CHAPTER 8

Nuances in agriculture mechanization

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Much research has observed that agriculture mechanization in Nepal is lacklustre, confined largely to the Tarai plains, and is constrained by land fragmentation, difficult terrain, poor credit access and lack of investments. However, a careful study of the experiences of other countries within South and Southeast Asia reveals several nuances of policy significance. While for most studies, mechanization is essentially about large farms, capital-intensive equipment and canal irrigation systems, a small number of works show that there are major differences in the way countries like India and Bangladesh have progressed on mechanization. This is not to rule out overlaps in the mechanization strategies of the two countries, but there are significant differences, and, by implication, the outcomes are also varied.

This review chapter provides evidences that, for political and ideological reasons, mechanization is used interchangeably with large farms, canal irrigation systems and capital-intensive large equipment (e.g., four-wheel tractors, combines).[1] According to this strand of research, it is dynamics like fragmentation and poor infrastructure that slow down mechanization-related progress and hence any subsequent improvement in agriculture. This may be called the dominant agriculture development paradigm (dominant because corporations and multilaterals hold such positions). India's mechanization pattern, for example, in its very successful and transformative Green Revolution, has remained closer to the dominant paradigm and it is mostly the large- and medium-scale

farmers—accounting for a rather large share of India's overall arable land—that have benefitted from the Green Revolution.

Nepal's context appears a patently different one. Among other things, it is characterized by its small proportion of arable land, minimal fiscal capacity (for example, to subsidize four-wheel tractor purchase) and predominantly smallholder farming. None of this can be wished away in the medium term. While transformative long-term solutions to development may not be forthcoming, incremental gains can indeed be made. Often, incremental gains, a function of credible technological, organizational and institutional experiments and learning, are the ones anchoring transformative policies.

Mechanization, and as a result better agronomic practices addressing drudgery, labour shortage, intensity and the synchronization issue, offers a window for such incremental gains. Indeed, very rudimentary operations, such as the usage of chest-mounted spreaders, have resulted in greater profits and yields. They have reduced unpredictability in profits. Mechanization involving large farms and large capital-intensive machines appears a less suitable design in Nepal's context. It is, for example, because of the landholdings and the investment (or subsidy) capabilities. Still, specific learning certainly cannot be ruled out. As evidenced, mechanization, currently low, needs to be speeded up. For that, major technological, organizational and institutional learning and experiments are required.

The Bangladesh case, like Vietnam's, is driven largely by small, low-cost and multi-purpose equipment, such as two-wheeled tractors and low-lift pumps. This appears to be a more feasible strategy in Nepal's context and can potentially offer major technological and institutional learning. The development outcomes of mechanization driven by the use of largely small, inexpensive and multipurpose machines and implements have been dramatic. Bangladesh's agriculture is possibly the most mechanized in the region with, for example, 80 percent of land preparation mechanized. Despite sustained land fragmentation, its rice productivity has risen. Though passing references are made by a lot of research about small imple-

ments, such as two-wheeled tractors (2WTs), rapidly penetrating Nepal, there is no credible estimate of the stock of rural capital goods. This chapter contends that credible assessments of some developments and practices must not be ignored as it results in a distorted picture, essentially bad scholarship, invariably harms credible policymaking, and hence hurts progress in mechanization.

Agricultural transformation in Nepal

"Prosperity" aspirations

Proclamations and exhortations around building a "prosperous" society aside, the prospects of achieving rapid inclusive growth and development look bleak, if not entirely unforeseeable. Indeed, by implication, prosperity of any sort means reasonable, sustained incomes. This requires jobs. However, Nepal's dismal performance in job creation, a function of developmental structural transformation and not merely gross domestic product (GDP) growth[2], means the "prosperous" Nepal achievement will be no mean feat. Consider this: over six in ten in the labour force are in agriculture[3], while the sector accounts for under 30 percent of the GDP. Going by GDP and employment share, Nepal is the most agrarian country in the region. Low productivity in agriculture means not just vulnerable livelihoods, but a massive underproduction of food commodities like rice.

Financing rice imports via remittance transfers, which finance over 80 percent of the overall trade deficit, may not be a sustainable strategy, although remittance transfers have arguably been the single biggest contributor to rather resilient consumption capabilities and social development. Among the top five imports, rice yields, at roughly three tons per hectare (ha, hereon), are below what most regional peers (Uprety, 2011) produce. The picture is not very different for overall cereal yields: Nepal is behind most regional peers (Park et al., 2018). The manufacturing sector, on the other hand, considered critical for sustained growth and development[4] as well as job creation, has the lowest GDP share in South Asia.

Focal interdependencies

Although a dynamic construct, Nepal's economic structure is not developmental and is not geared to provide dynamism, partly because there are major circular and cumulative interdependencies among sectors (Andreoni, 2013). Classical development economists provide insights into such interdependencies—when agriculture sector workers with near-zero incremental productivity get absorbed into technologically superior sectors such as manufacturing, this triggers not just sector-specific, but overall, dynamism (Lewis, 1954).[5] On the other hand, agricultural improvements are critical for overall dynamism, including in driving manufacturing. This is due to the availability of surplus labour, raw materials and demand for industrial products. The interdependencies outlined go beyond the "industry" vs "agriculture" trade-off-type ideas, where it is argued that comparative advantage (rather, static comparative advantage) of developing countries lies in agriculture.[6]

As we will see in later sections, agricultural transformation cannot be achieved without incremental gains in manufacturing capabilities, which significantly impact societal learning capabilities regarding technology and organization.[7] Historically, agricultural improvements have occurred alongside incremental gains in manufacturing capabilities, which have further provided dynamism via mechanisms such as mechanization. Indeed, in almost all structural transformation cases from England[8] to Japan and even to China, recently, rapid improvements in agriculture preceded industrialization-driven growth. Institutional experiments in China such as the town-village enterprises[9] resulted in major development outcomes—poverty declined from 50 percent in 1980 to under 10 percent in the early-2000s (World Bank, 2008).

In India, the Green Revolution, between 1967 and 1986, led to an output expansion of 50 percent, while poverty declined by 20 percent (*ibid.*). Robust provisioning of inputs (e.g., improved seed varieties, pesticides), mechanization in farm operations via usage of equipment such as four-wheel tractors (4WTs, hereon) and ir-

rigation (via machines like pumps) drove India's Green Revolution (Andreoni, 2011). The agricultural transformation cases are a result of credibly coordinated technological, organizational and institutional learning and experiments, rather than "prerequisites of development"-type supply-side explanations such as that infrastructure or investment leads to development.

Other salient features of Nepali agriculture

Nepal is endowed with rich agroecology—fertile plains, river basins, rugged mid-hills and steep mountains having climates ranging from subtropical to warm-temperate to alpine to arctic. The latest estimation puts arable land at roughly 30 percent (IFAD, 2017). A third of it has year-round irrigation; about 50 percent has some form of irrigation (Gauchan et al., 2017). There are a significant number of landless tenants and absentee landlords. While average landholding is under 0.7 ha, fragmentation is widespread—on average three parcels per landholding (*ibid*.). Almost 90 percent of the landholdings are less than two hectares and account for nearly 75 percent of the arable land. Five percent of the landholdings, sized more than five hectares, account for the rest (IFAD, 2017). Within agricultural GDP, foodcrops, livestock, horticulture and forestry contribute, 40, 30, 20 and 10 percent, respectively.[10] Application of inputs, such as chemical fertilizer, continues to be, on average, below the figure achieved by regional peers—for example, the application rate of nitrogen is 40 percent of that in India's Bihar State (Park et al., 2018). This author's surveys found that access to inputs has improved, largely because its makes business-sense for traders.[11] However, most inputs are sourced in gray markets and, hence, the quality and other aspects go unregulated (*ibid*.).

Rising urbanization and rapid outmigration—among the most discussed themes—have resulted in labour shortages, shrinking cultivation, land abandonment and, consequently, declining food production. The evidence reviewed here presents useful insights and has strong, though not straightforward, links

to mechanization. A study by the World Bank (2016) observes that the area cultivated has not expanded, but rising prices and productivity improvements have resulted in increased agricultural incomes in some hill and mountain districts, like Manang and Baglung. Surprisingly, rising prices have not enabled "rational" farmers to expand the cultivated area. Gauchan et al. (2017) cite Central Bureau of Statistics figures showing that the net cultivated area has, in fact, shrunk by 10 percent between 2001 and 2010. District-specific case studies, such as one focused on the Parbat hills, report an abandonment rate of 37 percent. They show that abandoning less arable land is rather common in the hills (Paudel et al., 2014). Predictably, abandonment got exacerbated due to outmigration (*ibid.*).

Another case study in the western mid-hills provides evidence that labour scarcity has been common during the peak season, where successful institutional experiments such as joint labour contribution during planting and harvesting (called *perma*) served as a credible coping mechanism (Bauer et al., 2013). Rapid outmigration has rendered such institutional mechanisms largely ineffective (*ibid.*). Baudron et al. (2015) posit that migration has not just resulted in worker scarcity; even the quality of labour has declined, given the disproportionate male exodus. In the shrinking arable land, rapid urbanization remains a major dynamic and has led to conversion of arable land into other uses. Potentially useful policies like land classification remain under the carpet.

All in all, Nepal's agriculture has been stagnant and is marked by low productivity, poor infrastructure (farm access roads, irrigation, storage), minimal mechanization (the subject we deal with in the section below), a financial system poorly geared to serve the productive sector learning processes, and questionable extension provisioning. However, there are pockets of modest gains.[12] Consider the yields in vegetables and fruits, which compare well in the region and have been attributed largely to the diverse agroecology.[13] Both fruits and vegetables are considered sectors of high returns and greater labour intensity. However, even in these sectors, there is unpredictability in the prices that farmers get.

Mechanization: Rationale and evidence

Why mechanize

Roughly 500 million family farms produce 80 percent of the world's food in volume. Their production capabilities hinge on, among other things, how effectively and efficiently land, water and nutrients are used (Sims et al., 2017). As we have seen in the previous section, Nepal, like most populous developing country settings, is predominantly a smallholder-dominated system. Mechanization, as we will see here, is critical to farming and plays a significant role in addressing rural poverty, labour shortages, hunger, food supply and sustainable intensification (*ibid.*). A credible spread of mechanization aids structural transformation through various mechanisms, such as the market for instruments, and, hence, incentivizes manufacturing.[14] In farm-sector value chains—dairying, milling, packaging and extraction—mechanization occupies a major role.

Agricultural production entails broadly two independent processes: the biological course and the agricultural works like plowing, planting and irrigation.[15] Agricultural works are performed through capabilities embedded in humans, animals and instruments—mechanical and non-mechanical—like engines, water-pumps, power-tillers, seed-planters, sprayers and tractors. Well-coordinated and synchronized operations, via usage of instrument, animals and humans, result in efficiency, accuracy, multitasking, intensity and, the most important of all, reduction in drudgery. While agroecology is a given, agricultural work transforms the environment. Mechanization is significantly about farm-power, where instruments complement animal and human power. Indeed, smallholders in developing countries are severely power-constrained. For example, in developing regions like Africa and South Asia, over 60 percent of farm power comes from sources like animals and humans (Yahaya, 2017). From simple hand-implements to motorized equipment, mechanization enhances efficient use of resources—both farm inputs and labour—through greater intensity, precision and timeliness and synchronization of

farm operations (Andreoni, 2011). The quality of farm operations (intensity, precision and timeliness, and synchronization)—row-planting, optimal plant population, seed and fertilizer application and replacement, and efficient utilization of soil moisture during the planting window—impacts yields significantly (Yahaya, 2017).

While several traditional practices, when complemented with improvements, yield better outcomes, the others are plain harmful. Consider the use of the hand-hoe that causes permanent and structural damage to the soil by creating impermeable plough-plans at the depth of penetration (Sims et al., 2017). Mechanization has a circular and cumulative interdependence. Hence, manufacturing capabilities will determine, to a significant measure, the mechanization dynamics (Andreoni, 2011). Indeed, any green revolution like transformation of agriculture has taken credible technological and institutional learning, experiments and configurations. Among these was a sizable degree of rural mechanization (use of tractors and irrigation provisioning) (*ibid.*). Given a specific environment, agriculture depends sizably on the quality of farm operations. Mechanization—not just the implements and equipment but credible capabilities to use, maintain and manufacture them—entails robust technological, organizational and institutional learning. It is instrumental in agricultural improvements.

The evidence

The Agriculture Development Strategy, 2014 observes that low mechanization rates are among the principal causes of Nepal's weak performance in agriculture. Indeed, most literature[16] makes similar observations. The literature also shows that mechanization is largely confined to a specific geography—the Tarai plains—because of the terrain. A 2012 study by Nepal Agricultural Research Council (NARC) estimates that over 75 percent of the overall available farm-power comes from human and animals, whereas the 25 percent derived from mechanical sources is almost entirely confined to the Tarai (Shrestha, 2012). The study finds that even in the Tarai, animals and only rudimentary implements like iron

plough are common. Due to difficult terrains and poor infrastructure, mechanization is non-existent and largely unfeasible in other geographies (*ibid.*). World Bank (2016) posits that mechanization rates are low, and that most mechanization is restricted to the Tarai. It goes on to postulate that there is no indication that difficult terrains—hills and mountains—are making progress on rural mechanization.

There is, however, some evidence to the contrary. Takeshima et al. (2015), in their analysis of mechanization patterns, use the Nepal Living Standard Surveys and take tractor usage as a proxy for mechanization. In terms of area ploughed by tractor, they find that Nepal fares poorly when compared to countries like Vietnam: 20 percent in Nepal compared to over 70 percent (2010 figures) elsewhere. However, they also find that tractor usage in Nepal has increased from five percent of total farm households in 1995 to over 20 percent in 2010, while less than one percent own tractors, suggesting functional hiring mechanisms. The Tarai area, which Takeshima et al. (2015) argue is the most mechanized and where mechanization progress is much faster than in other parts of the country, has a tractor usage rate of about 46 percent (2010); up from eight percent in 1995 (*ibid.*).

Heavy outmigration has altered Nepal's social, economic and political landscape dramatically and, perhaps, even irreversibly. Both outmigration and urbanization-driven abandonment of agriculture in recent decades have exacerbated labour scarcity. This has a major relationship with mechanization dynamics (Baudron et al., 2015). Mechanization supplements and complements labour and addresses labour shortages,[17] but has this happened in Nepal? Recent Nepal-specific evidence on outmigration- labour shortage-farm-land abandonment-mechanization relationship provides interesting insights. It appears that a mere reduction in labour will not drive up mechanization rates. Credible, evidence-backed context-suitable policy support will be required for that. Multiple studies have found that arable land has not expanded, but rather shrunk, though prices of agricultural commodities have risen (or held-up).[18] In a case study examining mechanization patterns in

rice production, Uprety (2011) finds that mechanization (along with the system of rice intensification) was a compulsion due to labour deficiency. Since labour costs in rice production make up roughly 50 percent of the production cost, the overall production cost dropped 25 percent, whereas profits rose 36 percent following mechanization. Joshi et al. (2012), on the other hand, suggest that it is the poor progress in cutting drudgery and lack of hope in agriculture that has driven outmigration and farmland abandonment. Exploring an entirely different direction, Bhandari and Ghimire (2016) theorize that more mechanization (again the proxy being usage of tractor) pushes up the probability of a typical farm household towards adopting migration (as in Chitwan) by roughly 25 percent.

Intricacies in mechanization knowledge

Mechanization suitability

In assessing mechanization, most research takes large capital-intensive equipment like 4WTs, combine harvesters, high-powered pumps and threshers as proxies. Mrema and Kienzle (2018) call 4WTs the unsung heroes in Europe. The other common position is that fragmentation and smallholder-dominated systems are unsuitable for rapid mechanization. Fragmentation and smallholder farms are believed to disincentivize investments in improvements (World Bank, 2016). Indeed, the dominant agriculture development paradigm promoted by multilaterals is about canal irrigation systems, large equipment and large equipment-led heavily mechanized large farms—all associated with modernity (Biggs and Justice, 2016).

India's Green Revolution-like improvements adopted similar mechanization and technology strategies, perhaps because there are large farms where roughly five percent of the farmers own a disproportionately high share of arable land.[19] While transformative in many measures, India's green revolution is not without criticisms. They are blamed for environmental degradations such as

depletion of ground water and salinity, subsidy-driven wasteful use of inputs and energy, unequal benefits as it is the large and medium farmers who mostly benefit, widening regional disparities and creating dependence on seeds outside of the farmer ecosystem.[20]

Certainly, the dominant ideas in agriculture improvements, extremely demanding in resource terms and significantly wasteful, may be "feasible" for some contexts. Large equipment are a critical component in the dominant mechanization strategy. However, they appear not just unsuitable for small farms but are also extremely capital intensive amid minimal resource capacity. For Nepal, such strategy does not appear sustainable and context-suitable. On the other hand, it appears safe to conclude that smallholder farming and smallholders cannot be wished away unless major developmental structural transformation, one that creates reasonable jobs, takes place. That smallholder farms and farmers cannot be wished away comes without much "technical" thinking. But this is no good news for the ones dependent on smallholder farming for livelihood because on the question of whether it can be a reasonable livelihood source, the evidence is stacked against it (Collier and Dercon, 2014).

Hence, alternative mechanization practices need to be identified and credibly learnt. Credible learning is a much more complex and potent idea than "transfer of technology"-type notions (Khan, 2013). Towards an alternative design, the mechanization patterns of countries like Vietnam and Bangladesh, both smallholder contexts, are useful sources of learning.

Suitable mechanization designs[21]

Much of the literature on agricultural improvements is influenced by the dominant agriculture development paradigm. It makes no reference to small, low-cost, multipurpose equipment-driven mechanization in countries like Vietnam, Thailand and Bangladesh (Biggs and Justice, 2015). The mechanization strategy adopted by these Southeast Asian countries and Bangladesh has been different from India's. This is perhaps due to compulsion brought about by their

resource crunch and the dominance of smallholders (*ibid.*). The low-cost machines and implements—2WTs, low-lift pumps, shallow tubewells and riverboats—have resulted in efficient land preparation, careful water management and post-harvest operations such as transportation. Several of these small equipment were developed in close partnership with farmers (Biggs and Justice, 2016).

Bangladesh has had a rather different agriculture mechanization strategy within the South Asian region, for example, compared to India. Prior to independence, canal-based irrigation systems irrigated roughly half of the arable land. Farmers used swing-buckets and other mostly manual instruments in the other half (Soni et al., 2010). Owing to credible post-independence policy support, mechanization speeded up (Table 8.1). Policy interventions included lifting of a ban on cheap Chinese equipment (2WTs and pumps), and duty and tax reliefs.

While the Japanese introduced 2WTs in Bangladesh in the 1970s, it did not gain traction immediately. By the 1980s, low-cost and better quality Chinese 2WTs had penetrated rapidly (Biggs and Justice, 2015). Not just 2WTs, even the number of tractors grew 40-fold. The number of shallow tubewells (powered by low-cost, low-powered Chinese pumps), mini-tillers, low-lift pumps and manually operated weeders and sprayers (a million sprayers in Bangladesh) all grew at an even faster rate (Ou et al., 2010). Much

Table 8.1

Agriculture machinery, Bangladesh (1997–2006)

Machinery type	1977	2006
Tractors	300	12,500
Power-tiller	200	300,000
Shallow tubewell	3,045	1,182,525
Low-lift pump	28,361	119,135

Source: Soni and Ou (2010).

of the manually operated implements are made locally, while most mechanical instruments are largely imported. Robust mechanization has resulted in efficient use of water and mechanized land preparation. This may have been a factor in the 2.5-fold rise in the value of agricultural commodities produced between 1980 and 2000 (*ibid.*). Baudron et al. (2015) note that land preparation is by far the most demanding activity in rain-fed conditions. The elimination of soil inversion makes 2WTs viable within the region's specificities. Bangladesh has arguably the most mechanized farm sector today. Eighty percent of its land preparation and tillage operations are mechanized. The rate is greater than India's, where it is roughly 50 percent (Biggs and Justice, 2015).

Though India is a much bigger country, Bangladesh has a greater number of 2WTs than India (India: 300,000, Bangladesh: 500,000; Biggs and Justice, 2016). Baudron et al. (2015) observe that despite the 80 percent usage rates, ownership is only a fraction of it (one in thirty users), again suggesting functional renting mechanisms. The flourishing demand for 2WTs has also opened business opportunities for the private sector. This has resulted in robust supply chains and intense competition (*ibid.*). The small inexpensive equipment is employed not just in farm operations but also in post-harvest activities like transportation. In smallholder developing countries, the farm-to-collection hub distance constitutes a small portion of the overall distance that a typical commodity travels in the supply chain but takes a disproportionately high share of overall transportation costs (*ibid.*). Employing 2WT in transportation has significantly cut transportation costs while losses have been minimized in transporting goods to the collection point/market.

Highlighting the Bangladesh case is not to suggest transplantation of its strategy. The purpose is to highlight the idea that, for mechanization to progress, a context-suitable strategy must take shape. There will have to be a credible analysis of the context—agroecology (parcel size, workers), socio-economic context, infrastructure, scaling-up potential of the prioritized equipment, the repair, spares and maintenance potential, and the manufacturing potential. While the Bangladesh strategy is a potential source

of learning, there will have to be Nepal-specific adjustments and tweaks. Overall, the Bangladesh (and Vietnam or Thailand) strategy of small, inexpensive, multipurpose device-driven mechanization looks like a much relevant source of learning for Nepal.

Mechanization in Nepal

Nepal started importing 4WTs in the 1960s. Interestingly, the late 1960s and the 1970s were also a period when some small agricultural equipment were being tested. Somehow, the tests did not produce results then. It was only in the 1980s when the first 2WTs came to Nepal. Japanese aid programmes brought in 2,000 2WTs back then. Their use was initially confined to Kathmandu and Pokhara and the surrounding areas (Biggs and Justice, 2015). Most recent estimates suggest that there are 12,000 2WTs, mostly in and around Kathmandu, Pokhara and other well-connected valleys. They are being used for transport, tillage operations and threshing, among other activities (*ibid.*). Beginning in the early 2000s, there has been a rapid penetration by 2WTs and mini-tillers (*ibid.*). Apart from this these estimates (Biggs and Justice, 2015), there is not much data on 2WT penetration. The hypothesis is that the penetration intensified in the 2000s. Nepal has less than five percent of the 2WTs that Bangladesh has (Table 8.2), while Nepal has twice the number of 4WTs that Bangladesh has. More research is needed to credibly compare the two contexts.

Regarding the kind of agricultural equipment used, Gauchan et al. (2017) cite a 2013 Central Bureau of Statistics estimate (Table 8.3). It appears that the most widely used agricultural equipment are iron-ploughs, tractors, power tillers, pumping sets, sprayers and threshers.

They also suggest that the usage of 2WTs, power tillers, low-power pumpsets, and small-scale irrigation pumps has increased rapidly. This is more so in non-traditional farm activities such as horticulture, poultry and animal feed. Interestingly, non-traditional areas like vegetables and livestock have also been registering the fastest growth in recent years (IFAD, 2017). The same study notes

Table 8.2

Horsepower availability in agriculture by engine size

	Nepal			Bangladesh		
Energy source	No. of units	Total HP	% of HP	No. of units	Total HP	% of HP
2WTs*	12,000	168,000	10%	400,000	5,600,000	46%
4WTs**	30,000	900,000	53%	15,000	460,000	4%
Shallow tube well pump (diesel)***	120,000	600,000	36%	1,200,000	6,000,000	49%
Pump sets (electric)****	10,000	20,000	1%	100,000	200,000	1%
Total HP		1,688,000	100%		12,260,000	100%

Source: Reproduced from Biggs and Justice (2016).
Notes: Estimates of the numbers of power sources (and their HP ratings) used primarily in agriculture and processing uses, including groundwater irrigation pumps. These do not, for example, include the many engines used in Bangladesh to power riverboats, rice mills, processing, etc., although these are a vital part of Bangladesh's agriculture sector and rural economy.
HP: horse power.
**Average of 14 HP per 2WT.*
***Average of 30 HP per 4WT.*
****Diesel/petrol irrigation pumpsets, average 5 HP. 5-10% of pumpsets are petrol/kerosene.*
*****Electric irrigation pumpsets average 2 HP.*

that small-scale threshers and tillage equipment are widely available to buy. Shrestha (2012) observes that nearly all mechanical power is concentrated in the Tarai, while equipment like 2WTs, power tillers, hand sprayers, paddy shellers and grinders are used by valleys connected to road-heads. The same study observes that 2WTs are used both in farm operations and transportation and that they have been "revolutionary" for the valleys.

Mechanization is fundamentally about improved agronomic practices like managing soil fertility. Simple, small and low-cost implements can improve outcomes substantially. Park et al. (2018),

in a randomized control trial, experimented with a small equipment—a chest-mounted spreader—in Rupandehi (west Nepal) to tackle, mainly, the (i) problem of drudgery and inefficiency in hand-application of inputs in wheat cultivation; and (ii) late sowing, which negatively impacts yields. A major inefficiency in hand-application was non-uniformity in input application, which resulted in yield variability in the same field. For non-users, variability as well as inappropriate mix of inputs like seed and fertilizer resulted in losses in yield and unpredictability in returns. The method produced efficient outcomes with greater seed density and proper uniform application. This led to greater strength of the relationship between seed and fertilizer. Each plant was having access to fertilizer. Users derived greater yield and profit with greater predictability. Even when the control group used more fertilizer, the output did not respond proportionately. The treatment group

Table 8.3

Machinery/equipment in agriculture in Nepal

Machinery/ equipment used	No. of households	Households (%)
Iron ploughs	1,073,441	28.02
Tractor & power tillers	920,371	24.03
Thresher	803,154	20.96
Pumping sets	548,203	14.31
Sprayers	574,014	14.98
Shallow tube wells	367,744	9.56
Deep tube wells	159,725	4.17
Treadle pump (*dhiki*)	79,145	2.06
Animal drawn cart	334,978	8.74
Other Equipment	290,084	7.57

Source: CBS (2013), in Gauchan et al. (2017).

results show greater labour efficiency. Users need not have much experience to operate the equipment.

Context-specific paradigm

Despite numerous observations and a few estimates that there has been a rise in small equipment-led mechanization in Nepal, there is no credible analysis on penetration, usage and impact. On the other hand, much of the existing knowledge on mechanization patterns in Nepal, largely based on the dominant agriculture development paradigm, focuses only on a specific kind of mechanization—one that is about large farms, canal-based irrigation and large capital-intensive equipment. This is largely because of political and ideological reasons. It is the dominant strand because it is the position of corporations and multilaterals. For this dominant strand of research, mechanization is low and largely confined to the Tarai, requiring major investments and improvements in infrastructure.

Indeed, small and inexpensive equipment-led mechanization may well be making rapid inroads in addressing labour shortages. Cases corroborate the same, but not in much detail. Some of the evidence reviewed here suggests that many accounts and estimates of mechanization may be simplistic, if not erroneous. This is hardly a helpful position to be in if a credible mechanization strategy is to be forged. A possible way forward to come up with credible policy interventions in promoting suitable mechanization is to have a credible analysis of the stock of rural capital goods. This chapter has attempted to invigorate discussions on the issue. Given the need for agriculture improvements in not just Nepal but also in other South Asian countries, including Bangladesh, India and Pakistan, the intricacies highlighted here should be relevant to policymaking.

Notes

[1] This chapter has benefited from discussions at a session on rural economy, supported by Winrock International, at the Tenth South Asia Economic Summit, and a seminar at South Asia Watch on Trade, Economics and Environment conducted by Dr Stephen Biggs and Scott Justice.

[2] Jobless growth is a major phenomenon with few exceptions like China. India, though having consistently registered a 6 percent-plus growth, has an employment creation rate of 0.1 percent recently (EB, 2018).

[3] ILO (2017) figures from 2008 Labour Force Survey.

[4] Szirmai and Verspagen (2015); Khan (2013).

[5] See Thirlwall (1983) for how manufacturing triggers overall growth—the so-called Kaldor growth laws.

[6] The *World Development Report, 2008 (Agriculture for Development)* buttresses this position.

[7] Andreoni (2013).

[8] Wood (2002).

[9] See Cao and Birchenall (2013).

[10] MoF (2013), in Gauchan and Shrestha (2017).

[11] For IFAD (2017).

[12] World Bank (2016).

[13] IFAD (2017).

[14] See Andreoni (2013) for a detailed discussion on the processes.

[15] See Andreoni (2011), from which I draw heavily in this section.

[16] World Bank (2016); Uprety (2011); Gauchan and Shrestha (2017); Takeshima (2017); Shrestha (2012).

[17] OECD/ICRIER (2018) shows how labour shortages in states like Punjab have led to mechanization.

[18] World Bank (2016); Gauchan and Shrestha (2017).

[19] OECD/ICRIER (2018).

[20] See Mdee et al. (2018) for a critical assessment of the Green Revolution.

[21] I borrow significantly from Dr Stephen Biggs's work on rural mechanization.

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