Creating high-tech ‘agropreneurs’ through education and skills development

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ABSTRACT
Under current population growth and demographic trends – with food demand projected to increase by 60%–70% by 2050 – another quantum leap in food production and disruptive change in agricultural and food systems are needed in Asia. Certainly, the Green Revolution and other technological advances enormously improved agricultural productivity on the region’s farms. But to fully benefit from an infusion of advanced knowledge and high technologies, agricultural workforces need ‘Industry 4.0’ skills, but for now are falling short. This paper argues that investing in education and skills development to create a new breed of ‘agropreneurs’ in Asian developing countries is crucial.

INTRODUCTION

As Asian populations grow, incomes rise, and dietary preferences change, food production must rise. By 2050 Asia’s population is expected to reach 5.3 billion, from the 4.5 billion in 2017 (60% of the global total) (United Nations, Department of Economic and Social Affairs, Population Division, 2017). To meet this greater demand by 2050, food production needs to increase by 60%–70% by that year, from 2005–2007 baseline.

Asia is already the world’s largest food market. With its middle-class fast expanding, it will likely account for half of the annual global increase in beef and poultry consumption and over three-quarters of the rise in fish consumption from 2017 to 2030 (Food and Agriculture Organization [FAO], 2019). By then, more than 60% of developing world cereal demand will come from South and East Asia.

As such, traditional, input-driven agriculture is no longer an option. Until now, Asia’s farms have typically increased resource-use intensity to raise production and serve burgeoning demand. But emerging supply- and demand-side challenges call for more innovative and knowledge-intensive agriculture in which the capacity of the agricultural workforce will be important game changers. Greater investment in education and skills development will be crucial in developing a new breed of high-tech ‘agropreneurs’, or rather, entrepreneurs with a mastery of high-technology products and services to

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improve agricultural productivity and the value chain. Such agropreneurs can more readily embrace the potential in automation and data-exchange technologies such as cloud and cognitive computing, or the internet of things, and others emerging under the ‘Industry 4.0’ revolution.

This paper describes agriculture’s transition from traditional input-intensive subsistence production systems to more modern, knowledge-intensive business enterprises. It then assesses the role of agricultural education and skills development systems in this transition. The last section provides key conclusions and recommendations.

Evolving agricultural science, knowledge, and practice

Traditional agriculture

Agricultural practices in the recent past have evolved mostly by focusing on improvements in resource inputs. Until the 19th century, food production grew largely by expanding cultivated land area and using limited farm machinery in operations (such as seedbed preparation, seeding and/or planting, weed control, and water management). And the 20th century’s first decade brought the use of low-cost nitrogen as a fundamental scientific breakthrough.

Modern production techniques arising out of the mid-1960s Green Revolution in Asia then allowed smallholder farmers to triple cereal production, ensuring food for millions of people, especially in South and Southeast Asia. During this period, recommended crop production technologies included use of the best available commercial varieties, including hybrids and proper land preparation and seeding. It also stressed proper application of fertilizers and crop protection chemicals, timely weed control, and efficient water management. Better postharvest handling of crops also reduced losses from spoilage and infestation and allowed farmers to hold stocks while waiting for more favorable market prices (Borlaug, 2000).

Global trends since the 1960s have seen population growth hold relatively steady at 1.6% per year, yet cereal production rose at a faster 2.2%. This was due mainly to 2.0% annual average growth in yields (Food and Agriculture Organization [FAO], 2017); per capita supply of cereals in 2014 was thus 40% higher than it was in 1961. By 2050, however, cereal production will need to be 60% higher than the 2005–2007 baseline, based on projected global population of 9.8 billion people by then (United Nations, Department of Economic and Social Affairs, Population Division, 2017).

Emerging challenges

Agriculture over the ages has been viewed as a way of life: highly dependent on nature (weather conditions), very much driven by input supply (land, labor, materials, water resources), and subject to uncertainties (market prices). The agriculture market is fragmented and conservative, and the majority of farmers in Asia and the Pacific are smallholders. Increasing farm productivity under this approach requires more capital, labor, and material inputs at the same time, even as harvest failures hold consequences for food security and livelihoods. However, a range of emerging biophysical and socio-economic issues is challenging tradition (Figure 1).

On the demand side, steady population growth, rapid urbanization, changing dietary preferences, and evolving consumer mindsets about food are pressing in. And in the last
3 decades, most Asian economies have progressed from low-income to middle- or high-income status, this rising affluence fueling urbanization and making urban areas more attractive to rural dwellers. During 1980–2017, Asia’s total population increased 1.5% per year, on average, driven by urbanization: urban population grew an average 3.1% and rural only 0.4% per year. About 50% of Asia’s population is now urban and may reach 57% by 2030 and to 66% by 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2018).

Urbanization and higher incomes, in addition to increasing female labor force participation, are changing dietary patterns. Preferences are shifting to animal proteins, fruits, vegetables, and processed and packaged products (ADB, 2011), putting pressure on traditional production systems. Likewise, rising affluence accompanied by greater consumer awareness have led to demand for ‘clean’ foods produced sustainably, a noticeable change in mindset. In some food systems, supply chains to deliver food from ‘farm to table’ now use modern identity preservation techniques, cold chain management, and blockchain technology.

On the supply side, traditional/conventional agricultural production systems have been increasingly pressed against resource limitations. Area expansion is now limited due to land degradation, conversion, and urbanization. Extractive systems from competing users have depleted water resources, and agrochemical pollutants have degraded soil and water quality. Environmental degradation has made huge areas of land barren, with the United Nations Convention to Combat Desertification reporting that desertification affects nearly 40% of Asia’s total land area (United Nations Convention to Combat Desertification [UNCCD], 2019). Urbanization exacerbates land loss, with one estimate putting the loss of arable land to urban expansion in Asia at 3% per year (d’Amour et al., 2017).

At the same time, disasters including droughts, coastal flooding, and cyclones are getting more frequent and more devastating. While future warmer temperatures may benefit some crops in South Asia, climate change is expected to hurt agriculture overall, seriously threatening food security (Ahmed & Suphachalasai, 2014). Itself a significant source of the greenhouse gases that cause climate change, conventional agriculture is now under threat from climate change and disaster risk.
A lack of capital, meanwhile, limits smallholder farmers’ access to modern technologies such as higher-yielding crop varieties and farm equipment and machinery that would have minimized the need for labor (which has become a limiting production factor) and helped increase farm productivity. Throughout Asia, the migration of younger generations from rural to urban areas and shifts to employment in non-farm sectors have left the older generations to remain smallholder farmers.

Smallholder farmers are also not yet fully ready for the trend in agriculture toward consolidation of production, processing, marketing, promotion, and distribution under integrated agroenterprises. There is a related need to enhance and strengthen farmers’ agricultural business know-how, including business networks. Each of these factors accentuates the difficulties smallholder farmers have in transitioning from low-productivity subsistence farming to higher-productivity enterprise farming (Teng & Oliveros, 2017).

**Knowledge-intensive agriculture**

Emerging challenges have given rise to knowledge-intensive agriculture utilizing technological innovations. This requires understanding and application of advanced information that improves agricultural production and marketing, efficiently manages risks, and sustainably raises productivity and profitability (ADB 2014; Hasnie & Ra, 2018; Powell & Snellman, 2004).

In Figure 2, Briones, Basher, and Ahmed (2017) depict the sophisticated application of information and communication technologies (ICT) in knowledge-intensive agriculture. ICT can optimize the development and adoption of modern varieties, farm production inputs and operations, and postharvest operations (processing, storage, logistics, and marketing). High-level technologies have developed genetically engineered crops (such as Bt crops) with improved pest resistance, nanotechnology-formulated higher-efficacy agrochemicals, and precision agriculture practices that deliver precise quantities of water and fertilizers to plots and plants under a smart farming system. Now, with climate change, ‘smart greenhouses’ have been designed with remote environmental sensors and other green technologies to automate microclimate control systems for more controlled farming and processing conditions and manage weather, pests, and diseases.

![Figure 2. Role of information technology in knowledge-intensive agriculture.](image-url)
In the People’s Republic of China, farmers are using drones for crop dusting and spraying pesticides across huge areas within a shorter period and at much lower costs for labor and equipment maintenance (Hasnie & Ra, 2018). Beyond the fields, high-level technologies encompass the whole food value chain, from new processing and packaging methods to reduce wastage and ensure hygiene and quality, to smart logistics information systems and e-commerce or online marketing (Teng, 2019).

Also on the rise is ‘internet-plus rural economy’ or ‘digital agriculture’. Internet technologies (mobile internet, internet of things, cloud computing, big data, and satellite imagery) enable knowledge intensity that boosts efficiency in rural economies, from production and processing to the delivery of agriculture social services (finance, technical services). They can also diversify rural incomes from leisure agriculture and rural tourism and increase daily consumption in farming households (ADB, 2018b). In the People’s Republic of China, for example, internet technology has modernized many traditional rural industries, providing small farmers with access to fast, real-time, and reliable electronic information on weather forecasts, input–output prices, and local or global markets, thereby enhancing rural productivity and efficiency. Internet technology has also opened up new opportunities for rural entrepreneurship and innovation, motivating young people to engage in rural e-business ventures (ADB, 2018b; Hasnie & Ra, 2018).

Greater investment in agriculture innovation in coming years can further transform the sector. These include agricultural ICT (farm management software and agricultural data capturing services), biomaterials (on-farm waste processing), and value chain and agribusiness (commodities trading platforms, farm-to-consumer eGrocery services), according to the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA, 2018).

To cope with these knowledge and innovation trends, agricultural education and skills development need attention. Current and potential agricultural labor forces, farmers, farm managers, service providers, and processors can be equipped with new knowledge and skills through relevant education and training. These changes will boost employability, raise productivity and earning capacity, and help reinvigorate the agriculture sector.

**Education and skills development for agricultural transformation**

In recent decades, advances in science and technology have transformed all sectors, including agriculture. However, while agricultural outputs rose, industrial and service sector outputs grew faster (Table 1), and employment shifted away from agriculture to better-paying jobs in the two latter, mostly urban sectors (ADB, 2018a; International Labour Organization, 2018). From 2000 to 2017 within Asia and the Pacific, the share of industry in total employment increased in 24 of 36 economies and of services in 28 of 36, yet that of agriculture declined in 34 of 36 economies (ADB, 2018c). Agriculture still employs the most people in developing countries yet quality labor for the sector is limited. As noted, many younger farmers migrate to urban areas, leaving often older workers back home with declining productivity and fewer skills in adopting modern technologies and practices. For most Asian countries (including those with the largest populations), the shift of employment away from agriculture into other sectors has made it unviable to intensify labor needed to raise agricultural outputs (Briones et al., 2017).
This is where education becomes relevant. Studies have shown that better educated or more knowledgeable farmers are able to improve farm operations, productivity, and profitability; still other studies have found, nonetheless, that such farmers may in fact leave agriculture to join industry or services sectors for better wages and working conditions – although remittances to their families remaining in agriculture still contribute to farm enterprises.

Numerous studies have examined the relationship between farmers’ educational attainment and labor productivity. These include their perceptions of and willingness to adopt new, modern, and high-level production technologies (including options to address climate change and natural hazard impact) and their ability to adopt and improve recommended farm management and production practices. It also includes their propensity to shift to off- or nonfarm employment, among other things.

A study of 670 rice farm households across four provinces in Luzon, Philippines, for example, found that rice productivity can be increased by 26% through education of the household head (Luis, Paris, Rola-Rubzen, & Pede, 2015). Knowledge-intensive technologies – technologies that require knowledge for maximization of benefits such as drone technology, agribots, fertigation, biotechnology – require that farmers are able to absorb knowledge through modern communication technologies. Formal and informal ‘upskilling’ training can provide adult household members with technical knowledge to better understand production technologies and management techniques and to welcome innovations that can increase the farm’s technical efficiency, productivity, and profitability. Better understanding of consumer preferences, acceptable production and processing systems, and product value chains will also help in integrating small-scale farmers into domestic, regional, and global markets for high-value agricultural products (Davis, 2006).

In India, Sharma and Bhaduri (2009) found occupational mobility to be higher among younger farmers who were more sensitive to income differentials between farm and

| Table 1. Share of agriculture in employment and gross domestic product, selected Asian countries, 1970 (nearest year) to 2017 (%) |
|-----------------------------------------------|---------------|---------------|---------------|---------------|
| Share in Employment                      | Share in Gross Domestic Product                  |
| 1970a | 2000b | 2017b | 1970a | 2000b | 2017b |
| **East Asia**                             |                                             |
| China, People’s Republic of               |                                             |
| 80.8 | 50.0 | 27.7 (2016) | 34.8 | 14.9 | 8.2 |
| Japan                                      |                                             |
| 17.4 | 5.1  | 3.4      | 5.1  | 1.5  | 1.1 |
| Korea, Republic of                        |                                             |
| 50.5 | 18.7 | 4.8      | 27.5 | 4.4  | 2.2 |
| **South Asia**                            |                                             |
| Bangladesh                                 |                                             |
| 58.8 | 50.8 | 40.6     | 54.6 | 25.5 | 14.2 |
| India                                      |                                             |
| n.a. | 59.9 | n.a.     | 42.0 | 23.0 | 17.1 |
| Pakistan                                   |                                             |
| 57.3 | 48.4 | 42.3 (2015) | 36.8 | 27.4 | 24.4 |
| Sri Lanka                                  |                                             |
| n.a. | 36.0 | 26.1     | n.a. | 17.6 | 8.5 |
| **Southeast Asia**                         |                                             |
| Indonesia                                  |                                             |
| 61.5 | 45.3 | 29.7     | 23.3 | 15.6 | 13.7 |
| Philippines                                |                                             |
| 50.4 | 37.1 | 25.4     | 29.5 | 14.0 | 9.7 |
| Thailand                                   |                                             |
| 76.7 | 44.2 | 31.5     | 25.9 | 8.5  | 8.7 |
| Viet Nam                                   |                                             |
| n.a. | 65.1 | 40.2*    | n.a. | 24.5 | 17.0 |

*a* = preliminary; n.a. = not available.

1970 figures are from World Bank (n.d.), World Development Indicators; and FAO (2019).

2000 and 2017 figures are from ADB (2018c).
nonfarm occupations than older farmers. The farmer’s education and skill level also positively influenced the decision to shift out of agriculture, as these traits increased the person’s marketability and returns to migration. Low levels of educational attainment have thus led to inadequate supply of skilled labor in Indian agriculture, due to the greater potential for jobs in high-productivity manufacturing and services (ADB, 2016).

**Revamping agricultural education**

The key challenge is revamping agricultural education to ensure that the millions of smallholder farmers and agricultural labor – each with different skills and knowledge – are able to practice knowledge-intensive agriculture. Renewed agricultural education systems should produce a workforce responsive to the needs of a modernizing agriculture sector. The agricultural education ‘gap’ can be addressed by (i) updating curriculums and programs with the latest scientific knowledge and technical breakthroughs from the agricultural research and development community; (ii) enhancing the capacity of institutional facilities (laboratories) and human resources (faculty) to promote innovative technologies and practices; and (iii) strengthening academe-industry links and partnerships across the entire agriculture value chain.

Knowledge-intensive agriculture needs farmers who understand more sophisticated production technologies and modern systems of farm management, finance, and logistics. As such, high-technology universities with the appropriate physical facilities and qualified human resources should be developed. These subjects can be taught in the short-term to existing smallholder farmers if they are designed well with a specific focus.

**Strengthening the agricultural research and extension system**

Current agricultural extension services – designed mainly to deliver agricultural inputs – need to be refurbished to deliver the latest technologies and knowledge to farmers. Agricultural extension workers have to be educated and trained as well in advanced technologies. For example, e-extension offers tremendous promise for reaching farmers better and faster through mobile communication, smart phone-based decision support, and other novel e-learning platforms (Mushtaq et al., 2017). Sufficient investment in effective agricultural extension services will help ensure that appropriate knowledge and technologies are disseminated to target beneficiaries quickly and efficiently.

**Developing high-tech agropreneurs by investing in education and skills development**

Agriculture’s transformation rests on the availability and accessibility of advanced technologies and on countries’ capacity to develop human resources. Both more of and easier access to technologies should enable education, associated competencies, training, and skills that will increase employment, productivity, and income, and support transformation. The role of agricultural education and skills development should thus be examined to develop a new breed of high-tech agropreneurs.
Over the past 50 years, agricultural education and skills development programs have played a consistent albeit limited role in agricultural development and economic growth in developing countries (Jones, n.d.).

Better access to primary and secondary education, urbanization, and international markets, however, has shifted employment demands in various areas of agriculture and associated sectors. Vocational programs can be secondary or postsecondary in nature, and can focus on direct training for farmers and farm laborers. The role of higher education in agriculture is also increasingly important. National governments, private sectors, and donor communities should review the current state of agricultural education and skills development systems and approaches and strengthen their relevance in workforce development and in enhancing agricultural value chains based on lessons and insights drawn.

Reformed agricultural education and skills development systems are functional, responsive to emerging challenges, gender-sensitive, and flexible. The systems should enhance qualifications and competencies for better employability in agricultural value chains, as well as technical and business skills and capacities that will meet emerging public and private sector needs. The systems should strengthen the roles and contribution of female labor in high-technology agricultural production, processing, and trade through skills development. This is particularly important when male agricultural workers seek better paying nonfarm employment. In addition, the systems can offer short, flexible, convenient, and mobile skills enhancement programs to agricultural workers who may seek continuous education and training while working full time.

In addition, innovative, customized, and interactive training using modern technology will help build the skills, encourage participation, and enhance the productivity of elderly farmers and laborers in knowledge-intensive agriculture. Agricultural education and skills development systems can also design or upgrade existing job-matching services that pair candidates (elderly ones included) with appropriate jobs (Ra, Chin, & Liu, 2015).

**Increasing government investments**

Nonetheless, government expenditure on education, as a percentage of gross domestic product (GDP), has stagnated in some Asian countries (ADB, 2018c; Dewan & Sarkar, 2017). While Pacific countries tend to invest a higher percentage of GDP in education, Asian countries such as Armenia, Bangladesh, Sri Lanka, and Cambodia, have invested less than 3% of GDP since 2000 (Table 2). In other Asian countries, such as Mongolia, investment shares of GDP dropped in recent years and in other Asian countries education expenditure has been volatile. For instance, India reduced public spending on education in relative terms from 3.2% in 2000 to 1.9% in 2010, but increased it to 4.6% of GDP in 2016 (ADB, 2018c).

Looking more closely, however, government expenditure on secondary and postsecondary nontertiary vocational education as a percentage of total government spending appears to be extremely low across South Asia. Policymakers ought to realize that while universal quality foundational education is a priority, specific trade-related vocational training can offer young people an opportunity to cultivate capacities that will help build their employability. Quality vocational training needs to be promoted so that
communities can recognize that they provide a more sustainable alternative to leaving school early and entering the formal and informal labor market in the long run.

Government investments will be important in upgrading the quality of technical teachers, which in turn will boost the quality of education and skills development (ADB, 2017). Education and skills development systems should move from a supply-oriented to a more market-demand-oriented training system that is relevant and responsive to changing market demand. Innovations such as competency-based training and vocational qualification frameworks can help establish appropriate quality standards in the workplace.

Harnessing public–private partnerships

The importance and role of partnership among stakeholders is increasingly being recognized in knowledge-intensive agriculture. The most common form is public–private partnership (PPP), which broadly refers to ‘any research collaboration between public-and private-sector entities in which partners jointly plan and execute activities with a view to accomplishing agreed-upon objectives while sharing the costs, risks, and benefits incurred in the process’ (Spielman, Hartwich, & von Grebmer, 2010, p. 1). PPPs can play a role in addressing technical, financial, and other constraints in developing, promoting, and practicing knowledge-intensive agriculture. These partnerships range from simple procurement (public sector engages private entity to provide a service or construct an asset) to full-blown collaboration, where the private partners engage in asset operation, service delivery, and uptake of new technologies.

With respect to agricultural education and skills development, partnership with the private sector can help ensure that trainees (farmers, farm laborers, and/or the general farming community) are equipped with the practical know-how and skills required by knowledge-intensive agriculture. Farmers and agropreneurs can use more of the new agricultural knowledge from formal education systems (universities and research institutions) if theory and practice are linked more strongly. Because many rural dwellers can neither afford to attend university nor access research institutions, PPPs can help harness

Table 2. Government expenditure on education as proportion of gross domestic product, selected Asian countries, 2000–2017a.

| Country                      | 2000  | 2010  | 2017  |
|------------------------------|-------|-------|-------|
| **East Asia**                |       |       |       |
| China, People’s Republic of  | 3.3 (2002) | 3.0   | 3.7   |
| Japan                        | 3.7   | 2.9   | 2.7 (2016) |
| Korea, Republic of           | 3.1   | 3.0   | 3.3 (2016) |
| **South Asia**               |       |       |       |
| Bangladesh                   | 2.0   | 2.0   | 2.5   |
| Indiab                       | 3.2   | 1.9   | 4.6 (2016) |
| Nepalc                       | 2.4   | 3.9   | 4.2   |
| Sri Lanka                    | 2.4   | 1.6   | 1.9   |
| **Southeast Asia**           |       |       |       |
| Cambodia                     | 1.3   | 1.6   | 2.3   |
| Malaysia                     | 5.6   | 6.1   | 4.5   |
| Philippines                  | 3.3   | 2.5   | 4.4   |
| Thailand                     | 3.8   | 3.0   | 3.0 (2016) |

*a* Data refer to expenditure of the central government, except for Bangladesh, where data refer to the consolidated expenditure of central and local governments.

*b* Data are based on fiscal year beginning 1 April.

*c* Data are based on fiscal year ending 15 July.
the best scientific knowledge and technical breakthroughs, disseminate agricultural
technologies for adoption, and strengthen academe–industry partnership across the
entire agriculture value chain (Ra et al., 2015). And as an ultimate beneficiary, the private
sector can play an active role in the agricultural education and skills development
systems by offering courses and assist in government decision-making to make agricul-
tural education and skills development systems more relevant and responsive to market
needs (Song, 2016).

In South Asia, for example, while each actively plays its role in skills development,
governments and private institutions must work together in expanding capacity to
provide training to the growing workforce, enhancing the quality of workers and their
skills to match demand, and harnessing quality employment for different skills levels
(ADB, 2017). These will bridge the information gap and facilitate knowledge transfer in
the practice of knowledge-intensive agriculture.

**Enhancing the policy environment**

Governments also have to work with other sector stakeholders to provide and maintain
a conducive policy environment. Overall, education and skills development systems
ought to be integrated into countries’ broader agricultural development strategy. The
links between relevant institutions (government, training systems, local institutions, and
donors) need to be established to support sector development priorities, including
timely response to structural transformation, reducing rural unemployment or under-
employment rates, and increasing the productivity of rural labor (ADB, 2017).

Governments must pursue education reform and promote lifelong learning (ADB,
2018a). They should encourage and provide schools with incentives to strengthen
foundational and other skills that enable individuals to learn and relearn. Universities
and vocational training institutions will play significant roles in imparting the specialized
skills needed to work with new technologies to increase the number of agropreneurs,
both new graduates and ‘re-learners’.

Lastly, governments can shift the role of skills training to the private sector, but
continue to provide it where private options are either expensive or not available, such
as in remote geographical areas (ADB, 2017). Governments should also actively provide
the public with information about current and future labor market requirements, training
programs, and the performance of the public education system.

**Conclusions and recommendations**

Asian developing countries need to invest in education and skills development to develop
entrepreneurship in the agriculture sector, so called high-tech agropreneurs. Productivity
in the sector in the last few decades has progressed, but another quantum leap in food
production is necessary and inevitable given pending demographic changes.

Demand for food in the region is expected to increase in both quantity and quality as
populations grow and move to the cities, incomes rise, and dietary preferences change.
Indeed, by 2050, food demand is expected to be 60%–70% higher than 2005–2007
baseline. Asia’s farmers should move away from traditional input driven agriculture into
knowledge-intensive agriculture if they are to meet demand.
The time to revamp agricultural education and skills development is therefore now. Advanced knowledge and higher technologies will need to be increasingly accessible to millions of smallholder farmers. For this, modern agricultural education and skills development will be required. Universities can strengthen curriculums, institutional capacity, and their links with industry to support young, high-tech agropreneurs. Agricultural extension services can also transform existing agricultural workforces into agropreneurs by embracing e-learning to absorb knowledge and technologies available under Industry 4.0. Agricultural education and skills development should be reformed into a functional, gender-sensitive, and flexible system that is responsive to newer challengers.

This transformation requires government investment, public-private partnership, and an enabling policy environment. And government spending on education and skills development needs to be increased in Asian countries to revamp agricultural education and skills development. The increased budget needs to be spent for modernizing curriculums, pedagogies and laboratories, recruiting and developing quality teachers, and conducting industry relevant research. Public-private partnerships in agricultural education and skills development can, especially when implemented under a country’s broader agricultural development strategy, be instrumental in developing high-tech agropreneurs.

Moving forward, key recommendations are:

- **Agriculture’s transformation rests on availability and accessibility of advanced technologies and on human resources development.** Agricultural education and skills development systems should be examined to develop a new breed of high-tech agropreneurs. This transformation requires the systems to be integrated into broader agricultural development strategy.

- **National governments, private sectors, and donor communities should review agricultural education and skills development systems to strengthen relevance in workforce development and agricultural value chains.** Partnership with the private sector can help ensure trainees are equipped with the practical know-how and skills required by knowledge-intensive agriculture. The PPPs can help address technical, financial, and other constraints in developing, promoting, and practicing knowledge-intensive agriculture.

- **Agricultural education and skills development systems can offer short, flexible, convenient, and mobile skills enhancement programs to agricultural workers who may seek continuous education and skills development while working full time.** In particular, the systems can strengthen the roles and contribution of female labor in high-technology agricultural production, processing, and trade through skills development.

- **Agricultural education and skills development should move from a supply-oriented to a more market-demand-oriented training system.** Innovations such as competency-based training and vocational qualification frameworks can help establish appropriate quality standards. Innovative, customized, and interactive training using modern technology will also help build the skills, encourage participation, and enhance the productivity of elderly farmers through lifelong learning.
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References

ADB. (2011). Competitive cities in the 21st century: Cluster-based local economic development. Manila: Asian Development Bank.

ADB. (2014). Innovative Asia: Advancing the knowledge-based economy—The next policy agenda. Manila: Asian Development Bank.

ADB. (2016). The determinants of structural transformation in Asia: A review of the literature (ADB Economics Working Paper Series No. 478: Sen, K). Manila: Asian Development Bank.

ADB. (2017). Human capital development in South Asia: Achievements, prospects, and policy challenges. Manila: Asian Development Bank.

ADB. (2018a). Asian development outlook 2018: How technology affects jobs. Manila: Asian Development Bank.

ADB. (2018b). Internet Plus agriculture: A new engine for rural economic growth in the People’s Republic of China. Manila: Asian Development Bank.

ADB. (2018c). Key indicators for Asia and the Pacific 2018. Manila: Asian Development Bank.

Ahmed, M., & Suphachalasai, S. (2014). Assessing the costs of climate change and adaptation in South Asia. Manila: Asian Development Bank.

Borlaug, N. E. (2000, September). The green revolution revisited and the road ahead. Oslo: Special 30th Anniversary Lecture, The Norwegian Nobel Institute.

Briones, R. M., Basher, A., & Ahmed, A. K. M. M. (2017). Reflections on agricultural transformation: The evolution of knowledge-intensive agriculture. (Unpublished manuscript). Asian Development Bank, Manila.

d’Amour, C. B., Reitsma, F., Baiocchi, G., Barthel, S., Güneralp, B., Erb, K., … Seto, K. C. (2017). Future urban land expansion and implications for global croplands. Proceedings of the National Academy of Sciences of the United States of America, 114(34), 8939–8944.

Davis, J. (2006). How can the poor benefit from the growing markets for high value agricultural products? Kent, UK: Enterprise, Trade and Finance Group, Natural Resources Institute.

Dewan, S., & Sarkar, U. (2017). From education to employability: Preparing South Asian youth for the world of work. JustJobs Network Inc. and UNICEF South Asia, Washington D.C.

FAO. (2019). FAOStat annual population: The food and agriculture organization of the united nations. Retrieved from http://www.fao.org/faostat/en/#data/OA
FAO. (2017). The future of food and agriculture: Trends and challenges. Rome: The Food and Agriculture Organization of the United Nations.

Hasnie, S., & Ra, S. (2018) How the gig economy can transform farms in the developing world. Retrieved from https://www.weforum.org/agenda/2018/03/this-is-how-farm-drones-will-transform-the-way-your-food-is-grown/

International Labour Organization. (2018). World employment and social outlook: Trends 2018. Geneva: ILO.

Jones, K. (n.d.). The role of agricultural technical and vocational education and training in developing countries: A review of literature, issues and recommendations for action. USAID/BFS/ARP-Funded Project, Innovation for Agricultural Training and Education (Innovate). Pennsylvania, USA: The Pennsylvania State University.

Luis, J. S., Paris, T. R., Rola-Rubzen, M. F., & Pede, V. O. (2015). Rural labor outmigration and gender dimension in an assessment of farm technical efficiency: A case study in selected rice villages in the Philippines. Asian Journal of Agriculture and Development, 12(1), 53–65.

Mushtaq, S., Reardon-Smith, K., Cliffe, N., Ostini, J., Farley, H., Kealley, M., & Doyle, J. (2017). Can digital discussion support tools provide cost-effective options for agricultural extension services? Information Technologies and International Development, 13, 52–68.

Powell, W. W., & Snellman, K. (2004). The knowledge economy. Annual Review of Sociology, 30, 199–220.

Ra, S., Chin, B., & Liu, A. (2015). Challenges and opportunities for skills development in Asia: Changing supply, demand, and mismatches. Manila: Asian Development Bank.

SEARCA. (2018). An expert’s consultation forum on reshaping agriculture and development in Southeast Asia. Laguna, Philippines: Southeast Asian Regional Center for Graduate Study and Research in Agriculture.

Sharma, A., & Bhaduri, A. (2009). The ‘tipping point’ in Indian agriculture: Understanding the withdrawal of the Indian rural youth. Asian Journal of Agriculture and Development, 6(1), 83–97.

Song, E. (2016). Skills development funds: Country experiences and implications for South Asia. (Unpublished manuscript). Asian Development Bank. Manila.

Spielman, D., Hartwich, F., & von Grebmer, K. (2010). Public–Private partnerships and developing-country agriculture: Evidence from the international agricultural research system. Public Administration and Development, 30(4), 261–276.

Teng, P. S. (2019). Asian agriculture: Disruptive technologies and the future of food. Keynote paper presented at the annual meeting, Singapore: CropLife Asia.

Teng, P. S., & Oliveros, J. A. P. (2017). The enabling environment for inclusive agribusiness in Southeast Asia. Asian Journal of Agriculture and Development, 13(2), 1–30.

United Nations Convention to Combat Desertification. (2019). Regional Implementation annex for Asia (Annex II: Asia). United Nations Convention to Combat Desertification. Retrieved from https://www.unccd.int/conventionregions/annex-ii-asia

United Nations, Department of Economic and Social Affairs, Population Division. (2017). World population prospects: The 2017 revision, key findings and advance tables. (Working Paper No. ESA/P/WP/248).

United Nations, Department of Economic and Social Affairs, Population Division. (2018). World urbanization prospects: The 2018 revision, online edition.

World Bank. (n.d.). World development indicators database. Retrieved from http://datatopics.worldbank.org/world-development-indicators/