Challenges in Sustainability
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Education Access Across Sustainability and Industry 5.0: Evidence from Marginalised Youth in Agri-Startups

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Received: 02-01-2026 **Revised:** 05-18-2026 **Accepted:** 05-19-2026

Citation: Ho, H. & Thai, T. M. (2026). Education access across sustainability and Industry 5.0: Evidence from marginalised youth in agri-startups. *Chall. Sustain.*, *14*(3), 483–498. https://doi.org/10.56578/cis140304.

Abstract: Despite increasing attention to inclusive education, sustainability transitions under the Industry 5.0 paradigm remain constrained by the limited integration of socio-cultural barriers affecting marginalised groups. This study examines how harmful cultural practices (HCPs) and socio-economic conditions are associated with education access among 467 ethnic minority youth engaged in agri-startups, contributing theoretically by linking social norms and human capital perspectives within sustainability transition frameworks. A mixed-methods approach combining regression analysis and the Analytic Hierarchy Process (AHP) is employed to capture both statistical relationships and priority-setting mechanisms. The regression results indicate that early marriage (-0.171), gender bias (-0.199), and restrictive religious norms (-0.127) are associated with lower education access, while household income shows a significant positive association (0.722); the model is statistically significant with acceptable explanatory power (R^2 = 0.315; Adjusted R^2 = 0.280). The AHP results, based on expert evaluation, demonstrate consistent judgments (CR = 8.120%) and identify personal factors (0.341), particularly HCP awareness, as the highest priority, followed by socio-economic conditions (0.310), education and skills (0.212) and cultural–community factors (0.141). These findings suggest that although economic capacity is a dominant enabling factor, individual agency and behavioural change are critical for reducing harmful practices and improving access to education. However, education access reflects both actual and perceived opportunities due to infrastructural constraints in remote areas. Although the study is limited to data from marginalised youth in agri-startups, the findings highlight that education functions as a key enabling condition linking cultural transformation and livelihood improvement, offering policy-relevant insights for designing inclusive, human-centred education systems to support future-oriented Industry 5.0 transitions.

Keywords: Education access; Ethnic minority youth; Harmful cultural practices; Industry 5.0; Analytic Hierarchy Process; Sustainability transitions; Agri-startups

1. Introduction

Education can function as both a mirror and a bridge, reflecting lived realities while enabling transformation. For many ethnic minority youth in Vietnam and globally, it represents dignity, belonging, and hope (UNESCO, 2023), yet this promise is often constrained by harmful cultural practices (HCPs), such as early marriage and gender-based restrictions, that limit educational attainment and perpetuate intergenerational poverty (Buchmann & Hannum, 2001). Addressing these challenges therefore requires approaches that respect cultural identity while dismantling barriers to inclusion and social justice. From a sustainability transitions perspective, education access is increasingly recognised as a systemic enabler that links social inclusion with long-term adaptive and economic resilience. Sustainability transitions research emphasises that technological and economic change must be accompanied by capability development and equitable participation in learning systems. Rather than viewing learning as passive transmission, it emphasises digital skills, resilience, and cultural engagement within a holistic educational ecosystem (Khan, 2025; OECD, 2025). This approach is particularly relevant for ethnic minority youth affected by HCPs, as it supports both skill development and social inclusion. However, this potential remains underexplored, especially in marginalised and culturally constrained contexts.

Industry 5.0 frameworks further emphasise human-centred innovation, inclusive capability building, and

socially responsive technology adoption, positioning education access as a core pillar of transition readiness. Within this perspective, education access serves as a key enabling condition linking human-centred innovation with inclusive sustainability transitions, enabling marginalised groups to participate in emerging socio-economic systems. In rural and agri-startup ecosystems, transition pressures linked to digitalisation and sustainable production are accelerating, but unequal access to education and skills may widen participation gaps if not addressed. Despite growing attention to sustainability transitions and Industry 5.0, there is limited empirical evidence on how harmful cultural practices constrain education access among ethnic minority youth in agri-startup ecosystems. Furthermore, few studies combine analysis of associations with structured prioritisation, limiting their relevance for policy design.

This study examines how education in Industry 5.0 transitions can be leveraged as an important enabling condition that mediates between tradition and opportunity, linking inherited barriers with future livelihoods. Positioning this analysis within sustainability transition theory allows education to be interpreted not only as a social service but also as a form of transition infrastructure that is associated with behavioural, cultural, and economic adaptation. Methodologically, the study integrates regression analysis and the Analytic Hierarchy Process (AHP) to capture both relationships and the relative importance of influencing factors. Regression analysis is employed to test the statistical relationships between reductions in HCPs and education access, whereas AHP complements this by identifying and ranking the relative importance of influencing factors. This combined approach enables the study to provide both empirical evidence and structured prioritisation within a unified research design. Additionally, the study centres on the lived experiences of ethnic minority youth working in agri-startups, a group with limited vocational skills that remains underrepresented in policy and research. This focus responds to calls in sustainability scholarship to generate micro-level empirical evidence from underrepresented social groups involved in emerging innovation ecosystems. By doing so, the study contributes to sustainability transition literature by linking cultural constraints, educational capability, and economic outcomes within a single analytical framework.

This aligns with scholarship that foregrounds student voice and cultural identity in education, as well as with global efforts to utilize education as a lever for sustainable development, gender equality, and digital inclusion. These dimensions correspond with transition principles of social inclusion and capability expansion that underpin sustainable development pathways. Overall, this study demonstrates how culturally responsive, human-centred learning can serve as a facilitator of transformation in marginalised communities. Framing these outcomes within transition dynamics helps connect education access with sustainability and resilience implications. By examining the interplay between HCPs, educational access, and household income, the study highlights the capacity of education to transmit knowledge while also challenging entrenched norms and fostering equity and lasting change. These insights provide practical implications for educators, curriculum designers, and policymakers seeking to design Industry 5.0–aligned education systems that advance inclusive sustainability transitions.

2. Theoretical Basis

2.1 Education Access in Industry 5.0 Transitions

Industry 5.0 heralds a paradigm shift, moving beyond the automation and digitisation focus of Industry 4.0 towards a more inclusive, sustainable, and human-centric model of industrial advancement (Breque et al., 2021). This next-generation framework prioritises resilience, stakeholder well-being, and ethical, sustainable production at the heart of economic development, aligning with contemporary policy debates on striking a balance between technological innovation and social and environmental imperatives. Industry 5.0 presents a unique opportunity to leapfrog towards inclusive growth but also poses formidable challenges: enterprises must embrace advanced technologies and reimagine their supply chains within resource-constrained, rapidly evolving contexts. Building on this perspective, the transition toward Industry 5.0 also requires a corresponding transformation in education and training systems. Education can no longer focus solely on technical competence, but must adopt a human-centred, sustainability-oriented, and innovation-driven approach that equips learners with adaptive capabilities, ethical awareness, and collaborative problem-solving skills. Such an approach is particularly relevant for emerging economies, where strengthening education–skills ecosystems plays a decisive role in enabling enterprises and communities to effectively engage with sustainable Industry 5.0 pathways. Education in Industry 5.0 transitions has emerged in response to the socio-technical transformations of the 21st century, building upon and extending previous models focused on digitalisation (Education 3.0/4.0). This approach emphasises a human-centred, technology-enabled framework that integrates advanced tools such as artificial intelligence, the Internet of Things, extended reality, and blockchain (Hashim et al., 2024). Within this framework, preparing future-ready citizens involves not only developing technical and digital competencies but also fostering socio-emotional, creative, and civic skills, including empathy, ethical reasoning, collaboration, and critical thinking (OECD, 2025). The objective shifts from solely equipping students for the digital economy to cultivating innovators and responsible citizens capable of driving social and entrepreneurial initiatives. Importantly, this orientation aligns closely with

sustainability transitions, which require systemic shifts in production, consumption, and governance supported by new skills, values, and forms of participation. Education access in Industry 5.0 therefore plays a foundational role in enabling sustainability transitions by equipping learners with the capabilities to support inclusive, green, and socially responsible innovation pathways (Zhang & Leong, 2024).

A defining feature of education access in Industry 5.0 is personalised and competency-based learning, which allows youth to progress through flexible and adaptive pathways based on demonstrated skills rather than time-based credentials (Khan, 2025; OECD, 2025). By integrating hard skills such as digital literacy, STEM, and technological problem-solving with soft skills including communication, resilience, and teamwork, education access enhances young workers' employability and capacity to navigate rapidly changing work environments. Although enabled by advanced technologies, meaningful access to education within Industry 5.0 transitions remains fundamentally human-centred, relying on educators as mentors and co-designers who guide learning processes and ensure that young people can fully acquire, apply, and translate these skills into sustainable livelihoods (PricewaterhouseCoopers, 2022). From a sustainability transitions perspective, such human-centred and competency-based models are essential for building adaptive capacity and long-term resilience in vulnerable communities. They also support the diffusion of sustainable practices by strengthening learners' ability to engage with green technologies, circular economy models, and community-based innovation systems across sectors, including agri-startups. In the context of ethnic minority youth engaged in agri-startups, these transitions are particularly critical, as limited access to education and skills may constrain their ability to participate in emerging Industry 5.0 ecosystems.

2.2 Factors Affecting Marginalised Youth's Access to Education

In the context of sustainability transitions and Industry 5.0, inclusive education access is not only a social objective but also a prerequisite for building adaptive, resilient, and human-centred innovation systems. Among the multiple determinants shaping marginalised youth's access to education, HCPs are widely recognised as some of the most persistent and structurally embedded barriers. Drawing on social norms theory, HCPs are understood as socially enforced practices sustained through collective expectations, sanctions, and shared beliefs (Bicchieri & Mercier, 2014). HCPs primarily encompass traditions such as early marriage, rigid gender role restrictions, and social or religious norms that discourage schooling, all of which constrain educational access among ethnic minority youth. Rather than reflecting isolated individual behaviours, these practices are embedded in broader socio-cultural and economic systems, including gender hierarchies and community expectations. While often valued as cultural heritage, these practices can undermine fundamental rights and disproportionately affect women, girls, and other vulnerable groups (Pemunta & Alubafi, 2016). As a result, HCPs reinforce structural disadvantage and limit both educational attainment and livelihood opportunities. HCPs do not operate in isolation but are reinforced through the interaction of personal, educational, socio-economic, and cultural–community factors.

From an individual perspective, limited awareness of the negative consequences of HCPs, low educational attainment, and constrained willingness to challenge entrenched norms reduce individuals' capacity to question practices rooted in patriarchal power structures. Passive social roles and restricted opportunities for participation further weaken individual agency (Boulhane et al., 2024; UNICEF, 2021). From the socio-economic perspective, unstable income and limited financial access often encourage coping strategies such as early marriage, particularly in resource-constrained households (Walker, 2012). Weak market linkages and underdeveloped digital infrastructure exacerbate these vulnerabilities, especially in remote areas. At the education and skills level, restricted access to vocational training, limited digital competencies, entrepreneurship capabilities, and underdeveloped soft skills constrain individuals' ability to pursue alternative livelihood pathways and engage in social transformation processes (OECD, 2025). From a capability approach perspective, these constraints limit individuals' ability to convert educational opportunities into meaningful functionings, thereby restricting both personal development and participation in emerging economic systems. These dimensions correspond to the key constructs employed in this study, including personal factors (PF), education and skills (ES), socio-economic factors (SE), and cultural and community factors (CC), which jointly shape education access among marginalised youth. At the cultural and community level, the high prevalence of HCPs, combined with strong social pressure from traditional and religious authorities, reinforces social norms that discourage deviation from established practices (Tomalin, 2013). Limited community support and low participation in collective dialogue further entrench these norms. As suggested by social norms theory, change is more likely to occur when collective expectations shift through community engagement rather than through isolated individual actions. Existing evidence indicates that sustainable change requires addressing these interconnected factors simultaneously. While legal reforms are necessary, they are rarely sufficient on their own. Effective strategies enhance HCP awareness, strengthen education and skills, improve socio-economic conditions, and mobilise community participation through inclusive and context-sensitive interventions (Mackie & LeJeune, 2009; Shell-Duncan et al., 2018; UNICEF, 2021).

Within the framework of Industry 5.0, which emphasises human-centred innovation and inclusive capability

development, education access becomes a critical enabling condition for marginalised youth to participate in sustainability transitions. Empirical studies highlight that education access, vocational skills, and entrepreneurial capabilities are closely associated with household welfare and economic participation (Gala et al., 2025; Tran et al., 2020). At the same time, social norm research demonstrates that HCPs significantly constrain access to these opportunities (Cislaghi & Heise, 2020; UNICEF, 2021). Building on this theoretical foundation, this study assumes that reductions in HCPs are associated with higher education access, while enhanced education and skills contribute to greater socio-economic participation within Industry 5.0 contexts. Accordingly, the study adopts a focused set of measurement dimensions covering education access, skills and capability development, socio-economic resources, personal agency, and cultural–community constraints. In this study, education access is conceptualised as encompassing digital learning access, human-centred education approaches, and vocational–innovation integration, consistent with Industry 5.0 principles. Without addressing HCPs, marginalised youth risk exclusion from Industry 5.0 learning ecosystems and sustainability-oriented labour markets. Therefore, analysing HCPs alongside education access provides a critical basis for understanding how sustainability transitions can be made more inclusive and equitable.

2.3 Relation Between Education Access, Harmful Cultural Practices and Household Income

Education in Industry 5.0 transitions can challenge HCPs by fostering critical consciousness and strengthening individuals' capacity to question entrenched norms. Through the development of empathy, communication, and critical thinking skills, education enables young people to engage constructively with families and communities in dialogue about social change (Ahmad et al., 2023; OECD, 2025; UNESCO, 2023). Several systemic conditions shape the effective implementation of education access in the context of Industry 5.0 transitions. In particular, adequate digital infrastructure and equitable access to technology are essential, as persistent digital divides risk exacerbating existing inequalities. Ensuring inclusive access for ethnic minorities and girls in conservative communities is therefore critical. Together, these conditions enable education systems to translate human-centred learning principles into tangible social and economic outcomes. In addition, integrating vocational education with innovation-oriented learning pathways enables learners to translate critical awareness into practical skills and livelihood opportunities, thereby strengthening both educational inclusion and socio-economic empowerment. Collectively, digital inclusion, human-centred pedagogy, and vocational–innovation integration form core enabling conditions through which Industry 5.0-oriented education can expand equitable access while challenging entrenched cultural barriers. In sustainability transition frameworks, such inclusive and capability-oriented education systems are increasingly recognised as enabling conditions for long-term social and economic resilience. This implies that expanding equitable education access under Industry 5.0 is not only an educational objective but also a structural component of inclusive sustainability transitions (Ahmad et al., 2023; Hashim et al., 2024; Zhang & Leong, 2024).

Access to education plays a role in shaping the persistence or decline of HCPs. It is well established that education and income are positively linked. Human capital theory (Becker, 1962) argues that education raises an individual's productivity and earning potential. Empirical studies across the developing world indicate that an additional year of schooling is associated with an increase in wages. Households with higher levels of education tend to have higher incomes and lower poverty rates. In rural areas, basic education can help families diversify beyond subsistence farming, adopt improved agricultural techniques, or access better-paying jobs in towns. According to Tran et al. (2020), each additional year of education raises wages, and households headed by individuals with secondary education earn substantially more. For example, in Vietnam, households headed by someone with a secondary education earn significantly more than those headed by someone with only primary education (Tran, 2023). In addition, education aligned with Industry 5.0 integrates digital literacy, entrepreneurship, and innovation skills and better matches labour market needs (Ahmad et al., 2023). This enables ethnic minority youth to access new income sources while challenging practices that restrict participation, especially for women (UNICEF, 2021). A virtuous cycle emerges in which rising income supports continued schooling (Tilak, 2020; Tran et al., 2020; Tran, 2023).

Education also brings broader life benefits, as it can be associated with higher health outcomes and help people navigate institutions, thereby reducing their vulnerability to shocks (Yang, 2005). This reciprocal relationship between education access and income generation further supports inclusive participation in Industry 5.0 learning and innovation ecosystems. Such feedback dynamics are frequently highlighted in sustainability transition studies as drivers of durable and self-reinforcing social change. Within the framework of education access in Industry 5.0 transitions, expanded educational access enhances young people's exposure to alternative social norms, rights-based values, and future-oriented capabilities (Ahmad et al., 2023; OECD, 2025). Improved access to education strengthens critical consciousness, empathy, and communication skills, enabling young people to question the legitimacy of entrenched practices and to engage families and communities in dialogue about change (UNESCO, 2023). Education influences attitudes, perceived norms, and individual agency, thereby weakening the social expectations that sustain early marriage, restrictive gender norms, and religious customs hindering education.

Empirical evidence consistently shows that higher and more inclusive educational attainment is associated with lower prevalence of harmful practices such as child marriage and gender-based violence, particularly among girls and marginalised groups (UNICEF, 2021). Consequently, equitable access to Education 5.0 functions not only as an enabling condition for skills development but also as a structural lever for transforming harmful cultural norms. From a sustainability transition perspective, this normative and behavioural change function of education is essential for enabling marginalised groups to participate more fully in adaptive and innovation-driven socio-economic systems.

There are some models commonly used to examine the relationships between EduAccess, SE, and CC, including linear regression models, logistic regression, and multi-criteria decision-making approaches. Tran et al. (2020) employed regression analysis to demonstrate that education significantly associates with higher household livelihoods, highlighting the role of schooling in income generation and poverty reduction. Similarly, Jafar et al. (2023) applied econometric regression models to analyse the implication of the digital divide on access to online education, confirming that socio-economic and infrastructural factors significantly shape educational outcomes. In addition to regression-based approaches, several studies have utilised multi-criteria decision-making methods to capture the relative importance of complex and interrelated factors in education and development contexts. Gala et al. (2025) adopted a multi-dimensional evaluation framework to assess strategies for improving digital skills among marginalised youth, emphasising the need to prioritise key factors.

Likewise, Hashim et al. (2024) highlighted the importance of structured evaluation approaches in Industry 5.0-oriented education systems, where multiple technological, social, and institutional dimensions must be considered simultaneously. Overall, prior studies suggest that regression models are effective in testing relationships between education, income, and social constraints, while multi-criteria approaches are better suited for evaluating and prioritising the relative importance of influencing factors in complex socio-economic systems. Although existing research has examined the links between education access, cultural barriers, and livelihood outcomes, limited studies have combined these approaches within a single analytical framework, particularly in the context of Industry 5.0 transitions and marginalised youth in agri-startups. Therefore, this study integrates a regression model and the AHP to simultaneously examine associations and prioritise key determinants, thereby providing a more comprehensive understanding of the factors shaping education access in sustainability transitions. Drawing on social norms theory, HCPs such as early marriage, gender bias, and restrictive religious norms are expected to constrain education access by reinforcing social expectations and limiting individual agency. In contrast, human capital theory suggests that higher household income enhances the ability to invest in education, which is associated with greater access. Based on the above theoretical research and empirical evidence, this study conceptualises HCPs and household income as key factors associated with education access in Industry 5.0-oriented sustainability transitions among ethnic minority youth. Within this study, Industry 5.0 is primarily interpreted as a future-oriented policy and educational framework that informs emerging transition pathways rather than as a fully institutionalised empirical condition. Therefore, the following hypotheses are proposed:

H1: Higher prevalence of early marriage (HCP1) in the community is negatively associated with ethnic minority youths' access to education.

H2: Strict gender role restrictions (HCP2) are negatively associated with ethnic minority youths' educational access.

H3: Social/religious norms that discourage schooling (HCP3) are negatively associated with educational access for ethnic minority youth.

H4: Higher household income is positively associated with access to educational access for ethnic minority youth.

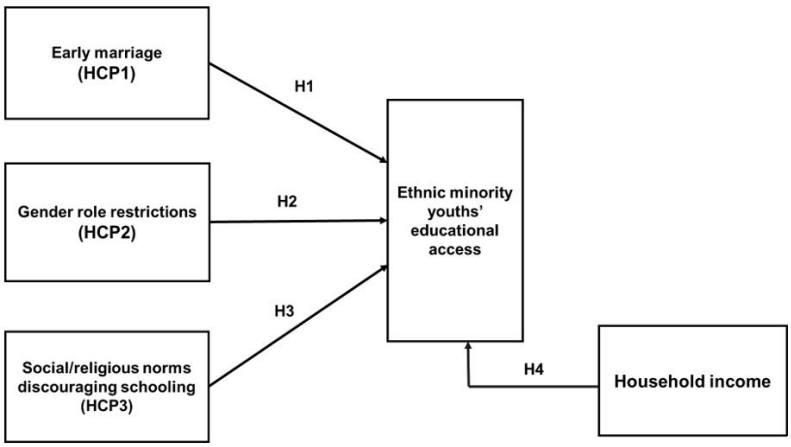

Figure 1. Conceptual model

Figure 1 presents the conceptual framework illustrating the hypothesised associations between HCPs, household income, and ethnic minority youths' educational access in Industry 5.0 transitions.

3. Methodology

3.1. Data Collection

In Vietnam, the national Youth Development Strategy for the period 2021–2030 has been promulgated with the objective of enhancing youth participation in socio-economic development, particularly among disadvantaged and ethnic minority groups. A central focus of this strategy is to promote vocational training, entrepreneurship, and engagement in production and business models aligned with sustainable development and digital transformation. Within this policy framework, ethnic minority youth are encouraged to participate in agricultural production, agri-startups, and value-chain–oriented livelihood models as a pathway to improving income, resilience, and social inclusion. However, youth in remote and marginalised regions continue to face structural challenges, including limited access to education, skills training, markets, and digital infrastructure, as well as the persistence of HCPs that constrain participation. In response to these challenges, various youth-focused production models have been implemented across mountainous and ethnic minority areas to support skills development and sustainable livelihoods. The data for this study were collected from ethnic minority youth participating in agri-startup and community-based production models in selected disadvantaged regions of Vietnam. These regions were chosen due to their high concentration of ethnic minority populations and their strategic importance in national youth development and sustainable rural transformation efforts.

The survey was conducted with 467 ethnic minority youth working in agri-startups across three provinces of Vietnam: Son La (in the northern highlands), Dak Lak (in the Central Highlands), and Vinh Long (in the Mekong Delta). These regions were selected for their significant ethnic minority populations and to ensure geographic diversity. Within each province, stratified random sampling was employed to include individuals from diverse districts and ethnic groups. Respondents were randomly selected within each stratum from local youth and agri-startup participation lists provided by community organisations and local authorities, ensuring both representativeness and feasibility of access. This study was conducted in accordance with ethical research standards. All participants were informed about the purpose of the study, and their participation was voluntary. Informed consent was obtained prior to data collection, and all responses were anonymised to ensure confidentiality. The survey instrument was developed in English, translated into Vietnamese, and back-translated to ensure accuracy. It gathered data on: (a) demographic characteristics (age, gender, education level, etc.); (b) exposure to or attitudes about HCPs, focusing on three domains including marriage practices, gender role norms, and religious/traditional beliefs that might affect education; (c) aspects of education access in Industry 5.0 transition, measured through participation in relevant training or learning opportunities (digital literacy courses, vocational training, life-skills workshops, sustainability or civic education programs) and current educational status (Ahmad et al., 2023; Khan, 2025); and (d) household income and livelihood indicators (monthly household income, number of income sources, and employment type) (Psacharopoulos & Patrinos, 2018; Tran, 2023).

In addition, to complement the survey data, 30 semi-structured interviews with a purposive subsample of survey respondents and community stakeholders were carried out. This included 20 ethnic minority youth (balanced by gender and spanning the major ethnic groups in the sample), 5 local educators or vocational trainers, and 5 community leaders (such as village elders or youth union leaders). Youth engaged in agri-startups were purposively selected for interviews to represent diverse educational experiences. Each interview typically lasted between 60 and 90 minutes. Interview data were used to contextualise and interpret the quantitative findings, particularly to explain how and why certain cultural practices persist and how education influences behavioural change. The qualitative insights were integrated at the interpretation stage to support and enrich the regression and AHP results rather than being analysed as a standalone dataset.

3.2. Analytical Strategy

A mixed-methods approach combining a regression model and the AHP was adopted to explore the relationships among HCPs, education access, and household income among ethnic minority youth in agri-startups. By combining these methods, the findings from regression analysis and AHP are complementary within the overall research design. While regression analysis identifies the direction and statistical significance of the relationships between HCPs, income, and education access, AHP provides a structured prioritisation of the broader set of influencing factors that may not be fully captured through regression coefficients alone. In other words, the regression model is used to evaluate the factors associated with education access, whereas the AHP model is used to prioritise factors in practice to reduce barriers and identify factors associated with improved outcomes. By integrating these two perspectives, the study not only establishes statistically significant associations but also translates them into actionable priorities for policy and intervention. This complementarity enhances both the

analytical depth and the practical relevance of the research, particularly in complex socio-cultural contexts where statistical significance and real-world importance do not always fully coincide.

Firstly, the regression model was employed to assess the relationship between reductions in HCPs and educational access among 467 marginalized youth engaged in agri-startup models, providing quantifiable evidence of these relationships. The independent and dependent variables, including demographic factors and HCPs (early marriage, gender bias, and religious customs hindering education), were measured using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The criteria included in the study are presented in Table 1. The education access construct reflects both actual exposure and perceived access to Industry 5.0–related learning components, particularly in contexts where access to advanced technologies remains uneven. The education access variable (EduAccess) used in the regression model was computed as the mean score of the three items (EA1–EA3 in Table 2). This aggregation approach is appropriate given the high internal consistency of the scale and allows for reliable estimation of relationships while maintaining interpretability. The regression model is specified as follows:

$$\text{EduAccess}_i = \beta_0 + \beta_1 \text{HCP1}_i + \beta_2 \text{HCP2}_i + \beta_3 \text{HCP3}_i + \beta_4 \text{Income}_i + \beta_k \text{Controls}_i + \varepsilon_i$$

where, EduAccess represents the level of access to education components aligned with Industry 5.0 transition principles, HCP variables capture HCPs (early marriage—HCP1, gender restrictions—HCP2, and religious norms discouraging schooling—HCP3), Income denotes household income level.

Table 1. Operationalization of variables

Variables	Definition	Source
Education access (EduAccess)	Learners' actual and perceived ability to engage with education and training components informed by Industry 5.0 transition principles, including digital, human-centred, and innovation-integrated vocational learning, particularly in contexts where access to advanced technologies remains uneven.	Ahmad et al. (2023); Gala et al. (2025); Hashim et al. (2024); Khan (2025); OECD (2025); Stromquist (2015)
Harmful cultural practices (HCPs)	The level of persistence or reduction of HCPs such as early marriage, gender bias, and restrictive religious customs affecting education.	Marcus & Harper (2014); Stromquist (2015); Tomalin (2013); UNICEF (2021); Walker (2012)
Personal factors (PF)	Individual attributes including awareness of harmful practices, education level, willingness to change, and active participation in learning and social activities.	Bicchieri & Mercier (2014); Karam (2015); Mackie & LeJeune (2009); UNICEF (2021)
Education & skills (ES)	The availability and development of vocational access and key competencies including entrepreneurship, digital, and soft skills.	Boulhane et al. (2024); Gala et al. (2025); Jafar et al. (2023); Marcus & Harper (2014); OECD (2025)
Socio-economic factors (SE)	The socio-economic conditions shaping opportunities through income stability, financial access, market linkages, and digital infrastructure.	Díaz et al. (2025); Gala et al. (2025); Jafar et al. (2023); Tran (2023)
Cultural & community factors (CC)	Community context reflected in the prevalence of harmful practices and the degree of community support and participation in development activities.	Cislaghi & Heise (2020); Karam (2015); Mackie & LeJeune (2009); Shell-Duncan et al. (2018); Tomalin (2013); UNICEF (2021)

Secondly, the AHP model was used to evaluate the relative weights of factors influencing the reduction of HCPs, offering a structured assessment of their importance and priority. This dual approach allows the study to capture both measurable statistical relationships and contextual, qualitative insights (Braun & Clarke, 2006). The AHP is used to evaluate the relative importance of multiple influencing factors on education access in Industry 5.0 transitions and HCP reduction, which are often complex, interrelated, and context-specific. The AHP enables researchers to structure expert judgments, assign weights, and rank factors in a systematic way, providing clarity on which social, cultural, or economic factors are most strongly associated with education access and HCP reduction. The criteria included in the AHP model are PF, ES, SE, and CC identified as influencing EduAccess and HCP reduction. In this study, factors were compared using a 1–9 pairwise comparison scale, as commonly applied in AHP methodology, to quantify expert priorities. The AHP procedure was implemented in two stages: (i) a pilot survey with 20 scientists and experts to establish the hierarchical structure, select criteria, and calibrate the pairwise comparison scale; and (ii) a formal survey conducted through three workshops across three surveyed provinces with 60 experts, including 15 scientists, 15 local government officials, and 30 agri-startup owners. In the context of education and agri-startups preparing for Industry 5.0, these participants are considered to possess

knowledge of operations, resources, and strategic decision-making, making them appropriate experts for AHP-based studies on access to Education 5.0 for sustainable development. Consistency was evaluated for each pairwise comparison matrix using the Consistency Ratio (CR) following Saaty (1980). Matrices with CR ≤ 0.10 were accepted for further analysis. Final weights were aggregated across expert evaluations by normalizing and averaging the valid matrices, thereby reducing individual bias and enhancing the stability of the results. This selection strategy ensured a diverse and representative sample, capturing a broad range of perspectives necessary for reliable and valid pairwise comparisons in the AHP analysis.

Table 2. Measurement items and constructs

Factors	Cronbach's α	Items	Code	Example Item
Education access (EA)	0.861	Digital learning access	EA1	"How important is digital learning access in improving education access for marginalised youth in agri-startups?"
		Human-centred learning	EA2	"How important is human-centred learning in enhancing education access for marginalised youth?"
		Vocational–innovation integration	EA3	"How important is vocational–innovation integration in supporting education access within Industry 5.0-oriented agri-startups?"
Reduction of harmful cultural practices (HCPs)	0.813	Early marriage	HCP1	"How important is reducing early marriage in improving education access for marginalised youth?"
		Gender bias	HCP2	"How important is reducing gender bias in enabling sustained participation in education?"
		Religious customs hindering education	HCP3	"How important is reducing religious or customary norms that restrict education participation?"
Personal factors (PF)	0.707	HCP awareness	PF1	"How important is awareness of HCPs in reducing barriers to education access?"
		Educational level	PF2	"How important is educational level in enabling youth to challenge harmful practices?"
		Change willingness	PF3	"How important is willingness to change traditional practices in improving education access?"
		Active participation	PF4	"How important is active participation in learning and livelihood activities for education access?"
Education and skills (ES)	0.845	Vocational access	ES1	"How important is access to vocational training in improving education and livelihood opportunities?"
		Entrepreneurship skills	ES2	"How important are entrepreneurship skills for enabling sustainable agri-startup participation?"
		Digital skills	ES3	"How important are digital skills in supporting education access and work participation in Industry 5.0 contexts?"
		Soft skills	ES4	"How important are soft skills in enabling effective learning and social engagement?"
Socio-economic factors (SE)	0.821	Income stability	SE1	"How important is income stability in supporting sustained education participation?"
		Financial access	SE2	"How important is access to financial resources for enabling education and agri-startup activities?"
		Market linkage	SE3	"How important are market linkages in supporting sustainable livelihood pathways?"
		Digital infrastructure	SE4	"How important is digital infrastructure in improving education access in marginalised areas?"
Cultural & community factors (CC)	0.843	HCP prevalence	CC1	"How important is the prevalence of HCPs in constraining education access?"
		Community support	CC2	"How important is community support for education and youth entrepreneurship?"
		Community participation	CC3	"How important is community participation in reducing cultural barriers to education access?"

4. Results and Discussion

4.1. Descriptive Statistics of Demographic-Economic Variables

The 467 respondents are ethnic minority youth engaged in agri-startup models across Vietnam's Northern, Central, and Southern regions. Most participants are young, primarily aged 19–22 and 23–26, with female involvement slightly exceeding male participation, highlighting the growing role of women in agri-startups. The majority have vocational or university education, households average about five members, and key ethnic groups include Muong, Thai, Dao, Ede, and Tay; moreover, most respondents belong to organizations such as the Youth

Union, Communist Party, or cooperatives, reflecting strong social and institutional connectivity that support the development of agri-startups (Table 3).

Table 3. Descriptive statistics of demographic-economic variables

Variables	Descriptions	Code	Mean	SD	Min	Max
Age	The age of respondents (year)	1 = 16–18 years; 2 = 19–22 years; 3 = 23–26 years; 4 = Above 26 years	2.031	0.290	1	4
Gender	Respondent gender	1 = Male; 2 = Female	1.652	0.471	1	2
Education	The educational level of respondents	1 = Secondary school; 2 = Vocational training; 3 = University; 4 = Postgraduate	2.940	0.841	1	4
Household size	Number of members in the household	Members	4.961	1.292	1	9
Ethnicity	The ethnicity of respondents	1 = Muong; 2 = Thai; 3 = Dao; 4 = Ede; 5 = Tay	2.320	1.131	1	5
Household income	Total annual income of the respondent's household	Million VND per year	136.500	158.330	3	900
Digital training course participation	Participation in digital skills related training courses	1 = Never participated; 2 = Occasionally participated; 3 = Frequently participated; 4 = Regularly participated	2.412	0.881	1	4
Joining associations	Involvement in social, professional, or community groups	1 = Youth Union; 2 = Communist Party; 3 = Cooperative; 4 = Other organizations	2.951	0.372	1	4

Besides, household income among ethnic minority participants shows substantial variation, with an average annual income of approximately 137 million VND, ranging from 3 to 900 million VND per year. This wide dispersion (SD = 158.330) reflects significant differences in production scale, market integration, and access to resources across regions.

4.2. Reductions in Harmful Cultural Practices Influencing Educational Access of Ethnic Minority Youth in Agri-Startups

The regression model is statistically significant, indicating that the explanatory variables are jointly associated with educational access among ethnic minority workers in agri-startups. The model shows a moderate explanatory level ($R^2 = 0.315$; Adjusted $R^2 = 0.280$), which is reasonable for social and behavioural research on complex socio-cultural factors, suggesting that cultural and social determinants play an important role in educational access as well as additional unobserved socio-cultural and institutional factors may also be associated with education access. The regression results presented in Table 4 indicate that ethnic minority youth's access to education within agri-startups is jointly associated with demographic, socio-economic, and particularly cultural factors in the form of HCPs. These findings provide empirical support for the conceptual model by identifying the direction and statistical significance of key relationships, which are subsequently complemented by the AHP analysis in prioritising the relative importance of these factors. These factors are highly relevant in the context of the ongoing transition toward Industry 5.0, which emphasises human-centred development, inclusiveness, and knowledge-intensive skills.

In Table 4, regarding demographic factors, age exhibits a positive and statistically significant associations with educational access (0.024), suggesting that older youth tend to have better access to education. In contrast, gender has a negative association (-0.065), indicating persistent gender disparities in educational access among ethnic minority youth. Such disparities are a substantial barrier to the development of inclusive human capital aligned with the principles of Industry 5.0. Household size negatively affects educational access (-0.067), implying that economic pressures and family responsibilities may constrain learning opportunities, particularly participation in digital skills training, innovation-oriented education, and agri-startup management programs. Conversely, participation in social organizations has a positive and statistically significant association (0.181), highlighting the critical role of social networks and intermediary institutions in facilitating access to information, training, and educational support relevant to smart agriculture and sustainable development. Participation in digital training courses is positively and significantly associated with educational access (0.092), suggesting that engagement in digital capacity-building activities is associated with greater readiness among ethnic minority youth to participate in Industry 5.0–related educational and entrepreneurial opportunities. In addition, significant differences across

regions (0.087) and ethnic groups (0.061) reflect persistent inequalities in educational infrastructure, technological readiness, and access to knowledge among different geographical areas and ethnic communities.

Table 4. The results of the regression model

Variables	Coefficient	SE	*p*-Value
Age	0.024	0.011	0.032
Gender	-0.065	0.028	0.021
Household size	-0.067	0.038	0.079
Joining associations	0.181	0.071	0.012
Household income	0.722	0.251	0.004
Regions	0.087	0.038	0.022
Ethnicity	0.061	0.027	0.025
Digital training course participation	0.092	0.039	0.021
Early marriage (HCP1)	-0.171	0.054	0.002
Gender bias (HCP2)	-0.199	0.068	0.004
Religious customs that hinder education (HCP3)	-0.127	0.049	0.010
Constant	0.294	0.121	0.015
Observations	467	–	–
Prob > F	0.000	–	–
R^2	0.315	–	–
Adj R^2	0.280	–	–

Notably, all examined HCPs demonstrate negative and statistically significant associations with educational access. Among these, early marriage (HCP1) (-0.171) and gender bias (HCP2) (-0.199) emerge as the most substantial barriers, significantly reducing learning opportunities for ethnic minority youth. In addition, religious and social norms that discourage schooling (HCP3) also exert a pronounced negative association (-0.127). While regression analysis identifies these associations in terms of magnitude and significance, it does not fully capture the relative priority of intervention areas, which is addressed through the AHP results. These findings indicate that beyond economic and infrastructural investments, transforming social perceptions and reducing entrenched cultural constraints are essential for enhancing educational access in a human-centred Industry 5.0 context. HCPs, such as early marriage, strict gender roles, and schooling taboos, significantly hinder youth participation in Education 5.0 opportunities (Nguyen et al., 2020). Youth from communities with higher prevalence of these practices were less likely to remain in school, engage in digital or vocational programs, or pursue non-traditional learning paths, highlighting the strong association between cultural norms and educational trajectories (UNICEF, 2021). Qualitative interviews confirmed this, showing teenage marriage and traditional gender expectations often forced ethnic minority youth out of school and into family labor. More importantly, interview evidence helps explain the enabling conditions underlying the statistical relationships, illustrating how cultural expectations are reproduced within households and communities and how they influence educational decision-making processes.

With respect to economic factors, household income shows a strong positive association with educational access (0.722), underscoring the importance of economic capacity in enabling ethnic minority youth to invest in education, technology, and new competencies required for agri-startups under the Industry 5.0 paradigm. This relatively large coefficient is contextually plausible in the case of agri-startup models in Vietnam, where access to education, particularly training related to digital skills, innovation, and value-chain participation, often requires direct financial investment from households. In many remote and mountainous areas, public provision of advanced training, digital infrastructure, and Industry 5.0–oriented learning opportunities remains limited, meaning that participation is highly dependent on a household's ability to cover costs such as tuition, transportation, devices, and internet access. As a result, income becomes a critical enabling condition that influences whether youth can participate in education and training, thereby producing a stronger observable statistical association compared to other factors. While some respondents reported engagement with digital tools and basic technology-enabled learning, access to advanced Industry 5.0 technologies (e.g., AI, IoT) remains limited. Therefore, education access captures a combination of actual exposure and perceived or aspirational access. This quantitative finding is further supported by interview data, where respondents consistently reported that financial constraints limited their ability to participate in training programs, while improved income was associated with continued schooling and skill development. Greater access to education and Industry 5.0–oriented training opportunities was positively associated with higher household income, as skills from digital, vocational, and language programs enabled youth to secure higher-paying jobs and diversify livelihoods (Tran et al., 2020). In turn, higher household income was associated with continued educational participation by covering school fees, technology, and transportation, creating a virtuous cycle between education and income (Tilak, 2020). However, youth from poorer households often missed training opportunities due to financial constraints, highlighting the need for scholarships or flexible program designs to ensure inclusive access to innovation-oriented education initiatives.

4.3. Factors Associated with Reducing Harmful Cultural Practices

The AHP results for the factors indicate that the average CR of the pairwise comparison matrices rated by the experts was 8.120%, below the acceptable threshold (CR < 10%), reflecting a satisfactory level of consistency among the evaluations. Therefore, the experts' judgments are considered reliable for subsequent analyses. For Level 1 factors, the AHP results indicate that personal factors (PF) carry the highest priority weight (0.341), ranking first among all factor groups (see Table 5). This finding underscores the pivotal role of individual awareness, maturity, attitudes, and behavioral agency in sustaining or transforming HCPs. Quantitative results are reinforced by qualitative evidence showing a clear age and maturity association: older youth were significantly less likely to accept or comply with practices such as early marriage. With each additional year of age within the 18–35 range, respondents were less inclined to perceive teenage marriage as normal or acceptable. Interview data further suggest that life experience and exposure to the negative consequences of early marriage among peers foster greater resistance to traditional pressures, supporting arguments on cohort differences and agency development (Walker, 2012). As educational access expands and marriage is delayed, these individual-level changes may generate broader normative shifts, gradually shifting community norms.

Table 5. The results of Analytic Hierarchy Process (AHP) model for level 1 factors

Factors	Weight 1	Rank
Personal factors (PF)	0.341	1
Education and skills (ES)	0.212	3
Socio-economic factors (SE)	0.314	2
Cultural and community factors (CC)	0.141	4

Furthermore, SE rank second (0.314), highlighting the strong role of income stability and access to financial resources on the persistence of HCPs. This finding is consistent with the regression results, where household income was found to have a strong positive association with education access, reinforcing the interconnected role of economic capacity across both analyses. This aligns with evidence that economic vulnerability reinforces reliance on traditional practices as informal safety mechanisms. Participation in vocational training and youth associations was found to correlate with lower prevalence of HCPs across domains, as such engagement broadens social networks, exposes youth to alternative norms, and enhances their perceived stake in future-oriented development pathways (Karam, 2015; Shell-Duncan et al., 2018). The education and skills (ES) group ranks third (0.212), reflecting its role as an enabling condition for long-term normative change. Beyond formal schooling, non-formal and extracurricular education, particularly training that emphasizes critical thinking, communication, and social responsibility emerges as highly influential in reshaping attitudes toward gender roles and education.

Finally, cultural and community factors receive the lowest weight (0.141), suggesting that while community norms matter, their associations are largely mediated through individual empowerment and socio-economic change (World Bank, 2018). The extent of change in HCPs varied notably by ethnic group and region. Controlling for other factors, respondents from some communities (particularly certain highland ethnic groups) reported significantly higher persistence of practices like arranged teen marriages or stringent religious taboos, whereas others indicated these were lessening. This aligns with the idea that cultural change is not uniform; it depends on local history, leadership, and exposure to outside influences. One elder from Son La admitted that in his village, "people still think a girl must marry by 18, because that is how it has always been," whereas an elder from Vinh Long noted that "now most families want their daughters to finish high school first". Studies such as Khan (2025) further illustrate how tribal women in regions like Ganderbal face compounded educational exclusion due to entrenched socio-cultural constraints. The policy implication is that interventions must be tailored; strategies that work in one community (such as involving monks and teachers to discourage child marriage among Thai communities) might differ from those needed in another (such as engaging clan leaders among Dao). There is no one-size-fits-all solution; instead, context-specific, culturally sensitive strategies are essential. The effort to eliminate harmful practices is multifaceted. These findings suggest that personal development and values-oriented education (e.g., soft skills, ethics, and sustainability content…) complement structural approaches (such as vocational opportunities and community engagement…) in supporting shifts in attitudes and educational participation. Strengthening youth's knowledge, critical thinking skills, and supportive networks may help reduce adherence to restrictive social norms and improve engagement with education and livelihood opportunities. However, efforts should be carefully designed to benefit everyone and consider local contexts; otherwise, well-meaning programs might have limited effectiveness or bypass those most affected.

For Level 2 factors in Table 6, the highest-ranked factors are HCP awareness (0.133), market linkage (0.116), and financial access (0.113), highlighting the central importance of individual awareness and socio-economic enabling conditions in reducing HCPs and improving education access. In contrast, entrepreneurship skills (0.024) and educational level (0.034) receive the lowest priority weights, suggesting that formal qualifications and business-oriented competencies alone may be insufficient to drive meaningful socio-cultural transformation

without broader structural and normative support. According to the personal factors group, awareness of HCPs exhibits the highest total weight (0.133), followed by willingness to change (0.106) and active participation (0.069). These findings resonate strongly with interview data, where older youth emphasized having seen the consequences of early marriage and therefore actively resisting its continuation. Such patterns are consistent with cognition-based behavioral change frameworks, which stress awareness and intentionality as prerequisites for norm transformation (Ajzen, 1991). In the education and skills group, soft skills emerge as the most influential component (0.085), followed by vocational access (0.060), digital skills (0.045), and entrepreneurship skills (0.024), indicating a clearer hierarchy of skill relevance. These results further reveal that participation in soft-skills and life-skills training, often embedded within Education 5.0-oriented programs, was one of the important factors associated with reduced gender bias. Workshops on communication, leadership, and gender equality helped both young women and men to question assumptions such as prioritizing boys' education, supporting prior findings on the potential role of non-formal education in normative change. Additionally, exposure to values-based education, including sustainability and social responsibility, was associated with reduced adherence to harmful religious or cultural practices, as such content encourages reflection on fairness, long-term community well-being, and inclusion (Boulhane et al., 2024).

Table 6. Analytic Hierarchy Process (AHP) results for level 2 factors

Factors	Weight 1 (w1)	Items	Weight 2 (w2)	Total Weight (w1*w2)	Total Rank
Personal factors (PF)	0.341	HCP awareness	0.390	0.133	1
		Educational level	0.101	0.034	14
		Change willingness	0.311	0.106	4
		Active participation	0.201	0.069	6
Education and skills (ES)	0.212	Vocational access	0.284	0.060	7
		Entrepreneurship skills	0.113	0.024	15
		Digital skills	0.213	0.045	10
		Soft skills	0.401	0.085	5
Socio-economic factors (SE)	0.314	Income stability	0.133	0.041	13
		Financial access	0.361	0.113	3
		Market linkage	0.370	0.116	2
Cultural and community factors (CC)	0.141	Digital infrastructure	0.143	0.044	11
		HCP prevalence	0.331	0.047	9
		Community support	0.370	0.052	8
		Community participation	0.301	0.042	12

Regarding SE, market linkage (0.116) and financial access (0.113) emerge as the two dominant drivers of educational access, with market linkage slightly surpassing financial access in importance, followed by digital infrastructure (0.044) and income stability (0.041). However, findings related to entrepreneurship programs indicate mixed associations. While entrepreneurial training encouraged questioning of superstition and rigid beliefs, it did not consistently translate into more equitable gender norms. This may reflect gender-blind program designs that inadvertently reinforce male-dominated economic roles, underscoring the need to integrate gender and social-norm components into economic empowerment initiatives. This suggests that economic resources alone are not sufficient to transform deeply embedded social expectations; rather, financial empowerment needs to be accompanied by reflective learning and norm-sensitive facilitation. From a sustainability transition perspective, stable income and inclusive financial access function as enabling conditions that allow marginalised youth to remain in education and participate more actively in innovation-oriented agri-startup ecosystems.

Within the cultural and community factors group, community support holds the highest weight (0.052), followed by HCP prevalence (0.047) and community participation (0.042). Qualitative evidence highlights significant community and regional variation in the pace of change. Some ethnic groups and regions continue to exhibit strong adherence to early marriage and restrictive norms, whereas others report notable shifts toward later marriage and continued schooling for girls. These findings reinforce the argument that cultural change is context-specific and shaped by local leadership, history, and exposure to external influences (Khan, 2025). The variation observed across communities further indicates that interventions should be locally co-designed rather than uniformly replicated, as identical program models may generate very different outcomes across cultural settings. In addition, the relatively higher weight of community support compared to HCP prevalence suggests that positive social capital and collective endorsement of change can be more influential than the mere existence of harmful norms. This highlights the strategic role of community mentors, local organisations, and youth networks in accelerating norm change and strengthening education access within Industry 5.0–oriented rural transformation processes.

Overall, the AHP results demonstrate that reducing HCPs requires prioritizing individual awareness, maturity, and agency, while simultaneously strengthening soft skills, values-based education, economic security, and

community engagement. In combination with the regression results, which quantify the association of HCPs and income with education access, the AHP findings provide a complementary perspective by identifying which factors should be prioritised in practice. This integrated interpretation enhances the robustness of the research design by linking statistical explanation with decision-oriented prioritisation. From a sustainability transitions perspective, these priorities highlight that social inclusion and capability development are foundational conditions for long-term transformation within emerging Industry 5.0-oriented transition pathways. The results also show that HCPs are a barrier to educational access, and that education in Industry 5.0 transitions may serve as an important enabling condition for economic improvement, with education and income showing a potentially reinforcing relationship with each other. This reinforcing dynamic is particularly important in agri-startup ecosystems, where skills, innovation capacity, and adaptive learning directly shape sustainable livelihood pathways. These findings support the core premise of the conceptual model: education can act as a facilitator that simultaneously challenges social norms and enhances material well-being. In this sense, expanding education access is not only a social intervention but also a transition mechanism supporting more inclusive and human-centred sustainability transitions. The results show the importance of addressing cultural constraints in tandem with expanding educational opportunities. From a policy perspective, education approaches aligned with Industry 5.0 principles should be adapted to local socio-cultural conditions and accompanied by poverty-reduction measures to help break the cycle of low education and low income, contributing simultaneously to SDG 4 (quality education), SDG 5 (gender equality), and SDG 10 (reduced inequalities). Within Industry 5.0 transitions, this also supports more equitable participation in innovation-driven and sustainability-oriented economic activities. To achieve this potential, policymakers must address both structural barriers and deeply rooted social norms, ensuring that education initiatives aligned with Industry 5.0 transition principles are genuinely inclusive and accessible to those most at risk of exclusion. This is especially critical for marginalised youth in agri-startups, whose inclusion depends on whether sustainability transitions are broad-based or uneven in practice.

5. Conclusions

This study demonstrates that HCPs remain a major barrier to educational advancement among Vietnam's ethnic minority youth, while also highlighting the transformative potential of education access in Industry 5.0 transitions. As can be seen from the model results, the findings show that HCPs including early marriage (-0.171), gender bias (-0.199), and restrictive religious and customary norms (-0.127) remain significant barriers to educational access while AHP results indicate that personal factors carry the highest priority weight (0.341), followed by socio-economic factors (0.310) and education and skills (0.212), while cultural and community factors have the lowest weight (0.141). Overall, the mixed-methods approach (regression and AHP) shows that reductions in HCPs are associated with higher education access, while household income is positively associated with education access. Education is linked to an important enabling condition enhancing income and suggesting a reinforcing relationship between learning and livelihood improvement. However, effective interventions must simultaneously address entrenched socio-cultural constraints to ensure equitable participation in Industry 5.0 development pathways. Education in this context serves a dual role including helping equalise economic opportunities and acting as an agent of social change by contributing to shifts in oppressive norms. Key factors, such as age, exposure to soft skills, HCP awareness and economic security, amplified these positive associations, highlighting the importance of both individual empowerment and collective action.

Notably, the findings also show that initiatives lacking a social or gender lens (for example, some entrepreneurship programs) did not fully deliver on changing norms and could even inadvertently reinforce them. This finding reinforces the need for education reform to be intentionally inclusive and culturally sensitive to achieve its transformative potential as well as support the view that bridging tradition and transformation requires an integrated approach. To realise these outcomes, stakeholders must take deliberate steps to make Education 5.0 truly inclusive. No matter how innovative a curriculum or technology is, it will not benefit those who are forced to drop out or never attend school. Ensuring that education becomes a space of healing, empowerment, and opportunity for marginalised communities requires tackling both the hard barriers (like infrastructure and cost) and the soft barriers (social norms and attitudes). Education approaches aligned with Industry 5.0 principles offer a framework for this by engaging learners not just as recipients of information, but as co-creators of knowledge and change. These findings are encouraging, suggesting that even in remote, tradition-bound communities, young people are ready to embrace positive change if given the opportunity. Translating these insights into policy and practice, the study proposes a multi-pronged strategy to maximise the association of education access in Industry 5.0 transitions in marginalised, culturally diverse communities:

Firstly, cultural relevance should be central to education reform. Policymakers should work with communities to distinguish traditions that support learning from those that hinder it, while ensuring curricula and pedagogy respect local languages, histories, and identities. Engaging community elders and religious leaders as partners helps frame education as aligned with local values rather than an external imposition, increasing acceptance and reducing harmful practices.

Secondly, education approaches aligned with Industry 5.0 principles should be embedded in national curricula and teacher development. Curricula need to emphasise vocational skills, digital skills, critical thinking, soft skills, entrepreneurship skills and project-based learning linked to real community issues. Teacher training should shift mindsets toward innovation and student-centred learning. Clear guidelines on gender- and norm-sensitive are also essential for addressing sensitive topics such as early marriage or gender roles.

Thirdly, reducing educational exclusion requires financial, material, and infrastructural support. Scholarships, conditional cash transfers, school meals, dormitories, and subsidies for learning materials can ease economic pressures that link to dropout. Improving transport and ensuring equitable digital access through devices, community internet hubs, or subsidised educational connectivity are also critical to preventing the digital divide from widening inequalities.

Fourthly, policies should adopt participatory approaches that co-design interventions with local communities. Community consultations can identify potential resistance and generate culturally appropriate solutions, such as alternative rites of passage or mentorship models instead of purely punitive approaches to early marriage. Region-specific strategies should target dominant HCPs and local needs related to young people's school retention, legal enforcement, and collaboration with religious leaders.

Fifth, given their strong relationship with social norms, soft skills as well as values-based education should be treated as a core component of education approaches aligned with Industry 5.0 principles. Life skills, gender equality, and civic education can be delivered through dedicated classes, integrated subject content, or extracurricular clubs that foster leadership and critical reflection. In addition, addressing the intertwined challenges of culture, education, and poverty requires coordinated, cross-sector collaboration. Alignment among schools, NGOs, international organisations, and private-sector actors such as telecommunications or technology firms can amplify the reach and sustainability of Education 5.0 initiatives.

While the study provides valuable insights, several limitations must be acknowledged. First, the data are cross-sectional, limiting our ability to make strong causal claims. Although results align with the hypotheses (e.g., HCPs reduce educational access, and education boosts income), causality cannot be confirmed without longitudinal data. More progressive communities (due to unmeasured factors) may both have fewer harmful practices and embrace education approaches aligned with Industry 5.0 principles more readily. Longitudinal or experimental designs are needed to confirm directionality. While geographically and ethnically diverse, the sample is not fully representative of Vietnam's entire ethnic minority population. Besides, the qualitative component, though rich, included only 30 interviews, which may not capture all viewpoints, particularly given the community's diversity. Despite these limitations, convergence between our quantitative and qualitative findings strengthens confidence in the results. Future work using longitudinal data, larger qualitative samples, or intervention trials would be valuable.

Author Contributions

Conceptualization, H.H. and T.M.T.; methodology, H.H. and T.M.T.; software, H.H.; validation, H.H. and T.M.T.; formal analysis, H.H.; investigation, H.H. and T.M.T.; resources, H.H.; data curation, H.H.; writing—original draft preparation, H.H.; writing—review and editing, H.H. and T.M.T.; visualization, H.H.; supervision, H.H.; project administration, H.H.; funding acquisition, H.H. All authors have read and agreed to the published version of the manuscript.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Acknowledgements

The authors would like to thank Dr. Pham Van Luong, Dr. Nguyen Thi Tho (Vietnam Youth Academy, Hanoi, Vietnam) for their valuable administrative and research support.

Conflicts of Interest

The authors declare no conflicts of interest.

Declaration on the Use of Generative AI and AI-assisted Technologies

The authors declare that artificial intelligence (AI) tools were used solely to assist with language editing and improving the clarity of expression during the preparation of this manuscript. Specifically, ChatGPT was used to refine grammar, sentence structure, and readability in selected sections of the text.

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