

This study has several limitations. First, because data for some counties were incomplete, the final analysis was limited to 11 of the 37 counties in Fars Province. Therefore, the exclusion of 26 counties may affect the overall picture of deprivation distribution across the province, and the findings should not be generalized to the entire province without further testing. Second, the deprivation indicators correspond to 2021, whereas the approved budget pertains to 2022; consequently, the findings are cross-sectional and do not capture changes in the indicators over time. Third, the model was developed under the assumption that the total budget and model parameters are certain, whereas government budgets are affected in practice by fluctuations in prices and revenues, as well as by policy changes. Fourth, absorptive capacity was incorporated into the

model primarily in quantitative terms, while qualitative factors such as the quality of local governance, institutional coordination, and social capital were not directly measured. Finally, the results are sensitive to the selection and weighting of indicators. Therefore, applying the model to other provinces would require the indicators, weights, and constraints to be adjusted to the specific conditions of each region.

8. Research Recommendations

Future research can extend the proposed model in four directions:

1. Use multi-year panel data.
2. Use GIS to develop a deprivation map.
3. Combine goal programming with metaheuristic algorithms.
4. Use machine learning to predict the effects of budget allocation on development indicators.

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