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Political power in innovation systems: Smallholder sustainable intensification and rural mechanization[1]

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Table of Contents

Introduction

Rural Mechanisation

- **The spread of Agricultural and Rural Equipment Bangladesh**
- **The spread of agricultural and rural equipment Nepal**
- **Summary of the spread of smaller scale equipment and service markets**

Observations on the history and debates on rural mechanisation

- **General**
- **Framing of debates**
  - **Large scale is better than small scale**
  - **Characterization of "stand alone family farms"**
  - **Separation of the agricultural sector from other sectors**
  - **Representation of the Green Revolution**
  - **Energy and water scarcity**
- **Cultures of Mechanical Engineering**
- **Cultures of Commercial/ Bureaucratic /Projects**
- **Sources of Innovation**

Ways forward

- **Location, time and actor specific: Nepal**

Innovations Systems Theory and Practice

- **Personal reflections**
- **Ways forward: Institutions are always in the making**

Conclusions

References

Tables/Figures/map

Introduction

The organizers of the consultation have asked us for "assistance in identifying the ways forward in advancing the thinking and theory on Innovation Systems (IS) and building research capacity for influencing policy and practice and building research capacity for influencing policy and practice" (CTA/COS-SIS concept note). And more specifically that we help to address the theme of "Sustainable intensification-smallholders". In several places in the concept paper there is emphasis given to the development of the Innovation Systems approach (ISA) so that policy and practice "benefits smallholder farmers". This is a useful directive, as it means we will not be addressing topics, such as the use of an ISA for increasing agricultural production based on large scale production processes.

We are pleased to do this and will address these issues by looking at the long history of the intensification of agricultural production by the spread of smaller scaled mechanical equipment in the agrarian/rural structures of Bangladesh and Nepal. We have both been engaged in policy and practical issues of rural mechanization in South Asia for many years, and have used methods and techniques from the innovation systems theory and guidelines in our work on rural mechanization; especially for us in a consortia of allied projects for the promotion of smaller scaled rural machinery. At the end of the paper we shall reflect on our own experiences of using the IS framework.

We do not have a great deal of experience of countries outside of South Asia, yet we find ourselves in the midst of advising new projects in Asia, Latin America which are just beginning and are struggling to find information, orientations and ideas for ways forward for the promotion of small scale mechanization. We hope that this brief paper concerning the history of the intensification of production on smaller holdings in some countries and regions in South Asia will be of interest to others in other circumstances.

Whether "sustainable intensification" of smallholders will come about in the future, depends on the political contexts in which social and technical change take place, and a consideration of these issues is beyond the scope of this note. However, as we conclude, if IS theory and practice is not embedded in a recognition of ongoing political processes sustainable intensification is unlikely to be achieved.

Rural Mechanisation

We are writing this paper against a background where the advocacy and promotion of larger scale mechanization is being undertaken by many actors. Besides the more dramatic cases of "land grabs' where large scale equipment is generally very evident, there is a more general advancement or bias that "larger scaled" agriculture is somehow better. For example, when expert assessments of global food are published, there are often pictures of combined harvesters, large 4 wheel tractors, large canal irrigation systems, and GIS systems for precision placement of nutrients illustrating the documents. However, rarely do we see pictures of 5 horsepower (HP) pumpsets, a 2 wheel tractor, or locally made,

cheap plastic lay flat pipes for the careful placement of water. Sometimes we hear stories about the Green Revolution coming about as the result of the spread of high yielding crops, 4 wheel tractors, combine harvesters, deep tubewells and other larger scale equipment. We see it in situations where governments massively subsidized the agricultural sector with cheap energy (urea, diesel, and electricity for pumping fossil water), and subsidies for large scale equipment. However, we do not hear so often the stories of green revolutions in agrarian/rural economies, where the spread of small scale mechanical equipment, rather than larger scale equipment is the dominant pattern. And this spread is not limited to just South Asia. Evidence is emerging from east Asia- China, Thailand, Vietnam, etc- that they too have experiences massive small scale mechanization that, in the cases of Thailand and Vietnam have become the major exporters of rice.

This lack of interest or familiarity in smaller scale equipment has been expressed in others ways. FAO dramatically reduced its agricultural mechanization capability in 2003 and the international agriculture engineering institute at Silsoe closed in 2004. Unfortunately, FAO has also until recently only classified agricultural mechanization as happening by data on 4 wheel tractors. As we shall see, by these criteria, Bangladesh's agriculture is hardly mechanized. The reality on the ground is that Bangladesh has the most mechanized and …counter-intuitively… labour- intensive agricultures in South Asia.

In many agricultural policy debates there is also an assertion that small holdings need consolidating in order to intensify agricultural production. The empirical evidence from Bangladesh tells a very different story: the agricultural and rural economy has been growing steadily while at the same time holding size has been getting smaller.

The spread of Agricultural and Rural Equipment in Bangladesh[2]

Figure 1 shows that over the thirty year period from the early 1980s to 2010 the number of Chinese two-wheel tractors (2WTs) increase for about 500 to 420,000, while over the same period four-wheel tractors (4WTs) increased from about 400 to 26,000. However the greatest expansion of small mechanized equipment was the spread of small (average 5 HP) pumpsets (a diesel engine with a pump) for shallow tubewells. In 2010 it was estimated that there were about 1,425,000 of these units.

If we look at figure 2 we see that the implications of these numbers is that only 8% of the total tractor HP (2WTs and 4WTs) comes from the larger equipment and the other 92% comes from smaller 2WTs. If we now look at the overall total numbers of engines (tractors and small scale irrigation pumpsets) we find that 49% of the overall total available rural and agricultural HP is provided by small scale engines which power the small pump sets.

[2] The numbers in the tables are not always totally consistent. Getting reliable estimates in a cost effective way is quite challenging. However, the discrepancies do no effect our main argument.

As an indicator of what has been happening in Bangladesh agricultural production we look at the expansion of the most important crop- rice. Figure 3 shows a more or less continuous rise in production from the early 1990s to the present day. Part of the reasons for this growth was the spread of smaller scale mechanical equipment in a highly differentiated agrarian/rural economy, where the average size of holding has decreased from 2.00 acres in 1983/84 to 1.26 acres in 2008. It can be seen that marginal and small farmers (farms up to 2.5 acres) are now dominating even more the agrarian structure and in 2008 made up 63% of all farms, in contrast to 53% in 1983/84. Additionally, mechanization (water and tillage) along with widespread shallow aquifers, has led to farming intensification and increased cropping intensity to where the earlier winter fallows have been replaced by winter rice (boro rice) (and other winter crops like wheat, maize and vegetables) which now exceeds the main monsoon season rice production.

The spread of smaller scale equipment has been accompanied by the spread of a wide range of markets in engine services. In this agrarian/rural economy, small scale engines may be used for multiple purposes. Rural entrepreneurs use them on their own holdings and hiring them out for multiple services. In the case of 2WTs this might be for transport of people, goods, tillage operations, pumping water, powering threshers etc. Though the income may not be high these service markets are very active. It is beyond the scope of this paper to investigate the income distribution effects of this smaller scale mechanization process.

The spread of Agricultural and Rural Machinery in Nepal

The spread of mechanization in Nepal is a very different story. In addition to the great diversity of ecological conditions as the mountains on the Map makes clear, there are tremendous differences in the languages spoken, ethnic groups, history and the history of economic planning. However, in the context of rural mechanization of smallholder's agricultural operations, Nepal has a history going back to the mid 1970s when more expensive Japanese and then Korean 2WTs were introduced into the Kathmandu and Pokhara valleys. Today the agriculture of those two valleys is some of the most intensive and productive agriculture in Nepal. Significantly, the two wheel tractors (whether Japanese or Chinese) have always been used for multiple purposes: for transport, as well as for tillage, threshing, and other purposes. Equally important is that there have always been strong markets for the buying and selling of tractor services. Especially since the introduction of the Chinese first in the 1980s and then later again in 2000[3], the economic rates of return have always been very high and the pay back periods have generally been less than two years. A large system of local repair and fabrication shops slowly emerged and keep some of the early Japanese and Korean tractors of thirty plus years ago still running and providing services.

However, in spite of this evidence of how smaller scale equipment helped to increase the timeliness of field operations and agricultural intensity, Table 5 and 6 shows that it is only in recent years that two wheel tractors have started to

[3] See Biggs et. al., 2002 for more details.

spread more generally in Nepal. Currently, they only make up 10% of the total mechanized horse power used in rural areas. This is a very different picture from Bangladesh where the horse power from two wheel tractors made up 46%. (Table 1).

Conversely the wide spread use of 4 wheel tractors in Nepal began many years before they did in Bangladesh. Thousands were being imported through out the 1980s, 1990s and 2000s and early on most were being utilized in the terai (flatlands) for agriculture, although their use was also common in transportation in the off-season. Since the 2000s the demand for them is still strong, bolstered by very low import tariffs. However, many are being mainly used for transport services, due in part to continued and very high import duties on trucks. Increasingly 4 wheel tractors are being used more for transport and haulage than for tillage and other agricultural operations. Even more so in the mountains where the costs of providing hard top roads is very high, and 4WTs are used mainly for haulage transport purposes on rough local roads.

On the plains (terai), small scale pumpsets have been spreading slowly since the 1980s. Until recently they were mostly comprised of the heavy and expensive and rather ancient Lister type diesel engines from India. Surprisingly, it appears that the knowledge and experiences of Bangladesh, which started over 25 years ago in the use of cheap, good enough, lightweight, Chinese diesel engines, and the promotion of water markets for the careful and intensive use of irrigation water, have only recently come to Nepal. Starting in about 2008 sales of these Chinese diesel pumpsets began to climb dramatically. There are of course, many reasons for this, but to some extent, it would appear that those who influence agricultural, irrigation, and energy policy in Nepal have traditionally looked only towards India for ways forward, rather than to Bangladesh[4] or China. Interestingly, it appears the small scale mechanized equipment is now spreading fast in India, much of this being Indian equipment being powered by the same lightweight and inexpensive Chinese diesel engines used in Bangladeshi and Nepalese.

Summary of the spread of smaller scale equipment and service markets

There are many key features of these smaller scale equipment and service markets such as being marked by a long history, great diversity by regions, national resources, policies, institutions, and trade regimes. Some key features are:

- In Bangladesh a key policy change was to reduce import machinery tariffs.
- Import "quality control" measures in Bangladesh were scraped in the late 1980s. For decades imported smaller scale Chinese engines did not meet

[4] For a discussion of the absence of smaller scale mechanisation in India see Biggs, Justice and Lewis.

engineers standards -- but later were found to be "good enough" for millions of farmers and rural entrepreneur

- The private sector came in strongly and now imports thousands of small scale equipment and rural machinery. While there was an early interest and changes in policy there were no continuing government or international projects to aid mechanization.
- Multiple markets for diverse service (transport, water pumping, tillage) were a key part of the rural mechanization process.
- Rural entrepreneurs owned and/or operate smaller scale equipment. In the case of 2WTs, these entrepreneurs are using them as mobile, multipurpose power units.
- Energy policies are a central component for understanding processes of rural mechanization. E.g. number of tillage passes in both Nepal and Bangladesh came down due to increasing diesel prices, with no loss in productivity.
- Agrarian/rural social structures always important. In Nepal, the 2 WTs are generally operated by rural labourers who also manage the marketing of services and machine maintenance. However, they are owned by "larger" small farmers, who have access to private capital, and sometimes Bank loans. Up until now in Nepal, those without land collateral have been unable to access loans for these types of highly remunerative rural investment opportunities.

Observations on the history and debates on rural mechanization

The case study of Bangladesh and to a lesser extent Nepal shows that's the intensification of agricultural production has taken place as a result of the spread of smaller equipment and associated institutions. During this period a number of other things were also happening which we want to list and highlight further below:

General

Since the late 1980s there has been a closing down of rural mechanization debates, and a major reduction public sector R&D funding and extension capabilities.

In the last two decades there has been a creeping science & technology public policy bias towards plant sciences and away from applied agronomy and agricultural/rural engineering. Even after the 2007 energy price increases, and the renewed international interest in agricultural and rural development, many of the response have been genetically based with little orientation towards smaller scale patterns of rural mechanization.

Framing of debates

The framing of debates is important, and we raise these issues because, while there has been plenty of evidence available that extensive smaller scale mechanization had been taking place, we often found ourselves in situations where debates and discussions were, from the outset framed in other ways. This

meant that meetings were often confrontational situation, rather than debates about a policy issues. Some of these framing issues are:

Larger scale production is inherently better

Assertions are being made from the outset that the consolidation of holdings is necessary in order to increase intensification and efficiency of agricultural and rural production. The Bangladesh, and many other country/regional cases tells a very different empirical story.

Characterization of "small, stand alone family farms

In the context of smaller scale equipment, sometimes small farmers are characterized, or better yet, idealized as small standalone units, which have little contact with the outside world. The small scale equipment is there so they can do everything for themselves on the self-contained, independent "family farm". Where smaller scaled equipment has spread in south Asia, the situation could not be more different from this characterization. Rural entrepreneurs own the equipment, hire it out, and sometimes use it on their own holdings.

Separation of the agricultural sector from other sectors

While the cases we have looked at show that smaller scaled equipment is used in multisectorial ways, the bureaucracies and policy frameworks that dominant in planning, and some academic institutions make the assertion that sectors can be meaningfully separated in this way. Perhaps one of the most obvious examples of this is the use of tractors: whether large or small. While we generally think of a tractor as a piece of agricultural machinery, in most cases it is fair to say that tractors are used for transport- of people, goods, in the construction and other "sectors"- and sometimes for agricultural inputs and products. They then might also be used for tillage and other agricultural operations. Rarely are these cross sector consideration taken into account, at least in rural mechanisation debates.

(Mis-) Representation of the Green Revolution

At the start of the paper, we discussed how "the" green revolution is sometimes represented as a single event, taking place in one way with improved varieties accompanied by large mechanized farmers- the Punjab way. The example of the labour intensive, highly mechanized – but with smaller scaled equipment- "green Revolution" from Bangladesh, shows there are many types and very different "green revolutions".

Energy and water scarcity

Many agricultural policy debates in South Asia have been framed in the policy prescriptions transferred from the UK, USA, and other OECD countries. Namely that agriculture should be highly subsidized and protected. This is not the place to investigate the reasons for this simplistic "transfer" of policy prescriptions. However, it has resulted in many of the Asian green revolutions coming about as a result of the high subsidization of energy inputs (subsidized urea, diesel and sometimes free electricity for pumps for irrigation, large surface irrigation

projects, and direct grants for mechanical equipment, etc.). One could say that past agricultural growth has been as much the result of a cheap energy policy for agriculture, as that of the development of improved varieties of crops. However, agricultural policy debates (whether reflecting on the past, or thinking about the future) are rarely framed in the light of these subsidized energy policy dimensions. In the future these are issues that will become a central concern for different patterns of agricultural and rural development; especially in the light of peak oil where fossil fuel prices will only continue to grow and urea and other intensive fossil fuel inputs' costs will continue to rise. In the future macro policy interest in smaller scale, clean renewable energy sources, like micro hydro, solar, and wind energy is likely to grow.

Cultures of Mechanical Engineering

While running the risk of us representing people with engineering training in an unfair way there are a number of characteristics about the discourses of engineers that have an important bearing on policy debates on rural mechanization. Besides the more obvious ones of sometimes being preoccupied with larger, more sophisticated equipment and showing a greater interest in newer machines as opposed to smaller and older models of equipment, there are a number of dimensions in their professional training that are particularly important.

Data collection and the presentation of engineering information

It appears there has been little professional training in the collection, analysis and presentation of field information on mechanisation. For example, how to estimate national numbers of different types of equipment or to undertake empirical studies of the spread and outcomes of different patterns of mechanisation. For example, had they been better able and equipped to communicate their success stories for which there are many (axial flow rice threshers, wheat threshers, axial flow pumps, etc.) it is possible that there may not now be such a need to reigniting the mechanization debates.

Prevalence of generalized stage theories of mechanizations

These theories often promulgate stage wise linear processes, that have little empirical basis, and often detract attention away from analyzing a country's specific unique context.

Proof of Concept

Experiments with new equipment on the basis of "proof of concept", with little reference to existing technology, and existing economic/social conditions, which might also included suggesting something was new, when it already existed in that context. Indeed, some international agricultural engineering journals articles are simply "…what a great idea I have", but never discuss whether these ideas made it to market. This is a quintessential example of the linear theory of research and development where research has no role in taking the idea past their doorstep.

Leaving claims unchallenged

Often the scientific promises of "scaling up and scaling out" of specific equipment and institutional models are left unchallenged. One area where often occurs is in of "new "institutional models of ownership and management of agricultural equipment, models that reflect little knowledge of the outcomes of these types of models in the past. (E.g. group ownership and management, government hiring schemes, and a whole range of market led business models). The prevalence of this behavior amongst engineers and their allies makes it difficult to engage in an empirically based policy debate, where other actors might be invoking evidence from past experiences.

Cultures of Commercial/ Bureaucratic /Projects

We will not elaborate here, but there are a whole host of cultures that come into the working of development projects. And there is a large literature which shows that issues like the power of major donors, government ministries, large funding NGOs, and the stage in a government budgetary process, etc. can influence the technical and associated institutional options considered and promoted. The point for this discussion is that these political and cultural issues are as important as any innovation systems considerations concerning the development of policies to promotion different patterns of rural mechanization.

Interestingly, an issue that has come up more recently, in connection with the behavior of staff in aid projects is that agricultural and rural mechanization issues are emerging in political debates - an emphasis to promote agricultural intensification – the promote market based value added chains, rural poverty reduction, etc. However, there is often a lack of knowledgeable engineering expertise to be brought to bear on issues. Consequently advice is given by people with little or no knowledge- "everybody is an engineer". Some of this due to the neglect of rural engineering and mechanization in debates over the last 20 years. For example, as far as we know there are no experienced young or mid-level professionals working in rural and agricultural mechanization in international development as there have been no jobs there for 20 years. Some of these skills may now be found in the NGO sector.

Sources of Innovation

A feature of rural mechanization is that the nature of the technology is different from say, plant varieties. In particular innovations often come from multiple sources - "other sectors", such as cheap lay flat plastic pipe, or local engineering innovations that can be so essential to the spread of any introduced equipment. On other occasions, old technology in a new place at a new time might be as relevant as new, "state of the art" technology. In addition, in some cases engineering innovations represent a fundamentally different way of doing things, rather than a gradual modification/ change of business as usual. Rural engineering innovation and promotion has special issues which are sometimes different from other areas of technology, and this has to be recognized.

Ways forward

Location, time and actor specific: Nepal

There is no general formula for ways forward. Each situation is different. We have taken Bangladesh and Nepal as case studies here, and they illustrate the diversity and complexity in each country and their differing paths to mechanization. The differences in agro climatic resources, etc. are obvious differences. In the context of Nepal, the country has large water resources from the Himalayas that can be used for irrigation in Nepal, or by downstream users in India and Bangladesh. Nepal also has potential hydro electricity energy, and other usable energy sources. Bangladesh on the other hand does not have the Himalayas but has energy in the form of natural gas deposits. We could elaborate further on these kinds of technical differences, but here we wish to point to other kinds of differences. We have listed a whole range of cultural and behavior themes that have repeatedly come up in the history of the mechanisation processes that we have been part of, and it is these issues which we feel are as important as any of the more technical "resource endowments" dimensions, or even the knowledge that now in the contemporary world, there is a tremendous range of mechanical equipment of all shapes and sizes, expensive and high quality or inexpensive and of good enough quality- which was not widely available just a decade ago.

For us the issue then becomes one of developing and exploring "room to maneuver" in any given political and job context. In this method, techniques, frameworks' and theories are always in the making.

In the Nepal context, at this time, there may be opportunities for smaller scale mechanization as a result of the migrant labour economy which contributes over 25% percent of GDP. In many rural areas especially many young men have left and make up the 1000+ workers who leave each day for employment in the Middle East, Malaysia, etc. Local wage rates in rural areas of Nepal are rising. At the same time a generation of migrant laborers who saw things done in a different way in these other countries are returning and thinking about what they want to do with their money and their lives in Nepal. Even though many aspire to urban lives, many have an interest in agriculture and the rural economy, but lack information, ideas and knowledge about smaller scale machinery for different types of agricultural ad rural mechanization. In addition, some local Banks are now developing financial products for poor rural people, especially rural women that go beyond micro loans, and small livestock models, but extend to small and medium size loans for equipment, with the equipment as collateral. While these banking options may be available in some other countries, they are a new product in Nepal. A recent Asian Development Bank sponsored Agricultural Development Strategy and its various reports, are opening up some policy options as regards ways forward on agricultural and rural mechanization in Nepal (Tomeko and KC, 2012). In the Nepal context this is a major step forward, where since the late 1990s the major government and donor planning document – the Agricultural Perspective Plan (APP) explicitly excluded consideration of mechanization issues.

There are no general policy prescriptions across countries. the policy discussion around rural mechanization in another country, and in Nepal at a different point in time will be different.

Innovations Systems Theory and Practice

Personal reflections

About ten years ago we and colleagues wrote a paper entitled, The Changing Power Tiller Innovation System in Nepal: An Actor-Oriented Analysis. It was a paper prepared for a workshop on Agricultural and Rural Mechanization held at the Bangladesh Agricultural University, Mymensingh, Bangladesh in November 2002. It went onto a website as we felt others might be interested. In the paper we describe histories of mechanization and illustrate how Innovation Systems approaches and methods might be used in practice. For us it was a useful exercise.

However, we do not know if it has been of any use to others. Hopefully it has, but we don't know!

What we have observed though, is that people and organizations in powerful positions, use IS frameworks and techniques selectively to promote particular economic and cultural agendas. Theories, ideas and frameworks developed on the basis of some experience and evidence, can be used for many purposes. These are not new findings as regards the politics of science and technology. However, they do highlight that a narrow apolitical preoccupation with the development of innovations systems theory and practice, might detract attention away from the strengthening the analytical capability of innovation systems that looks at the nature of innovation in science and technology. Personally we feel taking the political nature of S&T out of ISs work would not be useful. To start including it in the innovation systems theory and practice would mean seeking out those people who are already working in the area of Science and Technology Studies (STS), such as Latour, Mosse, Lewis and Jasanoff.

On a more practical level, anything that can be done to introduce into mechanical engineering training, an appreciation of and ability to do research based historical and economic studies, as well as cost effective methods for the collection and analysis of contemporary data relating to agricultural and rural mechanization would be welcome. It may well lead to an improved basis for some policy debates and a change in the behavior of powerful actors.

Conclusion

There is a need to reopen the policy debates on rural mechanization. Part of this will involve asking whether rural economic/social development and polices to encourage worthwhile jobs in rural areas is a policy goal. This might sound like a harping back to the policy concerns of the 1970s - and to some extend it is, but the globalization of the contemporary world makes it an even more contentious area of policy debates.

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Table 1

Table 5: Number of machines used for agriculture purposes

Machine	1977	1984	1989	1996	2006	2008	2009	2010	2011
4 Wheel Tractors[A]	300	400	1,000	2,000	12,500	14,890	17,905	21,638	26,369
2 Wheel Tractors[B]	200	500	5,000	100,000	300,000	343,000	366,700	400,030	420,027
DTWC	4,461	15,519	22,448	24,506	28,289	31,302	32,174	32,912	-
STWD	3,045	67,103	223,588	325,360	1,182,525	1,304,973	1,374,548	1,425,136	-
LLPE	28,361	43,651	57,200	41,816	119,135	138,630	146,792	150,613	-
Threshers (Open drum)[F]	-	500	3,000	10,000	130,000				190,000
Threshers (Close drum)[G]	-	100	1,000	5,000	45,000				65,000
Maize sheller[H]				100	850				5,000
Combine Harvester[I]						±30			100
Winnower[J]						±500			±200
Sprayer[K]						1,250,000			1,250,000
Reaper[L]						±40			±50
Dryer[M]						±500			
PTOS[N]					451	481	620	870	1190
VMP[O]									45

VMP= Versatile Multi-crop Planter

PTOS= Power tiller operated seeder

A, B= Data till 2006 has been taken from Roy and Singh (2008), other data came from estimations and triangulations made during this study. It should be noted that annual import for 2WT and 4WT is around 50,000 and 10,000 respectively. In case of 4WT, only 50% of the imported machines are exclusively sold for haulage purpose and the rest does both tillage and haulage. Estimating that 2006 data represents the actual number of 4WT operating exclusively for tillage at that time, we have estimated the 4WT data in the following years considering the annual drop out from agricultural uses and also the yearly import. In case of 2WT, even though 60,000 are imported, it is estimated that nearly 60% are not being used for agriculture each year, thus potentially around 20,000 units are being added to the agriculture tillage system

C, D, E= Data came from Minor Irrigation Survey of BADC.

F, G, H= Data till 2006 has been taken from Roy and Singh (2008), other data came estimation.

I, J, K, L M= Data taken from Rashid (2009) and Wohab (2011)

Source: iDE 2012

Table 2. Horsepower availability in agriculture by size of engine for Nepal and Bangladesh (Estimates for 2010)

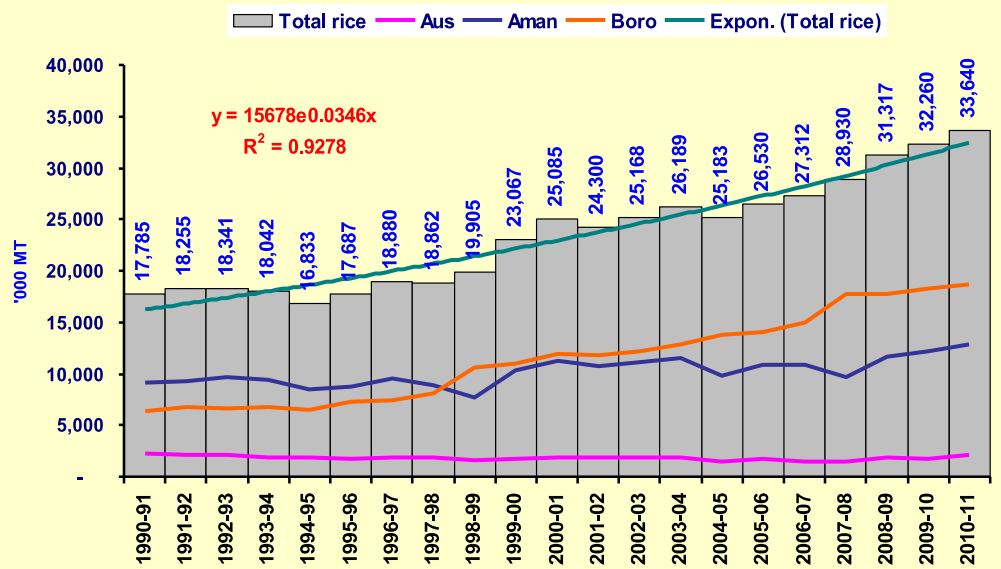
	Nepal			Bangladesh		
Energy Source	**No. units**	**Total hp**	**% of total hp**	**No Units**	**Total hp**	**% of total hp**
2WTs*	12,000	168,000	10%	400,000	5,600,000	46%
4Wts**	30,000	900,000	53%	15,000	460,000	4%
Irrigation shallow tube well pump Diesel ***	120,000	600,000	36%	1.2 M	6,000,000	49%
Irrigation pumpsets Electric******	10,000	20,000	1%	100,000	200,000	1%
Total Available Horsepower		1,688,000			12,260,000	

Estimates of the numbers of power sources (and their hp ratings) used primarily in agricultural 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 the Bangladesh agriculture and rural economy.
*Average of 14 hp per 2-wheel tractors (2WT)
** Average of 30 hp per 4-wheel tractor
***Diesel / petrol irrigation pumpsets are average 5 hp. 5 – 10 % of the pumpsets are petrol/kerosene.
****Electric irrigation pumpsets are average 2 hp

Source: Justice and Biggs 2012

Table 3

How Has Agriculture Done in Rice Production?



- Productions of other crops (except pulses & oilseeds), fish, poultry and livestock products also increased.

M A S Mandal, 2011, BAU 4

Table 4

Changing Structure of Farms

Farm holdings	1983/84	1996	2008
No. of marginal farms (LT 0.5 acre) million	2.42	3.35	4.10
No. of small farms (0.5 - 2.5 acres) million	4.65	6.07	8.43
No. of medium farms (2.5- 7.5 acres) million	2.48	2.08	2.11
No. of large farms (GT 7.5 acres) million	0.50	0.30	0.23
Av. Farmsize (acres)	2.00	1.50	1.26
No. of absolute landless holdings (million)	1.20	1.81	3.68

- **Net cultivated area is decreasing very fast**

- **Small & marginal farms are dominating, while Medium & large farms are declining**

- ***Implications:***
  - Timely delivery of inputs, credit & extension services increasingly challenging task – involving pvt sector & NGOs

- **Farm to Market linkages for dispersed small production become crucially important- infrastructure & reform of marketing services initiated**

M A S Mandal, 2011, BAU 3

Table 5

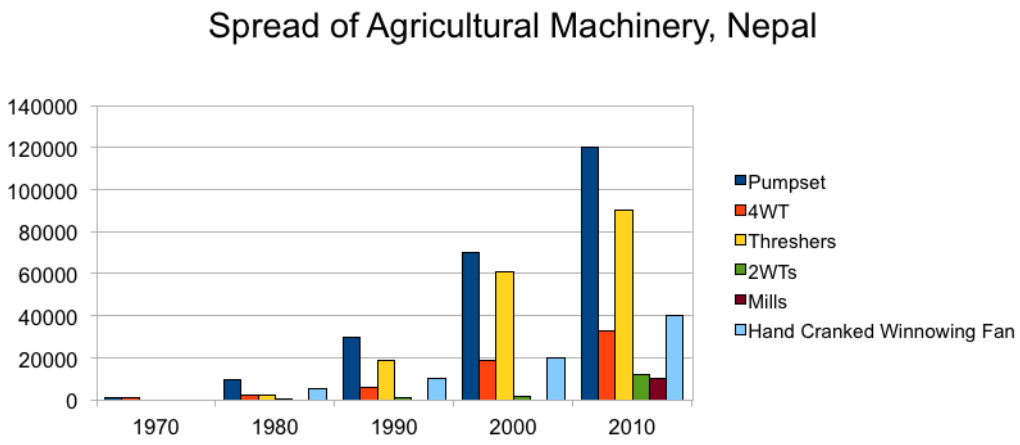
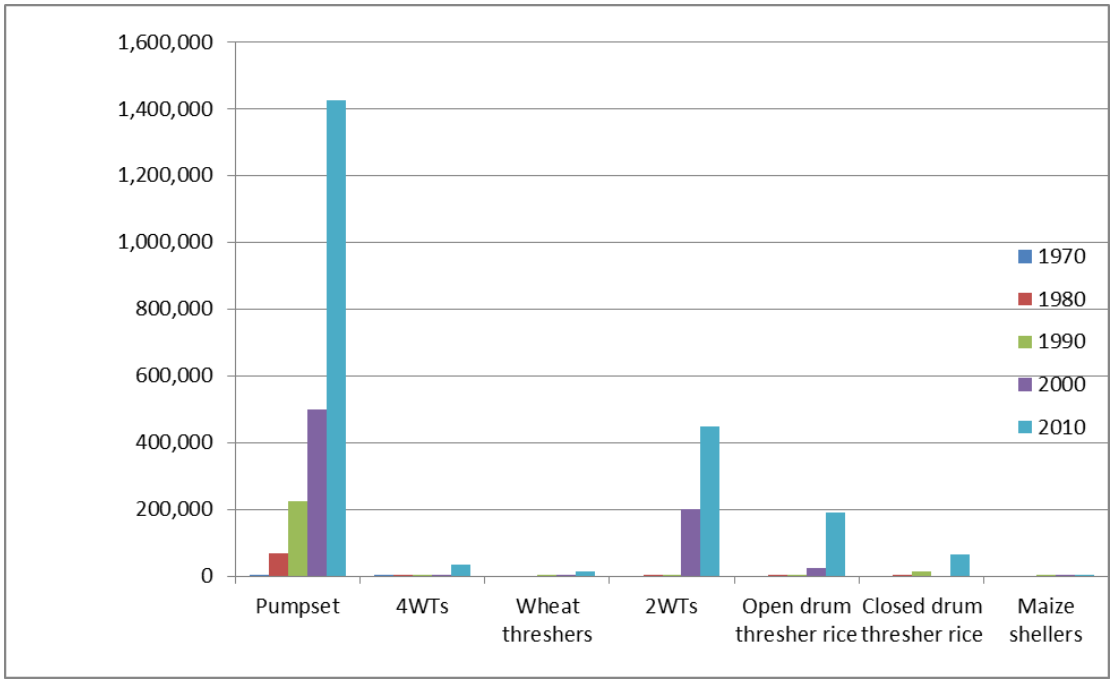

Spread of Agricultural Machinery, Nepal
140000
120000
100000
80000
60000
40000
20000
0
1970
1980
1990
2000
2010
Pumpset
4WT
Threshers
2WTs
Mills
Hand Cranked Winnowing Fan

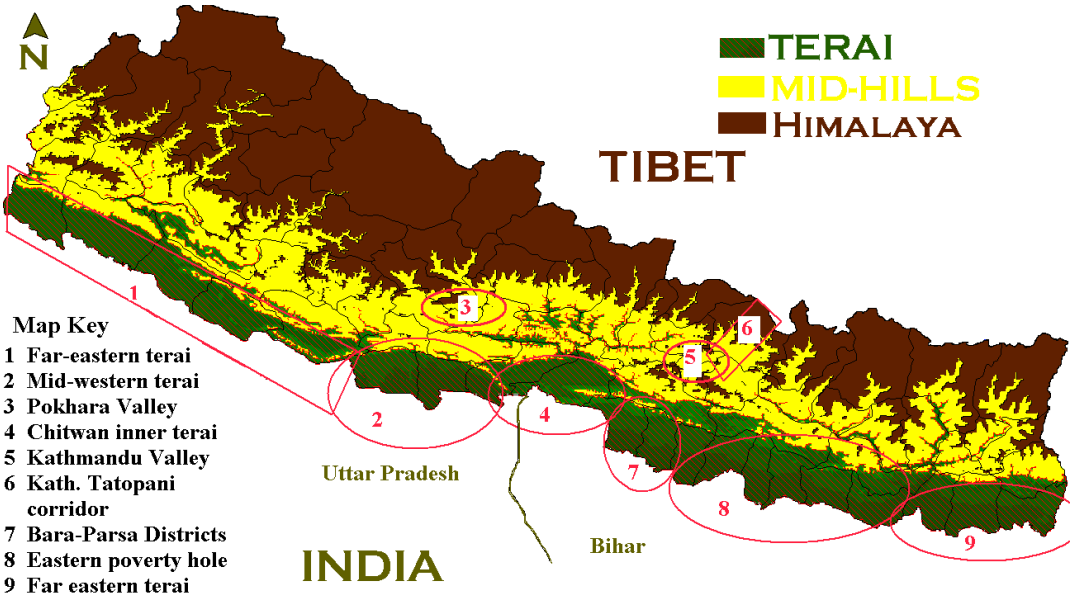
Table 6 Spread of Agricultural Machinery, Bangladesh



Source: iDE 2012

Map

Figure 7. Socio-economic zones of different agricultural and rural mechanisation patterns



Source: Justice and Biggs 2012