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## Article

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## Index on relative sustainability impact-a suggestive tool for strengthening regional cooperation: Case of South Asia

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### ABSTRACT

Partnership and cooperation remain the essence of *United Nations 2030* (UN2030) Agenda. However, the regional cooperation framework often lacks comprehensive economic analysis and estimation of probabilistic impacts of any country's socio-economic and environmental activities on the people and ecosystems of other countries. This study attempts to develop an index on a country-pair basis that elucidates six channels of bilateral cooperation and respective strengths of those: trade, technological advancement, labors' productivity, regional interconnectedness, human development, and emission management. Criteria Importance Through Inter-criteria Correlation (CRITIC) objective weighting method is applied for multi-criteria decision-making. Empirical analysis encompasses all South Asian countries. Results show that India remains the country with the highest impact on the other countries in this South Asian region followed by Sri Lanka and Bangladesh. Bhutan, Afghanistan and the Maldives have the highest probability of attaining the gain from other South Asian countries. The study also analyzes countries' component-wise strengths of bilateral impacts.

### Introduction

UN 2030 Agenda compels the countries to achieve the universal aspirations targeting to end all sorts of poverty, protecting the planet, and ensuring prosperity for all by 2030 (UN, 2015). In attaining the Sustainable Development Goals (SDGs), along with ensuring sustained economic growth, countries also need to tackle a lot of challenges like the global climatic changes, environmental degradation, development of technologies, and human resources. Considering the extent of global integration and regional interconnectedness, actions taken by one nation may affect the development path of others, especially for the neighboring countries. Any sort of socio-economic havoc or environmental lapses in neighboring countries could substantially hamper the economic progress, social stability, and emission reduction target of a country. Therefore, countries should strategize the comprehensive regional or sub-regional cooperation frameworks so that they can mutually overcome the challenges while being benefited from each other. UN2030 Agenda emphasizes the collectivity, indivisibility, and universality of the SDGs and pledges to *leave no one behind*. Besides, since the development challenges and the prospects of the countries are highly interconnected in the current context, the mere advancement in the

developed countries cannot be sustained if the least-developed countries are not able to accomplish their goals and vice-versa (Helgason, 2016). Hence, it is worthwhile to mention that inclusiveness would remain at the heart of SDG implementation which acknowledges the need for concerted efforts not only within the country but also among the countries. Though many of the SDGs can be allied with partnerships and regional cooperation for their implementations, goal 17 explicitly refers to '*strengthen the means of implementation and revitalize the global partnership for sustainable development*'. The SDG 17 recognizes that the collectivity, indivisibility, and universality of the development processes can be best achieved by adopting the partnerships while embracing all related stakeholders (UN, 2015).

Nevertheless, attaining the SDGs would require substantial reforms and structural changes in the countries' development policies. The urges are more demanding for the least-developed and developing countries since they have to formulate and adopt the changes on a larger scale (Rudolph, 2017). Primarily, the countries should focus on the modification in fiscal and regulatory policies, integration of the environmental and green growth policies their respective national development strategies, enactment of high-tech financial market regulations, and implementation of the new investment strategies to support the SDGs.

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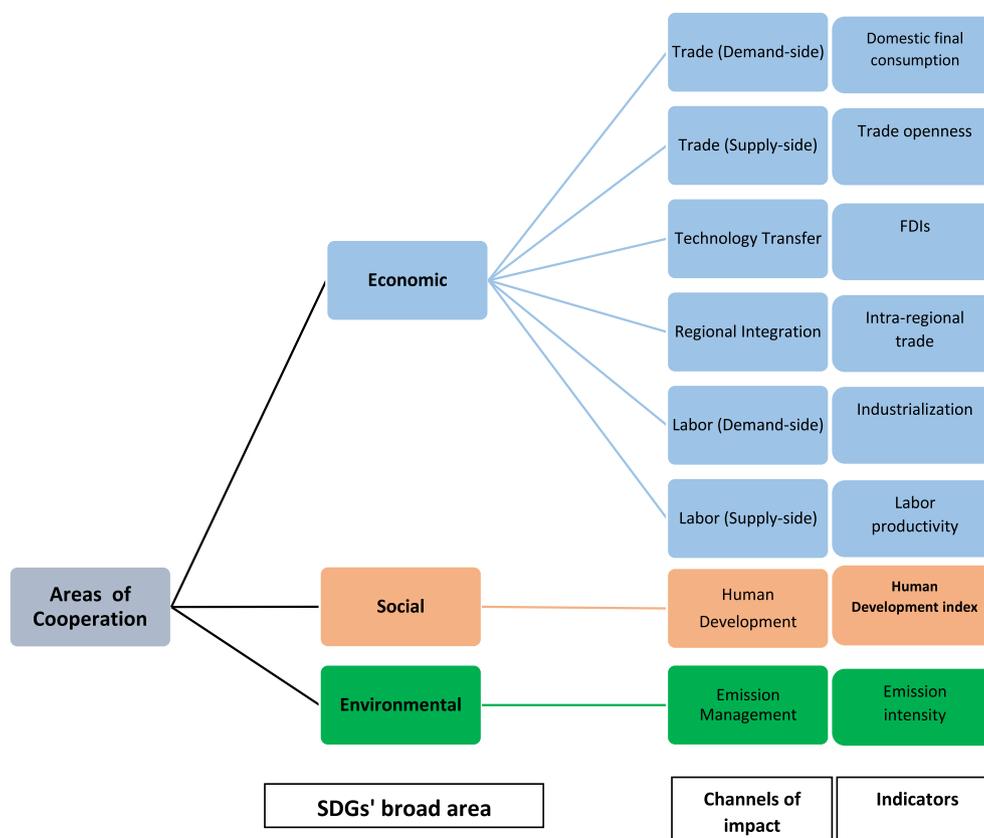


Fig. 1. Areas of Bilateral or sub-regional cooperation (Sustainability perspective).

Understandably, the entire transformation and reform process would entail huge financial and non-financial resources to support the adoption of technological advancements, and to facilitate a broader range of cooperation both from the internal and external sources (Bhattacharya & Ali, 2014; Kharas et al., 2014). Hence, the role of regional cooperation in SDG is undisputable. The critical question arises that how best the regional cooperation strategies can be adopted or reframed that would best serve the 2030 agenda.

Primarily, any regional cooperation would broaden the markets and input resources for the countries which would ensure better allocation of resources and the higher efficiency of resource usages (ADB, 2013). Members can expect mutual benefits by using their comparative advantages in dealing with tangible and intangible resources, goods, and services (Schiff & Winters, 2002). There are very few attempts to quantify the extent of regional integration of the countries primarily based on some standard composite indices constructed with a set of indicators representing cross-border economic activities and interconnectedness among the economies. For instance, in 2017, the Asian Development Bank developed the Asia-Pacific Regional Cooperation and Integration Index (ARCII) combining 26 indicators under six broad regional cooperation and integration factors, such as trade and investment, regional value chains, money and finance, movement of people, infrastructure and connectivity, and institutional and social integration (ADB, 2017). The index has multifaceted objectives: measuring the extent of regional (and sub-regional) integration of each economy in Asia and the Pacific, identifying strengths and challenges across different subregions and respective regional integration drivers, and monitoring the progress over time and against the targets. Under this ARCII, the country's score and ranking among all countries are based on its cross-border activities, but its internal resource and capacity utilization issues are not directly addressed in constructing the index. On top of that, mutual interactions and impacts of one country on the other, which is very crucial for designing an apt cooperation framework,

cannot be determined from such analyses. Notably, most of the regional cooperation indices unheeded two critical pillars of sustainability issued: social and environmental cooperation. There are, of course, a few sustainable development indices developed in contemporary literature (Shi et al., 2019; Reznichenko et al., 2018; Antanasijević et al., 2017; Kılıç, 2016), yet, none of them linked with the regional cooperation context, at large.

To optimize the benefit out of any regional cooperation framework, there should have a more comprehensive economic analysis for incorporating the sustainable development issues. The analysis should extensively encompass the areas of cooperation at the bilateral or sub-regional level with an adequate quantitative examination of the strengths and probable extent of cooperation that might be extended between the countries. The analysis should be able to determine the probable impacts of any country's socio-economic and environmental activities on the people and ecosystems of the other countries in that region. A country-pair basis indexing may be helpful to precisely identify the probable prospective areas of cooperation between two countries and then it could be taken as an input to design an extended sub-regional or regional cooperation framework.

This study, therefore, attempts to develop such an on a country-pair basis that would elucidate the probable channels or areas of bilateral cooperation and respective strengths or extent of the sustainable development factors. From the components of the index, this study also attempts to map how best regional cooperation can be boosted in attaining the SDGs within the region.

#### Areas of sub-regional or bilateral cooperation

The sustainable development measures or indices are derived largely under two methods: single composite indicator, and comprehensive multi-hierarchy indicators (Shi et al., 2019). A single composite indicator elucidates the extent of progress of an economy or region with a set

of variables composed into a single weighted indicator. On the other hand, a comprehensive multi-hierarchy indicators system considers the sustainable level more extensively. Standard data required for such analysis are often not available for all the countries in the same time–frequency and validity, especially for the developing and least-developed countries. Calculation of such multi-hierarchy indicators is also complex which makes this difficult to implement under the context of developing countries (Shi et al., 2019).

This study, therefore, chooses to construct a practicable single composite indicator to epitomize the sustainable development areas under a bilateral cooperation framework. As we know, there are three major pillars of sustainable development: economic, social, and environmental. In terms of cross-border cooperation, economic factors are having the utmost priority followed by social factors while environmental issues are often prioritized the least (Zaman, 2018a). One of the main reasons for countries' lesser intent to cooperate in environmental issues is the growing challenges perceived during the lengthy elongating intercession process (Rauschmayer & Wittmer, 2006). Therefore, in selecting the areas of sustainable development cooperation from a practical essence, more emphasis is given towards economic factors as compared to the other two. Economic factors of cooperation are driven by the cross-border trades along with its demand (i.e., domestic consumption) and supply sides (i.e., industrialization), Foreign direct investments (FDIs) and transfers of technologies, and movement of labors. Manifestly, some of the economic and social factors are overlapped and interconnected. For instance, trades and FDIs would support equitable growth and per capita income which would improve the living standards of the society.

There are several areas and channels of bilateral or sub-regional cooperation for the sustainable development of the countries, as illustrated in Fig. 1.

#### *Economic channels*

Economic benefits might take four broader channels to impact other countries: Trade, technology, labor market, and regional interconnectedness framework.

#### *Implications of trade*

Trade policies are assumed to have direct or indirect impacts on the welfare of households, firms, and the economy as a whole. Trade would influence both the demand as well as the supply-side of an economy. For the demand-side, trade, in the form of import, creates the demand for an economy. Domestic final consumption is an indicator reflecting the demand-side of an economy. The more direct effect of trade comes through the price channel. McCulloch et al. (2001) explain that households' welfare is influenced by the relative prices of the goods and services they consume, and trade has a big role to play in this.

From the macro perspective, trade can generate revenue in the economy which may be used to redistribute the incomes among households and firms. Trade liberalization or trade protection can induce employment generation and capacity development for both export-oriented as well as import-substituted services and industries (Dix-Carneiro & Kovak, 2017).

#### *Technological dissemination*

The technological channel has of more indirect impact on the household and firms. FDI induces technological changes through diffusions of innovations, information technology, and productivity (Yi & Naghavi, 2017; Shu & Steinwender, 2019).

#### *Labor market*

The labor market may be influenced both through the demand and supply sides. Higher labor productivity of one country refers to a more high-skilled pool of laborers; hence, it could be a good supply channel for the labor market of other countries (Bryan & Morten, 2019). Higher

labor productivity will be able to complement the resource or skill gaps of the other countries within the region.

From the demand-side perspective, if a country has more industrialization, it usually creates more job opportunities (Summers, 2019). Therefore, a higher extent of industrialization in a country would attract more labor migration from the neighboring countries.

#### *Regional integration*

Since the trade (liberalization) policies vary across the sector, and its level in different countries, the impacts should also differ. Trade with the neighbors (i.e., within an intra-regional bloc) may have more impacts as the costs and tariffs are expected to be lower (Zaman & Kalirajan, 2019). The intraregional trade intensity factor may expose how much (i.e., the extent) a country is interconnected with others in a particular region through trade.

#### *Social channels*

Social dynamics of SDG are largely highlighted through various specific goals such as health care (SDG 3), Education (SDG 4), gender equality (SDG 5), decent work (SDG 8), social protection (SDG 1), and equality and social inclusion (SDG 10). These refer to a vision for everyone to grow, learn, work, and live in an environment without any discrimination while realizing their potentials for society and human wellbeing. In this connection, the Human Development Index (HDI)-prepared by the UNDP would provide a good indication as to how the countries are performing in developing their human resources in line with the SDGs (Jin et al., 2020). Since this single HDI score captures three significant social development factors, such as health (through measuring the life expectancy), education (through years of schooling), and economic wellbeing (through per capita income), it is mostly demonstrative to signify all key social development factors (Babiarz et al., 2018; Gumenyuk, 2017). Hence, this study deploys this HDI score to represent the social development landscape as a whole. The higher-ranked countries may extend their cooperation through sharing their experiences, providing training and capacity-building facilities to others which remain with lower HDI scores.

#### *Environmental channels*

Because of the shortcomings of the standard data for each environmental sector, such as biodiversity, climate adaptation, clean water, agriculture, renewable energy, and natural resources, this study adopts a single factor of emission level to encompass all the environmental sustainability as a whole. According to Zaman (2018b), countries can extend bilateral or regional cooperation to support environmental development (i.e., strengthening green growth and reducing emission levels) through four key sectors: energy, agriculture, trades of environmental goods, and natural resources management. The key concern of all these sectors is the emission management capacities of the countries in different sectors. Higher the capacity in emission management, the higher the extent of cooperation a country could extend to others.

### **Construction of the framework of an index**

Construction of an index usually needs to follow several steps, such as the establishment of the scope and definition of the index, identification of the appropriate criteria, selection and determination of weights for each criterion, and calculation of the index (Casanovas-Rubio et al., 2020; Maleki et al., 2019).

#### *Scope and definition of index on relative sustainability impact (IRSI)*

The suggestive index on relative sustainability impact should encompass the effect of various factors representing the bilateral cooperation channels relating to the sustainable development agenda. It

should reflect the extent (in relative measure) to which a country would be beneficial (i.e., having higher strength to cooperate) for another country in supporting its higher attainments of sustainability in the economic, social, and environmental indicators. Hence, a multi-criteria approach to decision-making is adopted in this study. Of course, such a multi-criteria approach ends up with an informative ranking of the countries, however, in the context, measuring bilateral impacts would provide the thoughtful inputs in the decision-making elements in the form of probable strong areas of cooperation and the likely extents of those among the countries.

IRSI, therefore, by definition, is a country-pair measure through which the relative importance (i.e., impacts) of different factors are calculated on the pro-rata basis between two countries.

#### Identification of appropriate criteria

Section 2 identifies various channels of bilateral cooperation for strengthening the sustainable development of the countries. Based on the analysis, eight criteria are identified for constructing IRSI. These are the domestic final consumption ratio, Trade openness ratio, FDI inflow ratio, Labor productivity ratio, Industrialization ratio, Intra-regional trade intensity ratio, HDI ratio, and Emission intensity ratio.

The relative impact of country-*i* on country-*j* at time *t* for final consumption of the countries is calculated by the following formula:

$$\text{Finalconsumptionratio}_{ij} = \frac{\text{Finalconsumptionofcountry } i}{\text{SumofFinalconsumptionsofcountry } i \text{ and } j}$$

Formula reveals that the impact will not only depend on country-*i*'s final consumption or market size, rather it also depends on the final consumption or market size of country-*j*. For instance, if the country-*i*'s consumption is 3-times greater (irrespective of the level of consumption) than that of country-*j*, the impact of country-*i* on country-*j*, i.e.,  $\text{Finalconsumptionratio}_{ij}$  will be equal to 0.75. Conversely, the impact of country-*j* on country-*i*, i.e.,  $\text{Finalconsumptionratio}_{ji}$  will be equal to 0.25.

$$\text{IntraRegionalTradeIntensityratio}_{ij} = \frac{\text{IntraSouthAsiantradeintensityofcountry } i}{\text{SumofIntraSouthAsianTradeintensitiesofcountry } i \text{ and } j}$$

Perceptibly, higher consumption or market size of a country would enhance its capacity to impact the other country because the higher the consumption market, the higher will be the imports of that country. Hence, there is a likelihood of an increase in exports of the 'other country' (i.e., country-*j*) to the 'reference country' (i.e., country-*i*). This seems to be a rational assumption and the applicability is evident from the mentioned formula and given numerical example.

The relative impact of country-*i* on country-*j* at time *t* for trade openness of the countries is calculated by the following formula:

$$\text{Tradeopennessratio}_{ij} = \frac{\text{Tradeopennessofcountry } i}{\text{SumofTradeopennessesofcountry } i \text{ and } j}$$

Again, if the relative trade openness of a country is higher as compared with the other country, it is likely to induce a higher impact of that country on the other. For instance, if the country-*i*'s trade openness is 3-times greater than that of country-*j*, the impact of country-*i* on country-*j*, i.e.,  $\text{Tradeopennessratio}_{ij}$  will be equal to 0.75. Conversely, the impact of country-*j* on country-*i*, i.e.,  $\text{Tradeopennessratio}_{ji}$  will be equal to 0.25. Distinctively, higher trade openness of a country would increase its capacity to impact the other country through facilitating higher trade (i.e., both exports and imports) of that country. This also seems to be a rational assumption and the applicability is evident from the stated formula and given numerical example.

The role of FDIs is implicated with technological changes, in-

novations, and productivity. Therefore, the higher the inflows of FDI in a country, the higher the level of technological adaptation, innovation, and productivity is expected. Consequently, the relative impact of country-*i* on country-*j* on the FDI factor is portrayed by the following formula:

$$\text{FDIinflowratio}_{ij} = \frac{\text{FDIinflowincountry } i}{\text{SumofFDIinflowsincountry } i \text{ and } j}$$

Like the previous ratios, the relative gap (i.e., extent of difference) between the FDI inflows determines the level of impact of one country on other in terms of cooperating through the technology diffusion channel.

As mentioned earlier, a country with higher labor productivity can complement the resource or skill gaps of the other countries within the region, hence, assumed to have a higher impact through this labor-supply channel. Accordingly, the following formula is used in this study to depict the impact of this factor:

$$\text{Laborproductivityratio}_{ij} = \frac{\text{Laborproductivityofcountry } i}{\text{SumofLaborproductivitiesofcountry } i \text{ and } j}$$

A higher degree of industrialization in a country would exert a pull on more labor migration from the neighboring countries. The more the industrialization gap between two countries, the higher would be the likelihood of labor migration between them. Hence, the impact of country-*i* on country-*j* through this channel is defined by the following formula:

$$\text{Industrializationratio}_{ij} = \frac{\text{Industrialoutputofcountry } i}{\text{SumofIndustrialoutputsofcountry } i \text{ and } j}$$

The regional integration factor is another key driver that can impact the extent of cooperation through the intra-regional trade channel. The higher the intra-regional trade intensity of a country, the higher it is integrated with the regional cooperation bloc; hence, the impact of that country on others within the region would be also higher in proportion.

Here,

$$\text{IntraSouthAsianTradeintensityofcountry } i = \frac{\text{IntraSouthAsiantrade (i.e., Export + Import) ofcountry } i}{\text{GlobalTradeofcountry } i}$$

Countries with higher-ranked HDI are relatively able to extend their cooperation through sharing their experiences, training, and capacity-building facilities to others with lower HDI scores. The relative impact of country-*i* on country-*j* through this channel is defined as follows:

$$\text{HDIratio}_{ij} = \frac{\text{HumanDevelopmentIndexofcountry } i}{\text{SumofHumanDevelopmentIndicesofcountry } i \text{ and } j}$$

For instance, countries A, B, and C have HDI scores of 0.80, 0.80, and 0.20 respectively. Since A and B have the same level of human resources development, the mutual impact of A and B would be the same and equally distributed, i.e., impact equals 0.5 for both. However, the impact of A on C would be much higher (0.8) than the impact of A on B (0.5) which seems a rational one since country C has so low HDI that it can be highly benefitted from the cooperation from country A.

Environmental cooperation is channeled through several sectors as mentioned earlier; yet, the ultimate objective of environmental cooperation is to reduce the level of emission in the countries. Emission intensity refers to the emission of pollutants for each unit of output

produced. Higher the value of emission intensity indicates that the country is relatively inefficient in emission management. Therefore, this emission intensity factor will adversely affect the extent of cooperation by the countries. Hence, for calculating the relative impact of cooperation through emission management, the formula takes a different pattern than the previous ones. Here the impact of country-*i* on country-*j* is determined by the following formula:

$$\text{Emissionintensityratio}_{ij} = \frac{\text{Emissionintensityofcountryj}}{\text{SumofEmissionintensitiesofcountryiandj}}$$

For instance, if country A has an emission intensity of 100 units while country B has an intensity of 50 units. It indicates that country B emits half to produce a single unit output as compared to country A. Therefore, the emission management capacity of country B is double as compared to country A. Consequently, the impact of country A on country B will be lower (i.e.,  $50/150 = 0.33$ ) than the impact of country B on country A (i.e.,  $100/150 = 0.67$ ), which seems plausible.

Analyzing the list of criteria, it is evident that indicators are a mix of intensive and extensive nature. Four of them are strongly related to the size of the economy or market (e.g., final consumption, trade openness, FDI inflows, and industrialization) while the rest four are related to the country's level of capacity or efficiency (e.g., labor productivity, HDI, regional trade intensity, and emission management capacity). Both the size as well as efficiency of a particular factor are critical in determining the country's capability to cooperate with the other country in that field. A good balance between the number of intensive and extensive criteria depicts that the proposed model is well-designed and hence, can be adopted for apt policymaking.

#### Weighting of criteria

The weighting of the components plays a significant role in constructing an index while using a multi-criteria decision-making (MCDM) approach. Weights represent the relative importance of the components of the index. Based on the areas of application, numerous quantitative and qualitative methods are used for the determination of weights.

In subjective methods, the weight of attributes is principally based on judgment, experience, and preference of the experts or researchers (Liu et al., 2016; Alemi-Ardakani et al., 2016). Surveys, questionnaires, and interviews are a few of the techniques adopted to obtain the required information and data for the evaluation of these subjective methods (Tavana et al., 2015; Walters, 2017). Broadly, there are two categories of subjective weighting: *Direct weighting procedure* and *Pair-wise comparison techniques*. Direct weighting procedure encompasses Swing, Trade-off, Point Allocation, Delphi method, and Simple Multi-attribute Rating Technique (SMART) (Jahan et al., 2012). These methods are simple and assumed to be practical as the decision-makers directly allocate the weights to various attributes. Nevertheless, the successful adoption of determining the appropriate weights depends on too many qualitative settings and constraints of design (Sahoo et al., 2016). The Pair-wise comparison methods include Analytic Hierarchy Process (AHP), modified digital logic approach (MDL), eigenvector, and weighted least square method (Anojkumar et al., 2014; Milani et al., 2013; Jahan et al., 2012). The subjective methods are widely applied, especially in designing the industrial and service-oriented performance matrices based on products or services' features, consumers' tastes, and other market behaviors (Wang & Ming, 2018; Siddiqui & Tyagi, 2017).

The objective methods of determining the multi-criteria weighting, on the other hand, are solely based on the known data of the problem. The objective or quantitative weighting is appropriate, especially for an economic analysis where reliable subjective weights are not readily available. For most economic analyses, it is sometimes not plausible to impose subjective weights especially, under a heterogenous context (e.g., different countries with different socio-economic states or characteristics) (Sahoo et al., 2016; Wang, 2015).

Literature reveals that in a few instances the weights calculated by

the objective methods remain inconsistent with the decision-maker's subjective preferences. While the subjective approaches may also prone to probable biases owing to specific knowledge or experience of the DMs, recently, a lot of literature adopts integrated approaches by blending both subjective and objective weighting methods (Zhao et al., 2016; Liu et al., 2015; Lu et al., 2015).

MCDM targets to determine the best alternative weightings from the set of multiple, conflicting, and interactive measures. Often, many of the criteria may be found highly correlated which could yield a misleading determination of weights and hence, the subsequent poor construction of a composite index. Besides, the arbitrary omission of some criteria may also affect the true representation of factors into the index. Hence, many pieces of the literature suggest that it is preferable to use a framework based on objective criteria, especially for a new area to minimize qualitative bias and time (Zhang et al., 2016; Jee & Kang, 2000).

This paper also adopts the principle of using objective criteria for framing the index. There are different categories of objective weighting methods used in literature. The *mean weight* method remains too simplified as all the attributes receive equal weights, which may not be practical in most cases (Jahan et al., 2012). The *entropy method* is based on the discrete probability distribution of the attributes where the factors having very different performance ratings receive more weights as those factors assume to have a higher impact on the outcomes or ranking (Shanian & Savadogo, 2009). The *standard Deviation* method may often give a similar result to the *Entropy method* as the method assigns more weight to the criteria having higher standard deviations (Yin & Shang, 2017). *Preference Selection Index (PSI)*, proposed by Maniya and Bhatt (2010), uses the degree of convergence (unlike the degree of divergence as used in the *Standard Deviation* and *Entropy* methods) in calculating the weights. The application of the PSI method requires additional prudence due to this extreme contrast. PSI, in a few cases, may also provide negative weights which may be misleading to define the relative importance of criteria in MCDM (Jahan et al., 2012). *Criteria importance through inter-criteria correlation (CRITIC)* is an advanced version of the objective weighting method developed by Diakoulaki et al. (1995). It uses correlation analysis to determine the intensity of contrast between the criteria and the conflict in the structure of the decision-making problem (Wang et al., 2018). The method is well-structured as the decision matrix derived by this method incorporated both the contrast intensity of each criterion along the conflict between the criteria (Wang et al., 2019). The standard deviation of the normalized criteria values is used for measuring contrast intensity while the correlation coefficients of each pair determine the criteria contrasts (Madic & Radovanović, 2015).

The abstraction and exploitation of these contrast intensity and conflict features make this CRITIC method more advantageous to the decision-making process as the intrinsic information in the data is well-explained by these two features (Rostamzadeh et al., 2018). Therefore, by considering the compatibility and applicability of the objective weighting methodologies, the CRITIC model is used for this paper. The model is explained in the following sub-section.

*CRITIC method: A stepwise algorithm*

#### Step 1: Formation of Decision-matrix

First, the decision matrix X is formed using the performance of different alternatives (*m*) with respect to various criteria (*n*).

$$X = [X_{pq}]_{m \times n} = \begin{bmatrix} X_{11} & X_{12} & \dots & X_{1n} \\ X_{21} & X_{22} & \dots & X_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ X_{m1} & X_{m2} & \dots & X_{mn} \end{bmatrix} \quad (p = 1, 2, \dots, m \text{ and } q = 1, 2, \dots, n)$$

$X_{pq}$  represents the performance value of *p*-th alternative (i.e., countries) on *q*-th criteria

**Table 1**  
Average values of the variables (2015–2018).

Country	Final Consumption (in USD bill)	Trade Openness	FDI Inflow (in USD bill)	Labor Productivity (in USD/labor)	Industry in GDP (in USD bill)	Regional Integration	HDI	Emission Intensity (in kg CO <sub>2</sub> /USD)
Afghanistan	19.17	50.36	0.11	1701.3	4.41	0.25	0.49	0.49
Bangladesh	121.49	38.40	2.58	2702.4	52.54	0.10	0.60	0.49
Bhutan	2.55	79.78	0.01	6060.5	0.92	0.86	0.61	0.65
India	1702.17	41.50	42.68	5251.3	743.92	0.03	0.64	0.95
Maldives	2.09	141.53	0.45	18370.6	0.44	0.17	0.71	0.22
Nepal	19.36	52.05	0.11	1267.3	2.82	0.64	0.57	0.43
Pakistan	212.08	26.70	2.42	3584.7	44.81	0.07	0.56	0.78
Sri Lanka	62.04	50.65	1.14	10158.9	21.40	0.18	0.78	0.29

Source: SAARCFINANCE, UNDP, UNCTAD, ILO, World Development Indicators, Crippa et al. (2019).

**Step 2: Normalization of decision matrix**

Each element of the decision matrix is then normalized using the max–min technique for each criterion as follows:

$$X_{pq}^* = \frac{X_{pq} - \min(X_{pq})}{\max(X_{pq}) - \min(X_{pq})} \text{ for } q\text{-th criteria}$$

$X_{pq}^*$  expresses the degree to which  $p$ -th alternative is close to the ideal value (i.e.,  $\max(X_{pq})$ ) which is the best performance in criteria  $q$  and far distant from the anti-ideal value (i.e.,  $\min(X_{pq})$ ) which is the worst performance in criteria  $q$ . Notably, this normalization process is not differentiated among different types of criteria.

**Step 3: Calculate the standard deviation of each criterion**

The standard deviation of the  $q$ -th criteria is calculated as

$$\sigma_q = \sqrt{\frac{\sum_{p=1}^m (X_{pq}^* - \bar{X}_{pq}^*)^2}{m}}$$

**Step 4: Construction of correlation coefficient matrices**

The correlation coefficient matrix ( $n \times n$  dimension) is constructed for all criteria from the normalized decision matrix. Let's the generic element of this matrix is  $r_{qq'}$ .

**Step 5: Calculate information measures for each criterion**

The quantity of information contained in  $q$ -th criteria is calculated as

$$C_q = \sigma_q \sum_{q=1}^n (1 - r_{qq'})$$

A higher value of  $C_q$  implies that the criterion has a higher standard deviation and a lower correlation with other criteria; hence, a greater amount of information is attained from that criterion.

**Step 6: Calculate the weights of each criterion**

As mentioned earlier, in determining the weight of a criterion under the CRITIC method, both the standard deviation of the criterion and its correlation with other criteria are included. Since the higher information measures should have higher importance, the objective weight of the  $q$ -th criterion ( $w_q$ ) resulted by normalizing these values to unity is calculated as:

$$w_q = \frac{C_q}{\sum_{q=1}^n C_q}$$

*Implication of CRITIC method for this study*

The description of the CRITIC method may often look generic that is constructed based on criteria and alternatives. This study incorporates

eight criteria as described earlier. For empirical analysis, this study encompasses eight South Asian countries. Therefore, with a country-pair basis, this study generates  $8 \times 7 = 56$  alternatives. Since the permutations of these alternatives represent different settings for each criterion, a wider variance of the observations is assumed which helps to normalize the decision matrix that consequently develops the symmetric matrix, information measures for each criterion, and finally leads towards estimating the objective weights of the criterion. Hence, this CRITIC method is perfectly adaptable for a multi-country, multi-criteria model like this study.

**Description of data**

In constructing the index, six different channels are considered: Bilateral trade (demand-side as well as supply-side), technological advancement, labors productivity (demand as well as supply-side), degree of regional interconnectedness, human development index, and emission management capacity. Eight criteria are used from this framework, such as domestic final consumption, trade openness, FDI inflows, labor productivity, industrialization, regional integration measured in trade intensity ratio, HDI, and emission management capacity measured by the extent of emission intensity.

For empirical analysis, this study encompasses all South Asian countries with data from 2011 to 2018. To trace how the sustainability impact factors (on a country-pair basis) are changing over time, the entire analysis is divided into two-time phases: 2011–2014, and 2015–2018. Data on domestic final consumption, GDP, and Industrial share of GDP (for measuring industrialization) are extracted from World Development Indicators of World Bank. FDI inflows and countries' trade data are collected from UNCTAD. SAARCFINANCE Database is primarily used for extracting the intraregional (within South Asian countries) trades. Data on labor productivity are sourced by ILO. HDI-related ranking, scores, and data are extracted from UNDP's website while for emission data, EDGARv5.0\_FT2018 is used.

**Results and findings**

*Summary of the indicators*

Table 1 presents the average values of the different indicators in all South Asian countries over the 2015–2018 period. As mentioned in the previous section, to track the movements of the country-pair indicators over the longer time horizon, the overall analysis is split into two study periods: 2011–2014 and 2015–2018. Since the values may have substantial variability over time, the average value, therefore, would better capture the relative medium-term states of the variables. Hence the mean values are shown for comparison among the countries.

India shares about 79.5 percent of regional consumption with an average of USD 1.7 trillion per annum during the 2015–2018 period. This is quite expected since India shares about 75 percent of the South Asian population. India is followed by Pakistan and Bangladesh with average domestic final consumption of USD 212.1 billion and 121.5

**Table 2**  
Correlation coefficient matrix.

	C1	C2	C3	C4	C5	C6	C7	C8
C1	1.00	-0.78	0.82	-0.23	0.98	-0.77	-0.09	-0.40
C2	-0.78	1.00	-0.46	0.56	-0.75	0.38	0.34	0.33
C3	0.82	-0.46	1.00	0.18	0.81	-0.92	0.28	-0.22
C4	-0.23	0.56	0.18	1.00	-0.18	-0.20	0.83	0.26
C5	0.98	-0.75	0.81	-0.18	1.00	-0.76	-0.04	-0.42
C6	-0.77	0.38	-0.92	-0.20	-0.76	1.00	-0.12	0.33
C7	-0.09	0.34	0.28	0.83	-0.04	-0.12	1.00	0.51
C8	-0.40	0.33	-0.22	0.26	-0.42	0.33	0.51	1.00

Note: C1: Domestic Final consumption ratio, C2: Trade openness ratio, C3: FDI inflow ratio, C4: Labor productivity ratio, C5: Industrialization ratio, C6: Intra-regional Trade intensity ratio, C7: HDI ratio, C8: Emission intensity ratio.

**Table 3**  
Standard deviation, measure of conflict, quantity of information, and weights.

Criterion	Standard Deviation ( $\sigma_j$ )	Measure of Conflict $\sum_{j=1}^n (1 - r_{jj})$	Quantity of Information ( $C_j$ )	Weights ( $w_j$ )
C1	0.40	7.47	2.99	16.9%
C2	0.24	7.37	1.78	10.0%
C3	0.40	6.51	2.61	14.7%
C4	0.29	5.78	1.66	9.4%
C5	0.41	7.36	2.99	16.9%
C6	0.31	9.06	2.79	15.7%
C7	0.22	5.30	1.18	6.7%
C8	0.26	6.61	1.71	9.7%

Source: Author’s calculation.

billion respectively. Maldives and Bhutan, having the smallest populations, have the least final consumptions with USD 2.1 and 2.6 billion per annum on average during the 2015–2018 period.

Maldives has been found as the most open in trade with a trade to GDP ratio of 141.5 percent. The Maldives is followed by Bhutan and Nepal with trade openness ratios of 79.8 and 52.1 respectively. Three big economies-Pakistan, Bangladesh, and India have the least trade openness ratios with 26.7, 38.4, and 41.5 respectively.

India attracts the highest FDI with average inflows of USD 41.5 billion per annum during 2015–2018, followed by Bangladesh and Pakistan with USD 2.6 billion and 2.4 billion respectively.

Maldives, Sri Lanka, and Bhutan have the highest labor productivities in the South Asian region measured in USD per laborer per annum. A laborer in the Maldives generates an average output of USD 18,371 (2010 constant) per annum while a laborer in Sri Lanka and Bhutan generates USD 10,159 and USD 6,060 per annum respectively. Labor productivity is lowest in Nepal, Afghanistan, and Bangladesh with average annual outputs of USD 1267, 1701, and 2702 respectively.

India, by far, remains the most industrialized country in the South Asian region with an industrial output of USD 743.9 billion on the 2015–2018 period average. Bangladesh follows India with an annual

**Table 4**  
Bilateral scores of Index on Relative Sustainability Impact (IRSI), 2015–2018.

	Reference country	Impacting country							
		Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Pakistan	Sri Lanka
	Afghanistan		67.4	39.3	68.7	47.9	51.6	65.5	70.1
	Bangladesh	32.6		35.6	67.4	38.8	34.6	48.5	48.1
	Bhutan	60.7	64.4		64.1	54.4	62.9	62.7	70.0
	India	31.3	32.6	35.9		39.8	32.5	30.5	37.6
	Maldives	52.1	61.2	45.6	60.2		54.8	58.7	65.2
	Nepal	48.4	65.4	37.1	67.5	45.2		64.1	67.6
	Pakistan	34.5	51.5	37.3	69.5	41.3	35.9		49.8
	Sri Lanka	29.9	51.9	30.0	62.4	34.8	32.4	50.2	

Source: Author’s calculation.

Note: Green color cells refer to bilateral areas with higher probable impacts while red-colored cells refer to the areas with the least probable impacts. The shades of colors refer to the extents accordingly.

average industrial output of USD 52.5 billion. Maldives and Bhutan, on the other hand, remain the least industrialized economies in this region.

Regional integration is measured by using the intra-regional trade intensity (i.e., a country’s trade in South Asia divided by its global trade). Higher the value of this indicator, the higher the country is inclined to the South Asian region. The table shows that Bhutan remains the most integrated with South Asia as 86 percent of its trade is conducted within the South Asian region. Nepal follows Bhutan with 64 percent in the regional integration score. Notably, most of the countries, especially the big economies have very low regional integration scores. For instance, India, Pakistan, and Bangladesh score 0.03, 0.07, and 0.10 which reveals that intra-regional trade in South Asia has much-untapped potential to grow.

In terms of the Human Development Index, Sri Lanka tops with a 0.78 score, followed by the Maldives with 0.71, and India with 0.64.

Emission intensity remains highest in India with an annual average intensity of 0.95 kg CO2 per USD. Pakistan follows India with an annual average intensity of 0.78 kg CO2 per USD. The Maldives, and Sri Lanka on the other hand, have the least emission intensities with 0.22 and 0.29 kg CO2 per USD respectively over the 2015–2018 periods.

*Determination of weights for the criteria*

Based on the country-pair calculation of ratios under eight criteria, the normalization decision matrix is developed. Since there are eight countries and eight criteria, a  $[(8 \times 7 \times 2) \times 8] = [112 \times 8]$  dimensional matrix is developed. The correlation coefficient matrix is then formed as shown in Table 2. It appears that some pairs of the matrix have a high positive correlation, some have a high negative correlation while some have a lower correlation. Usually, in constructing an index, a higher positive correlation between the criteria is less desirable as the movement of one would be captured by the similar movement of the other in this case. Contrarily, a high negative correlation between two criteria would refer that both would influence more in constructing the index as no one’s movement is diluted with the movement of other. From the correlation coefficient matrix, a *Measure of conflict* is calculated for each

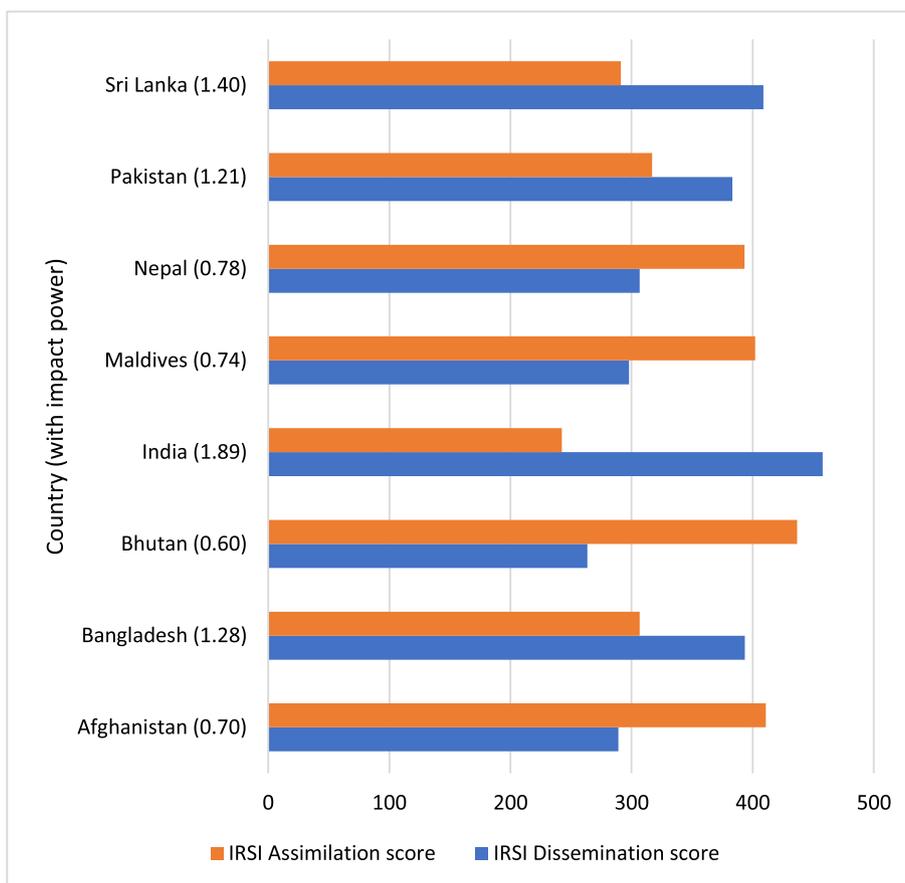


Fig. 2. IRSI Dissemination, Assimilation, and Impact Power of South Asian countries. Source: Author’s calculation.

Table 5

Index component scores (of impact) of South Asian countries (2015–2018).

Country	Final Consumption (17)	Trade Openness (10)	FDI Inflow (15)	Labor Productivity (9)	Industry in GDP (17)	Regional Integration (16)	HDI (7)	Emission Intensity (10)	Total Score (100)
Afghanistan	6.62	4.89	3.84	2.64	6.48	9.15	2.92	4.81	41.35
Bangladesh	11.52	4.16	10.60	3.63	12.45	5.88	3.30	4.82	56.35
Bhutan	2.06	6.13	0.29	5.47	2.84	13.01	3.33	4.10	37.25
India	16.29	4.37	14.42	5.15	16.49	2.43	3.41	3.14	65.69
Maldives	1.70	7.53	6.71	7.68	1.41	7.72	3.62	6.80	43.16
Nepal	6.65	4.98	3.83	2.08	5.40	12.22	3.20	5.17	43.53
Pakistan	12.84	3.22	10.47	4.27	12.09	4.65	3.15	3.63	54.32
Sri Lanka	9.76	4.91	8.81	6.59	10.35	7.94	3.78	6.20	58.34

Source: Author’s calculation.

of the criteria which is simply the summation of 1 minus the correlation values of that criteria with respect to the decision situation defined by the rest of the criteria. Hence, a criterion with more high positive correlation values (with other criteria) is supposed to find a lower value in the *Measure of conflict*. On the other hand, criteria with more negative correlation values are appeared to get a high *Measure of conflict*.

Then *Quantity of information* is calculated by multiplying the *Measure of conflict* with the respective standard deviation for each criterion. Higher the value of *Measure of conflict* and/or higher ranges of the criterion, the criterion is assumed to have more impact on the aggregated index. Hence, such a case would take the higher value in *Quantity of information*. Finally, the weights are determined in the proportion of the *Quantity of information* of each criterion.

Table 3 shows all these steps. Results reveal that under the CRITIC objective weighting methodology, the Domestic Final consumption ratio and Industrialization ratio receive the highest weights of 16.9 percent each. Intraregional Trade intensity ratio receives the following higher

weight of 15.7 percent while the FDI inflow ratio receives 14.7 percent weight. Concurrently, the Trade openness ratio, Emission intensity ratio, Labor productivity ratio, and HDI ratio receive respective weights of 10.0, 9.7, 9.4, and 6.7 percent.

*Index on relative sustainability impact (IRSI)*

Using the weights calculated through the CRITIC method, aggregated index scores in the country-pair basis are calculated. Table 4 shows the bilateral scores of the Index on Relative Sustainability Impact (IRSI) on a 2015–2018 period’s average.

The results would provide an important insight to explore which country or countries could have more impact on cooperating a country towards sustainable development growth. For instance, in the case of Afghanistan, India has the highest impact on it with an IRSI score of 68.7; followed by an impact from Bangladesh (with an IRSI score of 67.4). On the contrary, Bhutan and Maldives have the least impact on

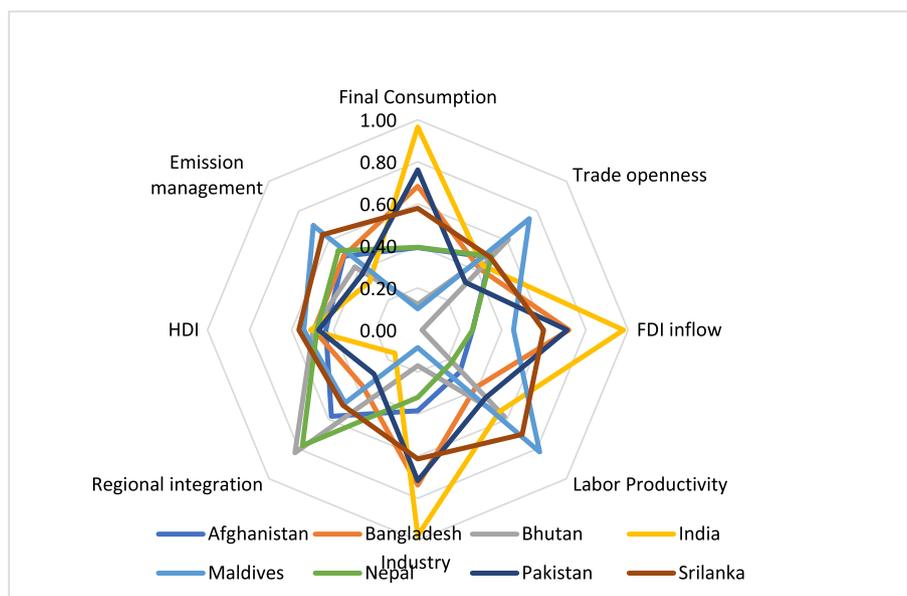


Fig. 3. Normalization of the average scores of each Criterion. Source: Author’s Calculation

Table 6  
Index component scores (of impact) of South Asian countries (2011–2014).

Country	Final Consumption (17)	Trade Openness (10)	FDI Inflow (15)	Labor Productivity (9)	Industry in GDP (17)	Regional Integration (16)	HDI (7)	Emission Intensity (10)	Total Score (100)
Afghanistan	6.99	5.61	2.56	3.00	6.67	8.94	2.94	4.62	41.34
Bangladesh	11.48	4.22	10.24	3.50	12.10	6.25	3.26	5.06	56.12
Bhutan	1.44	6.32	1.88	5.43	2.89	13.00	3.34	3.66	37.95
India	16.25	4.59	14.47	4.93	16.47	1.81	3.37	3.17	65.08
Maldives	1.97	7.47	6.93	7.70	1.16	7.21	3.63	5.55	41.62
Nepal	6.74	4.21	3.48	2.15	5.54	12.45	3.20	5.98	43.76
Pakistan	12.83	3.28	10.09	4.32	12.21	5.43	3.15	3.82	55.14
Sri Lanka	9.74	4.49	9.32	6.48	10.45	7.89	3.82	6.80	59.00

Source: Author’s calculation.

Table 7  
Changes in Index component (of impact) between (2011–2014) and (2015–2018).

Country	Final Consumption	Trade Openness	FDI Inflow	Labor Productivity	Industry in GDP	Regional Integration	HDI	Emission Intensity	Total Score
Afghanistan	-0.37	-0.72	<b>1.28</b>	-0.36	-0.19	<b>0.21</b>	-0.02	<b>0.18</b>	<b>0.01</b>
Bangladesh	<b>0.03</b>	-0.06	<b>0.36</b>	<b>0.13</b>	<b>0.35</b>	-0.38	<b>0.04</b>	-0.24	<b>0.24</b>
Bhutan	<b>0.63</b>	-0.19	-1.59	<b>0.05</b>	-0.05	<b>0.01</b>	-0.01	<b>0.45</b>	-0.70
India	<b>0.04</b>	-0.22	-0.05	<b>0.22</b>	<b>0.01</b>	<b>0.62</b>	<b>0.03</b>	-0.03	<b>0.62</b>
Maldives	-0.27	<b>0.06</b>	-0.22	-0.02	<b>0.25</b>	<b>0.51</b>	-0.01	<b>1.24</b>	<b>1.54</b>
Nepal	-0.10	<b>0.77</b>	<b>0.36</b>	-0.07	-0.14	-0.24	<b>0.01</b>	-0.82	-0.23
Pakistan	<b>0.01</b>	-0.06	<b>0.38</b>	-0.05	-0.12	-0.78	0.00	-0.19	-0.82
Sri Lanka	<b>0.02</b>	<b>0.42</b>	-0.51	<b>0.11</b>	-0.11	<b>0.05</b>	-0.04	-0.60	-0.66

Source: Author’s calculation (Green fonts represent the improvement in impacting capacity).

Afghanistan with IRSI scores of 39.3 and 47.9 respectively. Similarly, in the case of India, the Maldives and Sri Lanka have the most impacts with IRSI scores of 39.8 and 37.6 while Pakistan and Afghanistan have the least impacts of cooperation with IRSI scores of 30.5 and 31.3 respectively.

Since each column of Table 4 represents the bilateral impact of each impacting country on the reference country, the sum of these columns will represent total assimilation impact scores, hereby termed as *IRSI Assimilation score* of the reference country. On the other hand, the sum of each row will indicate the total dissemination of impact by an impacting country on the other South Asian countries. It is, therefore, termed as the *IRSI Dissemination score*.

Fig. 2 illustrates the *IRSI Assimilation* and *IRSI Dissemination* scores for

each country. It reveals that India has the highest *IRSI Dissemination score* of 459.9, followed by Sri Lanka with 408.4 and Bangladesh with 394.5. On the other hand, Bhutan has the highest probability of attaining the gain (as receiving country) from other South Asian countries with an *IRSI Assimilation score* of 439.2. Bhutan, in this aspect, is followed by Afghanistan and the Maldives with respective *IRSI Assimilation scores* of 410.5 and 397.9 respectively in the 2015–2018 periods. The ranking completely reversed for the *IRSI Assimilation score* as Bhutan and Afghanistan have the highest while India and Sri Lanka have the least assimilation impacts.

To understand the extent of the resultant impacting capability of a country, the *Impact power* ratio is used and stated in the parenthesis after the country names shown in the Y-axis title in Fig. 2. The ratio is defined

**Table 8**  
Heat map on Relative Sustainability Impact (IRSI) Matrix.

Reference country	Partner country	Final Consumption (17)	Trade Openness (10)	FDI Inflow (15)	Labor Productivity (9)	Industry in GDP (17)	Regional Integration (16)	HDI (7)	Emission Intensity (10)
Afghanistan	Bangladesh	2.30	5.70	0.61	3.62	1.31	11.21	3.00	4.82
Afghanistan	Bhutan	14.88	3.89	13.91	2.06	13.95	3.58	2.98	5.48
Afghanistan	India	0.19	5.51	0.04	2.30	0.10	13.93	2.91	6.35
Afghanistan	Maldives	15.20	2.64	2.95	0.80	15.35	9.41	2.72	3.02
Afghanistan	Nepal	8.39	4.94	7.39	5.38	10.29	4.44	3.08	4.50
Afghanistan	Pakistan	1.40	6.57	0.65	3.02	1.51	12.29	3.14	5.91
Afghanistan	Sri Lanka	3.98	5.01	1.32	1.35	2.88	9.17	2.59	3.55
Bangladesh	Afghanistan	14.56	4.35	14.13	5.76	15.57	4.53	3.67	4.85
Bangladesh	Bhutan	16.52	3.26	14.70	2.89	16.58	1.68	3.31	5.49
Bangladesh	India	1.12	4.83	0.84	3.19	1.11	11.90	3.24	6.37
Bangladesh	Maldives	16.58	2.14	12.56	1.20	16.74	5.90	3.05	3.03
Bangladesh	Nepal	14.54	4.27	14.13	6.39	16.02	2.16	3.42	4.52
Bangladesh	Pakistan	6.14	5.93	7.61	4.03	9.11	9.28	3.47	5.92
Bangladesh	Sri Lanka	11.16	4.33	10.23	1.97	11.99	5.68	2.92	3.57
Bhutan	Afghanistan	1.98	6.16	0.83	7.32	2.93	12.16	3.70	4.19
Bhutan	Bangladesh	0.35	6.78	0.04	6.49	0.29	14.07	3.36	4.17
Bhutan	India	0.03	6.61	0.00	5.03	0.02	15.16	3.27	5.75
Bhutan	Maldives	9.27	3.62	0.22	2.33	11.46	13.14	3.08	2.49
Bhutan	Nepal	1.96	6.08	0.83	7.76	4.17	9.00	3.45	3.86
Bhutan	Pakistan	0.20	7.53	0.04	5.89	0.34	14.54	3.50	5.28
Bhutan	Sri Lanka	0.67	6.15	0.09	3.50	0.70	13.00	2.94	2.97
India	Afghanistan	16.67	4.54	14.70	7.08	16.78	1.82	3.77	3.31
India	Bangladesh	15.74	5.22	13.90	6.19	15.76	3.85	3.43	3.30
India	Bhutan	16.84	3.44	14.74	4.35	16.86	0.58	3.41	3.92
India	Maldives	16.84	2.28	14.59	2.09	16.87	2.56	3.15	1.85
India	Nepal	16.67	4.46	14.70	7.56	16.81	0.77	3.52	3.02
India	Pakistan	14.99	6.11	13.95	5.57	15.92	4.99	3.57	4.36
India	Sri Lanka	16.27	4.53	14.36	3.20	16.40	2.43	3.01	2.25
Maldives	Afghanistan	1.66	7.41	11.80	8.58	1.52	6.34	3.95	6.65
Maldives	Bangladesh	0.29	7.90	2.19	8.18	0.14	9.84	3.62	6.64
Maldives	Bhutan	7.59	6.43	14.53	7.05	5.42	2.61	3.59	7.18
Maldives	India	0.02	7.77	0.15	7.29	0.01	13.19	3.52	7.82
Maldives	Nepal	1.64	7.35	11.81	8.77	2.26	3.30	3.70	6.35
Maldives	Pakistan	0.16	8.45	2.31	7.85	0.16	11.11	3.75	7.50
Maldives	Sri Lanka	0.55	7.40	4.17	6.04	0.34	7.63	3.20	5.43
Nepal	Afghanistan	8.47	5.11	7.36	4.00	6.59	11.30	3.59	5.17
Nepal	Bangladesh	2.32	5.78	0.61	2.99	0.86	13.59	3.25	5.15
Nepal	Bhutan	14.90	3.97	13.91	1.62	12.71	6.75	3.23	5.80
Nepal	India	0.19	5.59	0.04	1.82	0.06	14.98	3.16	6.65
Nepal	Maldives	15.22	2.70	2.94	0.61	14.61	12.45	2.97	3.31
Nepal	Pakistan	1.41	6.64	0.65	2.45	1.00	14.18	3.39	6.22
Nepal	Sri Lanka	4.01	5.09	1.32	1.04	1.96	12.28	2.84	3.87
Pakistan	Afghanistan	15.46	3.48	14.09	6.36	15.37	3.46	3.54	3.76
Pakistan	Bangladesh	10.72	4.12	7.14	5.35	7.77	6.47	3.20	3.74
Pakistan	Bhutan	16.66	2.52	14.70	3.49	16.53	1.21	3.18	4.39
Pakistan	India	1.87	3.93	0.79	3.81	0.96	10.76	3.11	5.31
Pakistan	Maldives	16.70	1.59	12.43	1.53	16.71	4.64	2.92	2.17
Pakistan	Nepal	15.45	3.41	14.09	6.93	15.88	1.57	3.29	3.45
Pakistan	Sri Lanka	13.05	3.47	10.03	2.45	11.42	4.44	2.79	2.61
Sri Lanka	Afghanistan	12.88	5.04	13.42	8.03	13.99	6.57	4.08	6.11
Sri Lanka	Bangladesh	5.70	5.72	4.51	7.41	4.89	10.07	3.76	6.10
Sri Lanka	Bhutan	16.20	3.90	14.66	5.87	16.18	2.75	3.73	6.69
Sri Lanka	India	0.59	5.52	0.38	6.18	0.47	13.32	3.66	7.42
Sri Lanka	Maldives	16.31	2.65	10.57	3.34	16.54	8.11	3.47	4.24
Sri Lanka	Nepal	12.85	4.96	13.43	8.34	14.91	3.46	3.84	5.80
Sri Lanka	Pakistan	3.82	6.58	4.72	6.93	5.46	11.30	3.89	7.06

Note: Green color cells refer to bilateral areas with higher probable impacts while red-colored cells refer to the areas with the least probable impacts. The shades of colors refer to the extents accordingly. MS-Excel 3-color scale formatting is applied here (for each criteria). The cell that holds the minimum value is colored as dark red while the cell that holds the maximum value is colored dark green. The cell that holds the median is colored yellow, and. All other cells are colored proportionally.

as a country's *IRSI Dissemination score* divided by its *IRSI Assimilation score*. India has an *Impact power* of 1.91 implying that India could add 91 percent more impact for the South Asian countries than as compared to the impact it would assimilate from the South Asian countries. Sri Lanka, Bangladesh, and Pakistan have an *Impact power* of more than one while the rests of the countries have an *Impact power* of less than one.

Table 5 shows the component-wise scores (annual average of 2015–2018) of IRSI for each country (i.e., as an impacting country). India, Pakistan, and Bangladesh have higher impacts than other countries through the *Final consumption* channel; Maldives, Bhutan, and Nepal remain top scorers in *Trade openness*; India, Bangladesh, and

Pakistan score the highest in *FDI inflows*. Scores in outputs per worker are the highest in Maldives, Sri Lanka, and Bhutan. India, Bangladesh, Pakistan, and Sri Lanka- all receive higher scores in industrialization. Bhutan, Nepal, and Afghanistan score the highest in terms of *Regional integration*. The deviations in HDI scores are found minimal among the countries. Sri Lanka, Maldives, and India score marginally higher than the others in this criterion. Maldives, Sri Lanka, and Nepal remain at the forefront in emission management criteria. India has the highest aggregated annual average score of 65.7, followed by Sri Lanka and Bangladesh with 58.3 and 56.4 respectively. Contrarily, Bhutan, Afghanistan, and the Maldives have the least aggregated scores in this

connection.

Fig. 3 illustrates the component-wise normalized scores (annual average of 2015–2018) of IRSI in a radar-scaling. The scores are normalized on a scale of one (i.e., each score is divided by the weight of that criterion).

#### *Comparative changes of the component-wise scores over time*

To understand and trace how the sustainability impact factors (i.e., impacting capacities) of the countries in each criterion are changing over time, the scores of 2015–2018 are compared with the 2011–2014 period's scores. It would provide a good indication of the movements of countries impacting capacities in each area of cooperation.

Table 6 shows the component-wise scores of each impacting country on a 2011–2014 average basis. The overall ranking of the countries remains the same in both the 2011–2014 and 2015–2018 periods. However, the impacting capacities of different criteria have some changes for the countries. Table 7 reveals the comparative analysis and the improvements of the impacting capacities are calculated over these two periods. Of course, the higher impacts or improvement in impact value is good from a regional cooperation's perspective as it shows a higher capacity of the country to impact the other to support the SDGs under a regional cooperation framework.

For instance, Afghanistan has improved its impacting capacities in three criteria: FDI inflow, Regional integration, and Emission management between these two periods. Bangladesh improves its capacities in Domestic final consumption, FDI inflow, Labor productivity, Industrialization, and HDI. Impacting capacities of Bhutan have increased in Domestic final consumption, Labor productivity, Regional integration, and Emission management. India experiences its impacting capacity improvements in Domestic final consumption, Labor productivity, Industrialization, Regional integration, and HDI. The Maldives shows positive changes in Trade openness, Industrialization, Regional integration, and Emission management between the 2011–2014 and 2015–2018 periods. Nepal has improved its impacting capacities in three criteria: Trade openness, FDI inflow, and HDI. Pakistan registered advancement in impacting in two areas- Domestic final consumption, and FDI inflows while Sri Lanka experiences its impacting capacity improvements in Domestic final consumption, Trade openness, Labor productivity, and Regional integration.

#### **Policy implications and conclusion**

This study elucidates a detailed country-pair matrix to diagnose the extent of the impact of each channel on a country-to-country basis. As illustrated in Table 8, the heat map matrix may be considered as a noteworthy economic analysis input that would help the policymakers to understand the probable areas, direction, and potentials of any bilateral cooperation towards sustainable development of the countries. There is also a substantial scope to broaden the cooperation periphery and design a regional cooperation framework based on this country-pair analysis.

For instance, the results show that the impact of bilateral trade's demand-side (i.e., through domestic market consumption) by India, Pakistan, and Bangladesh are more prominent as compared to other countries. The Maldives, Bhutan, and Nepal have more impact on others through their trade openness channel. India, Bangladesh, and Pakistan have a higher impact through their respective technological advancement channel. Labor productivities of the Maldives and Sri Lanka are highest among the South Asian region, which also have a higher impact through the supply-side channel of skilled laborers. India, Bangladesh, and Pakistan, however, have more potential to influence through the labor demand-side channel. Bhutan and Nepal have higher inclination within the South Asian region for their trade, and hence, their impacts through the regional integration channel remain higher as compared to the other countries. Sri Lanka, the Maldives, and India have higher

impacts through the Human Development channel. The Maldives, Sri Lanka, and Nepal are better performers at emission management and therefore, have higher capacities to support the rest of the countries through this channel.

This study has some important policy implications, both under bilateral as well as a regional cooperation framework. It would provide indications of the economic essence regarding how, and in which specific areas, the countries may extend their supports to other countries and vice-versa (i.e., they may be benefitted from others). Diagnosis of mutual wellbeing is plausible based primarily on the current states of the respective countries and their comparative advantages in defined areas.

Of course, there are some practical challenges to implementing any successful bilateral or regional cooperation. Countries may have diversified priorities and interests in their development agenda based on their respective development states. For instance, developed countries focus on sustaining their high living standards and equitable welfare while the least-developed countries try to remain aggressive in exploiting resources for faster economic growth. Besides, within the complex geopolitical settings and economic orientations, there are several external (i.e., outside the region) development actors, donor countries, and multilateral organizations to support the development agenda of each country. Hence, ensuring the right balance between regional and external cooperation remains to be a big challenge for the countries. Besides, the institutional settings, especially, of the recipient countries must be strengthened to take the most benefit out of the cooperation. Improved governance, transparency, and accountability should be reinforced in the operationalization and implementation process of the agencies, both in the public and private sectors. Resource allocation, the optimal share of responsibilities and rights, and the risks sharing mechanism between the actors within the country should also be planned effectively.

Nevertheless, if South Asian countries may use these empirical results to identify the potential areas of bilateral and multilateral supports, especially for the countries that lag in certain SDG targets. Throughout this process, South Asia may revisit its enormous potentiality to prosper and flourish as a strong regional bloc in Asia.

#### **CRedit authorship contribution statement**

**Kazi Arif Uz Zaman:** Conceptualization, Methodology, Software, Visualization, Writing - review & editing. **Zannatul Fardoush:** Data curation, Writing - review & editing.

#### **Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## References

- ADB. (2013). Regional Cooperation and Integration in a Changing World. Asian Development Bank. Manila, the Philippines. Retrieved 25 April 2020, from <https://www.adb.org/sites/default/files/publication/30224/regional-cooperation-changing-world.pdf>.
- ADB. (2017). *Asian Economic Integration Report 2017: The Era of Financial Interconnectedness: How Can Asia Strengthen Financial Resilience?* Manila: Asian Development Bank. Retrieved from <https://aric.adb.org/aeir>.
- Alemi-Adakani, M., Milani, A. S., Yannacopoulos, S., & Shokouhi, G. (2016). On the effect of subjective, objective and combinative weighting in multiple criteria decision making: A case study on impact optimization of composites. *Expert Systems with Applications*, 46, 426–438.
- Anojkumar, L., Ilankumaran, M., & Sasirekha, V. (2014). Comparative analysis of MCDM methods for pipe material selection in sugar industry. *Expert Systems with Applications*, 41(6), 2964–2980.
- Antanasijević, D., Pocajt, V., Ristić, M., & Perić-Grujić, A. (2017). A differential multi-criteria analysis for the assessment of sustainability performance of European countries: Beyond country ranking. *Journal of Cleaner Production*, 165, 213–220.
- Babiarz, P., Grabiński, T., Migala-Warchol, A., & Szczygiel, E. (2018). The application of customized human development index to the analysis of socio-economic development of the European Union member states. *Economics & Sociology*, 11(4), 332.
- Bhattacharya, D., & Ali, M. A. (2014). The SDGs—What are the “Means of Implementation”? *Future United Nations Development System*.
- Bryan, G., & Morten, M. (2019). The aggregate productivity effects of internal migration: Evidence from Indonesia. *Journal of Political Economy*, 127(5), 2229–2268.
- Casanovas-Rubio, M. D. M., Ramos, G., & Armengou, J. (2020). Minimizing the social impact of construction work on mobility: A decision-making method. *Sustainability*, 12(3), 1183.
- Crippa, M., Oreggioni, G., Guizzardi, D., Muntean, M., Schaaf, E., Lo Vullo, E., ... Vignati, E. (2019). *Fossil CO2 and GHG emissions of all world countries - 2019 Report, EUR 29849 EN*. Luxembourg: Publications Office of the European Union.
- Diakoulaki, D., Mavrotas, G., & Papayannakis, L. (1995). Determining objective weights in multiple criteria problems: The critic method. *Computers & Operations Research*, 22(7), 763–770.
- Dix-Carneiro, R., & Kovak, B. K. (2017). Trade liberalization and regional dynamics. *American Economic Review*, 107(10), 2908–2946.
- Gumenyuk, I. S. (2017). Human development index as a tool to assess social development in the Baltic States. *Baltic Region*, 9(3), 45–57.
- Helgason, K. S. (2016). The 2030 Agenda for Sustainable Development: Recharging Multilateral Cooperation for the Post-2015 Era. *Global Policy*, 7(3), 431–440.
- Jahan, A., Mustapha, F., Sapuan, S. M., Ismail, M. Y., & Bahraminasab, M. (2012). A framework for weighting of criteria in ranking stage of material selection process. *The International Journal of Advanced Manufacturing Technology*, 58(1-4), 411–420.
- Jee, D.-H., & Kang, K.-J. (2000). A method for optimal material selection aided with decision making theory. *Materials & Design*, 21(3), 199–206.
- Jin, H., Qian, X., Chin, T., & Zhang, H. (2020). A global assessment of sustainable development based on modification of the human development index via the entropy method. *Sustainability*, 12(8), 3251.
- Kharas, H., Prizzon, A., & Rogerson, A. (2014). *Financing the post-2015 Sustainable Development Goals*. London: Overseas Development Institute.
- Kilkiş, Ş. (2016). Sustainable development of energy, water and environment systems index for Southeast European cities. *Journal of Cleaner Production*, 130, 222–234.
- Liu, H.-C., You, J.-X., You, X.-Y., & Shan, M.-M. (2015). A novel approach for failure mode and effects analysis using combination weighting and fuzzy VIKOR method. *Applied Soft Computing*, 28, 579–588.
- Liu, S., Chan, F. T. S., & Ran, W. (2016). Decision making for the selection of cloud vendor: An improved approach under group decision-making with integrated weights and objective/subjective attributes. *Expert Systems with Applications*, 55, 37–47.
- Lu, C., Li, L., & Wu, D. (July 2015). In *Application of combination weighting method to weight calculation in performance evaluation of ICT* (pp. 258–259). IEEE.
- Madić, M., & Radovanović, M. (2015). Ranking of some most commonly used nontraditional machining processes using ROV and CRITIC methods. *UPB Sci. Bull. Ser. D*, 77(2), 193–204.
- Maleki, B., Rubio, M. D. M. C., Hosseini, S. M. A., & De La Fuente Antequera, A. (2019, June). Multi-criteria decision making in the social sustainability assessment of high-rise residential buildings. In *IOP Conference Series: Earth and Environmental Science* (Vol. 290, No. 1, p. 012054). IOP Publishing.
- Maniya, K., & Bhatt, M. G. (2010). A selection of material using a novel type decision-making method: Preference selection index method. *Materials & Design*, 31(4), 1785–1789.
- McCulloch, N., Winters, L. A., & Cirera, X. (2001). *Trade liberalization and poverty: A handbook*. Centre for Economic Policy Research.
- Milani, A. S., Shanian, A., Lynam, C., & Scarinci, T. (2013). An application of the analytic network process in multiple criteria material selection. *Materials & Design*, 44, 622–632.
- Rauschmayer, F., & Wittmer, H. (2006). Evaluating deliberative and analytical methods for the resolution of environmental conflicts. *Land Use Policy*, 23(1), 108–122.
- Reznichenko, S. M., Takhumova, O. V., Zaitseva, N. A., Larionova, A. A., Dashkova, E. V., Zotikova, O. N., & Filatov, V. V. (2018). Methodological aspects of assessing factors affecting the sustainable development of the region. *Modern Journal of Language Teaching Methods*, 8(11), 69–79.
- Rostamzadeh, R., Ghorabae, M. K., Govindan, K., Esmaeili, A., & Nobar, H. B. K. (2018). Evaluation of sustainable supply chain risk management using an integrated fuzzy TOPSIS-CRITIC approach. *Journal of Cleaner Production*, 175, 651–669.
- Rudolph, A. (2017). *The Concept of SDG-Sensitive Development Cooperation. The Concept of SDG-Sensitive Development Cooperation Implications for OECD-DAC Members*. Discussion Paper 1/2017. German Development Institute, Bonn.
- Sahoo, M., Sahoo, S., Dhar, A., & Pradhan, B. (2016). Effectiveness evaluation of objective and subjective weighting methods for aquifer vulnerability assessment in urban context. *Journal of Hydrology*, 541, 1303–1315.
- Schiff, M., & Winters, L.A. (2002). Regional cooperation, and the role of international organizations and regional integration. World Bank Policy Research Working Paper 2872, Washington DC, USA.
- Shanian, A., & Savadogo, O. (2009). A methodological concept for material selection of highly sensitive components based on multiple criteria decision analysis. *Expert Systems with Applications*, 36(2), 1362–1370.
- Shi, Y., Ge, X., Yuan, X., Wang, Q., Kellett, J., Li, F., & Ba, K. (2019). An integrated indicator system and evaluation model for regional sustainable development. *Sustainability*, 11(7), 2183.
- Shu, P., & Steinwender, C. (2019). The impact of trade liberalization on firm productivity and innovation. *Innovation Policy and the Economy*, 19(1), 39–68.
- Siddiqui, Z. A., & Tyagi, K. (2017). Study on service selection effort estimation in service oriented architecture-based applications powered by information entropy weight fuzzy comprehensive evaluation model. *IET Software*, 12(2), 76–84.
- Summers, G. F. (2019). Industrialization. In *Rural Society in the US: Issues for the 1980s* (pp. 164–174). Routledge.
- Tavana, M., Di Caprio, D., Santos-Arteaga, F. J., & O'Connor, A. (2015). A novel entropy-based decision support framework for uncertainty resolution in the initial subjective evaluations of experts: The NATO enlargement problem. *Decision Support Systems*, 74, 135–149.
- UN (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*. A/RES/70/1. New York: United Nations.
- UN. (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*. A/RES/70/1. United Nations. New York: Author. Retrieved from <https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf>.
- Walters, William H. (2017). Do subjective journal ratings represent whole journals or typical articles? Unweighted or weighted citation impact? *Journal of Informetrics*, 11(3), 730–744.
- Wang, Endong (2015). Benchmarking whole-building energy performance with multi-criteria technique for order preference by similarity to ideal solution using a selective objective-weighting approach. *Applied Energy*, 146, 92–103.
- Wang, P. P., & Ming, X. G. (2018). Value evaluation method of industrial product-service based on customer perception. *International Journal of Services Operations and Informatics*, 9(1), 15–39.
- Wang, S. S., Huang, T. Y., Chen, H., Liu, M. Y., & Xue, H. L. (2018). Application of Fuzzy Comprehensive Evaluation Model Based CRITIC Weighting in Water Quality Evaluation. *Water Resources and Power*, 6, 13.
- Wang, X., He, L., Zhu, K., Zhang, S., Xin, L., Xu, W., & Guan, Y. (2019). An integrated model to evaluate the impact of social support on improving self-management of type 2 diabetes mellitus. *BMC Medical Informatics and Decision Making*, 19(1), 197.
- Yi, Xianzhong, & Naghavi, Alireza (2017). Intellectual property rights, FDI, and technological development. *The Journal of International Trade & Economic Development*, 26(4), 410–424.
- Yin, Yi, & Shang, Pengjian (2017). Multivariate weighted multiscale permutation entropy for complex time series. *Nonlinear Dynamics*, 88(3), 1707–1722.
- Zaman, K. A. U. (2018). *Regional Cooperation in Strengthening the Low-Carbon Green Growth: Challenges, Prospects & Policy Framework*. Retrieved 25 April 2020, from [https://openresearch-repository.anu.edu.au/bitstream/1885/154267/1/Thesis%20FINAL%20submission\\_Kazi%20Arif%20Uz%20Zaman%20November%202018.pdf](https://openresearch-repository.anu.edu.au/bitstream/1885/154267/1/Thesis%20FINAL%20submission_Kazi%20Arif%20Uz%20Zaman%20November%202018.pdf).
- Zaman, K. A. U. (2018). *Regional Cooperation in Strengthening the Low-Carbon Green Growth: Challenges, Prospects & Policy Framework*. Retrieved from <https://openresearch-repository.anu.edu.au/handle/1885/154267>.
- Zaman, K. A. U., & Kalirajan, K. (2019). Strengthening of energy security & low-carbon growth in Asia: Role of regional energy cooperation through trade. *Energy Policy*, 133, 110873.
- Zhang, Ling, Xu, Yan, Yeh, Chung-Hsing, Liu, Yao, & Zhou, Dequn (2016). City sustainability evaluation using multi-criteria decision making with objective weights of interdependent criteria. *Journal of Cleaner Production*, 131, 491–499.
- Zhao, Jun, Jin, Juliang, Zhu, Jiezhong, Xu, Jinchao, Hang, Qingfeng, Chen, Yaqian, & Han, Donghao (2016). Water resources risk assessment model based on the subjective and objective combination weighting methods. *Water Resources Management*, 30(9), 3027–3042.