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Mechanization in Nepalese agriculture: Potential knowledge gaps and significance

Avinash Gupta*

Abstract

The essay evidences that while the dominant narrative on mechanization is essentially about large farms, capital-intensive equipment and canal irrigation system, a less-highlighted, "heterodox" strand in scholarship provides evidence that there are major differences in the way countries like India and Bangladesh have progressed in mechanization. Although there are overlaps in the two strategies, the paper argues that recognizing the differences has scholarship and policy significance for Nepal and for the rest of the region if an effective mechanization strategy is to be devised. The paper observes that if India's mechanization is largely explained by the dominant approach, made feasible by its fiscal, institutional and industrial capacity, Bangladesh's mechanization is based on small, inexpensive and multipurpose equipment. Indeed, Bangladesh achieving significant mechanization despite sustained land fragmentation has especial salience for Nepal. In Nepal, like Bangladesh, smallholders form the bulk of farmer households while fragmentation is on the rise. Moreover, rapid emigration to foreign lands for work has created labour shortages on the farm while, owing to the agriculture sector stagnation and remittance-driven credibly rising consumption capabilities, imports of agricultural goods are soaring. Credible policy support in mechanization is identified as having contributed to Bangladesh's success.

While much of the agriculture mechanization scholarship on Nepal finds that mechanization is low and confined to specific geography such as the Tarai plains, the paper contends, drawing out of some estimation efforts from a less-discussed strand of the literature, that the prevailing narrative may be simplistic, if not erroneous. The argument is that the analytical frame used in much of the existing scholarship is narrow as it does not consider small equipment largely because of ideological and political reasons; indeed, much of the existing knowledge is based on the dominant paradigm. The essay contends that, *inter alia*, this potentially prevents formation of a credible picture which can then be exercised in devising policy interventions for increasing mechanization; considered a potent tool to shore up stagnant agricultural productivity. Upon broadening the analytical frame, i.e., inclusion of small equipment, there is suggestive evidence (quantitative estimates in, for instance, some case-studies) to indicate that rural mechanization, driven by inexpensive small equipment, may well be occurring in Nepal; including in the hills and mountains, areas considered poorly mechanized in the existing literature. Interestingly, much of even the dominant paradigm literature does make some passing references to small equipment-drive mechanization and that this has resulted in efficient agronomic practices in certain pockets. The article contends that to devise a suitable mechanization strategy, there is need for more research on this dimension of farm mechanization, beginning with a credible analysis of rural capital goods that does not equate mechanization with the use of large equipment.

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1.0 INTRODUCTION

Agriculture mechanization, for much of the agriculture development scholarship, has been synonymous with large farms, capital-intensive equipment (like combine-harvesters and four-wheel tractors or 4WTs) and canal-irrigation systems[1]. To this dominant strand (dominant because corporations and multilateral bodies buttress this position), land-fragmentation (for instance, smallholder-dominated farming systems with fragmented parcels), credit constraints and poor infrastructure hinder mechanization and hence improvements in agriculture. Predictably, almost all the existing scholarship evidences that agriculture mechanization in Nepal is lackluster, confined largely to the Tarai-plains (due to difficult terrain and relatively poor infrastructure in the hills) and constrained due to land-fragmentation, poor infrastructure and constrained credit-access (ibid.). India's mechanization pattern, for instance, including in its transformative Green Revolution, appears closer to the dominant paradigm[2]; potentially because large and medium farmers account for a rather large share of India's overall arable land[3]. Indeed, it is this group that has benefited disproportionately from the Green Revolution[4].

A less-noticed strand in research, however, finds differences in mechanization patterns between, for example, India and Bangladesh; by implication, their agriculture development has also been varied[5]. Agriculture mechanization in Bangladesh, unlike India, is away from the dominant paradigm and has instead been driven largely by small, inexpensive and multi-purpose equipment, such as two-wheeled tractors (2WTs) and low-lift pumps[6]. Biggs et al (2015) observe that the development outcomes of Bangladesh's agriculture mechanization have been dramatic. For instance, Bangladesh's agriculture is arguably the most mechanized in South Asia with over 80 per cent of land-preparation mechanized compared to under 50 per cent in India (ibid.). Despite sustained land-fragmentation, Bangladesh's rice productivity, for instance, has grown (ibid.). Perhaps Bangladesh's context - dominance of smallholders and small fragmented parcels as well as minimal capacity to subsidize purchase of large equipment – has been a compulsion to adopt this pattern.

Although for mostly political and ideological reasons, agriculture mechanization has been about large capital-intensive equipment such as combine-harvesters and large-farms, the paper engages with, if you will, an unorthodox strand on mechanization-scholarship; one that includes not just large capital-intensive equipment but also small, low-cost multipurpose implements. Engaging with and employing this strand opens several dimensions and intricacies of policy significance, the paper contends. Broadening the analytical lens here by including small, low-cost equipment potentially renders the existing Nepal-specific mechanization-knowledge, based overwhelmingly on the dominant paradigm, simplistic if not entirely erroneous. Somehow and rather interestingly, much of the recent literature on agriculture mechanization in Nepal makes somewhat passing references to rapid penetration of small equipment – two-wheel tractors (2WTs), hand-sprayers, low-powered water-pumps and small-scale threshers[7]. Some of these works go on to claim that there is rapid progress in rural mechanization

[1] See (World Bank 2016), (Takeshima 2017; Takeshima et al. 2015), (Bhandari and Ghimire 2016) among others.
[2] See (Biggs and Justice 2015). Also (Andreoni 2011)
[3] See (OECD/ICRIER 2018)
[4] See (Mdee et al. 2018) for a critical treatment of India's Green Revolution.
[5] Based on (Biggs and Justice 2015). This seminar paper, the broader analytical frame it suggests, is based on Dr. Biggs's work.
[6] See (Biggs and Justice 2015, 2016)
[7] See (Gauchan et al 2017), (Bhandari and Ghimire 2016)

and that much of it is driven by inexpensive small equipment and that this has resulted in efficient agronomic practices[8].

Indeed, few scholars[9] that employ the unorthodox analytical frame, i.e., including the small equipment, observe that small and inexpensive equipment such as 2WTs have been in use not just in farms (tillage, threshing) but also in, for instance, transportation since the mid-1980s itself. However, these observations and some preliminary estimation efforts[10], while useful to invigorate a debate, are extremely preliminary in nature and do not provide a credible picture into, for instance, mechanization rates and patterns. Though potentially suitable in Nepal's context - suitable for small parcels, simple to use, low-cost to scale-up and even manufacture or initially assemble - and perhaps central to mechanization, not enough is known about these small multipurpose instruments and machines. Despite some observations that small equipment is rapidly penetrating in Nepal, there is no credible stock of farm-sector capital goods.

Unlike India which is significantly resourced in fiscal, institutional and industrial terms and a significant chunk of its arable land is with large and medium farmers, Nepal's context is rather different. In fact, Nepal resembles Bangladesh far more. For instance, it is characterized by its small proportion of arable land, minimal fiscal capacity (for example to subsidize four-wheel tractor purchase) and predominantly smallholders and smallholder farming. None of this can be wished away in the medium-term and without developmental structural transformation. Indeed, Nepal's agriculture sector has seen only modest improvements; major food crops like rice show major production-supply gaps and need to be imported despite being among the most cultivated crops[11]. Indeed, Nepal's rice yield is the smallest in the region although agriculture share in GDP is the highest in the region. Rural poverty and rapid growth and development cannot be addressed if agricultural improvements are not made. Indeed, while transformative long-term solutions to agriculture development may not be forthcoming, incremental gains need to be made. In fact, incremental gains, a function of credible technological, organizational and institutional experiments and learnings, are the ones anchoring transformative policies. Mechanization, and as a result better agronomic practices addressing drudgery, labour shortage (a reality with rapid outmigration for the last three decades or so), intensity and the synchronization issue, offers a window for such incremental gains to improve agriculture. 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 (the case discussed later[12]).

This seminar-paper aims to invigorate debate and research on mechanization and contends that the current analytical frame employed by much of the existing scholarship constrains formation of credible picture; by implication, the scholarship negatively impacts possibility of effective and suitable mechanization strategy. Moreover, Nepal and its productive sectors, including agriculture, have undergone rapid transformation owing to intense outmigration resulting in labour shortages and abandonment of arable land. Interesting, though not straightforward, links emerge in outmigration and mechanization. For instance, evidence reviewed here suggests increased use of small and inexpensive implements not just due to labour-shortage but also because of greater resources owing to remittances. Even though intense migration over the last three decades has transformed agriculture, no not always positively, much of the existing mechanization scholarship and its readings of the ground realities remain unchanged. What the paper does not claim are equally important to mention. While the paper evidences that the findings of much of the existing scholarship may be simplistic and conservative because the frame is narrow (they exclude small equipment), this is not to

[8] See (Devendra Gauchan and Shrestha 2017)
[9] (See Biggs et al 2015,2016)
[10] Such as by Biggs et al (2015, 2016)
[11] See (Park et al. 2018)
[12] From (Park et al. 2018)

suggest that credible improvements may be there although the literature and several consultations point in that direction. Moreover, arguing that mechanization patterns have been different in Bangladesh and India is not to rule out overlaps. In terms of significance and policy implications, given the want of agriculture improvements in, not just Nepal but also in the region; countries like India, Bangladesh and Pakistan.

Conceptualization and methods: This seminar-paper was conceptualized during a day-long seminar on why agriculture mechanization, despite an evident need, remains lackluster in Nepal. Conducted by a SOAS (University of London) academic at SAWTEE[13], the review-article is based on subsequent desk research and consultations. The discussion studies evidence and discussions on mechanization dynamics – patterns, rate and concentration - between 2012-2016. The paper uses both qualitative and quantitative approaches. Along with descriptive statistics, the paper draws from observations and intuitive discussions from cases to carry the objective of the paper forward.

Paper organization: The paper is structured as follows. It begins with a brief discussion on the characteristics of Nepalese agriculture sector focus and in it the recent developments. Section 3 dwells into the theoretical underpinnings and evidence around why mechanization has been critical in improving agriculture. The fourth section briefly sheds light on major analytical frames in assessing mechanization and attempts to trace the intricacies and limitations of the dominant analytical lens. Section 5 is the case-study on mechanization dynamics in Nepal, the evidence and the inherent limitations in current assessments followed by the conclusion.

2.0 AGRICULTURAL TRANSFORMATION IN NEPAL

1.1 ***'Prosperity' aspirations****:* Proclamations and exhortations around building a 'prosperous' society aside, the prospects to achieve rapid inclusive growth and development look bleak, if not entirely unforeseeable. Indeed, by implication, prosperity of any sort means reasonable, sustained incomes which instead requires jobs. However, Nepal's dismal performance in job creation, a function of developmental structural transformation and not merely GDP growth[14] (volatile and slow, nevertheless), means the 'prosperous' Nepal achievement will be no mean feat. Consider this – over six in ten in the labour force are in agriculture[15], while the sector accounts for under 30 per-cent of the GDP. Going by GDP and employment share, Nepal is the most agrarian country in the region. Only modest improvements in agriculture mean not just vulnerable livelihoods, but a massive underproduction of food commodities like rice. Financing rice imports via remittance transfers, which finance over 80 per-cent of the overall trade deficit, has been touted as a vulnerable strategy. Yet, remittance transfers have arguably been the single biggest contributor to rather resilient consumption capabilities and social development. Among the top five imports, yield in rice, at roughly three tons

[13] Mechanization in Bangladesh, conducted by Dr. Stephen Biggs, a SOAS academic, and Scott Justice, of CIMMYT (September 2017). I thank both. SAWTEE or South Asia Watch on Trade, Economics and Environment, a think-tank is my workplace. www.sawtee.org. I thank both.

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

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

per hectare (*ha,* hereon), is below what most regional peers (Uprety 2011) produce. The picture is not very different for the overall cereal yield. Nepal is behind most regional peers (Park et al. 2018). The manufacturing sector, on the other hand, considered critical in credible growth and development[16] as well as job-creation, has the lowest GDP share South Asia.

1.2 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)[17]. On the other hand, agricultural improvements are critical for overall dynamism, including in driving manufacturing. This is due to 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 lie in agriculture (Agriculture for Development: World Development Report, 2008 buttresses this position).

As we will see in later sections, agricultural transformation cannot be achieved without incremental gains in manufacturing capabilities, which, instead, significantly impact societal learning capabilities regarding technology and organization[18]. 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[19] 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[20] resulted in major development outcomes – poverty declined from 50 per-cent in 1980 to under 10 per-cent in early-2000s (World Bank 2008). In India, Green Revolution, between 1967 and 1986, led to an output expansion of 50 per-cent, while poverty declined by 20 per-cent (ibid.). Robust inputs provisioning (improved seed varieties, pesticides), mechanization in farm operations via usage of equipment such as four-wheel tractors (4WTs, hereon) and irrigation (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 learnings and experiments, rather than 'prerequisites of development' type supply-side explanations such as that infrastructure or investment, leads to development.

1.3 Other salient features of Nepalese 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 (Gupta and Others 2017). A third of it has year-round irrigation (about 50 percent of the arable land 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 0.7ha, fragmentation is widespread – on

[16] (Szirmai and Verspagen 2015; Khan 2013)
[17] (Thirlwall 1983) for how manufacturing triggers overall growth – the so-called Kaldor growth laws
[18] (Andreoni 2013)
[19] (Wood 2002)
[20] See (Cao and Birchenall 2013)

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 greater than five hectares account for the rest (Gupta and Others 2017). Within the agricultural GDP, foodcrops, livestock, horticulture and forestry contribute, 40, 30, 20 and 10 percent respectively[21]. 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[22]. 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 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 CBS 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 per-cent. 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 evidences 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, however critical, 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), financial system poorly geared to serve the productive sector learning processes and questionable extension provisioning. However, there are pockets of modest gains.[23] Consider the yields in vegetables and fruits, which compare well in the region and have been attributed largely to the diverse agroecology[24]. Both fruits and vegetables are considered sectors of high returns and greater labour intensity. However, even in these sectors, there is unpredictability of prices that farmers get.

[21] MoF 2013 in (Devendra Gauchan and Shrestha 2017)
[22] For (Gupta and Others 2017)
[23] (World Bank 2016)
[24] (Gupta and Others 2017)

2.0 RATIONALE AND EVIDENCE OF MECHANIZATION

2.1 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). 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.).

Agricultural production entails broadly two independent processes – the biological course and the agricultural works like plowing, planting and irrigation[25]. Agricultural works are performed through capabilities embedded in humans, animals and instruments – mechanical and non-mechanical - like engines, water-pumps, power-tillers, seed-planters and sprayers and tractors. Well-coordinated and synchronized operations, via usage of instrument, animals and humans, results in efficiency, accuracy, multi-tasking, intensity and, the most important of all, reduction in drudgery.

Mechanization is significantly about farm-power, where instruments complement animal and human power. Indeed, smallholders in developing countries are severely power-constrained. For instance, in developing regions like Africa and South Asia, over 60 per-cent 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). It is the improved quality of farm-operations - row-planting, optimal plant population, seed and fertilizer application and replacement and efficient utilization of soil moisture during the planting window – that results in significant yield improvements (ibid.). While several traditional practices, when complemented with improvements, yield better outcomes, the others are plain harmful. Consider the use of 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 improves agronomic practices like managing soil-fertility. Indeed, in India's green revolution, mechanization, use of pumps and tractors, has been instrumental[26]. Even 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, to tackle mainly – 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 among parcels in the same field. Since, usage of the sprayer resulted in greater seed density and uniform application and hence greater strength of the relationship between seed and fertilizer, users derived greater yield and profit with less unpredictability. Even when the control group used more fertilizer, the output did not respond proportionately; potentially a factor that disincentivizes investment in inputs like fertilizers. In the

[25] (Andreoni 2011) – from which I draw heavily in this section
[26] Ibid.

treatment group, there was greater labour efficiency while learning to operate the equipment did not take much time.

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 learnings, experiments and configurations. Among these was a sizable degree of rural mechanization (use of tractors and irrigation provisioning, ibid.). Mechanization – not just the implements and equipment but credible capabilities to use them, maintain and manufacture them – entails robust technological, organizational and institutional learnings. A credible spread of mechanization aids structural transformation through various indirect mechanisms, such as the market for instruments, and, hence, incentivizes manufacturing[27]. In the farm-sector value chains, for instance, in, dairying, milling, packaging and extraction, mechanization occupies a major role.

2.2 Nepal's mechanization patterns and evidence*:* Agriculture Development Strategy, 2014 observes that low mechanization rates are among the principal causes of Nepal's weak performance in agriculture. Indeed, much of the literature[28] makes similar observations - that mechanization rates are low, confined largely to Terai plains (roughly two-thirds of Nepal's territory is hilly and mountainous while Terai plains, less than a fifth of the overall territory, have relatively better infrastructure owing to the terrain) and a result, negatively impact intensification and productivity. A 2012 study by Nepal Agricultural Research Council (NARC, hereon) estimates that over 75 per-cent of the overall available farm-power comes from human and animals, whereas the 25 per-cent derived from mechanical sources is almost entirely confined to Tarai (Shrestha 2012). The study finds that even in Tarai, animals and only rudimentary implements like iron plough are common. Due to the difficult terrains and poor infrastructure, mechanization is non-existent and largely unfeasible in most hill and mountain areas (ibid.). A World Bank (2016) study observes that mechanization rates are low; that most mechanization is restricted to Tarai. It goes on to postulate that there is no indication that difficult terrains – hills and mountains – are making progress on rural mechanization. Takeshima et al (2015), in their analysis of mechanization patterns, use the Nepal Living Standard Surveys and take tractor usage as the mechanization proxy. They observe that in terms of area ploughed by tractor, Nepal fares poorly when compared to countries like Vietnam; 20 per-cent in Nepal compared to Vietnam's over 70 per-cent (2010 figures) though there is progress in tractor usage. They find that tractor usage has increased from five percent of total farm households in 1995 to over 20 percent in 2010, while less than one percent actually own tractors suggesting functional hiring mechanisms. Tarai, which Takeshima et al (2015) argue is most mechanized and that progress is much faster than other regions, 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 the recent decades has exacerbated labour scarcity. This has a major relationship with mechanization dynamics (Baudron et al. 2015). Mechanization, as we have evidenced, supplements and complements labour and addresses labour shortages,[29] 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 mere reduction in labour will not drive up

[27] (Andreoni 2013) for a detailed discussion on the processes

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

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

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)[30]. 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 per-cent of the production cost, the overall production cost dropped 25 per-cent, whereas profits rose 36 per-cent post-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 proxy being usage of tractor) pushes the probability of a typical farm-household towards adopting migration (as in Chitwan) roughly 25 per-cent higher.

3.0 ORTHODOX SCHOLARSHIP AND ITS POTENTIALLY NARROW ANALYTICAL LENS

***3.1 Not one mechanization pattern*:** In assessing mechanization, much of the research takes large capital-intensive equipment like 4WTs, combine harvesters, high-powered pumps and threshers as proxies. For instance, Mrema and Kienzle (2018) call 4WTs the unsung heroes in Europe. The other common position is that fragmented smallholder-dominated systems are unsuitable for rapid mechanization and greater productivity expansion (World Bank 2016). Hence, that fragmentation and smallholder farms inherently and naturally disincentivize investments in agriculture (ibid.). To the dominant agriculture development paradigm (dominant because multilaterals, international financial institutions and corporations hold and buttress such position), mechanization is not just about canal irrigation systems, large equipment and large-equipment led heavily mechanized large farms but also modernity and progress (Biggs and Justice 2016). India's mechanization, for instance, in its Green Revolution-like improvements, is closer to the dominant paradigm. This potentially was possible because large farmers, roughly five percent of the total farming households, own a disproportionately high share of arable land[31]. While transformative in many measures, India's green revolution is not without criticisms. The Green Revolution is blamed for environmental degradation- depletion of ground-water and soil salinity, subsidy-driven wasteful use of inputs and energy- and disparity in benefits as it is the large and medium farmers who mostly benefited (Mdee et al. 2018, for a critical assessment of the Green Revolution).

The dominant paradigm in agriculture improvement, although the basis for much of Nepal's agriculture research and policy, is not just demanding in terms of fiscal and institutional capacity (capital, infrastructure, subsidies, land-consolidation if it is a smallholder dominated society) but is also, going by India's record, significantly wasteful[32]. Nepal, an LDC with minimal fiscal, industrial and institutional capacity and endowed with a smallholder-dominated highly fragmented system that cannot be wished away (unless, for instance, a major developmental structural transformation occurs) predictably has made only modest gains in mechanization. By implication, improvements in agriculture have been lackluster. Indeed, Nepal's mechanization policy and strategy so far mirrors that

[30] (World Bank 2016; Gauchan and Shrestha 2017)
[31] In (OECD/ICRIER 2018)
[32] See (Biggs and Justice 2016, 2015)

of India and is closer to the dominant paradigm. There is potentially a need for alternative mechanization models which can bring about incremental gains. 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)[33]. In this, mechanization patterns of countries like Bangladesh and Vietnam, both smallholder contexts, offer useful learnings. The Bangladesh case, which we delve into here, its mechanization pattern provides a much broader and useful analytical lens to understand mechanization. When this, if you will, broader analytical frame is introduced, much of the existing analysis on mechanization-related progress in Nepal, appears simplistic if not erroneous necessitating further analysis.

***3.2 Small, inexpensive and multipurpose equipment for incremental gains*[34]:** Much of the literature on agricultural improvements, influenced by the dominant agriculture development paradigm, makes no reference to small, low-cost, multipurpose equipment-driven mechanization in countries like Vietnam and Bangladesh (Biggs and Justice 2015). The mechanization pattern in these countries has been different from India's though this is to not suggest that there are no overlaps; obviously there would be large tracts where large capital-intensive equipment would be suitable (ibid.). Partly the small equipment-driven mechanization (two-wheel tractors and low-lift pumps for instance) is a consequence driven by the context - resource crunch and the dominance of smallholders, for instance (ibid.). The low-cost small-sized machines such as 2WTs 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 et al 2016).

Prior to independence, canal-based irrigation systems irrigated roughly 50 per cent of the arable land in Bangladesh. In the other half, farmers used swing-buckets and other mostly manual instruments (Soni et al 2010). When the Japanese introduced 2WTs in the 1970s, it did not gain traction immediately. By the 1980s, low-cost and better quality Chinese 2WTs had penetrated rapidly (Biggs et al, 2015). Timely policy interventions such as lifting an earlier ban on cheap Chinese equipment (2WTs and pumps) and duty and tax reliefs played a major role in rapid penetration of 2WTs (ibid.). The number of shallow tubewells (powered by low-cost low-powered Chinese pumps), mini-tillers, low-lift pumps and manually-operated weeders and sprayers (there are a million sprayers in Bangladesh) all have grown rapidly (Figure:1, Ou et al 2010). Much of the manually-operated implements are made locally, while most mechanical instrumental are largely imported (ibid.). Robust mechanization has resulted in efficient use of water and mechanized land preparation has been a major factor in the 2.5-fold rise in the value of agricultural commodities produced between 1980 and 2000[35]. Baudron et al (2015) note that land preparation is by far the most demanding activity in rain-fed conditions. Credible mechanization progress means 80 percent of Bangladesh's land preparation and tillage operations are mechanized – the highest in South Asia (Biggs and Justice 2015). The rate is significantly greater than India's, where it is roughly 50 percent (ibid.). Despite the 80 percent usage rate, ownership is only a fraction of it (one in thirty users), suggesting functional renting mechanisms (ibid.).

There are indeed differences in the mechanization patterns in India and Bangladesh; by implication, the outcomes have varied. Though India is a much bigger country, Bangladesh has a greater number

[33] (Khan 2013)
[34] I borrow significantly from Dr. Stephen Biggs's work on rural mechanization
[35] From (Biggs and Justice 2015, 2016)

of 2WTs than India (India – 300,000 2WTs, Bangladesh – 500,000[36]). The flourishing demand for 2WTs has opened business opportunities for the private sector. This has resulted in robust supply-chains and intense competition. The small inexpensive equipment is employed not just in farm operations but also in post-harvest activities, like transportation which, it appears, cuts costs. In smallholder-dominated developing countries, while the farm-to-collection hub distance constitutes a small portion of the overall distance that a typical commodity travels in the supply chain, this takes a disproportionately high share of overall transportation costs (ibid.). Employing 2WT in transportation has not just cut transportation costs but also reduced losses in transporting goods to the collection point/market.

Figure: 1, Agriculture machinery, Bangladesh (1997-2006)

Machinery-type	**1977**	**2006**
Tractors	300	12500
Power-tiller	200	300000
Shallow tubewell	3045	1182525
Low-lift pump	28361	119135

Source: From (Soni and Ou 2010)

The small equipment-driven mechanization pattern in Bangladesh and its outcomes provide useful insights. Based on the dominant paradigm, existing scholarship and, as a result, policies, are potentially not considering the context it seems – agroecology (parcel size, workers), infrastructure (which Nepal may not have the capacity to improve in the short-term), scaling-up potential of the mechanization equipment, spares and maintenance potential and even the possibility to manufacture. One factor in this appears to be emulation of the Indian model (closer to the dominant paradigm), a regional power. However, in this specific area, India 's performance is not too stellar while Nepal's context and capacity are much different than India's.

The other important insight from the small, inexpensive equipment-led mechanization is the narrow analytical frame of the dominant paradigm. As we will see in the next section, by excluding small equipment, much of the existing scholarship, based as it is upon the dominant framework, gives a rather simplistic potentially misleading picture when it comes to mechanization-related progress; certainly not helpful if credible policy is to be devised.

4.0 MECHANIZATION IN NEPAL UPON AFTER ALTERING THE ANALYTICAL FRAME

Why dominant scholarship may be simplistic[37]: Nepal started importing the first 4WTs in the 1960s. Interestingly, the late 1960s and 1970s were also a period when some small agricultural equipment

[36] See Figure:2, from (Biggs and Justice 2016)

[37] I draw from a specific strand of scholarship. This comes from Dr. Stephen Biggs's work on rural mechanization. See (Ellis and Biggs 2001; Feldman and Biggs 2012; Biggs and Justice 2015, 2016)

was being tested but did not produce results then. It was only the 1980s, when Japanese aid programs brought in 2000 2WTs to Nepal that small equipment came into Nepal. However, the use of the 2WTs was initially confined to Kathmandu and Pokhara (major cities) and the areas around. While there is not much data, some novel largely preliminary estimates suggest that there are 12,000 2WTs – most in and around Kathmandu, Pokhara and other well-connected valleys and are being used for transport, tillage-operations and threshing, among other activities (Figure:2). Estimates by Biggs et al (2015) suggest that since early 2000s, there has been a rapid penetration by 2WTs and mini-tillers but apart from this, there is not information on 2WT penetration. Despite the reported growth, Nepal has less than five percent of 2WTs that Bangladesh has (Figure:2). On the other hand, emulation of the Indian model means Nepal has twice the number of 4WTs than Bangladesh; indeed, 4WTs are among the top imports in the recent years[38].

Figure: 2, Horsepower availability in agriculture by engine size

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

Estimates of the numbers of power sources (and their HP ratings) used primarily in agriculture and processing uses, including groundwater irrigation pumps. It does 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. +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. Source: Reproduced from (Biggs and Justice 2016)

Upon altering the analytical frame, i.e including the small equipment, brings into light new dimensions. While not in much detail, the existing literature does passingly talk about the small equipment and in fact presents some estimates. Gauchan and Shrestha (2017) cite a 2013 estimation (Figure:3) where 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 2WT, power-tillers, low-power pumpsets and small-scale irrigation pumps has increased rapidly but do so rather anecdotally. The study notes that small scale threshers and tillage equipment are widely available to buy.

[38] See trade data in www.tepc.gov.np

Figure:3, Machinery/Equipment in agriculture

Machinery/ Equipments 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.

Gauchan et al (2017) observe that small equipment-led mechanization is more common in non-traditional activities such as horticulture and poultry Interestingly, the non-traditional areas like vegetables and livestock have also been registering the fastest growth in agriculture in recent years[39]. Shrestha (2012) observes that while all mechanical power is concentrated in Tarai, equipment like 2WTs, power-tiller, hand-sprayer, paddy-sheller and grinders are used in valleys connected to road-heads. The 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 (Nepal) to tackle mainly – 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, potentially inhibiting investment into inputs like fertilizers. The treatment group results show greater labour efficiency. Users need not have too much experience to operate the equipment.

[39] See (Gupta and Others 2017)

5.0 CONCLUSION: CONTEXT-SPECIFIC PARADIGM

While a less noticed strand in research suggests rising penetration of small equipment-led mechanization, there is no credible data and analysis. Conversely, existing knowledge, based on the dominant paradigm, focuses only on a specific kind of mechanization- one that is about large farms and large equipment. For the dominant strand, mechanization is low and confined to Tarai, wanting of investments.

The paper evidences that small equipment may well be making rapid inroads, addressing, for example, labour shortages. Cases reviewed here corroborate the same. On the other hand, broadening the analytical lens renders the existing orthodox analysis simplistic, if not erroneous; hardly a helpful position if credible mechanization strategy is to be forged. A possible way-forward is to have a credible analysis of farm-sector capital goods.

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