Discover Sustainability

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# Implementation of sustainability into training, upskilling, and reskilling curricula of technical and vocational education and training in south and southeast Asia

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**Abstract**
The adaptation to climate change and the adoption of circular strategies are macrotrends that require business transformations. In response, profound changes are required to skill formation systems across the world. The present empirical research study is built on the discourse on education for sustainable development as well as institutionalist and constructivist lenses to investigate the role of Technical and Vocational Education and Training (TVET) in meeting skill requirements for global sustainability agendas. The objectives of the study are to investigate a) modalities in use to mainstream sustainability into course offerings, i.e., training, upskilling, and reskilling with micro-credentials and credit transfers in learning pathways, b) the implementation of six Sustainable Development Goals (SDGs) into curricula, namely 'Quality Education', 'Decent Work and Economic Growth', 'Industry, Innovation, and Infrastructure', 'Clean Water and Sanitation', 'Affordable and Clean Energy', and 'Climate Action', and c) the existence of partnerships for curricula development with reference to SDG17. By adopting the positivist research paradigm and an explanatory research design, a survey was conducted in 11 countries in South and Southeast Asia to which 761 TVET teachers responded. The findings show that SDGs were incorporated into new courses supporting vertical integration as well as SDGs were embedded into existing curricula supporting horizontal integration. The findings also offer a nuanced understanding of various modalities in use to mainstream sustainability into course offerings. The findings imply intricate challenges institutes face when implementing sustainability into curricula and emphasise the value of multi-stakeholder partnerships for curricula development. Partial $\eta^2$ values, reflecting variances as much as 6%, suggest the presence of significant differences between countries that can be attributed to a country's 'region' and 'annual growth rate of real gross domestic product per employed person'. This conveys that national and regional economic conditions impact on a country's skill formation systems.

**Keywords** Curricula, Education for sustainable development, Education for sustainability, Greening curriculum, Higher education, Sustainable development goals, Sustainability curriculum, Reskilling, Upskilling

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## 1 Introduction

The emergent issues concerning the environment led to introduce roadmaps to mitigate adverse human activities on the environment and to promote sustainable development, such as Sustainable Development Goals (SDGs), the Paris Agreement, and the European Green Deal. These roadmaps insist on massive transformations in the way of doing business. Consequently, substantial changes are occurring in the labour market [1–3] and the workforce must develop a mindset to appreciate the changes and improve their adaptability to fit into the new context [4, 5]. Essentially, skills play a vital role in workforce adaptability and employability while driving business transformations. Skills formation discourse is mainly two-fold—institutionalism and constructivism [6]. Institutionalism supports the idea of a universal skill set applicable to almost all industrial settings. On the contrary, constructivism supports the idea that workers trade their skills through market mechanisms; skill requirements are mostly subjective in response to changes in industrial settings [6]. Individuals can effectively participate in the market mechanism only if they possess the required skills, such as skills for greening and circularity in the present day. Education and training institutes must supply the required skills. However, the common understanding is that skill systems do not adequately respond to changing requirements of the labour market [7, 8].

The present study investigated skill formation in Technical and Vocational Education and Training (TVET) institutes in tertiary-level STEM courses. When questioning what should be taught to the learners within education for sustainable development (ESD), curricula are a major concern [9–11]. The emphasis is to maintain a curriculum relevant to the labour market desired skills, conditioned by economic perturbations such as greening and circularity. We argue that an understanding of 'where we are' in curriculum relevance is vital for better decision-making on the progress made in the education and training spheres. Therefore, by using the term 'courses' to represent all types of education/training offerings in TVET institutes, the objectives of the article are to present findings of a study that investigated:

(1) modalities in use to mainstream sustainability into course offerings, i.e., training, upskilling, and reskilling with micro-credentials and credit transfers in learning pathways,
(2) whether SDGs were implemented into curricula,
(3) whether partnerships exist for the implementation of SDGs into curricula and the monitoring of progress, and
(4) whether TVET's response to above (1), (2), and (3) differs by a country's region (South Asia and Southeast Asia) and the 'annual growth rate of real gross domestic product per employed person' (identified as 'GDP growth' in this article).

The first objective is on training, upskilling, and reskilling on sustainability as well as the existence of micro-credentials, credit transfer mechanisms, and learning pathways to support lifelong learning. This objective supports SDG4 target 4.4, whether 'a wide range of education and training modalities' are used [12]. The second objective is on the use of vertical and horizontal approaches to integrate six SDGs into curricula, namely, SDG4 'Quality Education', SDG8 'Decent Work and Economic Growth', SDG9 'Industry, Innovation, and Infrastructure', SDG6 'Clean Water and Sanitation', SDG7 'Affordable and Clean Energy', and SDG13 'Climate Action'. This objective supports SDG4 target

4.7, whether relevant 'knowledge and skills are promoted for sustainability through ESD' [12]. The third objective is on the existence of partnerships with reference to SDG17 'Partnership for the Goals' [12]. The final objective tests for differences in terms of a country's region and GDP growth. Technical and vocational education and training curricula across countries and regions are not updated uniformly [8, 13–15]. Although upskilling and reskilling are among the top priorities of employers 'across all geographies and economies at all income levels' [3, p. 52], there are major differences in the way skill formation systems respond, i.e., in the level of implementation [1, 5, 8].

The importance of the present study and the research gap it addressed are fourfold. First, by recognising the importance of STEM courses for sustainability, the scope is skill formation in TVET institutes in tertiary-level STEM courses. When framing TVET for ESD, its role must be understood through three lenses, namely, providing a skilled workforce for the economy, providing skill development opportunities for citizens inclusively and equitably, and providing skill development opportunities to achieve a sustainable future. When considering the latter, sustainability movements are expected to create new jobs or alter existing jobs, mostly in medium-skilled occupations, for which TVET is directly responsible [1, 13]. Second, TVET has secured the place as the main provider of upskilling and reskilling options for working adults [1]. However, it is very difficult to find empirical research studies on TVET in the mainstream literature. Third, TVET has more adaptability to adjust curricula and pedagogy in response to rapidly changing economic conditions compared to universities [14, 15]. Therefore, STEM courses of TVET at the tertiary-level must play an important role in providing skill development opportunities to youth and upskilling and reskilling opportunities to working adults in facilitating business transformations. Hence, understanding TVET's response is vital. Fourth, an understanding of factors that influence TVET's response outside of TVET institutes, such as the region and GDP growth, is also vital to better articulate solutions to respond to challenges of green and circular transitions faced by nation-states.

## 2 Literature review

### 2.1 Environmental protection, effective resource utilisation, and changing skill requirements

Sustainability covers environmental, social, and economic spheres, and requires strategies, policies, and implementation plans to sustain and reconcile demands deriving from these three spheres [16]. Sustainable development goals are the best portrayal to evaluate environmental, social, and economic spheres since all countries under the umbrella of the United Nations are bound to achieve these [12]. The European Green Deal provides the roadmap to reach climate neutrality [1]. It places sustainability at the core of its policies and proposes strategies to reduce net emissions of greenhouse gas covering all sectors [1, 16, 17]. The circular economy is a production and consumption model built on 'produce-use-service-reuse' [1, 5]. From the labour market standpoint, the circular economy propagates a labour-rich model, which alters existing jobs and creates new jobs [5].

The implementation, monitoring, and control spectrums of business transformations ultimately call for new and/or different types of skills from the workforce—existing workforce and newly added in years to come [1, 2, 4, 8, 18]. The workforce must possess a technical and transversal skill-mix supporting sustainability at all levels, i.e.,

occupation-specific, across occupations of a specific business sector, and/or across business sectors [2, 4, 5]. Further, business transformations are expected to create more jobs that demand medium-skilled workers compared to high-skilled workers [13]. The skill requirements of medium-skilled occupations can best be addressed through training, upskilling, and reskilling in TVET institutes [1, 8]. This emphasises the importance of TVET institutes in adapting to climate change and adopting circular strategies. Furthermore, there are gender disparities since most medium-skilled occupations are held by men [13, 19]. However, most employers believe that a diversified workforce with appropriate skills can better address the needs of environmental protection and effective resource utilisation with creative solutions [3, 20]. Still, Levin et al. [21] showed that women are often severely underrepresented in tertiary-level STEM courses in TVET.

### 2.2 Training, upskilling, and reskilling with micro-credentials and credit transfers in learning pathways

The target groups of TVET are youth and working adults. Technical and Vocational Education and Training institutes offer a variety of courses for youth to secure employment in numerous occupations in the world of work. These are mainly monolithic centre-based training courses with rigid course structures covering numerous knowledge domains to prepare them to enter the labour market for the first time [22]. Working adults require upskilling and reskilling options to better fit into their current jobs, move into different jobs within/outside their current workplaces, or be employed with a new set of skills since they are currently unemployed. That is, to improve their skill adaptability and employability [7]. Upskilling provides a new or additional complementary set of skills to improve the capacity to perform the job for which one is already trained [23]. In the workplace, upskilling allows employers to get the maximum out of the existing workforce instead of requiring new hires. Reskilling provides a new set of skills to perform a different job [23]. When workers with in-demand skills are in short supply, employers may consider hiring reskilled workers, or such reskilled workers may find employment opportunities in the reskilled domain with the same employer. The technological advancements in pedagogy allow delivering upskilling and reskilling as standalone modular courses (i.e., micro-learning) using hybrid modes [24]. Micro-credentials digitally certify the 'record of learning outcomes' of micro-learning and allow for easy storage and sharing of credentials with employers through digital wallets [25], like Europass Digital Credentials and the National Skills Passport of Sri Lanka [26]. In more developed skill systems, micro-credentials can be accumulated and stacked together with traditional qualifications to create a credit course. However, the recognition of prior learning is a requirement for the successful implementation and transfer of micro credentials across higher education systems [25, 26].

When workers move across jobs vertically and horizontally instead of a straight line within a single organisation, learning pathway models become important to connect skill acquisition with occupations in a specific industry grouping, such as manufacturing [7, 25]. The 'Initial Vocational Education and Training (IVET)' model prevailing in Europe is an example of a learning pathway [7]. Micro-credentials offer flexible and personalised upskilling and reskilling options for workers to enter and progress within an occupational pathway, supporting and promoting a culture of lifelong learning [7, p. 26].

However, lifelong learning policies vary substantially between countries, which hinders worker movement between countries and within regions, such as the EU [7, 19].

### 2.3 Education for sustainable development

A growing body of literature insists that higher education institutes must implement an appropriate sustainability curriculum in all courses of all types as a part of SDGs [6, 9, 10, 15, 20]. The vertical and horizontal approaches are popular mechanisms to implement SDGs into curricula [27]. The implementation is vertical when institutes introduce new specific courses to address newly emerging knowledge domains (e.g., a higher diploma in renewable energy) [27]. The implementation is horizontal when institutes incorporate sustainability into existing courses by either revising existing curricula to include sustainability-related topics or making changes to existing pedagogical approaches, such as moving to an action-oriented learning approach without curriculum revisions [11]. Accordingly, implementing SDGs into curricula can be vertical and/or horizontal at a particular institute [11, 27].

### 2.4 Partnerships for incorporating sustainability into course curricula and monitoring of progress

Institutes must have partnerships with stakeholders for curriculum development and creating appropriate policy and regulatory frameworks to monitor progress [15, 28, 29]. Previous studies provide evidence for sectoral partnerships for mapping skills and skills needs across entire value chains [4] and creating learning pathways [25, 30]. In addition, previous studies provide evidence for TVET institutes establishing international cross-border partnerships to offer courses addressing the emerging needs of the labour market [28]. However, such partnerships must facilitate ESD by covering curriculum updates as time goes by [28]. National-level monitoring and accountability mechanisms are important to account for progress towards SDGs; regional-level mechanisms are important to account for adherence to policy priorities and monitor progress made; global-level mechanisms are important to assess the extent of implementation from a comparative standpoint [5].

### 2.5 Differences by region and GDP growth

The literature provides evidence to suggest that sustainability implementations, such as green transition and green skill requirements, are not uniform across the world [1, 5]. Regional cooperation for economic development [18], skill formation [1], and skill recognition [29] influence a country's skill formation systems. When regional cooperation for economic development is considered, the Association of Southeast Asian Nations (ASEAN) is prominent in making long-term economic transformations and creating favourable conditions for green job creation across Southeast Asia [18, 29]. When regional cooperation for skill formation is considered, evidence can be seen in the EU and ASEAN with established common priorities for TVET [1, 20, 30], such as implementing SDGs into curricula. When countries within a region allow skill migration, having a common skill recognition system is essential [29]. When regional cooperation for skill recognition is considered, accreditation and standardisation bodies play a critical role [2, 14, 25, 29]. However, the evidence of cooperation for economic development, skill formation, and skill recognition in South Asia is very limited. The South Asian

Association for Regional Cooperation (SAARC), established in 1985, has been largely considered inactive since 2014 due to geopolitical issues India continues to have with its neighbours. The Bay of Bengal Initiative (or BIMSTEC), having only five South Asian (SAARC) countries (i.e., Bangladesh, Bhutan, India, Nepal, and Sri Lanka), and only two Southeast Asian (ASEAN) countries (i.e., Myanmar and Thailand), is not a regional cooperation of either South Asia or Southeast Asia. Further, Maclean et al. [18] identify TVET courses in South Asia as largely supply-driven, leaning more towards institutionalism. Therefore, it is hypothesised:

*H1* Modalities in use to mainstream sustainability into course offerings, the implementation of SDGs into curricula, and the existence of partnerships differ by the region of a country.

*H1a* The offering of training, reskilling, and upskilling as well as the existence of micro-credentials, credit transfer mechanisms, and learning pathways supporting lifelong learning differ by the region.

*H1b* The implementation of SDGs into curricula differs by the region.

*H1c* The existence of partnerships for implementing SDGs into curricula and monitoring of progress differs by the region.

Unlike other educational settings, the provision of TVET involves heavy expenses to design, develop, and implement curricula, accommodate smaller class sizes, and establish and maintain laboratory/workshop infrastructure and supplies [18, 24]. Still, to date, most of the allocation of public funding is directed to K12 and university education while TVET often receives secondary treatment [1]. Previous research showed an unquestionable link between the characteristics of market economy, labour market, and skill formation systems of a country [24, 31]. In terms of economic indicators, an undisputable connection exists between the outcomes of education and training efforts of a country and its 'annual growth rate of real gross domestic product per employed person', which is the indicator of labour productivity [8, 31]. By recognising the value of this indicator, it is specified as one of the targets of SGD8 (target 8.2.1) [12]. Research studies showed significant differences between South Asia and Southeast Asia in the implementation of Industry 4.0 competencies in TVET by this indicator [24]. By using the term GDP growth to represent this indicator, it is hypothesised:

*H2* Modalities in use to mainstream sustainability into course offerings, the implementation of SDGs into curricula, and the existence of partnerships differ by the GDP growth of a country.

*H2a* The offering of training, reskilling, and upskilling as well as the existence of micro-credentials, credit transfer mechanisms, and learning pathways supporting lifelong learning, differ by GDP growth.

*H2b* The implementation of SDGs into curricula differs by GDP growth.

*H2c* The existence of partnerships for implementing SDGs into curricula and monitoring of progress differs by GDP growth.

## 3 Methodology

The present empirical research is underpinned by the positivist research paradigm, where we ground our arguments through observable phenomena objectively and measurably. We empirically quantified the implementation of SDGs into curricula, tested the hypotheses, and attempted to generalize findings in terms of a country's region and GDP growth. Therefore, to support our research paradigm, the research design is explanatory. One of the main purposes is to examine whether a country's region and GDP growth explain the variation in the implementation of SDGs into curricula. The decision-tree model for incorporating sustainability with the two explanatory variables, i.e., region and GDP growth, is shown in Fig. 1.

### 3.1 Measures

The measures of the study are classified into three groups following the objectives of the study. All measures used in the study were developed by the authors. Further, all measures inquired about the level of implementation on a five-point Likert scale (5 = To a great extent, 4 = Much, 3 = Somewhat, 2 = Little, and 1 = Not at all). The 11-item measure that inquired 'modalities in use to mainstream sustainability into course offerings' is shown in Table 1.

The 34-item measure that inquired 'the implementation of SDGs into curricula' and its coverage are shown in Table 2. We used the term 'competencies' to denote a combination of knowledge, skills, values, and attitudes desired for a job or a profession. The measures covered six SDGs (4, 8, 9, 13, 6, and 7) as the main classification. We offered an alternate classification too, i.e., existing courses were used to implement SDGS (EC), new courses were introduced to implement SDGs (NC), new courses incorporate competencies for environmental impact assessment (EI), courses are attractive to entrepreneurs (E), and courses promote inclusivity (W).

Table 3 shows the 4-item measure that inquired 'the existence of partnerships for implementing SDGs into curricula and monitoring of progress'.

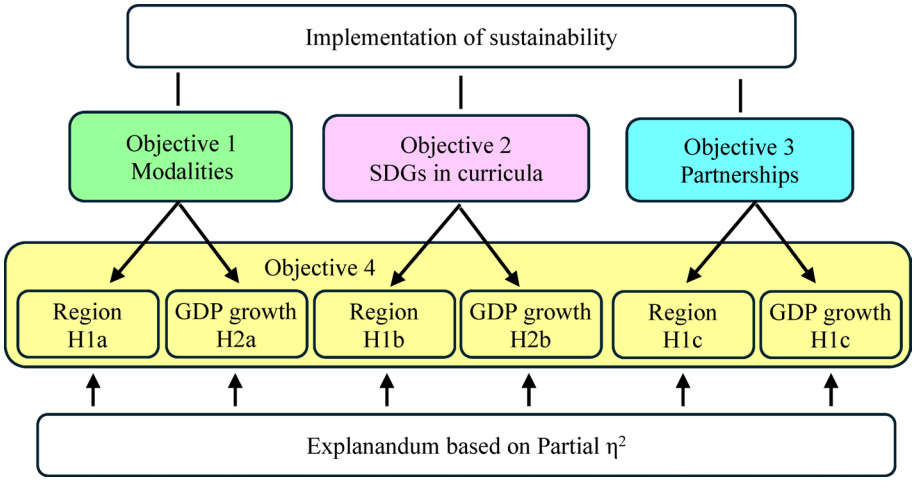


**Fig. 1** Decision-tree model for implementing sustainability

**Table 1** Modalities in use to mainstream sustainability into course offerings

| Item No | Item | Area of interest |
|---|---|---|
| 1.1 | Courses offered by my TVET institute promote sustainability with a lifelong learning approach for youth and adults | T |
| 1.2 | My TVET institute takes active measures to popularise courses that incorporate sustainability among youth and adults | T |
| 1.3 | Youth and adults in my country recognise TVET as an alternative route to higher education | T |
| 1.4 | My TVET institute considers the needs of working adults when offering courses that incorporate sustainability | UR |
| 1.5 | Courses that incorporate sustainability offered by my TVET institute are delivered with digital technologies to increase enrolments of working adults | UR |
| 1.6 | My TVET institute offers specialised courses of longer duration, incorporating sustainability for working adults | UR |
| 1.7 | My TVET institute offers specialised courses of shorter duration, incorporating sustainability for working adults | UR |
| 1.8 | Courses of shorter duration that incorporate sustainability offered by my TVET institute allow flexibility to stack together credentials to create a credit course | LP |
| 1.9 | My TVET institute recognises prior learning when enrolling for specialised courses of longer duration that incorporate sustainability | LP |
| 1.10 | Higher education institutes (HEIs) in my country allow learners to transfer credentials obtained from TVET institutes when enrolling for higher learning | LP |
| 1.11 | HEIs in my country recognise prior TVET learning when enrolling for higher learning | LP |

T ,Training in general; UR, Upskilling/reskilling; LP, Micro-credentials and credit transfers in learning pathways

### 3.2 Sample and method of data collection

Eleven countries were included in the study. These countries are shown in Table 4 along with the regional classification [refer to 32, p. 3]. The respondents were identified as TVET teachers involved in STEM tertiary-level courses. We were provided with the email directory of the Colombo Plan Staff College located in the Philippines, which provide training to TVET teachers from 26 countries in South Asia, Southeast Asia, and the Pacific since 1973. The participation in the survey was anonymous and voluntary. We emailed the survey link to over 2000 TVET teachers in the email list who had at least two years of experience as TVET teachers and attended country-specific training courses during the last three years from these 11 countries.

A total of 761 valid responses were received as shown in Table 4, where 43.23% from South Asia and 56.85% from Southeast Asia. In the analysis, the countries were classified as 'high GDP growth' (4% or higher) or 'low GDP growth' (less than 4%) based on the 'annual growth rate of real gross domestic product per employed person'. The year selected is 2019 [refer to 33, p. 49] since it is a neutral year for all the countries. Accordingly, 42.16% of the responses were from high GDP growth countries while 57.94% of the responses were from low GDP growth countries. Of the total respondents, 37.4% were females while 62.4% were males. Mean age was 39.71 years (s.d. = 9.11, minimum = 28, maximum = 52). Further, 14.4% of the respondents had doctorates, 45.6% had master's degrees, 27.3% had bachelor's degrees, and 12.8% had higher diplomas.

### 3.3 Methods of data analysis

Principal Component factor analysis was conducted with varimax rotation. Kaiser–Meyer–Olkin and Bartlett's test of sphericity statistics confirmed the adequacy of the measures (KMO > 0.80, Bartlett's $\chi^2$ $p < 0.05$). Wilks' Lambda statistic showed significant differences ($p < 0.05$) by country. The hypotheses were tested for differences using the

**Table 2** SDGs in the curriculum

| Item No | Item | Main classification (SDGs) | Alternate classification |
|---|---|---|---|
| 2.1 | Already available courses now encourage sustainable economic enterprises | 4 | EC |
| 2.2 | Courses are useful in managing small enterprises | 4 | E |
| 2.3 | Already available courses now develop competencies to diagnose problems, propose solutions, and implement solutions to mitigate sustainability challenges faced by my country | 4 | EC |
| 2.4 | Already available courses now provide sustainability competencies to succeed in employment | 4 | EC |
| 2.5 | Already available courses now develop sustainability competencies to respond to changes in the job market | 4 | EC |
| 2.6 | Already available courses now provide sustainability competencies to be employable | 4 | EC |
| 2.7 | Courses provide sustainability competencies important to establish business start-ups | 4 | E |
| 2.8 | Already available courses are now in line with the sustainability competency requirements of my country's job market | 8 | EC |
| 2.9 | Already available courses are now in line with demand for green skills/green jobs | 8 | EC |
| 2.10 | Courses provide sustainability competencies for micro/small/medium-enterprise business owners | 8 | E |
| 2.11 | Courses are useful for women seeking employment | 8 | W |
| 2.12 | Courses develop sustainability competencies required to access financial services/micro-credit, and advanced technical support | 8 | E |
| 2.13 | Courses stimulate women to enrol | 8 | W |
| 2.14 | Courses stimulate ex-combatants, security staff, or military staff to enrol | 8 | W |
| 2.15 | Already available courses now develop an understanding of the needs and challenges of sustainability at the national, regional, and global levels | 9 | EC |
| 2.16 | Already available courses now develop an understanding of the environmental/health standards of relevant industries | 9 | EC |
| 2.17 | Already available courses now develop an understanding of new opportunities/markets for sustainable industrial development | 9 | EC |
| 2.18 | Already available courses now develop the competencies required for sustainable industrial development | 9 | EC |
| 2.19 | Already available courses now develop competencies required to plan/design/operate sustainable management systems | 9 | EC |
| 2.20 | Already available courses now develop competencies that can be used to plan/design/implement systems in the workplace that promote environmental sustainability | 9 | EC |
| 2.21 | Already available courses now develop values that promote solving occupational environmental issues | 9 | EC |
| 2.22 | Courses develop competencies to evaluate economic issues due to climate change | 13 | EI |
| 2.23 | Courses develop competencies to evaluate social issues due to climate change | 13 | EI |
| 2.24 | Courses develop competencies to evaluate environmental issues due to climate change | 13 | EI |
| 2.25 | Courses develop competencies appropriate to develop/improve systems to respond to climate change | 13 | EI |
| 2.26 | Introduced new courses that incorporate environmental protection regulations | 13 | NC |
| 2.27 | Courses develop competencies to respond to environmental issues | 13 | EI |
| 2.28 | Introduced new courses that incorporate areas of ecological footprint and eco-efficiency | 13 | NC |
| 2.29 | Introduced new courses that incorporate areas of sustainable production/consumption | 13 | NC |

**Table 2** (continued)

| Item No | Item | Main classification (SDGs) | Alternate classification |
|---|---|---|---|
| 2.30 | Introduced new courses on water supply technology and management | 6 | NC |
| 2.31 | Introduced new courses on wastewater technology and management | 6 | NC |
| 2.32 | Introduced new courses that incorporate recycling and waste disposal management | 6 | NC |
| 2.33 | Introduced new courses that incorporate different types of energy sources | 7 | NC |
| 2.34 | Introduced new courses that incorporate renewable energy sources and efficiencies | 7 | NC |

**Table 3** Partnerships

| Item No | Item | Area of interest |
|---|---|---|
| 3.1 | Mechanisms in place to monitor the implementation of the priorities of SDGs in TVET institutes | Monitoring |
| 3.2 | Mechanisms are in place at the national strategic planning level to monitor the implementation of the priorities of SDGs in TVET institutes | Monitoring |
| 3.3 | TVET courses attract private sector involvement | Partnership |
| 3.4 | TVET courses attract partnerships to promote environmentally sound, up-to-date technologies | Partnership |

**Table 4** Sample

| Region | Country | GDP growth % | % responses (N = 761) |
|---|---|---|---|
| South Asia | Pakistan | < 4 | 9.07 |
| | Sri Lanka | < 4 | 7.36 |
| | Nepal | ≥ 4 | 6.96 |
| | India | ≥ 4 | 10.9 |
| | Bangladesh | ≥ 4 | 8.94 |
| Southeast Asia | Malaysia | < 4 | 9.46 |
| | Thailand | < 4 | 9.98 |
| | Philippines | < 4 | 11.03 |
| | Indonesia | < 4 | 11.04 |
| | Cambodia | ≥ 4 | 6.40 |
| | Vietnam | ≥ 4 | 8.94 |

Compare Means procedure. Partial eta squared (partial $\eta^2$) values and associated effect sizes were computed.

## 4 Results

### 4.1 Modalities used to mainstream sustainability into course offerings

As shown in Table 5, factor analysis yielded one factor (KMO = 0.962; Bartlett's $\chi^2$ (55) = 5103.43, $p < 0.001$) for 'modalities in use to mainstream sustainability into course offerings.'

The country-wise differences are shown in Table 6 along with Mean, SE (in brackets), and Partial $\eta^2$ values. The differences are significant for all areas ($p < 0.001$). For example, Partial $\eta^2$ value of 0.125 for item 1.3 'Youth and adults in my country recognise TVET as an alternative route for higher education' suggests that differences between the countries are significant and 13% of the variance is explained by country-wise differences, likewise.

**Table 5** Factor analysis—modalities

| Item No. | Factor loading |
|---|---|
| 1.1 | 0.740 |
| 1.2 | 0.797 |
| 1.3 | 0.786 |
| 1.4 | 0.831 |
| 1.5 | 0.812 |
| 1.6 | 0.811 |
| 1.7 | 0.752 |
| 1.8 | 0.772 |
| 1.9 | 0.776 |
| 1.10 | 0.817 |
| 1.11 | 0.821 |
| Eigenvalue | 6.915 |
| % of Variance | 62.866 |
| Cronbach's Alpha | 0.941 |

**Table 6** Country-wise differences—modalities

| Region | Country | Total | Item No. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Training | | | Upskilling/reskilling | | | | Micro-credentials and credit transfers in learning pathways | | | |
| | | | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 1.10 | 1.11 |
| South Asia | Sri Lanka | 3.40 (0.13) | 3.77 (0.17) | 3.41 (0.17) | 3.38 (0.18) | 3.22 (0.16) | 3.43 (0.18) | 3.54 (0.18) | 3.54 (0.16) | 3.32 (0.18) | 3.51 (0.18) | 3.03 (0.19) | 3.24 (0.20) |
| | Nepal | 3.57 (0.18) | 4.00 (0.24) | 3.45 (0.22) | 3.25 (0.27) | 3.60 (0.21) | 3.75 (0.23) | 3.90 (0.19) | 3.85 (0.18) | 3.20 (0.24) | 3.65 (0.23) | 3.10 (0.30) | 3.50 (0.24) |
| | Bangladesh | 3.72 (0.15) | 3.90 (0.17) | 3.82 (0.18) | 3.73 (0.16) | 3.65 (0.18) | 3.86 (0.16) | 3.73 (0.18) | 3.88 (0.17) | 3.63 (0.17) | 3.71 (0.16) | 3.42 (0.19) | 3.61 (0.21) |
| | Pakistan | 3.80 (0.13) | 4.00 (0.14) | 3.86 (0.15) | 3.65 (0.19) | 3.88 (0.15) | 4.00 (0.13) | 3.92 (0.15) | 4.08 (0.14) | 3.76 (0.15) | 3.67 (0.17) | 3.55 (0.19) | 3.51 (0.17) |
| | India | 3.99 (0.10) | 4.22 (0.12) | 4.10 (0.10) | 3.89 (0.11) | 4.02 (0.13) | 4.16 (0.10) | 4.09 (0.11) | 4.13 (0.12) | 3.81 (0.15) | 4.02 (0.13) | 3.84 (0.14) | 3.82 (0.12) |
| Southeast Asia | Indonesia | 3.89 (0.18) | 4.18 (0.22) | 3.97 (0.21) | 4.14 (0.19) | 3.86 (0.24) | 3.64 (0.22) | 3.82 (0.23) | 4.00 (0.25) | 3.77 (0.23) | 3.68 (0.26) | 3.77 (0.23) | 3.77 (0.22) |
| | Vietnam | 3.89 (0.15) | 4.26 (0.15) | 4.02 (0.15) | 4.04 (0.16) | 3.52 (0.26) | 4.00 (0.18) | 3.81 (0.25) | 3.85 (0.20) | 3.67 (0.21) | 3.93 (0.19) | 3.48 (0.24) | 3.96 (0.17) |
| | Cambodia | 3.89 (0.12) | 3.97 (0.14) | 3.83 (0.18) | 4.03 (0.14) | 4.00 (0.15) | 3.85 (0.13) | 4.00 (0.15) | 3.88 (0.15) | 3.79 (0.16) | 3.85 (0.12) | 3.71 (0.20) | 3.74 (0.17) |
| | Malaysia | 4.06 (0.09) | 4.44 (0.09) | 3.98 (0.13) | 4.19 (0.12) | 4.00 (0.14) | 4.11 (0.10) | 4.09 (0.14) | 4.02 (0.15) | 3.94 (0.13) | 4.18 (0.11) | 3.78 (0.14) | 3.87 (0.13) |
| | Thailand | 4.29 (0.08) | 4.31 (0.08) | 4.33 (0.09) | 4.27 (0.09) | 4.27 (0.09) | 4.42 (0.08) | 4.29 (0.09) | 4.25 (0.09) | 4.21 (0.10) | 4.27 (0.09) | 4.29 (0.10) | 4.29 (0.10) |
| | Philippines | 4.35 (0.08) | 4.49 (0.10) | 4.30 (0.11) | 4.41 (0.10) | 4.40 (0.09) | 4.32 (0.09) | 4.30 (0.10) | 4.51 (0.09) | 4.27 (0.09) | 4.43 (0.09) | 4.14 (0.13) | 4.30 (0.10) |
| F | | 4.82 | 2.38 | 3.03 | 4.55 | 3.68 | 4.44 | 2.69 | 2.96 | 3.11 | 3.48 | 4.06 | 3.74 |
| Sig | | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Partial $\eta^2$ | | 0.131 | 0.069 | 0.087 | 0.125 | 0.103 | 0.122 | 0.078 | 0.085 | 0.089 | 0.098 | 0.113 | 0.105 |

Table 7 shows that differences are significant by region and GDP growth. For example, Partial $\eta^2$ value of 0.047 for region and 0.029 for GDP growth suggest that 5% and 3% of the variance are explained by the region and the GDP growth, respectively. That is, both region and GDP growth significantly explain the extent to which various modalities are in use to mainstream sustainability into course offerings. The significant differences support H1a and H2a.

**Table 7** Differences—modalities in use to mainstream sustainability into course offerings

| | Total | Region | | | | | GDP growth | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | South Asia | South-east Asia | Sig. | F | Partial $\eta^2$ | Low | High | Sig. | F | Partial $\eta^2$ |
| Modalities | 3.92 (0.03) | 3.72 (0.06) | 4.08 (0.04) | 0.000 | 27.70 | 0.047 | 3.84 (0.04) | 4.36 (0.12) | 0.000 | 8.46 | 0.029 |

### 4.2 Implementation of SDGs into curricula

The 34-item measure was subjected to factor analysis (KMO = 0.978; Bartlett's $\chi^2$ (561) = 21670.19, $p < 0.001$). The factor analysis yielded two factors, having a total item Cronbach's Alpha of 0.890 and 70.87% of total variance explained. All the items corresponding to SDGs 4, 8, and 9 were loaded into factor 1, i.e., 'SDGs in Curriculum1' whereas all the items corresponding to SDGs 6, 7, and 13 were loaded into factor 2, i.e., 'SDGs in Curriculum2' (Table 8).

The country-wise differences are shown in Table 9. The differences are significant for both SDGs in Curriculum1 and SDGs in Curriculum2 ($p < 0.001$). For example, Partial $\eta^2$ value of 0.133 for SDGs in Curriculum1 and 0.157 for SDGs in Curriculum2 suggest that 13% and 16% of the variance in SDGs in Curriculum1 and SDGs in Curriculum2 are explained by country-wise differences, respectively. Hence, country-wise differences significantly explain the extent to which SDGs were implemented into curricula.

Tables 10 and 11 show that differences are significant ($p < 0.001$) for all items in SDGs in Curriculum1 and SDGs in Curriculum2, respectively, by region and GDP growth. For example, Partial $\eta^2$ value of 0.047 for the region total and 0.021 for the GDP growth total suggest that 5% and 2% of the variance in SDGs in Curriculum1 are explained by region and GDP growth, respectively. This suggests that both region and GDP growth significantly explain the extent to which SDGs were implemented into curricula. These results support H1b and H2b.

Table 12 shows that country-wise differences are significant ($p < 0.001$) across the five categories, which are introduced in Table 1. For example, Partial $\eta^2$ value of 0.127 for 'existing courses were used to implement SDGS' (EC) and 0.141 for 'new courses were introduced to implement SDGs' (NC) suggest that 13% and 14% of the variance are explained by country-wise differences, respectively. Accordingly, country-wise differences significantly explain the extent to which SDGs were implemented into curricula based on the alternate classification.

Table 13 shows that differences are significant ($p < 0.001$) for all five categories in the alternate classification by region and GDP growth. For example, Partial $\eta^2$ value of 0.052 for region total and 0.024 for GDP growth total suggest that 5% and 2% of the variance in the alternate classification are explained by region and GDP growth, respectively. That is, both region and GDP growth significantly explain the implementation of SDGs into curricula based on the alternate classification. This also supports H1b and H2b.

### 4.3 Partnerships

The factor analysis yielded one factor for partnerships (KMO = 0.887; Bartlett's $\chi^2$ (6) = 1336.21, $p < 0.001$) as shown in Table 14.

Table 15 shows that country-wise differences are significant ($p < 0.001$) for items considered for partnerships. For example, the Partial $\eta^2$ value of 0.149 for partnership total suggests that 15% of the variance in partnership is explained by country-wise differences.

**Table 8** Factor analysis—SDGs in the curriculum

| Item No. | SDGs in Curriculum 1 | SDGs in Curriculum 2 |
|---|---|---|
| 2.1 | 0.752 | |
| 2.2 | 0.727 | |
| 2.3 | 0.739 | |
| 2.4 | 0.828 | |
| 2.5 | 0.757 | |
| 2.6 | 0.808 | |
| 2.7 | 0.744 | |
| 2.8 | 0.753 | |
| 2.9 | 0.701 | |
| 2.10 | 0.760 | |
| 2.11 | 0.739 | |
| 2.12 | 0.690 | |
| 2.13 | 0.713 | |
| 2.14 | 0.536 | |
| 2.15 | 0.746 | |
| 2.16 | 0.759 | |
| 2.17 | 0.803 | |
| 2.18 | 0.762 | |
| 2.19 | 0.748 | |
| 2.20 | 0.745 | |
| 2.21 | 0.739 | |
| 2.22 | | 0.813 |
| 2.23 | | 0.780 |
| 2.24 | | 0.815 |
| 2.25 | | 0.793 |
| 2.26 | | 0.803 |
| 2.27 | | 0.744 |
| 2.28 | | 0.836 |
| 2.29 | | 0.813 |
| 2.30 | | 0.807 |
| 2.31 | | 0.833 |
| 2.32 | | 0.823 |
| 2.33 | | 0.828 |
| 2.34 | | 0.799 |
| Eigenvalue | 13.081 | 11.013 |
| % of variance explained | 38.475 | 32.392 |
| Cronbach's Alpha | 0.974 | 0.974 |

Therefore, country-wise differences significantly explain the extent to which partnerships exist for implementing SDGs into curricula and the monitoring of progress.

Table 16 shows that differences are significant ($p < 0.001$) for partnerships by region and GDP growth. For example, the Partial $\eta^2$ value of 0.058 for region and 0.025 for GDP growth suggest that 6% and 3% of the variance in partnerships are explained by region and GDP growth, respectively. This suggests that both region and GDP growth significantly explain the existence of partnerships for implementing SDGs into curricula and the monitoring of progress. This supports H1c and H2c.

Table 17 shows the summary of hypotheses testing.

**Table 9** Country-wise differences—SDGs in Curriculum1 and SDGs in Curriculum2

| Region | Country | Total | SDGs in Curriculum1 | SDGs in Curriculum2 |
|---|---|---|---|---|
| South Asia | Sri Lanka | 3.00 | 3.28 | 2.72 |
| | | (0.13) | (0.12) | (0.15) |
| | Nepal | 3.34 | 3.61 | 3.08 |
| | | (0.20) | (0.16) | (0.25) |
| | Bangladesh | 3.67 | 3.91 | 3.43 |
| | | (0.14) | (0.12) | (0.18) |
| | Pakistan | 3.60 | 3.75 | 3.44 |
| | | (0.14) | (0.13) | (0.16) |
| | India | 3.87 | 4.05 | 3.68 |
| | | (0.11) | (0.09) | (0.13) |
| Southeast Asia | Indonesia | 3.80 | 4.03 | 3.53 |
| | | (0.19) | (0.18) | (0.20) |
| | Malaysia | 3.80 | 4.09 | 3.48 |
| | | (0.09) | (0.08) | (0.12) |
| | Cambodia | 3.85 | 3.99 | 3.72 |
| | | (0.13) | (0.13) | (0.15) |
| | Vietnam | 3.88 | 4.10 | 3.66 |
| | | (0.16) | (0.13) | (0.19) |
| | Philippines | 4.13 | 4.37 | 3.89 |
| | | (0.09) | (0.08) | (0.12) |
| | Thailand | 4.26 | 4.28 | 4.23 |
| | | (0.07) | (0.06) | (0.08) |
| F | | 6.01 | 4.92 | 5.94 |
| Sig | | 0.000 | 0.000 | 0.000 |
| Partial $\eta^2$ | | 0.158 | 0.133 | 0.157 |

## 5 Contribution of the findings to existing literature, and implications for practice and policymaking

The present study investigated skill formation for sustainability in TVET institutions. First, the findings showed various modalities used to mainstream sustainability into course offerings. Second, the findings showed the introduction of new courses to implement SDGs, supporting vertical integration as well as the implementation of SDGs into existing course curricula, supporting horizontal integration. In another stance, the progress along the lines of sustainability yields better results only if skills for environmental impact assessment are incorporated into curricula. Under the alternate classification, the findings showed the implementation of these into curricula. Further, the results showed that institutes offer courses for inclusivity targeting women and other disadvantaged groups for them to fit into sustainability transitions in line with SDG4 targets 4.3, 4.4, and 4.5. Third, the findings showed the existence of partnerships for curriculum development and monitoring of progress with reference to SDG17. Most importantly, the findings showed differences by a country's region and GDP growth. This is inspired by the contentions of previous studies [such as 5, 8, 24]. The findings of the study have important contributions to existing literature as well as implications for practice and policymaking.

### 5.1 Contributions to existing literature

First, international development agendas, like SDGs, are most often viewed with scepticism due to potential gaps between ambitions, efforts, and achievements. Still, such agendas help to create a shared understanding of future directions. An understanding of the progress made along these agendas and benchmarking are important for formative

**Table 10** Differences—SDGs in Curriculum1

| SDG | | Total | Region | | | | | GDP growth | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | South Asia | Southeast Asia | Sig. | F | Partial $\eta^2$ | Low | High | Sig. | F | Partial $\eta^2$ |
| SDG4 | 2.1 | 3.88 (0.04) | 3.65 (0.06) | 4.06 (0.04) | 0.000 | 25.78 | 0.044 | 3.79 (0.05) | 4.13 (0.07) | 0.002 | 6.22 | 0.022 |
| | 2.2 | 3.95 (0.04) | 3.76 (0.06) | 4.09 (0.04) | 0.000 | 16.89 | 0.029 | 3.89 (0.04) | 4.14 (0.06) | 0.017 | 4.12 | 0.014 |
| | 2.3 | 3.90 (0.04) | 3.73 (0.06) | 4.04 (0.04) | 0.000 | 14.67 | 0.025 | 3.83 (0.04) | 4.17 (0.08) | 0.020 | 3.96 | 0.014 |
| | 2.4 | 4.18 (0.04) | 3.99 (0.05) | 4.33 (0.04) | 0.000 | 23.21 | 0.040 | 4.10 (0.04) | 4.37 (0.06) | 0.001 | 6.84 | 0.024 |
| | 2.5 | 3.99 (0.03) | 3.81 (0.06) | 4.14 (0.04) | 0.000 | 16.94 | 0.029 | 3.92 (0.04) | 4.20 (0.07) | 0.003 | 5.81 | 0.020 |
| | 2.6 | 4.20 (0.03) | 4.05 (0.05) | 4.32 (0.04) | 0.000 | 14.80 | 0.026 | 4.14 (0.04) | 4.35 (0.06) | 0.006 | 5.19 | 0.018 |
| | 2.7 | 3.90 (0.03) | 3.73 (0.06) | 4.04 (0.04) | 0.000 | 14.99 | 0.026 | 3.84 (0.05) | 4.11 (0.06) | 0.011 | 4.56 | 0.016 |
| SDG8 | 2.8 | 4.18 (0.03) | 3.98 (0.05) | 4.33 (0.04) | 0.000 | 26.47 | 0.045 | 4.10 (0.04) | 4.36 (0.06) | 0.001 | 6.98 | 0.024 |
| | 2.9 | 3.82 (0.04) | 3.60 (0.07) | 3.99 (0.05) | 0.000 | 20.21 | 0.035 | 3.76 (0.05) | 3.97 (0.07) | 0.115 | 2.17 | 0.008 |
| | 2.10 | 4.02 (0.03) | 3.83 (0.06) | 4.18 (0.04) | 0.000 | 20.26 | 0.035 | 3.95 (0.04) | 4.22 (0.06) | 0.007 | 5.05 | 0.018 |
| | 2.11 | 4.04 (0.03) | 3.90 (0.06) | 4.15 (0.05) | 0.002 | 9.86 | 0.017 | 3.97 (0.04) | 4.19 (0.07) | 0.003 | 5.88 | 0.021 |
| | 2.12 | 3.82 (0.04) | 3.63 (0.07) | 3.97 (0.05) | 0.000 | 15.73 | 0.027 | 3.79 (0.05) | 3.97 (0.08) | 0.015 | 4.22 | 0.015 |
| | 2.13 | 3.94 (0.04) | 3.79 (0.06) | 4.05 (0.05) | 0.002 | 9.32 | 0.016 | 3.99 (0.05) | 4.04 (0.07) | 0.156 | 1.87 | 0.007 |
| | 2.14 | 3.52 (0.05) | 3.23 (0.08) | 3.75 (0.06) | 0.000 | 27.56 | 0.047 | 3.43 (0.06) | 3.82 (0.08) | 0.002 | 6.17 | 0.022 |
| SDG9 | 2.15 | 4.00 (0.04) | 3.82 (0.06) | 4.14 (0.04) | 0.000 | 16.01 | 0.028 | 3.97 (0.05) | 4.07 (0.07) | 0.050 | 3.01 | 0.011 |
| | 2.16 | 4.07 (0.04) | 3.88 (0.06) | 4.22 (0.04) | 0.000 | 20.76 | 0.036 | 3.99 (0.04) | 4.30 (0.06) | 0.001 | 7.00 | 0.024 |
| | 2.17 | 4.05 (0.03) | 3.90 (0.06) | 4.16 (0.04) | 0.001 | 11.56 | 0.020 | 4.00 (0.04) | 4.20 (0.06) | 0.064 | 2.76 | 0.010 |
| | 2.18 | 4.08 (0.03) | 3.91 (0.06) | 4.22 (0.04) | 0.000 | 17.96 | 0.031 | 4.00 (0.04) | 4.29 (0.07) | 0.002 | 6.33 | 0.022 |
| | 2.19 | 3.96 (0.04) | 3.77 (0.06) | 4.10 (0.04) | 0.000 | 16.47 | 0.028 | 3.88 (0.04) | 4.17 (0.06) | 0.006 | 5.13 | 0.018 |
| | 2.20 | 3.91 (0.04) | 3.66 (0.07) | 4.10 (0.04) | 0.000 | 30.24 | 0.051 | 3.84 (0.05) | 4.12 (0.06) | 0.011 | 4.53 | 0.016 |
| | 2.21 | 3.94 (0.04) | 3.77 (0.06) | 4.08 (0.04) | 0.000 | 15.00 | 0.026 | 3.90 (0.04) | 4.08 (0.07) | 0.149 | 1.91 | 0.007 |
| Total | | 3.97 (0.03) | 3.78 (0.05) | 4.12 (0.03) | 0.000 | 27.52 | 0.047 | 3.90 (0.03) | 4.16 (0.05) | 0.003 | 5.87 | 0.021 |

and accountability purposes. Today, the relevance of higher education, TVET in particular, is considered crucial in implementing SDGs. We showed findings in terms of 'actions already taken' or the level of implementation corresponding to ESD. Further, we used a replicable methodology. Therefore, the methodology adopted and the findings are valuable, novel, and have the potential to initiate dialogue among scholarly, practitioner, and policymaking communities, ultimately accelerating efforts towards achieving global ambitions.

**Table 11** Differences—SDGs in Curriculum2

| | | Total | Region | | | | | GDP growth | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | South Asia | Southeast Asia | Sig. | F | Partial $\eta^2$ | Low | High | Sig. | F | Partial $\eta^2$ |
| SDG13 | 2.22 | 3.51 (0.05) | 3.24 (0.08) | 3.72 (0.05) | 0.000 | 23.38 | 0.040 | 3.42 (0.06) | 3.78 (0.08) | 0.008 | 4.93 | 0.017 |
| | 2.23 | 3.54 (0.05) | 3.25 (0.08) | 3.76 (0.05) | 0.000 | 27.09 | 0.046 | 3.44 (0.06) | 3.80 (0.08) | 0.005 | 5.34 | 0.019 |
| | 2.24 | 3.54 (0.05) | 3.26 (0.08) | 3.77 (0.06) | 0.000 | 25.12 | 0.043 | 3.46 (0.06) | 3.79 (0.09) | 0.024 | 3.75 | 0.013 |
| | 2.25 | 3.51 (0.05) | 3.21 (0.08) | 3.75 (0.05) | 0.000 | 30.44 | 0.051 | 3.43 (0.06) | 3.77 (0.08) | 0.014 | 4.30 | 0.015 |
| | 2.26 | 3.57 (0.05) | 3.33 (0.08) | 3.76 (0.05) | 0.000 | 18.57 | 0.032 | 3.48 (0.06) | 3.85 (0.08) | 0.007 | 4.94 | 0.017 |
| | 2.27 | 3.63 (0.04) | 3.38 (0.07) | 3.84 (0.05) | 0.000 | 23.18 | 0.040 | 3.53 (0.05) | 3.92 (0.07) | 0.002 | 6.26 | 0.022 |
| | 2.28 | 3.34 (0.05) | 3.09 (0.08) | 3.53 (0.06) | 0.000 | 17.18 | 0.030 | 3.25 (0.06) | 3.59 (0.09) | 0.022 | 3.86 | 0.014 |
| | 2.29 | 3.54 (0.05) | 3.33 (0.08) | 3.71 (0.06) | 0.000 | 14.48 | 0.025 | 3.46 (0.06) | 3.80 (0.08) | 0.015 | 4.24 | 0.015 |
| SDG6 | 2.30 | 3.47 (0.05) | 3.27 (0.08) | 3.63 (0.07) | 0.001 | 11.62 | 0.020 | 3.39 (0.06) | 3.73 (0.09) | 0.022 | 3.85 | 0.014 |
| | 2.31 | 3.36 (0.05) | 3.10 (0.08) | 3.56 (0.06) | 0.000 | 18.19 | 0.031 | 3.24 (0.06) | 3.72 (0.09) | 0.001 | 7.20 | 0.025 |
| | 2.32 | 3.54 (0.05) | 3.31 (0.08) | 3.72 (0.06) | 0.000 | 16.58 | 0.029 | 3.44 (0.06) | 3.87 (0.08) | 0.001 | 6.79 | 0.024 |
| SDG7 | 2.33 | 3.58 (0.04) | 3.33 (0.08) | 3.77 (0.06) | 0.000 | 20.50 | 0.035 | 3.50 (0.06) | 3.77 (0.08) | 0.021 | 3.89 | 0.014 |
| | 2.34 | 3.60 (0.05) | 3.39 (0.08) | 3.76 (0.06) | 0.000 | 13.71 | 0.024 | 3.51 (0.06) | 3.80 (0.08) | 0.006 | 5.13 | 0.018 |
| Total | | 3.52 (0.04) | 3.27 (0.07) | 3.71 (0.05) | 0.000 | 25.81 | 0.044 | 3.43 (0.05) | 3.78 (0.07) | 0.002 | 6.07 | 0.021 |

Second, TVET is the ideal venue for developing knowledge, skills, values, and attitudes for vocational contexts [21]. Although previous studies [such as 9, 10] emphasised the need for all types of education/training institutes to implement SDGs into curricula, skill formation in TVET institutes is largely underrepresented. We have addressed this gap in the literature. In a nutshell, the findings provided unique insights into the implementation of SDGs into curricula as vertical and horizontal integration, supporting the advancement of sustainability discourse.

Third, empirical studies that investigated curricular relevance for sustainability are inadequate in both the Global North and South. Levin et al. [21] and UNESCO-UNEVOC [5] suggest that challenges faced by TVET institutes in the Global South are more pronounced compared to those in the Global North. Given these gaps in scholarly, practice, and policymaking domains while building on ESD, we have provided novel insights by testing for differences by a country's region and GDP growth. In terms of GDP growth, connections between the market economy, labour market, and higher education may contribute to significant differences. In terms of region, regional cooperation covering trade, labour market, and skill formation may contribute to significant differences. For example, Southeast Asia's promotion of greening and freedom for skill migration could have created a consensus in establishing curricular relevance to sustainability. Further, the presence of regional skill formation agreements and skill accreditation systems could have substantial effects on Southeast Asian countries. The differences in both

**Table 12** Country-wise differences—alternate classification

| Region | Country | Total | Alternate classification | | | | |
|---|---|---|---|---|---|---|---|
| | | | EC | NC | EI | E | W |
| South Asia | Sri Lanka | 3.00 (0.13) | 3.35 (0.12) | 2.79 (0.17) | 2.61 (0.17) | 3.24 (0.14) | 3.05 (0.13) |
| | Nepal | 3.34 (0.20) | 3.63 (0.17) | 3.03 (0.25) | 3.16 (0.28) | 3.55 (0.17) | 3.58 (0.14) |
| | Pakistan | 3.60 (0.14) | 3.76 (0.13) | 3.45 (0.17) | 3.43 (0.18) | 3.79 (0.13) | 3.68 (0.14) |
| | Bangladesh | 3.67 (0.14) | 3.97 (0.13) | 3.42 (0.17) | 3.45 (0.19) | 3.82 (0.14) | 3.75 (0.15) |
| | India | 3.79 (0.11) | 4.00 (0.09) | 3.69 (0.13) | 3.68 (0.13) | 3.97 (0.10) | 4.04 (0.11) |
| Southeast Asia | Indonesia | 3.77 (0.19) | 4.04 (0.18) | 3.52 (0.21) | 3.48 (0.22) | 4.00 (0.20) | 4.00 (0.19) |
| | Malaysia | 3.77 (0.09) | 4.16 (0.08) | 3.44 (0.13) | 3.48 (0.13) | 4.03 (0.09) | 3.85 (0.09) |
| | Cambodia | 3.85 (0.13) | 4.02 (0.12) | 3.72 (0.17) | 3.72 (0.17) | 3.99 (0.13) | 3.84 (0.15) |
| | Vietnam | 3.88 (0.16) | 4.15 (0.13) | 3.60 (0.19) | 3.76 (0.21) | 4.12 (0.13) | 3.83 (0.16) |
| | Philippines | 4.13 (0.09) | 4.38 (0.07) | 3.82 (0.13) | 4.00 (0.11) | 4.36 (0.09) | 4.29 (0.10) |
| | Thailand | 4.26 (0.07) | 4.31 (0.06) | 4.20 (0.08) | 4.28 (0.08) | 4.25 (0.07) | 4.19 (0.07) |
| F | | 6.01 | 4.65 | 5.25 | 5.85 | 4.66 | 5.14 |
| Sig | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Partial $\eta^2$ | | 0.158 | 0.127 | 0.141 | 0.155 | 0.127 | 0.139 |

**Table 13** Differences—alternate classification

| Alternate classification | Total | Region | | | | | | GDP growth | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | South Asia | Southeast Asia | Sig. | F | Partial $\eta^2$ | Low | High | Sig. | F | Partial $\eta^2$ |
| Existing courses were used to implement SDGS | 4.01 (0.03) | 3.82 (0.05) | 4.16 (0.03) | 0.000 | 27.49 | 0.047 | 3.94 (0.03) | 4.20 (0.05) | 0.002 | 6.32 | 0.022 |
| New courses were introduced to implement SDGs | 3.50 (0.04) | 3.27 (0.07) | 3.68 (0.05) | 0.000 | 20.49 | 0.035 | 3.41 (0.05) | 3.77 (0.08) | 0.004 | 5.70 | 0.020 |
| New courses incorporate competencies for environmental impact assessment | 3.55 (0.04) | 3.27 (0.07) | 3.77 (0.05) | 0.000 | 29.24 | 0.049 | 3.46 (0.05) | 3.81 (0.07) | 0.005 | 5.40 | 0.019 |
| Courses are attractive to entrepreneurs | 3.92 (0.03) | 3.77 (0.05) | 4.07 (0.04) | 0.000 | 23.13 | 0.040 | 3.87 (0.04) | 4.11 (0.05) | 0.008 | 4.92 | 0.017 |
| Courses promote inclusivity | 3.83 (0.03) | 3.64 (0.06) | 3.98 (0.04) | 0.000 | 21.30 | 0.037 | 3.76 (0.04) | 4.02 (0.06) | 0.010 | 4.66 | 0.016 |
| Total | 3.74 (0.04) | 3.52 (0.94) | 3.92 (0.04) | 0.000 | 30.70 | 0.052 | 3.66 (0.04) | 3.97 (0.06) | 0.001 | 6.89 | 0.024 |

spheres imply the importance of a country's region and GDP growth on skill formation systems. The findings of the present study support the findings of previous studies [8, 30]. The investigation of differences in course offerings in terms of region and GDP growth is novel. Our study could be the first to empirically test the effects of a country's region and GDP growth on skill formation systems.

**Table 14** Partnerships

| Item No. | Factor loading |
|---|---|
| 3.1 | 0.859 |
| 3.2 | 0.878 |
| 3.3 | 0.786 |
| 3.4 | 0.823 |
| Eigenvalue | 2.805 |
| % of variance explained | 70.116 |
| Cronbach's Alpha | 0.858 |

**Table 15** Country-wise differences—partnerships

| Region | Country | Total | Item No | | | |
|---|---|---|---|---|---|---|
| | | | 3.1 | 3.2 | 3.3 | 3.4 |
| South Asia | Sri Lanka | 3.17 (0.13) | 3.14 (0.18) | 3.08 (0.19) | 3.43 (0.18) | 3.03 (0.17) |
| | Nepal | 3.34 (0.19) | 3.35 (0.23) | 3.20 (0.24) | 3.45 (0.23) | 3.35 (0.28) |
| | Pakistan | 3.64 (0.14) | 3.61 (0.18) | 3.59 (0.18) | 3.73 (0.16) | 3.63 (0.15) |
| | Bangladesh | 3.66 (0.15) | 3.51 (0.19) | 3.57 (0.18) | 3.84 (0.14) | 3.71 (0.16) |
| | India | 3.88 (0.11) | 3.82 (0.13) | 3.92 (0.12) | 3.98 (0.12) | 4.10 (0.12) |
| Southeast Asia | Indonesia | 3.84 (0.18) | 3.73 (0.22) | 3.86 (0.21) | 4.09 (0.20) | 3.68 (0.24) |
| | Vietnam | 3.85 (0.16) | 3.63 (0.24) | 3.85 (0.22) | 3.96 (0.21) | 3.96 (0.17) |
| | Malaysia | 3.92 (0.09) | 3.69 (0.12) | 3.81 (0.12) | 4.19 (0.10) | 3.98 (0.13) |
| | Cambodia | 3.92 (0.14) | 3.82 (0.17) | 4.00 (0.14) | 3.94 (0.17) | 3.91 (0.17) |
| | Philippines | 4.30 (0.08) | 4.24 (0.11) | 4.27 (0.09) | 4.48 (0.10) | 4.21 (0.10) |
| | Thailand | 4.32 (0.07) | 4.27 (0.09) | 4.35 (0.08) | 4.25 (0.10) | 4.40 (0.09) |
| F | | 5.58 | 3.22 | 4.96 | 3.92 | 4.50 |
| Sig | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Partial $\eta^2$ | | 0.149 | 0.091 | 0.134 | 0.109 | 0.123 |

**Table 16** Differences—partnerships

| | Total | Region | | | | | GDP growth | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | South Asia | Southeast Asia | Sig. | F | Partial $\eta^2$ | Low | High | Sig. | F | Partial $\eta^2$ |
| Partnerships | 3.83 (0.03) | 3.60 (0.06) | 4.02 (0.04) | 0.000 | 34.62 | 0.058 | 3.75 (0.04) | 4.07 (0.05) | 0.001 | 7.27 | 0.025 |

**Table 17** Summary of hypotheses testing

| Objective | Hypothesis | Result |
|---|---|---|
| 1 | H1a | South Asia scored lower for all |
| | H2a | Countries with low GDP growth scored lower for all |
| 2 | H1b | South Asia scored lower for all |
| | H2b | Countries with low GDP growth scored lower for all |
| 3 | H1c | South Asia scored lower for all |
| | H2c | Countries with low GDP growth scored lower for all |

### 5.2 Implications for practice

First, although new jobs are created in greening and circularity contexts, the number of jobs disappearing exceeds the number of new jobs created; the net increase in new jobs can surpass the jobs that can be filled by workforce reallocation [3, 7, 13]. Hence, upskilling and reskilling are effective and popular strategies to respond to macrotrends. However, youth and adults today may not move along an unbroken timeline from primary to secondary to tertiary education in their skill acquisition endeavours. They may look for micro-learning options for upskilling and reskilling to improve their performance in current jobs, move into distinctly different jobs compared to their current jobs, or change their careers from declining jobs/sectors to booming jobs/sectors.

Second, the findings showed that as part of vertical integration, TVET institutes offer courses with inclusivity in mind. In the years to come, a large majority of laid-off workers in response to greening and circularity could not be reallocated to the same or a similar occupation, even in another industry [1]. We identify TVET as an enabler capable of developing technical/technological solutions or new techniques/technologies for a sustainable future. Hence, institutes must introduce targeted interventions of skill development for working adults to smoothly transfer into newly emerging occupations. Further, TVET courses are in the best position to promote entrepreneurship, in general, as well as promote entrepreneurship to overcome green challenges.

Third, while results showed some consensus in establishing curricular relevance for sustainability, the institutes must timely update curricula. Timing and trends like greening and circularity are very important in training, upskilling, and reskilling. Institutes must develop capabilities to identify and anticipate industry trends to update curricula to have a solid pipeline of workforce for future business transformations. Active engagement with industry partners for skills anticipation and maintaining labour market information could guide the effective adaptation of curricula for industry needs.

Fourth, the use of a combination of modalities encompassing training, upskilling, and reskilling together with micro-credentials and credit transfers in learning pathways supports a wide variety of learners with flexible learning options. However, the recognition of prior learning is essential. Hence, on the one hand, skills contained within micro-credentials must be recognised by employers. On the other hand, the higher education system of a country/region must recognise prior learning, allowing the accumulation and stacking of micro-credentials with other traditional qualifications to create a credit course, as well as allowing credit transfers when a working adult intends to pursue further learning as part of lifelong learning. For these to happen smoothly, the higher education system must move out from the conventional framework and must create a national/regional qualification framework that fits the modern day. This is especially vital when upskilling and reskilling are for the acquisition of emerging skills, such as those for the circular economy.

### 5.3 Implications for policymaking

First, when a majority in the workforce must upskill or reskill for future employability, countries must consider popularising upskilling/reskilling courses, providing career counselling, and developing social protection measures to support mobility within industrial sectors as well as within occupations.

Second, in most countries, TVET courses are terminal in nature, without having pathways of learning to progress into higher learning options [7, 14]. Micro-credentials and learning pathways are important for those who engage in upskilling or reskilling courses as micro-learning. Further, the trust in courses and providers can be increased if upskilling/reskilling courses undergo quality assurance mechanisms and accreditation bodies are recognised in national quality assurance frameworks. Simply, a 'qualification corridor' must be created for learners to climb the skills acquisition ladder over time.

Third, although TVET is important in supplying skilled manpower in any country, most citizens perceive TVET institutes as second-tier entities promoting inclusivity and equality, and TVET qualifications as an inferior pathway to employment [14]. Hence, TVET institutes must take active measures to rebrand and popularise courses among youth and adults. The offering of courses that are in demand and educating the public on the pathways of learning are useful strategies.

Fourth, the TVET provision is mainly publicly funded, and the private sector is reluctant to provide workplace-sponsored learning options [1, 6]. Yet, the private sector partnerships can assist in setting standards for courses, investment in laboratories, curricular updates, and new course introductions. While multi-stakeholder cross-sectoral partnerships are required for the effective implementation of SDGs, national/regional governments are in the best position to be intermediaries facilitating partnerships. Further, policy and regulatory frameworks are vital in monitoring TVET institutes' progress in curricular relevance. Hence, the results must be translated into policy recommendations to address systemic issues of curriculum relevance, teacher development, and financial and infrastructure support.

### 5.4 Conclusion

The paper makes a novel and valuable contribution to the evolving discourse on ESD with specific reference to TVET in South and Southeast Asia. The findings effectively connect with global sustainability frameworks. A key strength of the paper is its theoretical grounding, drawing from both institutionalist and constructivist lenses, to understand the shifting role of TVET in meeting the labour market requirements with global sustainability agendas. Another key strength of the paper is its dual focus on the use of vertical integration and horizontal integration to offer a nuanced understanding of the mechanisms of mainstreaming sustainability into course offerings. The findings on modalities of training, upskilling, and reskilling with micro-credentials and credit transfers in learning pathways imply the intricate challenges TVET institutes face when implementing SDGs into curricula. Moreover, the findings on partnership dynamics with reference to SDG17 show the value of multi-stakeholder cooperation and collective engagement for the implementation of SDGs into curricula and monitoring of progress. Finally, the paper offers rigorous empirical underpinning, which allows to test differences in terms of region and GDP growth. The prevalence of differences conveys that national and regional economic conditions impact on a country's skill formation systems. Therefore, the findings have theoretical, practical, and policy relevance for several audiences, such as researchers, academics, policymakers, education practitioners, and industry stakeholders.

### 5.5 Limitations and future study

First, in the data collection, the study relied on an email directory that may have underrepresented private TVET institutions of the respective countries. Therefore, future research should consider having better representation in the sample selection. Second, the level of analysis is 'course level', i.e., the implementation of sustainability in course offerings. It is also important to understand 'institutional' and 'systemic' level integrations for sustainability. Hence, future research could consider incorporating these two levels. Third, we investigated the implementation of SDGs along the line of ESD. An understanding of SED could also provide valuable information, such as investments in training, infrastructure availability, digital transformations for course delivery, and teacher availability. In addition, future research can investigate public–private partnerships or stakeholder partnerships to analyse funding flows for upskilling and reskilling, targeting business transformations involving greening and circularity.

**Author contributions**
Both authors contributed equally to this article.

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**Data availability**
All the data is provided within the manuscript.

## Declarations

**Ethical approval**
In accordance with Sect. 2.1 of the University of Moratuwa, the University Ethics Review Committee (UERC) guidelines, this study qualifies for 'minimal-risk research on non-sensitive topics where participation is fully anonymous and voluntary, with no collection of personally identifiable data for processing, analysis, or tracing respondents'. In accordance with Sect. 5.1 of its guidelines, ethical review and ethical clearance are exempted for this type of studies. Accordingly, the study was conducted in compliance with the guidelines stipulated for exempt studies.

**Consent to participate and informed consent**
The consent statement recommended for exempted studies was provided to participants. The participants volunteered were allowed to proceed to complete the questionnaire only after indicating their consent for anonymous participation in the survey and dissemination of findings. Participants were allowed to quit the survey at any time without submitting it.

**Competing interests**
The authors declare no competing interests.

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