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Drivers of Agricultural Mechanization and Mechanized Conservation Agriculture: Synthesis from Experience of Successful Countries

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Summary

Based on literature, this paper reviews drivers of agricultural mechanization and mechanized conservation agriculture (CA) focusing on the experience of selected countries where mechanization and CA have been adopted at a large scale. The synthesis followed gradient approach where drivers of mechanized CA were evaluated considering different types of farm power use (mechanical, draft animal and manual), tillage types (conservation and conventional) and farm size (large and small holding). In the analysis, emphasis was given to major drivers of mechanized CA; namely, policies, markets, and institutional arrangements. Review results show that the expansion of mechanized CA is less proportionate across the World. Wider expansion has been observed in Latin America, North America, Australia, and South Asia regions whereas countries in sub-Saharan Africa (SSA) are the least in terms of the adoption of mechanized CA. The success of mechanized CA in the above indicated regions are mainly related to the availability of conducive markets, institutional and policy environments and the integration of diverse actors that helped in putting the necessary inputs, information and knowledge together. These all assisted in creating incentives to local CA-related machinery manufactures, machinery importers, distributors, local service providers, and farmers. Generally, literature supports that the expansion of mechanized CA is strongly related to the development, distribution and use of CA related farm machineries through the integrated efforts of different actors including private companies, international and national research institutes, government and non-government organizations, farmers, and extension service providers.

Keywords: Conservation agriculture, farm machinery, mechanized CA, expansion.

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1. Introduction

Increasing agricultural production and productivity through sustainable intensification is not an option but could be the only feasible means to feed the alarmingly increasing World population with less detrimental effects to the environment (Tilman et al., 2002; Pretty et al., 2003; Pretty, 2009; Friederich and Kassam, 2011; Friedrich et al., 2012). In this regard, the role of conservation agriculture (CA) as a means of attaining sustainable intensification and promoting productive capacity, soil health and environmental services under diverse agroecologies with different soil types has got scientific backings (Hobbs et al., 2008; Kassam et al., 2009; Giller et al., 2009; Haque et al., 2010; Erenstein et al., 2012).

However, one of the three core principles of CA, zero/minimum tillage or no mechanical soil disturbance (Wall, 2007), requires special machineries that help drilling seeds to the soil through crop residues retained in the field as soil mulch (Hobbs et al., 2008). Furthermore, residues retained in the field might need to be mixed with soil with the aim of improving soil organic matter and soil structure. Adaptation of these planting and residue management machineries has to go in line with the type of farm power farmers are using. In some cases, introduction of these machineries might require shifting power sources from human muscle to animal draught power or from animal draught power to tractors. The operational capacities of tractors to be considered might depend on the farm size farmers are operating and the possibilities of consolidating farm lands to the scale where farm powers are economically feasible. In general, intensification of production systems potentially creates farm power bottlenecks in operations like land preparation, harvesting and threshing (Pingali, 1997; Roy et al., 2004). Migration of young labor from agriculture to urban centers for better pays and livelihood could also aggravate the demand for more farm power through mechanization (Pingali, 1997). Most of the farmlands under CA are in North and South America, and Australia. These regions are mainly known for their high land-to-labor ratio and mechanization is the only means to operate under such circumstances. Thus, mechanized CA expected to be more concentrated in areas where large-scale farming is common and farmers are aware of CA's role in reducing machinery costs and maintain their soils for long term benefits. The main objective of this paper is to analyze the role of mechanization in the expansion of conservation agriculture based on literature review. It documents success stories of major countries benefited from mechanized CA. The remaining part of the paper is organized as follows. Section 2 gives analyses framework followed in the paper. Section 3 presents data on the global expansion of conservation agriculture by region and countries. Section 4 discusses on World agricultural mechanization. Section 5 analyzes agricultural mechanization and its role in the expansion of conservation agriculture, and finally, section 6 concludes the paper.

2. Analytical /Conceptual Framework

In this paper we follow the gradient approach along two components (level of agricultural mechanization and CA) where the first is clustered in three categories (motorized farm implements, draft animal powered machinery use and manual labor using human muscles) and the later in two groups (CA vs. conventional tillage practices). Thus, as indicated in table 1, we have six cells in the matrix with different levels of mechanization and CA.

Table 1. Matrix of agricultural mechanization and CA gradients

Level of mechanization (source of power)		Tillage practices	
		Conservation Agriculture (1)	Conventional Tillage (2)
		1	2
Motorized/ mechanical	A	• Direct seeding/planting using 2WTs, 4WTs • No soil disturbance at least in less than 4-5 years to break the hard pan.	• Planted on seedbeds prepared using 2WTs, 4WTs under conventional tillage • Land is cultivated each cropping season
Draft animal	B	• Direct seeding/planting using draft animal power	• Seedbed preparation under conventional tillage using draft animal power
Manual	C	• Planting in basins made manually • Direct seeding using Jab-planter and other hand tools	• Seedbed prepared using human muscle and hand tools each cropping season (mainly female labor in most SSA countries)

Overall, the objective of mechanized CA is moving farming practices from column 2 to 1 and from row C to B and then gradually from B to A. In general terms, mechanized CA help farmers moving gradually from the direction of 2C to 1A. The stepping-up along the gradient depends on the cost-benefit analyses farmers make which again depends on the opportunity cost of resources farmers are endowed with. In addition, policies, markets and institutional arrangements could also influence the opportunity cost of resources and farmers' decision in the type of power (level of mechanization) they use. There are also other external factors affecting the move along the gradient. For instance, topography of farmlands that farmers operate directly influence which power source they use. On a leveled and gentle sloped lands, use of tractors (whether two- or four-wheeled) is more practical than ragged topographies where farmers usually use either draft power or human muscle for land preparation.

There are recent experiences that some developing countries have started moving from drudgery labor intensive farming towards more mechanized agriculture due to both internal and external factors. Some of the internal factors are economic growth which enables smallholder farmers to have financial capacity to invest in machineries, rural youth migration to attractive payments in manufacturing and service sectors at urban centers, subsidies by governments on agricultural machineries, etc. Natural calamities such us floods and livestock disease are among the few external factors push farmers towards mechanized agriculture. As indicated above, these moves towards mechanized agriculture are gradual and in most cases it is common to see mix of power sources and level of mechanization within a village.

3. Global Expansion of Conservation Agriculture

According to *Friedrich et al. (2012),* tillage in fragile ecosystems was questioned for the first time in the 1930s when the dustbowls affected wide areas of the mid-west United States. The same authors argue that concepts for reducing tillage and keeping soil covered came up and the term conservation tillage was introduced to reflect such practices aimed at soil protection. Furthermore, the development of seeding machinery in the 1940s allowed to seed directly without any soil tillage, which is one of the core principles in CA. Based on this criterion, Garcı´a-Torres *et al.* (2003) estimated that conservation agriculture was, by then, practiced on about 80 million ha, which represents just over 5% of the 1500 million ha of arable land worldwide. Recent estimates show that worldwide farmland area under CA has reached 106 million ha (Kassam et al., 2009).

Nevertheless, the level of CA expansion is not similar across continents. North America, Latin America and South Asia are the three major regions of the World where CA has shown a tremendous expansion over the last 10-15 years. CA is also known and practiced in Europe, Australia and some parts of Africa though not as wider as the three continents indicated earlier. As indicated in Table 1 below, country specific highest farmland area under CA has been documented in USA where CA covers 26.5 million ha which is 25.5% of the cropped land in the country. Brazil and Argentina follow as second and third in terms of area under CA, with 25.5 million and 19.9 million ha, respectively (Derpsch and Friederich, 2008). Interestingly, about 70% of the CA land in Brazil is permanently practiced on zero tillage. According to Derpsch and Friederich (2008), the success of CA expansion in Brazil is associated to the availability of manufactured equipment for direct seeding using tractors, animal power and human muscle. In terms of CA adoption rate, countries like Uruguay and Canada stand first (i.e., about 82% and 46.1% of their cropped area, respectively).

With specific to Africa, South Africa stands first in terms of farmland area under CA (386,000 ha in 2008). Though there is no specific data available, Zimbabwe has also a considerable cropped area under CA. Tunisia from northern and Tanzania and Kenya from the eastern Africa have also put some crop area under CA. Details are presented in Table 1 below. More updated worldwide farm area under CA is also given in Appendix (Table A1).

Table 1. Area of farmland under Conservation Agriculture for selected countries

Continent	Country	Area under CA (Zero-tillage) *(in ha)* [a]	Year the data refers to
North America	USA	26,483,000	2007
	Canada	13,480,000	2006
Latin America	Brazil	25,500,000	2005/06
	Argentina	19,700,000	2006
	Paraguay	2,400,000	2008
	Uruguay	672,000	
	Venezuela	300,000	
	Chile	180,000	
	Colombia	100,000	2008
Orientals	Australia	12,000,000	
	New Zealand	160,000	2008
Asia	China [b]	2,660,000 [b]	2008
	China [c]	1,330,000 [c]	
	Kazakhstan	1,300,000	2008
	Indo-Gangetic-plains	1,900,000	2005
	Indo-Gangetic-plains [d]	5,000,000 [d]	2008
Europe	Spain	650,000	
	France	200,000	
	Finland	200,000	2008
	Ukraine	100,000	
Africa	South Africa	368,000	2008
	Southern and Eastern Africa	100,000 [e]	
	Kenya and Tanzania	20,000	
	Tunisia	6,000	2007

Note: [a] Data indicated in this table were summarized from Derpsch and Friederich (2008)
[b] conservation tillage; [c] zero-tillage; [d] wheat under no tillage, but not permanently practiced;
[e] excluding South Africa.

4. Mechanization in World Agriculture

Agricultural mechanization has a long history. Its introduction came with reducing the demand for and the scarcity of farm labor in the areas where extended farming is practiced (Pingali, 1997). In the history of agricultural mechanization, the invention and use of tractors have tremendously contributed towards the revolution of farm machinery use due to its ability to operate different machineries used for plowing, leveling, planting, cultivation, chemical application, harvesting, threshing, and transportation.

Table 2 shows substantial growth in the number of tractors in Asia, Latin America and East Region. The largest growth in the number of tractors has been witnessed in Asia where the number of tractors has shown by 500% between 1961 and 1970 and ten times between 1970 and 2000. The increment in Latin America and East region is substantial and consistent. However, number of tractors in sub-Saharan Africa has shown 60% growth during the 1960s but declined by 20% between 1970 and 2000. The decrease in the number of tractors observed in sub-Saharan Africa might be related to the changes in the government policies during the 1980's and 1990s from subsidized agricultural mechanization to more market oriented liberalized economy.

Table 2: Distribution of Tractors in the World (1960s-2000)

	Estimated number of tractors in years		
Region	**1961**	**1970**	**2000**
Asia	120,000	600,000	6,000,000
Latin America and Caribbean	383,000	637,000	1,800,000
East Region	126,000	260,000	1,700,000
Sub-Saharan Africa	172,000	275,000	221,000

Source: Mrema et al., 2008

Table 3 shows area of farmland under cereal production, number of tractors and concentration of tractors in selected countries across the world. These countries are where CA has shown considerable level of expansion during the last two decades. Large number of tractors is found in USA and China. This is not surprising as these two countries have large area of total arable lands. But, in terms of tractor concentration, Australia stands alone with 2,395 tractors per 100 km^2 arable land (which is equivalent to 4.2 ha/tractor).

Table 3. Area under cereal production and concentration of tractors in selected countries

Country	Land area under cereal production (in 1000 ha)		Number of tractors per 100 km^2		Number of tractors [a]	
	2000-02	2010-02	2000	2009	2000	2009
Argentina	9,826.0	10,371.9	89.6	87.7	88,041	90,962
Australia	813.4	811.5	2,394.8	2,390.3	194,793	193,973
Bangladesh	11,588.0	12,478.8	1.2	1.2	1,391	1,497
Brazil	17,877.2	19,557.7	138.0	116.9	246,705	228,630
Canada	15,174.8	14,148.9	159.1	162.5	241,431	229,920
China	81,466.3	92,648.0	81.8	81.8	666,394	757,861
Kazakhstan	13,901.1	15,662.2	24.9	25.2	34,614	39,469
Paraguay	741.0	1,455.0	70.0	68.9	5,187	10,025
Zimbabwe	1,661.8	1,441.2	66.6	n.d.	11,068	n.d.
USA	53,561.1	60,272.5	256.8	271.2	1,375,449	1,634,590
Uruguay	483.8	792.0	265.6	219.5	12,850	17,384

Source: World Development Indicator (WDI) 2013.
Note: [a] Computed from columns 2 to 4; n.d. refers to “no data”

4.1. Farm size and mechanization

Use of farm machineries usually goes with farm size due to two compelling reasons. First, machineries have overhead costs (fixed costs) that couldn't make them feasible unless the use intensity passes a given threshold (breakeven). However, nowadays, there are small tractors that could operate economically on less than 5 ha a year. Secondly, agricultural machineries are considered as a substitute for labor, and able to reduce average costs of production (Binswanger, 1978). Labor scarcity is more common on larger farms than on smaller ones. Thus, the larger the farm size, the more farmers tend to shift from labor-intensive to capital intensive operations using agricultural mechanizations.

4.2. Drivers of Mechanization

Considering experience in Asia, Pingali (2007) argues that agricultural mechanization in Asia was driven by the intensification of crop production system that created bottlenecks in farm power particularly in land preparation, harvesting and threshing operations. Youth migration from agriculture to service and manufacturing sectors could also be another driver for mechanization due to labor scarcity and also increasing wage. The pay rise in other sectors mobilizes people from agriculture and the agriculture sector has to adjust accordingly to maintain labor in farm operations. If this keeps increasing, there will be a point where mechanization is more feasible than use of farm labor.

5. Mechanized Conservation Agriculture

The role of machineries in CA expansion is tremendous as shifting from conventional tillage practices to CA requires the availability of proper farm machineries adapted to CA-based practices (Hobbs et al., 2008; Friederich et al., 2009). No-till direct seeder, furrow and ridge maker, knife-roller (crimper-roller), vegetation crusher, etc. are some of the accessories one needs in CA. Rollers and crushers are important in CA mainly for mechanical surface weed management. Appropriate farm equipment (whether drawn by animals or tractors) that could open furrows for seeding between piles of residues needs to be in place. In areas where there is a short window of time between two cropping seasons, farmers are expected to plant the second crop immediately after harvesting the first one. In conventional farming where land preparation is done using tillage practices, farmers face considerable yield reduction due to late planting as land preparation for the second crop takes some time. In such areas like Bangladesh where wheat is grown on rice fields, the introduction of direct seeding machines in zero-tillage has contributed significant increment in wheat harvest (Ekboir, 2003). In the subsequent section, experiences of selected countries in CA have been discussed from mechanization perspectives explaining the role of mechanization in CA expansion and what other factors (including enabling policy environments) contributed towards the tremendous expansion of farmland area under CA.

5.1. Large Scale Mechanized CA

It is more common to see CA on large scale mechanized farms. The rationale is apparent where large scale farms have high land-to-labor ratio that calls for mechanization and their net income on farm is maximized for every unit reduction in operational costs particularly saved on land preparation in terms of fuel. The level of farmers' awareness on the eco-service loss due to continuous tillage is higher for large farm owners than smallholder farmers who are usually less educated and loosely perceive the long-term consequence of the number of plowing.

5.2. Smallholder Mechanized CA

Bangladesh is one of the leading countries in terms of smallholder mechanization and particularly in population of two-wheel tractors (2WT) commonly known as '*power tillers*.' Though difficult to describe as CA, farmers use power tillers for direct planting of wheat immediately after harvesting rice. This helps to conserve moisture and mainly not to miss the short time window of planting between the two seasons.

The turning point in the history of 2WT population in Bangladesh was associated with the major floods and cyclones hit the country during the late 1980s and seriously affected the population of draught oxen used in agriculture. As an effect to these series of catastrophes, the country faced food crisis during early 1990s. This forced the government to re-visit its import policy on agricultural machineries as a quick-fix to the shortage of farm power in agriculture. As a consequence, a massive importation of Chinese-made 2WT during the 1990s has been observed (Biggs et al., 2011). The same authors (Biggs et al., 2011) argue that the machinery import in Bangladesh during 1990s was supported further by the World Bank project running in the country during that period focusing on promotion of market liberalization and lowering of tariffs on imports to Bangladesh. Currently, 80% of the 8.2 million ha arable land in Bangladesh is mechanized. Recent figures also show that there are nearly 400,000 diesel engine two-wheel tractors and around 3,000 four-wheel tractors available in the country (Biggs et al., 2011).

5.3. CA in hand-hoe system - The Case of Zimbabwe

Zimbabwe is one of the countries where zero-tillage under smallholder farming is practiced using hand-hoe. According to Marongwe et al. (2010), smallholder CA adoption expanded from 4,700 households in 214 Wards in 2004/05 to 88,262 households in 396 wards in 2009/10. This shows a substantial expansion of CA adoption both in terms of the number of smallholder farmers and geographical expansion (Wards in which CA has been practiced). In 2003 CA task force was established involving international research institutes (CGIAR centers), Ministry of Agriculture, NGOs, etc. The taskforce was coordinated and supported by FAO in setting guidelines for implementing CA. The further expansion of CA in Zimbabwe relies on moving from full manual system to animal traction system where machineries could reduce labor in seed basin preparation and weeding activities through effective weed management strategies.

5.4. Common Drivers of Mechanization and Conservation Agriculture

There are a number of common drivers positively influencing the expansion of mechanization and conservation agriculture. Shortage of agricultural labor is the major constraint that forces farmers to opt for mechanization and any agricultural practice that could save labor. Access to credit for input purchase, import policies on chemicals and farm (CA) implements, extension support, CA champions/leaders/leaders are some of the major CA drivers discussed below.

5.4.1. Credit facilities in expansion of machinery use

Both large or smallholder farmers need to get access to credit facilities through a well-developed financial markets. Availability and accessibility of credit arrangement for the purchase of farm implements is crucial. During the second wave of zero-tillage expression in Brazil, the government of Brazil and the World Bank facilitated credit system for watershed management where smallholder farmers were encouraged to do terraces/soil bands on hill-side farms. To conserve water and soil on the flat plots created farmers adopted zero tillage.

5.4.2. Import policy

Since most countries are importing farm machineries and other agricultural inputs, import policies imposed by governments of these countries have a direct effect on the quantity of machinery imports and use. It is worth mentioning the experience of Kazakhstan and Bangladesh in this regard. Although there is a domestic seed-drilling equipment manufacturing plant in Kazakhstan, due to a serious shortage of planting equipment, the Kazakhstan government opened up the country for importation of no-tillage seeding equipment. Bangladesh also lifted the import ban on Chinese made diesel engine 2WTs to cope-up with the shortage of draft-power due to devastating cyclones and floods in the country.

5.4.3. Extension services

During 2002 to 2004, CIMMYT and FAO have introduced Conservation Agriculture in Kazakhstan through a project. Since then, CA has expanded as a result of farmers' keen interest, enabling and facilitating government policies, and an active input supply sector. While the total CA area in the country in 2004 was below 1000 ha, it grew until 2007 to 600,000 ha and in 2008 to 1.3 million ha, placing Kazakhstan in only 4 years among the top ten CA adopting countries in the World. Besides a general policy support for CA, which encouraged public and private extension services to take up this message, the government provided initial subsidies for locally produced herbicides to decrease the initial costs and credit lines for purchasing no-till seeding equipment to overcome problem of capital availability for investment. Further, the country was open for importation of no-till seeding equipment, despite having one of the main seed drill manufacturing facilities from the Soviet times.

Similarly in Brazil, in the 1960s, the Brazilian government encouraged expansion of agriculture towards southwest, central-west and north (Ekoboir, 2003). This expansion put more land from livestock and coffee production to cereal production and aggravated soil erosion due to hilly landscape and heavy rains that put many farmers bankrupt (Ekboir, 2003). As an effect, farmers started using reduced tillage (Ekboir, 2003).

5.4.4. Champions/Pioneers/Lead actors

For a given technology to fly, the role of risk taking champions who act as pioneers is tremendous. A good case in point is Herbert Bartz in Brazil who adopted reduced tillage as a remedy for soil erosion (Ekboir, 2003). Bartz was not only a farmer but an innovator who identified a direct planter without disturbing the soil. This was identified through the support of GTZ and in collaboration between Rolph Derspch (working for GTZ, and based at IPEAME in Brazil, which latter changed to EMBRAPA's Soybean Center. In Zimbabwe, Brian Oldrieve was a pioneer CA adopter during the late 1980s at Hinton Estates in north-eastern part of the country (Marongwe et al., 2010),

5.4.5. Gradual Expansion through Learning by Doing-The Case of Brazil

In Brazil, expansion of CA took four waves. The first wave was during the 1970's and considered as a learning phase where different stakeholders were experimenting zero tillage. The role of herbicide producing companies, like ICI on paraquat and Monsanto on glyphosate, were tremendous as their aim was introducing the technology and create enough demand for herbicides for weed management.1 The second wave in 1980s was started with the credit facility

[1] Glyphosate produced by Monsanto happened to be more effective in weed control than Paraquat by ICI. This resulted in loss of bigger market share for ICI and later forced to cut all its research and promotion activities on zero tillage (Ekboir, 2003).

from the government of Brazil and World Bank supporting watershed management through the construction of very high terraces to reduce soil erosion and latter farmers adopted zero tillage as a supporting technology to the terraces (Ekboir, 2003).

The third wave of zero tillage adoption in Brazil is associated with expansion of agriculture in *Cerrados* (savanna-woodlands) in central and central-west region of Brazil located east of Amazon rain forest. This region comprises between 180 to 207 million ha of land and was occupied during late 1980s by small farmers from the southern states came to the region with the experience of zero tillage (Ekboir, 2003).

The fourth wave of zero tillage adoption in Brazil happened by commercial farmers in the 1990s when Monsanto reduced the price of glyphosate from 40USD/lt to 10USD/lt. This was supported by the research findings of Monsanto and EMBRAPA-CNPT on the adoption constraints of zero tillage among small farmers. The research came up with three major constraints: lack of a package adapted to local conditions, lack of planters adequate to small farmers, and insufficient command of the package by extension agents. As a solution to these constraints, Monsanto developed METAS[2] project that constituted herbicide company (Monsanto), research (EMBRAPA), fertilizers (Trevo), seeds (agroceres), and planters (Semeato) to develop integrated solutions to the identified adoption problems. In three years (1993-1997), the adoption of zero tillage leaped from 45,000 ha to 820, 000 ha at the specific locations where the adoption studies took place in the state of Rio Grande Do Sul. Moreover, CA adoption in the whole state of Rio Grande Do Sul has reached 2.2 million ha in 1997. Such a success attracted other potential stakeholders and, finally, the METAS program had seven private companies, three public

[2]It seems that MESTAS got its name by abbreviating the five companies: Monsanto, EMBRAPA, Trevo, Agrocers, and Semeato.

research and training institutes, the extension service, local planning offices, cooperatives and municipal authorities. The government of Brazil also invested huge resources in developing the necessary CA machineries and equipment adapted to different agroecologies and soil types (Sims et al., 2011).

Gradually, the adoption of zero tillage encouraged the establishment of Brazilian Zero Tillage Network that also gradually evolved into a conglomerate of regional networks involving farmers, input suppliers, NGOs, foreign aid agencies, public research institutions, research funding organizations, individual researchers, and government agencies.

6. Conclusions and Implications

From the existing body of literature, expansion of CA is strongly associated with the level of agricultural mechanization and supportive policies for sustainable farmland management. Literature shows that CA is widely practiced in North and South America and Australia. These continents are known for their larger area of farmlands per farmer and generally depending on machineries for farmland operations. Though the analysis and review done in this paper is mainly focusing on the experience of developed countries with large mechanized farms, most of the institutional arrangements that assisted the successful expansion of mechanized CA in these counties could still be adapted and used in the contexts of smallholder farmers in developing countries. In general, the integration of crucial stakeholders like policy makers, agrochemical dealers, small scale machinery manufacturers and suppliers, research organizations, extension and development institutes generating knowledge and disseminating information on CA and mechanized CA is a key factor for a successful and wider expansion of mechanized CA.

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ANNEX

Table A1. Latest update of farm area under CA across the world

Country	CA area (in 1000ha)	Year the data refers to
Argentina	25,553	2009
Australia	17,000	2008
Bolivia (Plurinational State of)	706	2007
Brazil	25,502	2006
Canada	16,590	2011
Chile	180	2008
China	3,100	2011
Colombia	127	2011
Democratic People's Republic of Korea	23	2011
Finland	160	2011
France	200	2008
Germany	5	2011
Ghana	30	2008
Hungary	8	2005
Ireland	0	2005
Italy	80	2005
Kazakhstan	1,600	2011
Kenya	33	2011
Lebanon	1	2011
Lesotho	2	2011
Madagascar	6	2011
Malawi	16	2011
Mexico	41	2011
Morocco	4	2008
Mozambique	152	2011
Namibia	0	2011
Netherlands	1	2011
New Zealand	162	2008
Paraguay	2,400	2008
Portugal	32	2011
Republic of Moldova	40	2011
Russian Federation	4,500	2011
Slovakia	10	2006
South Africa	368	2008

Table A1. Continued ….

Country	CA area (in 1000ha)	Year the data refers to
Spain	650	2008
Sudan and South Sudan	10	2008
Switzerland	16	2011
Syrian Arab Republic	18	2011
Tunisia	8	2008
Ukraine	600	2011
United Kingdom	150	2011
United Republic of Tanzania	25	2011
United States of America	26,500	2007
Uruguay	655	2008
Venezuela (Bolivarian Republic of)	300	2005
Zambia	200	2011
Zimbabwe	139	2011
Total	**127,904**	

Source: FAO: http://www.fao.org/ag/ca/6c.html (accessed on 02 November 2013)

Table A2. Farm area under CA by continent

Continent	Area (ha)	Percent of total
South America	49,579,000	46.8
North America	40,074,000	37.8
Australia and New Zealand	17,162,000	11.5
Asia	2,530,000	2.3
Europe	1,150,000	1.1
Africa	368,000	0.3
World total	115,863,000	100%

Source: Friederich and kassam (2011:24)

Table A3. Population of different farm machineries in Bangladesh over years

	Year				
Machine type	**1977**	**1984**	**1989**	**1996**	**2006**
Tractor	300	400	1,000	2,000	12,500
Power tiller	200	500	5,000	100,000	300,000
Maize sheller	-	-	-	100	850
Thresher (open drum)	-	500	3,000	10,000	130,000
Thresher (closed drum)	-	100	1,000	5,000	45,000
Deep tube well	4,461	15,519	22,448	2,4506	28,289
Shallow tube well	3,045	67,103	223,588	325,360	1,182,525
Low lift pump	28,361	43,651	57,200	41,816	119,135

Source: Roy and Singh, 2008 (cited in Islam, n.d.)