*Journal of Infrastructure, Policy and Development* 2024, 8(12), 9302.
https://doi.org/10.24294/jipd.v8i12.9302

Article

# An evaluation and comparative analysis of higher education health and sustainability: India's performance and global

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**CITATION**

Ye M, Ji F, Qi, T, et al. (2024). An evaluation and comparative analysis of higher education health and sustainability: India's performance and global. Journal of Infrastructure, Policy and Development. 8(12): 9302.
https://doi.org/10.24294/jipd.v8i12.9302

**ARTICLE INFO**

Received: 25 September 2024
Accepted: 18 October 2024
Available online: 5 November 2024



**Abstract:** This study evaluates the health and sustainability of higher education systems in nine countries: the USA, UK, Australia, Germany, Canada, China, Brazil, India, and South Africa. Using a multi-level analysis model and principal component analysis (PCA), nine key factors—such as international student numbers, academic levels, and graduate employment rates—were identified, capturing over 90% of the cumulative impact on higher education systems. India, scoring 6.2036 initially, shows significant room for improvement. The study proposes policies to increase graduate employment, promote international faculty collaboration, and enhance India's educational expenditure, which surpasses 9.8% of GDP. Post-policy simulations suggest India's score could rise to 8.7432. The paper also addresses the impact of COVID-19 on global education, recommending a hybrid model and increased graduate enrollment in China to reduce unemployment by 5.4%. The research aims to guide sustainable development in higher education globally.

**Keywords:** higher education; principal component analysis; multi-level analysis method evaluation mode; sensitivity analysis

## 1. Introduction

### 1.1. Problem background

Higher education remains a pivotal indicator of national strength and progress, garnering significant global scrutiny regarding its health and sustainability (Ellen Hazelkorn, 2018; Ronald, 2012; Zhang et al., 2011). India, in particular, holds a unique position where the development of its higher education system is indispensable for the country's overall advancement. As societies increasingly democratize and the knowledge economy takes precedence, the condition and sustainability of higher education systems across the globe, and notably in India, have attracted considerable attention (Jena, 2020; Rana et al., 2022). Developed nations have achieved notable milestones in this sector, however, each nation's unique historical, cultural, and economic context shapes its higher education landscape, posing formidable challenges in devising a comprehensive evaluation framework (Veidemane, 2022). To address these challenges, our research distills a multitude of influencing factors into nine key ones, capturing over 90% of cumulative impact, and proposes an evaluation model that assigns objective weights to each factor. This model is applied to nine selected countries, identifying India as a

country with substantial room for improvement in its higher education system. Given India's emerging status as a significant source of international students, coupled with its struggles with brain drain and insufficient investment in higher education, this research aims to propose targeted policies and implementation timetables to bolster the development of India's higher education system, aiming for a healthier and more sustainable future.

## 1.2. Theoretical background

The evaluation of higher education systems is a complex and multifaceted task that involves numerous influencing factors. These factors can be broadly divided into internal and external categories (Szadkowski, 2019). Internal factors include the quality of teaching and research, the composition of faculty, student enrollment rates, and graduation employment rates. External factors, on the other hand, encompass government policies, investments in school infrastructure, state funding for higher education, and international cooperation. To systematically analyze these factors, researchers often employ principal component analysis and multi-level analysis methods (Blair and Noel, 2014; Fan et al., 2022; Mizikaci, 2006;). Principal component analysis allows for the extraction of key influencing variables from a large number of factors, while multi-level analysis provides a framework for evaluating the interplay between these variables at different levels. Moreover, the concept of sustainability has been increasingly integrated into the evaluation of higher education systems. Sustainability in higher education encompasses not only economic aspects such as resource allocation and efficiency but also social and environmental dimensions. This holistic approach requires a comprehensive evaluation model that takes into account various indicators and their interactions.

## 1.3. Problem analysis

To address this challenge, we must first establish a comprehensive foundational model for assessing the health and sustainable development of higher education systems across nations. Given the multitude of influencing factors, it is imperative to create a model that filters and integrates the most impactful variables, providing a solid basis for subsequent analyses. Recognizing the diversity in higher education systems globally, we select nine representative countries spanning six continents. By analyzing and computing data collected from these nations, we aim to evaluate and rank their higher education health status. Our objectives, achieved through the construction and application of the model, are as follows:

1) Develop and validate a model for assessing the health and sustainability of higher education systems (RO1). This model utilizes Principal Component Analysis (PCA) and multi-level analysis to extract and quantify key factors influencing higher education systems.
2) Apply the model to nine selected countries, identify a country with room for improvement, and propose targeted policies and implementation timetables (RO2). The goal is to support the transition from the current state to an improved higher education system, presenting a feasible and reasonable vision for its development.

3) Measure the effectiveness of policy interventions by quantifying improvements in the health of the selected country's higher education system (RO3). The model will assess the system's current health and track the improvements after policy implementation. Discuss the practical challenges of implementing policies, from transitional phases to final execution.
4) Analyze the impact of the COVID-19 pandemic on global higher education and propose strategies for mitigation (RO4). Specifically, we assess how the pandemic has affected student mobility, graduate employment, and teaching modes. We propose solutions such as a hybrid education model and expanded graduate enrollment to mitigate these effects and foster the sustainable development of higher education systems.

## 1.4. Model implementation

The theoretical foundation of our evaluation model is built upon rigorous methodologies, such as PCA and multi-level analysis, to ensure comprehensive assessment of higher education systems' health and sustainability. PCA plays a critical role in condensing numerous influencing factors into the most significant ones, capturing over 90% of the cumulative impact. This method effectively reduces the complexity of evaluating higher education systems by isolating key variables, such as international student numbers, management systems, enrollment scales, state investments, and graduate employment rates, that drive the system's health and sustainability.

Multi-level analysis further enriches our model by providing a framework for understanding the interactions between these variables at different hierarchical levels. This approach acknowledges the multi-tiered nature of the higher education system—from individual institutions to broader national and global contexts—allowing for a more holistic evaluation.

The model implementation involves the following steps:

1) Data Collection: Comprehensive data is gathered from reputable sources like the World Bank, governmental reports, and international education databases.
2) Principal Component Analysis: Utilizing statistical software, PCA is conducted on the collected data, identifying nine critical factors influencing higher education system health. These factors include the number of international students, management structures, enrollment sizes, governmental investment, preferential talent policies, educational mechanisms, faculty composition, academic levels, and employment rates of graduates.
3) Weight Assignment: A judgment matrix is constructed through pairwise comparisons to determine the relative importance of each factor. We then apply the summation method to calculate the weight vector, reflecting each factor's influence on the overall health score.
4) Sensitivity Analysis: Sensitivity analysis ensures the robustness of our weight assignments by examining how variations in the judgment matrix impact the rankings.

The combined weighted factors are used to construct the evaluation model, which is applied to nine selected countries, including India, USA, UK, Australia, and

China, to assess and rank their higher education health statuses. Sources for core variables are carefully chosen to ensure transparency. For example, international student numbers come from governmental and academic data, while management systems and investment figures are derived from educational budgets and policy documents. Graduate employment rates are tracked through national surveys, ensuring the reliability and applicability of the model.

By grounding our model in these well-established methodologies and meticulously sourced data, we ensure that our evaluation is both robust and actionable. This approach paves the way for targeted policy interventions aimed at enhancing the development of higher education systems worldwide.

## 2. Assumptions

1) It is assumed that the official data collected is accurate.
2) The data is processed in accordance with the 4-rounding principle.
3) Assume that there are no emergencies in the model that affect the factors.
4) Assume that all countries after secondary education belong to higher education.

## 3. Models

### 3.1. Construct an evaluation model based on multi-level analysis

#### 3.1.1. Higher education system

The higher education system constitutes an intricate organizational framework, encompassing institutions of higher learning (such as colleges and universities) alongside the personnel and infrastructural backbone necessary for educating students beyond the secondary level. This system encompasses both professional and vocational education, premised on the completion of secondary education, and stands as the pivotal social endeavor for nurturing advanced professionals and specialists. It is noteworthy that the contours of higher education vary across nations, with Australia, for instance, primarily categorizing it into Technical and Further Education (TAFE) institutions and universities, whereas South Africa distinguishes its higher education landscape into universities, education colleges, and technical colleges. To gain insights into the pivotal factors shaping this landscape, we commence by leveraging principal component analysis to isolate the most significant influencing variables. These variables are shown in the Appendix. Following this, we meticulously calculate the weight assigned to each of these factors, recognizing that these weights may vary in their ordering across different countries. Ultimately, we apply a standardized scoring criterion to derive the health scores of various nations within the higher education realm, offering a quantifiable assessment of their performance and strengths.

Principal component analysis of each influencing factor:

Numerous factors contribute significantly to the health and sustainability of higher education, encompassing a wide range of elements such as: student enrollment rates, the number of international students and students pursuing studies abroad, university management systems, enrollment scales, investments in school infrastructure by universities, state funding for higher education, government

policies offering preferential treatment to talents, educational mechanisms, faculty composition, student gender ratios, project funding, academic standards, graduate employment rates, and international cooperation (Baumann and Hamin, 2011). To streamline the complexity of calculations, it is imperative to first sieve through these factors using principal component analysis. This process involves four distinct steps aimed at identifying the primary components that serve as the cornerstone of influencing factors:

① Calculate the correlation coefficient matrix of each characteristic factor, among them *xi* means *i* actors that affect the health and sustainability of higher education:

$$r = \left[\frac{\sum_{k=1}^{n}(x_{ki}-\overline{x_i})(x_{kj}-\overline{x_j})}{\sqrt{\sum_{k=1}^{n}(x_{ki}-\overline{x_i})^2\sum_{k=1}^{n}(x_{kj}-\overline{x_j})^2}}\right]_{p\times p} = \begin{pmatrix} a_{11} & \cdots & a_{1p} \\ \vdots & \ddots & \vdots \\ a_{p1} & \cdots & a_{pp} \end{pmatrix}_{p\times p} \quad (1)$$

$$and\ r = \begin{pmatrix} 0.73 & \ldots & 0.58 \\ \ldots & \ldots & \ldots \\ 0.31 & \ldots & 0.76 \end{pmatrix}_{p\times p}$$

② Find the characteristic root of rand the corresponding characteristic vector as follows:

$$a_1 = \begin{bmatrix} a_{11} \\ a_{21} \\ \ldots \\ a_{p1} \end{bmatrix}, a_2 = \begin{bmatrix} a_{21} \\ a_{22} \\ \ldots \\ a_{p2} \end{bmatrix}, \ldots, a_p = \begin{bmatrix} a_{1p} \\ a_{2p} \\ \cdots \\ a_{pp} \end{bmatrix} \quad (2)$$

③ Get the relationship formula of principal component

$$X_1, X_2, \ldots, X_i: G_i = a_{1i}X_1 + a_{2i}X_2 + \cdots + a_{pi}X_p, i = 1,2,\ldots,p \quad (3)$$

④ Select the main features according to the principal component contribution rate CR and the cumulative contribution rate SCR, and the cumulative contribution rate is required to reach 90%, and the first m new variable features that meet the conditions are selected as the principal components ($m < p$).

$$CR = \frac{\lambda_i}{\sum_{k=1}^{p}\lambda_k}, i = 1,2,\ldots,p \quad (4)$$

$$\mathrm{SCR} = \frac{\sum_{k=1}^{i}\lambda_k}{\sum_{k=1}^{p}\lambda_k}, i = 1,2,\ldots,p \quad (5)$$

Obtain $m = 9$, and the results are shown in **Table 1**:

**Table 1.** Principal component analysis results.

| $\lambda_i$ | $\lambda_1$ | $\lambda_2$ | $\lambda_3$ | $\lambda_4$ | $\lambda_5$ | $\lambda_6$ | $\lambda_7$ | $\lambda_8$ | $\lambda_9$ |
|---|---|---|---|---|---|---|---|---|---|
| CR | 10.3% | 6.4% | 6.8% | 16.5% | 14.3% | 6.2% | 7.4% | 12.8% | 15.7% |

$\lambda_1$, ..., $\lambda_9$ represents Number of international students, Management System, Enrollment scale, State investment in higher education, The government's

preferential treatment policy for talents, Education mechanism, Faculty, Academic levels, Graduate employment rate.

And SCR = 96.4% > 90%， Therefore, among the many factors that affect the health and sustainability of higher education, it shows that these nine have the greatest impact on the health and sustainability of higher education.

### 3.1.2. Establish a system level model

The establishment of the system level model is mainly to make a gradient division of the influencing factors of higher education, determine the affiliation between the factors at the upper and lower levels. In order to build the system hierarchy model, the levels are divided into three categories:

1) Top level: Factors affecting the higher education system.
2) Middle layer: Universities 'own factors, External factors, Quality of education.
3) Lowest level: Number of international students, Management System, Enrollment scale.

State investment in higher education, The government's preferential treatment policy for talents, Education mechanism; Faculty, Academic levels, Employment rate of graduates. As shown in **Figure 1**:

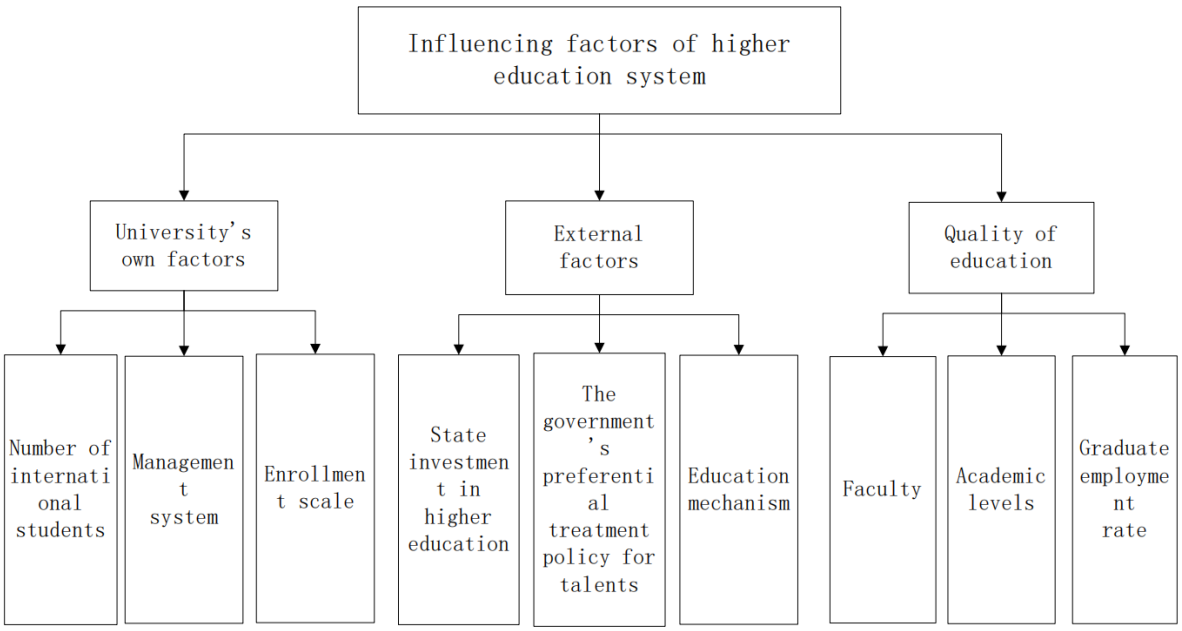


**Figure 1.** Influencing factors of higher education system.

### 3.1.3. Evaluation model based on multi-level analysis method

(1) Data collection and processing

The data collected from the World Bank database (Worldbank, 2023) on the gross enrollment rate of higher education in major countries in the world in recent years are shown in **Table 2**.

**Table 2.** Some indicators of countries in 2019.

| Country | Government expenditure on higher education as a percentage of GDP | Graduate employment rate | Number of international students |
|---|---|---|---|
| Australia | 1.2868% | 22.3% | 13319 |
| Brazil | 1.5205% | 19.8% | 67183 |
| Canada | 1.6541% | 20.6% | 48345 |
| China | 1.5837% | 20.2% | 993367 |
| Germany | 1.2517% | 26.8% | 122538 |
| India | 1.0924% | 19.5% | 375055 |
| United States | 1.4549% | 27.8% | 84349 |
| United Kingdom | 1.4496% | 27.6% | 38986 |
| South Africa | 0.9588% | 13.2% | 10178 |

The value includes not only the ranking value, but also the score value of each indicator. The first step in data processing is to positively negative indicators (International Comparative Education Research Center, 2012). The negative index is opposite to the positive index, and its value is inversely proportional to the result. The larger the value, the worse the situation reflected. The commonly used ranking value is a negative indicator, ranking first is the best. The larger the ranking value, the weaker the health and sustainability.

The formula for the passivation of negative indicators is as follows:

$$X_{\mathrm{i}}' = \max X_{\mathrm{i}} - X_{\mathrm{j}}, X_0 \leq X_{\mathrm{j}} \leq \max X_{\mathrm{i}} \tag{6}$$

$X_1$, $X_2$, ..., $X_9$ represent Number of international students, Management System, Enrollment scale, State investment in higher education, The government's preferential treatment policy for talents, educational mechanism, Faculty, Data on Academic level and Graduate employment rate, respectively. If the units of the various indicators are not unified, further standardization of the indicators is needed to unify the indicators into dimensionless units. The formula is as follows:

$$X_{ij}' = \frac{X_{ij} - X_j}{S_j} \tag{7}$$

Among them $x_j$ refers to the average value of each indicator, $S_j$ indicates the standard deviation of the indicator.

(2) Construct a judgment matrix

In order to obtain the scale of the relative importance of n factors through pairwise comparison, need to construct a judgment matrix, among them $u_1$, $u_2$, ..., $u_9$ represents educational mechanism, Academic levels, Management System, Number of international students, State investment in higher education, Enrollment scale, Management System, Graduate employment rate, The government's preferential treatment policy for talents. After establishing the hierarchical model, the affiliation relationship between the factors at the upper and lower levels is determined. Assuming that the factor C of the previous level is the criterion, the next factor determined is $u_1$, $u_2$, …, $u_n$, for criterion C, compare $u_1$, $u_2$, …, $u_n$ between every two, and use numbers 1–9 as the comparison scale, assign values to the relative

importance of $u_i$ and $u_j$, the definition of the comparison scale is shown in the **Table 3**:

**Table 3.** Assignment of comparison scale.

| **Scaling（$a_{ij}$）** | **Definition** |
|---|---|
| 1.0 | Indicates that $u_i$ and $u_j$ are equally |
| 1.2 | Important<br>Indicates that $u_i$ is slightly more<br>Important than $u_j$ |
| 1.4 | Means that $u_i$ is more important than $u_j$ to $u_i$ |
| 1.6 | Indicates that $u_i$ to $u_j$ is very important compared to $u_i$ to $u_j$ |
| 1.8 | Means that $u_i$ is extremely important compared to $u_j$ |

Comparing $n$ factors in pairs, the relative importance scales obtained from a judgment matrix:

$$A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1j} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2j} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nj} & \cdots & a_{nn} \end{pmatrix} \tag{8}$$

Among them, $a_{ij}$ is the comparative scale of the relative importance of factors $u_i$ and $u_j$ to criterion $C$.

(3) Calculate the weight vector of each layer factor

There are influencing factors for criterion $C$ $u_1$, $u_2$, …,$u_n$ , Their weights for criterion $C$ can be written in the form of vectors $W = (W_1, W_2, \ldots, W_n)^T$ , $W$ is the order of importance of factors, and $\sum_{i=1}^{n} W_i = 1$ the weight is calculated using the summation method:

$$W_i = \frac{1}{n}\sum_{j=1}^{n} \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \tag{9}$$

Get the weight value of each factor and its weight value sort in the **Table 4**:

**Table 4.** Sorting the weight value of each factor.

| Influencing factors | $u_4$ | $u_8$ | $u_5$ | $u_9$ | $u_1$ | $u_3$ | $u_2$ | $u_7$ | $u_6$ |
|---|---|---|---|---|---|---|---|---|---|
| Weight value Wi | 0.2752 | 0.1147 | 0.1047 | 0.0983 | 0.0972 | 0.0936 | 0.0895 | 0.0762 | 0.0506 |

It can be seen from the above table that the largest impact on higher education is the number of international students, followed by graduate employment rate, state investment in higher education, government preferential treatment policies for talents, education mechanism, faculty, academic level, management system, enrollment scale.

(4) Sensitivity analysis

Due to the existence of subjective factors in the evaluation of $a_{ij}$ or factors $u_i$ and $u_j$ relative to the relative importance of criterion C, therefore, $a_{ij}$ is analyzed.

The weight order derived from the judgment matrix $A$ is: $W_4 > W_8 > W_5 > W_9 > W_1 > W_3 > W_2 > W_7 > W_6$, considering the variation range of elements $a_{ij}$ and $a_{ji}$ (Other elements remain unchanged), in order to make the derived weight ranking of the new judgment matrix the same as the original judgment matrix, the variable range of $a_{ij}$ is $[a_{ij}^L, a_{ij}^U]$, due to the reciprocity of the judgment matrix $\left(a_{ij} = \frac{1}{a_{ji}}\right)$, calculate the upper triangular part of $A$, when $|i - j| \neq 1$:

$$a_{ij}^L = a_{ij}\, max\left(\left(\frac{W_{i+1}}{W_i}\right)^n, \left(\frac{W_j}{W_{j-1}}\right)^n\right),\ a_{ij}^U = a_{ij}\, min\left(\left(\frac{W_{i-1}}{W_i}\right)^n, \left(\frac{W_j}{W_{j+1}}\right)^n\right) \quad (10)$$

$$a_{ij}^L = a_{ij}\left(\frac{W_{i+1}}{W_i}\right)^{\frac{n}{2}},\ a_{ij}^U = a_{ij} min\left(\left(\frac{W_{i-1}}{W_i}\right)^n, \left(\frac{W_j}{W_{j+1}}\right)^n\right) \quad (11)$$

Among them, $a_{ij}^L$ is the lower limit, $a_{ij}^U$ is the upper limit of the value.

Get the sensitivity decision area $D = \{x \mid a_{ij}^L \leq x \leq a_{ij}^U, i, j = 1, \ldots, 9\}$, so as long as the value is assigned in this area, the original scheme order will not be changed.

(5) Build an evaluation model

Due to the indicator weight $W_i$ and the original score of the sample, can calculate sample evaluation value, the evaluation value, the evaluation value of the *i*-research object belonging to the *j* index is:

$$F_{ij} = W_i x'_{ij} \quad (12)$$

The value of each indicator and the corresponding weight are combined to obtain the overall evaluation of the health and sustainability of higher education, that is, the health score of the evaluation object is calculated:

$$F_i = \sum_{j=1}^{n} F_{ij} \quad (13)$$

Finally, the health status of all evaluation objects can be sorted according to the calculated health score $F_i$.

## 3.2. Application of the model

### 3.2.1. Evaluation model application

Based on the evaluation model of the health status of the higher education system based on multi-level analysis, the model was applied to the United States, Australia, Japan, China, and India and the scores of each country were calculated accordingly as shown in the table below. The higher the score, the better the health and sustainability of the country's higher education system.

**Table 5.** National higher education health and sustainability rating scale.

| Country | Score | Rank |
|---|---|---|
| United States | 9.8198 | 1 |
| United Kingdom | 9.7526 | 2 |
| Australia | 8.6025 | 3 |
| Germany | 8.4329 | 4 |
| Canada | 8.2615 | 5 |
| China | 8.0624 | 6 |
| Brazil | 7.6354 | 7 |
| India | 6.2036 | 8 |
| South Africa | 4.0623 | 9 |

A score above 7.5 indicates that the country's higher education system is relatively healthy and sustainable. The higher the score, the better the health. It can be seen from **Table 5** that both India and South Africa's scores are lower than 7.5, but India is the second largest source country of international students, but the number of international students.

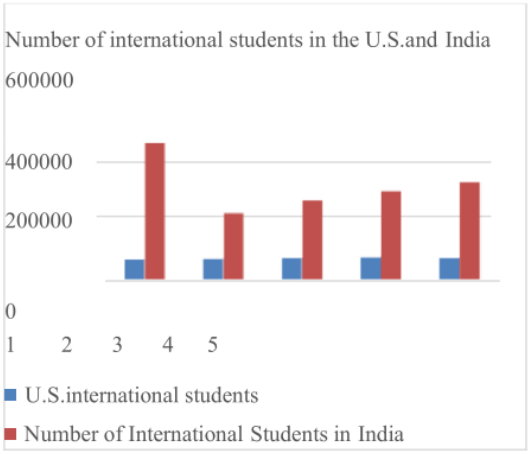


**Figure 2.** Number of international students.

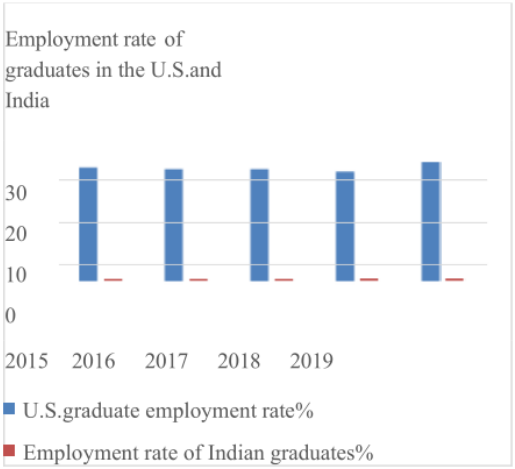


**Figure 3.** Graduate employment rate.

From **Figures 2–3**, it is obvious that according to statistics, India's expenditure on higher education as a percentage of GDP in 2015–2019 hovered around 1% and was much lower than that of the United States. Too little investment in higher education is one of the important factors contributing to the unhealthy Indian higher education system, and compared to the United States, the number of international students exodus from India in 2015–2019 is about 300,000 on average, leading to a brain drain in higher education, and the outflow of a large number of students has also had a certain impact on the country's economic development; In addition, the 0.91% employment rate of Indian graduates is far lower than that of the United States, which to a certain extent also reflects the great problems in the quality of higher education in India.

### 3.2.2. Policy presentation

(1) Enhance teachers' international level

Indian government regulations prohibit efficient and long-term employment of foreign teachers to teach (An, 2014). The government and schools can initiate cooperative research projects with foreign countries, exchange and study, and can also hire foreign-educated Indian teachers back to school to teach, communicate with teachers and students of this school, and bring them a more international perspective and improve international level.

(2) Attract the influx of international students

India sends about 35,000 students abroad and accepts about 30,000 international students. It can be seen from the data that India is the second largest source of international students, but the number of international students accepted only accounts for 0.6% of the global students. In order to attract international students, the following methods can be adopted:

Enable the credit-based transfer system, the credits of Indian universities and foreign institutions will be converted to the equivalent of credits to increase the mobility of students.

Each year, 20% of the international student quota is reserved for the enrollment of higher education in various universities.

(3) Incentive policies for talents

Establish "talent attraction" in India to retain domestic higher education talents and reduce the brain drain. Every year 40% of school education funds are used to support outstanding projects and reward scientific research talents.

(4) Strengthen support for graduates' employment

During the school, you can carry out corporate internships, project planning and other tasks to cultivate their abilities. After graduation, a job distribution system will be adopted for some students who are difficult to find employment.

(5) Government strengthens financial investment in higher education

The Indian government should increase its investment in higher education and devote 9.8% of its GDP to higher education every year.

Based on the above policies, we estimate the number of international students in India in the next ten years, the employment rate of graduates, and the government's financial investment as shown in the following chart:

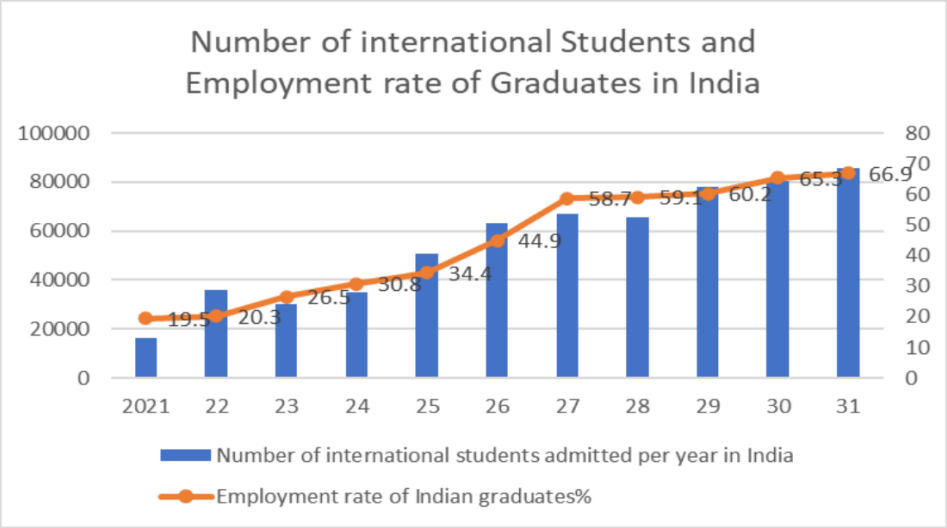


**Figure 4.** Number of international students in India and employment rate of graduates.

It can be seen from **Figure 4** that after a series of solutions have been proposed, the employment rate of college graduates in India in the next ten years will greatly increase, which shows that the quality of education has improved significantly and the ability of students has also been well developed. At the same time, the number of international students has also greatly increased, which not only promotes the internationalization of the school, but also introduces different talents, which is also very helpful for Indian students to absorb foreign knowledge.

### 3.3. Verify the validity of the policy

Taking India as the sample object of the model, the collected data samples are passed through the following process:

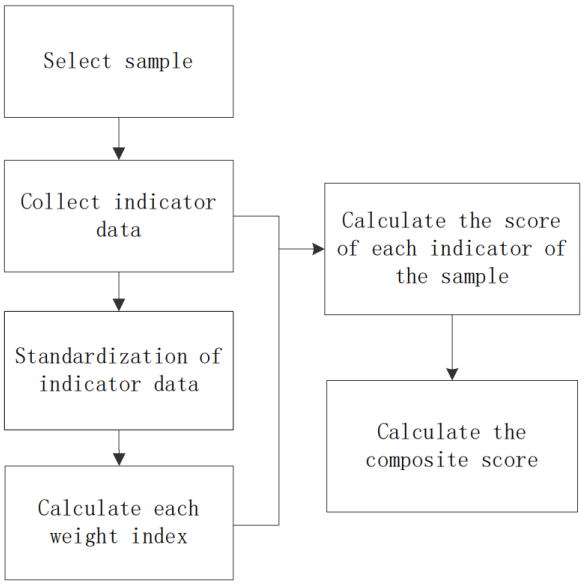


**Figure 5.** Model flowchart.

After the model is brought into the process shown in **Figure 5**, the comprehensive score (the comprehensive score for health and sustainability) can be

obtained as shown in the following **Table 6**:

**Table 6.** Data before and after comparison.

| Time | Government expenditure on higher education as a percentage of GDP | Number of international students | Employment rate | Overall rating |
|---|---|---|---|---|
| Before proposing policy | 1.09% | 16200 | 19.5% | 6.2036 |
| After the policy is proposed | 9.80% | 85691 | 66.9% | 8.7432 |

It can be seen from the table that before the policy was proposed, India's comprehensive score was 6.2036. After the policy was proposed, its original data reached the desired vision and brought into the model and process. The comprehensive score was 8.7432, ranking third in **Table 3**, second only to the UK level., That is, the policies we put forward are effective and are conducive to improving the health and sustainable development of higher education in India.

## 3.4. Analysis of realistic impact

**Table 7.** Comparison of various indicators between India and the United States.

| Index | India | United States |
|---|---|---|
| Gross enrollment rate of higher education (2016) | 16% | 89% |
| Number of top 500 universities in the world (2017) | 1 | 151 |
| Number of top 2000 universities in the world (2017) | 0 | 89 |
| Fiscal higher education expenditure as a percentage of GDP (2019) | 0.63% | 1.05% |
| Proportion of international students among PhD graduates (2016) | NA | 34.97% |
| National income per capita (2017, USD) | 1040 | 47930 |
| Population (2018, 10 million) | 120 | 31 |

**Table 8.** Comparison of data between the United States and India.

| Country | Government expenditure on higher education as a percentage of GDP | Overall rating |
|---|---|---|
| United States | 1.36% | 9.8198 |
| India after the policy is proposed | 9.80% | 8.7432 |

It can be seen from **Table 7**; economic factors are one of the important reasons affecting higher education. India's fiscal funding for higher education accounts for 0.63% of GDP and the United States's 1.05%. The difference between the two is only 0.42%. However, India's per capita income is US $1040, compared to US $47,930 (Pavlin and Marjan, 2012), India is much lower than the United States, so even if the proportion of investment in higher education between India and the United States is not much different, the level of higher education is still much lower than that of the United States, and the score is also very low. However, after the policy was proposed to increase India's higher education expenditure to 9.8% of GDP, India's overall score reached 8.7432 (Rizvi, 2016). Even so, there is still a big gap with the US score.

**Table 8** shows the attainable level of India under ideal conditions. However, based on the following realistic factors, the reform process is bound to be difficult:

### 3.4.1. The level of social economic development restricts the development of higher education

Although India's domestic economy has experienced substantial growth and development in recent years, the disparity between the rich and the poor and the uneven economic development have not been fundamentally improved. And have an impact on the overall economic level of the entire country. Therefore, even though the Indian Constitution proposed a plan to popularize 8-year free compulsory primary education in 1950, its actual implementation was delayed until 2010. "Universal" naturally has a long way to go.

### 3.4.2. A serious shortage of quality teachers and management personnel

In the current Indian education, the severe shortage of high-quality teachers and education administrators has also become an important issue in improving the quality of education. On the one hand, India's own teachers have a relatively low percentage of professionally trained and well-trained teachers. On the other hand, the proportion of teachers who have foreign training experience and are willing to teach and class is even lower. Establishing ahigh-quality education management team has also become a thorny problem.

## 3.5. The impact of the COVID-19 on the higher education system

The COVID-19 had a huge impact on the economy and education of all countries. According to the 2020 departmental budget data of the Ministry of Education of China, the expenditure on overseas education in China in 2020 will be 3.83 billion, compared with 3.98 billion in the same period last year, a year-on-year decrease of 3.8%. Financial revenue has declined significantly (Huang and Gong, 2020). In addition, the impact on higher education is also huge. The following **Figure 6** shows the COVID-19 has an impact on higher education:

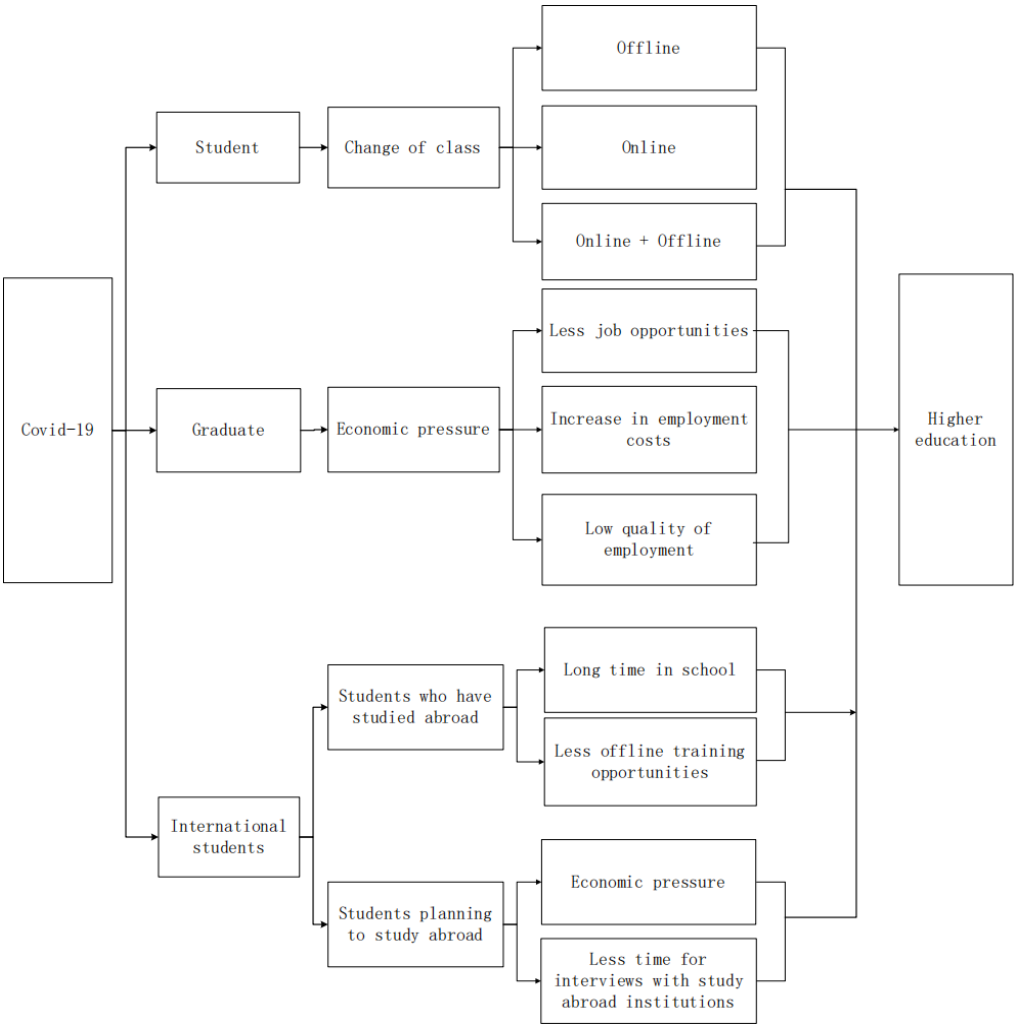


**Figure 6.** The impact of the COVID-19 on higher education.

The COVID-19 has affected the education methods of school students and international students, as well as the employment rate of graduates. According to the statistics of the Ministry of Education of China, the number of college graduates nationwide in 2020 will reach 8.34 million. It is expected that 2021 will have a net increase of 400,000 graduates compared with 2020. People, reaching 8.74 million people. Based on the negative impact of the COVID-19 on the country's economy and education, the following recommendations are made:

**Table 9.** Data comparison between 2020 and 2021.

| Years | Domestic enrollment rate of graduates | Graduate employment needs | Employment needs of graduates (except studying abroad and self-employment) |
|---|---|---|---|
| 2020 | 25.3% | 74.7% | 67.7% |
| 2021 | 27.8% | 69.3% | 62.3% |

Implement an online and offline education model for current and international students; in order to promote the employment of graduates and increase the employment rate of graduates, the Ministry of Education can implement graduate enrollment expansion, and the proportion of graduate enrollment is 15%, so the employment demand will decline 5.4%, the specific value is shown in the table below

(Huang and Gong, 2020):

From **Table 9** above, it can be seen that the implementation of graduate enrollment expansion can effectively reduce employment demand and reduce employment pressure. It shows that the enrollment expansion policy can effectively reduce the impact of the COVID-19 on national higher education.

## 4. Strength and weakness

### 4.1. Strength

(1) This article analyzes and discusses the impact of the recent emergence of the new coronavirus on the higher education system and proposes policies for how to respond under the current epidemic situation.

(2) This model can make a horizontal comparison of the health and sustainability of higher education in multiple countries, and analyze the differences in higher education between countries. And this model is applied to the health status of the higher education system in various countries, which can standardize the data of different units, thereby reducing the error of the model processing.

(3) This model can intuitively, uniformly and simply express the multiple factors that affect the health and sustainability of the country's higher education system with a comprehensive score, and can more clearly find out which country's higher education system has problems, so as to put forward corresponding questions. Resolve policies and programs.

(4) This weighting method can not only play the advantages of the subjective and objective weighting method, but also overcome the shortcomings of the subjective and objective weighting method. At the same time, it can better increase the accuracy of the comprehensive score under the principle that the index weight is consistent with the index importance.

(5) This model is highly flexible and can be evaluated by replacing or adding indicators according to different factors.

### 4.2. Weakness

(1) Due to different national conditions and different higher education systems in different countries, it is difficult to establish a universally applicable evaluation standard.

(2) For the sudden uncontrollable factor of the COVID-19, it will affect the health score in the model, resulting in a large difference between the score and the actual score. Therefore, it is necessary to update the data in time and apply it to the model to ensure the accuracy of the evaluation model.

(3) In the process of assigning values to the scale, there are personal subjective factors that affect the accuracy of the model; therefore, it is necessary to increase the number of samples and the range of samples to minimize the impact of errors.

(4) Since timeliness will affect the collected data, the accuracy of the model will be reduced.

## 5. Model promotion

The model established in this paper is an evaluation model based on multi-level analysis, which can evaluate the health and sustainable development of higher education systems in various countries. In this article, only the trend of changes in Indian higher education in the past five years is analyzed, but the trend of changes in the three factors of Indian higher education in the past ten to twenty years can be analyzed. Increasing the length of analysis time can more accurately predict changes in the Indian higher education system.

Make corresponding assessments and improvements to primary and secondary education, take school hardware measures and students' psychological quality as influencing factors, calculate the weight values of the influencing factors of primary and secondary education systems in various countries, and evaluate health conditions.

In addition to the education industry, it can be used to evaluate the health of the product in the field of machinery and electronic products, which can increase the safety of the product. However, due to the impact of the new crown epidemic, a large amount of data is still needed to optimize this model.

## 6. Conclusion and discussion

This study undertakes a comprehensive evaluation and comparative analysis of the health and sustainability of higher education systems, with a particular focus on India's performance in the global context. Using a multi-level analysis model, we have identified the key factors influencing the health and sustainability of higher education systems across various countries, including the USA, UK, Australia, Germany, China, and India.

The findings highlight several critical factors that significantly contribute to the overall health of higher education systems, such as student enrollment rates, international student mobility, university management systems, state funding for higher education, and graduate employment rates. These factors were weighted and analyzed, revealing variations in their importance across different countries.

In the case of India, the study identified several challenges, particularly low investment in higher education as a percentage of GDP and the substantial brain drain resulting from a large number of students pursuing education abroad. These issues contribute to the relatively low health score of India's higher education system compared to its international counterparts.

Despite these challenges, the research also points to significant opportunities for improvement. By implementing targeted policy interventions—such as attracting more international students, enhancing the quality of education, and increasing government investment in higher education—India could significantly boost the health and sustainability of its higher education system. The model predicts that these changes could lead to improvements in graduate employment rates and international student enrollment, both of which are crucial indicators of system health.

However, the implementation of these policies will require coordinated efforts across multiple stakeholders, including government agencies, educational institutions, and students. Additionally, the ongoing COVID-19 pandemic has introduced unprecedented challenges to global higher education systems, including disruptions to

international student mobility, campus operations, and graduate employment rates. Future research should explore the long-term impacts of the pandemic and adjust policy recommendations accordingly.

In conclusion, this study provides valuable insights into the health and sustainability of higher education systems worldwide, with a focus on India. The findings underscore the importance of a multi-faceted approach that accounts for diverse factors when assessing the health of a higher education system. Moreover, the proposed policy interventions could serve as a roadmap for countries seeking to improve the robustness and resilience of their higher education sectors in a rapidly changing global landscape.

**Author contributions:** Conceptualization, MY and FJ; methodology, TQ; software, YX; validation, MY, FJ and YX; formal analysis, TQ and YL; investigation, YM; resources, MY; data curation, TQ; writing—original draft preparation, FJ; writing—review and editing, YM; visualization, LZ; supervision, YX; project administration, LZ. All authors have read and agreed to the published version of the manuscript.

**Conflict of interest:** The authors declare no conflict of interest.

## References

A. H. Rizvi (2016). A study of e-governance educational projects in India. Global Journal for Research Analysis, 1, 37-38.

Anete Veidemane (2022). Education for sustainable development in higher education rankings: Challenges and opportunities for developing internationally comparable indicators. Sustainability, 14(9), 5102.

Chris Baumann & Hamin (2011). The role of culture, competitiveness, and economic performance in explaining academic performance: A global market analysis for international student segmentation. Journal of Marketing for Higher Education, 21(2), 181-201.

Ellen Hazelkorn (2018). Reshaping the world order of higher education: the role and impact of rankings on national and global systems. Policy Reviews in Higher Education, 2(1), 4-31.

Erik Blair & Keisha Valdez Noel (2014). Improving higher education practice through student evaluation systems: is the student voice being heard? Assessment & Evaluation in Higher Education, 39(7), 879-894.

Fatma Mizikaci (2006). A systems approach to program evaluation model for quality in higher education. Quality Assurance in Education, 14(1), 37-53.

International Comparative Education Research Center, Chinese Academy of Educational Sciences. (2012). International competitiveness of higher education: Models, indicators, and international comparisons. Educational Research, 7, 122-129.

Krystian Szadkowski (2019). The common in higher education: a conceptual approach. Higher Education, 78(2), 241-255.

Liubov Lysiak, Kachula Svitlana, Zarutska Olena, Hrabchuk Oksana, & Petrova Yana (2022). Diversification of sources of financing higher education: the experience of reform in european countries.

N Zhang, ID Williams, S Kemp & NF Smith (2011). Greening academia: Developing sustainable waste management at Higher Education Institutions. Waste management, 31(7), 1606-1616.

Ouyang Fan, Luyi Zheng, & Pengcheng Jiao (2022). Artificial intelligence in online higher education: A systematic review of empirical research from 2011 to 2020. Education and Information Technologies, 27(6), 7893-7925.

Pravat Kumar Jena (2020). Impact of Covid-19 on higher education in India. International Journal of Advanced Education and Research (IJAER), 5.

Ronald G Sultana (2012). Higher education governance: A critical mapping of key themes and issues. European Journal of Higher Education, 2(4), 345-369.

Samo Pavlin & Svetlicic Marjan (2012). Higher education, employability, and competitiveness. Hacettepe University Journal of Education, 43(4), 386-397.

Shuangxiong An (2014). Research on Indian educational strategy. Hangzhou: Zhejiang Education Press.

Sudhir Rana, Shubhangi Verma, Moon Moon Haque, & Gouher Ahmed. (2022). Conceptualizing international positioning

strategies for Indian higher education institutions. Review of International Business and Strategy, 32(4), 503-519.

Suyang Huang & Beijie Gong (2020). An analysis of the employment policy of fresh graduates under the background of the new coronavirus epidemic. Modern Business and Trade Industry, 17, 209-210.

Worldbank. (2023). Higher education gross enrollment rate data. (n.d.). Retrieved from http://data.worldbank.org.

# Appendix

**Table A1.** Symbols and their interpretations appearing in the article.

| Symbol | Explanation |
|---|---|
| $r$ | Correlation coefficient matrix. |
| $X_i$ | Sub variables of factors derived from principal component analysis. |
| $x_{i'}$ | Negative indicators are positive. |
| $x_{i'j}$ | Unified dimensionless index. |
| $u_i$ ($i$ = 1, ..., 9) | Factors affecting the higher education system. |
| $a_{ij}$ | Factors $u_i$ and $u_j$ relative importance scale for criterion. |
| A | Judgment matrix. |
| $W_i$ | The weight value of each factor. |
| $F_{ij}$ | Sample evaluation value. |
| $F_i$ | Overall score of the higher education system. |