

Promoting Canadian Agri-food Exports to Nepal with Biodegradable Polypropylene Mulch

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Nepal is a food insecure country. This is a result of the average production rate of cereals being much less than the population growth rate (Joshi, Conroy & Witcombe, 2012). In order to improve crop production and in turn, reduce food insecurity and poverty, Nepalese farmers need to be informed about methods of increasing crop production. A method of increasing crop production is using a biodegradable polypropylene mulch. With increased crop production, there will not only be an increase in food availability, but an increase in income for Nepalese farmers.

There are a few methods of producing biodegradable polypropylene mulches, including production using plant starch and polymers, which give the mulch the ability to disintegrate without environmental harm. In addition to this beneficial characteristic of biodegradable polypropylene mulch, the benefits of using this product include increased and earlier crop yields as well as healthier crops. Due to the combined cost of this product as well as machinery needed to install the mulch, biodegradable polypropylene mulch may not be suitable for Nepalese farmers, however, may be suitable for other developing countries where agriculture has great potential.

Part 1: Biodegradable Polypropylene Mulch

Mulching is a method of cropping where a material is placed to cover the soil surrounding plants (Dickerson, 2002). One type of material used to cover the soil is biodegradable polypropylene mulch. Using this material can efficiently control weeds, and results in greater and earlier crop yields, preserves moisture in the soil, and leads in increased soil temperatures (Corbin, 2013). This is achievable at a relatively low price, maintenance and waste production. This biodegradable plastic material is also becoming more recommendable for growing crops due to their abilities of reducing waste and pollution. This is a because of the

ability of biodegradable polypropylene mulch to degrade into the soil, which also saves the cost of labour and disposal in the process (Corbin, 2013).

Composition of Biodegradable Polypropylene Mulch:

A majority of biodegradable polypropylene mulches are composed of a mixture of plant starch, as well as polymers and/or plasticizers since on its own, starch is too brittle (Corbin, 2013). Although most biodegradable polypropylene mulches contain plant starch such as corn, potato and tapioca, they can also be composed of other renewable resources such as cellulose, soy protein and lactic acid. These materials can be decomposed back into carbon dioxide, water, as well as other plant materials when no longer in use (World Centric, n.d).

The strength of the starch depends on its polysaccharide ratio, with the two most prevalent polysaccharides being amylose and amylopectin. Amylose, being a linear molecule with very few branches, is responsible for the high strength of starch, whereas amylopectin, being a molecule with many branches is responsible for the low strength of starch. Therefore, the higher the amylose content, the stronger the starch.

Production Process:

One process used to produce biodegradable mulch begins with the fermentation of starch into lactic acid molecules, done so by microorganisms such as bacteria, which combine together to form long polymer chains (Corbin, 2013). These lactic acid molecules are called polylactides, and is a product that does not decompose when in contact with moisture (Ezeoha & Ezenwanne, 2013). This fermentation process occurs with polymers such as polylactic acid (PLA), which may be obtained from plant sources such as corn starch or tapioca root (Corbin, 2013). PLA is often used because large quantities of this relatively inexpensive biopolymer can be produced.

Polyhydroxyalkanoate (PHA) is another polymer source, known to be eco-friendly since they are composed of renewable resources. PHA's are produced via bacterial fermentation of sugars or lipids by microbes or plants, with the most common method of fermentation being accomplished using microbes (Corbin, 2013).

In addition to PLA's and PHA's, other plasticizers often used in the production of biodegradable polypropylene mulch include polymers such as sorbitol and glycerol (Ezeoha & Ezenwanne, 2013). These plasticizers are also used in order to increase the flexibility of the plastic, since these products simultaneously decrease the amount of hydrogen bonding between polymers and increase molecular space (Ezeoha & Ezenwanne, 2013).

Other methods of producing biodegradable polypropylene mulch include the conversion of synthetic polymers into a partially degradable polymer by combining it with biocomposites such as biopolymers or with bioactive compounds (Ezeoha & Ezenwanne, 2013). This process begins with breaking the polymers down into smaller components. To break the polymer down, bioactive compounds are combined with swelling agents, which when exposed to moisture, their molecular structure expand. The enlargement of the molecular structure gives the bioactive compounds the ability to degrade the plastic. Of the methods mentioned, including the fermentation of starch and the conversion of synthetic polymers into a partially degradable polymer, using starch is often preferred since it is inexpensive, and abundant (Ezeoha & Ezenwanne, 2013).

Application of Biodegradable Polypropylene Mulch:

Before applying the mulch to the field, certain preparations need to be made to ensure proper functioning. First, the soil needs to be deep-plowed (plowing to a depth of 50 cm/20

inches or more) no later than a month before the soil beds are to be prepared (Dickerson, 2002). In addition to the removal of weeds, any masses such as rocks and clods need to be removed from the soil, as this can interfere with the application of the mulch. The soil must also be moist, with Good soil moisture containing approximately 60 to 80 percent of the field capacity/amount of water left in the soil after drainage of excess water in order to make smooth and firm soil beds. (Dickerson, 2002).

The mulch can be applied by hand or with the use of machinery, with smaller practices normally applying it by hand and larger practices applying it with machinery (Dickerson, 2002). First, the soil is bedded and raised with the use of hilling disks, being spaced 5 to 6 ft apart, and the bed shapers are used to compress the bedded soil to be of the same height of approximately 4 to 6 inches, width of approximately 30 to 36 inches, and density. The beds should have a slight slope of 1.25 inches from the center to the end of the sides of the soil bed (Dickerson, 2002).

If applied with the use of machinery, the biodegradable polypropylene mulch roll is located on the mulch dispenser and mall disks located at the sides of the soil bed open the channels (Dickerson, 2002). This is where the ends of the mulch are pressed and is completed with the help of rubber inflatable tires. The mulch needs to be pulled tightly so that it is in contact with the soil. Lastly, soil is placed over the mulch in order to keep it in place with the help of the disks, and slits are cut where the plants will emerge (Dickerson, 2002).

Canadian Companies Producing this Product:

A Canadian company selling biodegradable polypropylene mulch is Indaco Manufacturing Limited. Indaco produces a biodegradable mulch made from a blend of the Biodegradable Products Institute (BPI) biodegradable ingredients (Richard Dance, personal

communication, October 28, 2014). One of the biodegradable ingredients is called Ingeo, which is a polylactic acid derived from corn. Degradation of the biodegradable film is controlled by factors such as heat, oxygen, moisture, soil, acidity microbes, enzymes, and uv rays. Indaco's mulch is converted into water, carbon dioxide, and biomass by these controlling factors (Richard Dance, personal communication, October 28,2014). This characteristic means that removal and disposal of the mulch is not needed (Indaco, 2010). For further information about Indaco's products, Richard Dance can be contacted at R.Dance@indaco.ca.

Benefits to Canada:

Exporting biodegradable polypropylene mulch to Nepal will give Canada the opportunity to sell this product for a possible exchange with goods from Nepal. In addition, exporting this product will also result in greater support for jobs in the biodegradable mulch industry since production and sales of biodegradable polypropylene mulch will increase. Companies that earn more money pay more taxes, which aids in the development of the exporting nation. Furthermore, increased production and sales may result in an increase in wage of employees, which ultimately results in greater national wealth (Government of Canada, 2012).

Products needed to make biodegradable polypropylene mulch include plasticizers and starch, both of which are produced in Canada. BASF, the world's leading chemical company producing plasticizers, has 60 sites in North America, and more than 600 employees at the head office located in Mississauga (BASF Canada, n.d.). An increase in sales may result in increased employee population as an increase in revenue would be observed. An increase in sales and employee population would ultimately result in greater development of BASF.

Another industry that would be affected includes the starch industry. Canada produces a lot of starch obtained from plants such as potato and corn. A Canadian company producing starch is The Canadian Starch Company Limited, producing starch mainly from corn (Western Libraries, 1967). Just like the plasticizer industry, the starch industry would experience an increase in sales and production, which would lead to an expansion and further development. Therefore, exporting biodegradable polypropylene mulch will result in increased production of products needed to produce the mulch, which results in the eventual development and expansion of these industries.

Part 2: Potential Benefits to Nepal

About Nepal:

Nepal is located in South Asia, having borders with the People's Republic of China to the north, and borders with India to the east, west, and south (Pariyar, 2002). It is one of the most undeveloped and food insecure countries in the world, with 41% of the population being undernourished (WFP, 2010). This is partially the result of the global food crisis of 2008 causing an inflation of food costs, as well as the increase in population which began in the 1800's. Even though the prices of food have decreased since 2008, food prices are still high with an inflation of 17.8% as of January 2010 (WFP, 2010). With the number of undernourished individuals being so high, food production must become more efficient and affordable.

About 22% of Nepal's adult population in rural areas work in the agriculture sector, and 61% of the total population is involved in agriculture (Joshi, Conroy & Witcombe, 2012). Of this population, 78% own their own farmland, although most have an area of less than 1 hectare. This makes it difficult to support one's family and at the same time, make a profit (Joshi et al, 2012).

With such a large portion of the population involved in the agriculture sector, it contributes to about one third of Nepal's Gross Domestic Product (GDP) (Joshi, Conroy & Witcombe, 2012). This makes it a significant contributor to the development of Nepal. Even though it contributes to such a large portion of the nation's GDP, earnings in this industry are very low, with the average GDP for an employee in this sector being \$140 USD (Joshi et al, 2012). Comparing this to Nepal's GDP per capita, which is \$470 USD, this sector does not provide a good source of income (Feed the Future, n.d.).

The population in poverty is three times greater in rural areas than in urban areas in 2003 and 2004, with the agriculture sector having the greatest amount individuals in the poverty level (Joshi, Conroy & Witcombe, 2012). For example, 95.3% of the rural population is in the poverty level, whereas 4.7% of the urban population is in the poverty level. Even though the hill region has a higher percentage of the population in poverty, with the population in poverty being 47.1% in the hill region and with 45.4% of the population of the terai region, the terai region has the highest number of individuals in poverty. This is because the terai region has a high population density (Joshi et al, 2012).

Agricultural Regions:

This landlocked country covering an area of 147,181 km² and a population of 26.5 million individuals, is separated into three ecological zones including the mountains, the hills, and the Terai (Government of Nepal: CBS, 2012).

With an area of 52000 km² and with 27% of the land available for cultivation, the mountain region is the least important in terms of agricultural production (Joshi, Conroy & Witcombe, 2012). With a slightly larger area of 61 000 km² and with 37% of land available for

cultivation, the hill region is the second most important region in regards to agriculture. With the smallest area of the three regions, the Terai region, known for its good farm land, covers an area of 34000 km² and has 56% of the land available for cultivation. This large amount of cultivated land makes the Terai region the most important in relation to agricultural production (Joshi et al, 2012).

Located in the south of Nepal, the terai region is flat and fertile with a majority of the land having an altitude of 70-300m (Pariyar, 2002). This characteristic makes the use of crop increasing products such as biodegradable polypropylene mulch appropriate. This region also provides 47% of Nepal's GDP, and accommodates 80% of the income per family. The amount of rainfall is high in most of this sub-tropical region with 80-98% of the rainfall occurring during the monsoon period from June to October (Pariyar, 2002).

Complications with farming in the terai region include subpar management of water, lack of micronutrients in the soil, and the unavailability of effective fertilization for maintaining healthy and reliable crop production (Pariyar, 2002).

Benefits to Nepalese Farmers:

Using a biodegradable polypropylene mulch would eliminate or greatly reduce challenges faced by Nepalese crop farmers, the target consumers, in addition to providing additional benefits including a faster growth period resulting in earlier yields, preventing water loss from the soil, aiding in the prevention of weed development, decreasing amount of fertilizer leaching, decreasing amounts of rotted crops, decreasing the amount of drowned crops and increasing yields by up to 2 to 3 times (Lament, 1993).

Using the mulch would result in earlier crop yields by up to 21 days, although the average is 7 to 14 day, as a result of increased soil temperatures (Lament, 1993). By increasing soil temperatures, plants grow more quickly and, therefore, are ready for harvest at a sooner time. Another benefit is the prevention of water loss. The biodegradable polypropylene mulch is impermeable to water vapour before it degrades at the end of the season, saving approximately 45% of water when used with a drip irrigation system. This mulch also aids in the prevention of weed growth by reducing the amount of light exposure to the soil. Furthermore, more nutrients will remain in the soil, making it more accessible to plant roots. The fruits of the plants are also less likely to rot since there will be increased water runoff. Increased water runoff occurs due to the hill shaped raised beds, also resulting in reduced likelihood of drowning. All of the benefits that the biodegradable polypropylene mulch offers ultimately results in a doubled or tripled crop yield (Lament, 1993).

Many women and men in Nepal grow crops for a living, with women working an average of 16 hours a day and men an average of 9 to 10 hours a day (IFADa, n.d.). Much of the time spent in the field is dedicated to the removal of weeds; this task being accomplished mostly by women. Using a biodegradable polypropylene mulch would result in women spending less time in the field removing weeds, and more time to earn money doing other tasks. In addition, higher crop yields may result in greater profits for Nepalese farmers (IFADa, n.d.).

Costs:

The price of the mulch depends on the amount used, although normally prices range from \$350 to \$700 per acre, inclusive of installation and removal costs (Shrefler & Brandenburger, n.d.). However removal is not necessary due to the fact that this product disintegrates throughout the year (Shrefler & Brandenburger, n.d.).

Indaco's biodegradable polypropylene mulches come in many different sizes, including a 0.6 mil, 0.8 mil and a 1 mil mulch. The cost of these mulches depends on the price, as seen in figures 1, 2 and 3. The cheapest mulch is product number MB3658 MC3658 and is \$266.52 for a 0.8 mil mulch that is 5000'×36" as seen in figure 2, although most are approximately \$300 to \$350.

Shipping costs also vary depending on the route the product travels through. A1 Freight ships the product in consolidated ocean containers and ships internationally, charging depending on the amount of cubic space needed (A1 Freight Forwarding, n.d.). Since Nepal is a landlocked country, it does not have any ocean ports. Therefore, the product needs to be shipped to a nearby country such as India or China, and from there, transported to Nepal. The cost of shipping for the cheapest mulch from Vancouver, British Columbia, Canada to Nhava Sheva, India would be about \$256.89 USD per unit (A1 Freight Forwarding, n.d.). From Nhava Sheva, the biodegradable polypropylene mulch would need to be transported either via transportation truck or freight train, these services being an additional cost.

The cost for a 50 HP rating with a 3×3 toolbar, a shaper pan in category -1/2 disk bedder, also known as a hilling disk, with an adjustable height of 5" or 6" is \$125 (Buckeye Tractor a, 2013). This is the cheapest disk bedder sold by Buckeye Tractor. For a 35 HP rating, category-1 narrow frame constructing a bed height of 4" bed shaper, the cost is \$96 and for a 6" bed shaper with the same characteristics as the 4" bed shaper, the cost is \$106 (Buckeye Tractor b, 2013). The 4" bed shaper is the cheapest bed shaper sold by Buckeye Tractor.

A marketing strategy can involve a Canadian sales person to communicate with potential investors, and a Nepalese sales person who is relatable to Nepalese farmers. By having a relatable sales person explaining benefits and statistics on increased crop yields, Nepalese

farmers are more likely to purchase the biodegradable polypropylene mulch because they will likely trust the sales person. In addition, a discount on the first purchase may also convince Nepalese farmers to try this product, and once they experience the drastic increase in crop yields, they will re-purchase this product.

Subsidies and Payment Options:

There are very few subsidies provided by the government of Nepal, and they are not accessible to all farmers (Ghimire & Kumar, n.d.). Subsidies provided to individuals in the agriculture sector depends on factors such as the poverty level of the farmer, property size, and income from the previous year. Figure 3 depicts that expenditure growth rate is significantly greater than production growth rate of crops, proving that crop production does not increase when government input in this sector increases (Ghimire & Kumar, n.d.). These results could be a possible reason for the small amount of subsidies available to Nepalese farmers by the Nepalese government.

Another option for Nepalese farmers is to take a small government loan. An initial investment of this product may result in drastically increased crop yields beginning from the first use, which may allow Nepalese farmers to pay back the loan quickly. The amount of loans the government gave out can be seen in figure 2, with internal loans in 2010/11 being 4251.58 million Rs (Government of Nepal: CBS, 2012). These loans may aid in the development of farms and eventually change the quality of life of Nepalese farmers.

Nepalese farmers that could potentially be negatively impacted by introducing this product may be farmers with smaller landholdings (0.1 hectares or less), as they may not have enough income to purchase the biodegradable polypropylene mulch and/or the products needed

to prepare the soil and install the product. This is because while other farmers with more resources increase yields and make more money, the margin between the poorer farmers with smaller landholdings and the less poor farmers with larger land holding becomes larger. In addition, increase in crop production may cause a decrease in crop prices, resulting in reduced income.

Unknowns:

There are many unknown aspects about this product, including complete transportation costs, regulatory costs, import duties, and number of relevant machinery already located in Nepal that are needed to install this product.

Although shipping costs from Vancouver, Canada to Nhava Sheva, India is known, the cost of transporting the biodegradable polypropylene mulch from Nhava Sheva to Nepal, as well as regulatory costs on the product is not known. In addition while there are not many agricultural related automobiles/machinery in Nepal currently, the amount is not known and the distribution across the country is not known (figure 4). This is an issue, as there are some machinery involved in the preparation and installation of the mulch, and without accessible sources, machinery will need to be purchased. This can be very costly, and unaffordable.

Competitive Products:

Biodegradable polypropylene mulch produced by countries other than Canada include Biosafe by Xinfu Pharmaceutical Co. Ltd. (China), Eastar Bio by Novamont (Italy), Eco-Flex by BASF (Germany), Ingeo by NatureWorks (USA), and Paragon by Avebe (Netherlands), which provide competition (Corbin, 2013). Of the mentioned companies producing biodegradable polypropylene mulch, ones of greatest concern is likely to be Biosafe by Xinfu Pharmaceutical

Co. Ltd., and Xiamen OMS Plastic Co. Ltd, as they are in close proximity to Nepal. This would likely mean transportation costs are not as high as from Canada to Nepal, and production in china also tends to be cheaper than in Canada. For 1 kilogram of Xiamen OMS Plastic Co. Ltd's biodegradable polypropylene mulch, the cost is \$1.5 to \$3 USD, so for a roll of mulch with a width of 95 cm, a length of 50 cm, a thickness of 20 microns, and a weight of 0.89 kg, the price would be approximately \$1.34 to \$2.67 USD (Alibaba Group, n.d.). Although the sizes are smaller than Indaco Manufacturing Ltd's sizes, they may be more appropriate for Nepalese farmers with smaller farms and with less money.

Recommendations:

Nepal has a large percentage of the population in poverty, most of which are individuals in the agricultural sector living in rural areas. The very low GDP per capita of individuals in this industry, being \$140 USD, greatly limits the resources available to them, including the biodegradable polypropylene mulch. While this product may greatly aid in crop yield increases, the cost of this product may not be worth the investment for most Nepalese farmers. Therefore, a recommendation is to introduce this product to developing countries with a GDP per capita that is high enough so that individuals growing crops for a living can afford to purchase this product without spending their entire salary.

Developing countries with a high enough GDP per capita and with agricultural potential include Argentina, Bolivia, Nigeria, Ghana, etc. (ISI, n.d.). In these countries, agriculture is very important, contributing to much of the GDP and employment, and these are places where there is a lot of potential in this industry.

In conclusion, biodegradable polypropylene mulch provide crop producers with increased yields and earlier harvesting due to its ability to provide prime growing conditions for plants and is a beneficial product for those who have limited space and resources such as water. Nepal is a country that is dependent on agriculture for much of the employment and income of Nepalese, and also is a country that has the potential to develop this sector further, however, without the resources to obtain biodegradable polypropylene mulch, not much can be done except to wait for a time when the mulch will be affordable for Nepalese consumers. In the meanwhile, developing countries such as Argentina and Nigeria that have the agricultural potential and the resources to obtain the biodegradable polypropylene mulch should be the target consumers. This way, developing countries that need help in expanding their production will be helped and distribution of this product to a country that is in need can proceed.

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Appendix

Biodegradable Black and Clear Mulch Film .6mil 15 microns

Product No	Size	Roll Weight
MB3676 MC3676	7000' x 36"	93.74 lb / 42.60 kg \$298.09
MB4856 MC4856	5000' x 48"	89.28 lb / 40.58 kg \$283.91
MB5056 MC5056	5000' x 50"	93.00 lb / 42.27 kg \$295.74
MB5356 MC5356	5000' x 53"	98.58 lb / 44.81 kg \$313.48
MB6046 MC6046	4000' x 60"	89.28 lb / 40.58 kg \$283.91
MB6646 MC6646	4000' x 66"	98.20 lb / 44.64 kg \$312.28
MB7246 MC7246	4000' x 72"	107.14 lb / 48.70 kg \$340.71

Table 1
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Biodegradable Black & Clear Mulch Film .8mil

Product No	Size	Roll Weight
MB3658 MC3658	5000' x 36"	83.81 lb / 38.09 kg \$266.52
MB4848 MC4848	4000' x 48"	89.40 lb / 40.63 kg \$284.29
MB5048 MC5048	4000' x 50"	93.12 lb / 42.32 kg \$296.12
MB5348 MC5348	4000' x 53"	98.71 lb / 44.87 kg \$313.90
MB6048 MC6048	4000' x 60"	111.74 lb / 50.79 kg \$355.33
MB6648 MC6648	4000' x 66"	122.92 lb / 55.87 kg \$390.89
MB7248 MC7248	4000' x 72"	134.09 lb / 60.95 kg \$426.41

Table 2
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Biodegradable Black & Clear Mulch Film 1 mil

Product No	Size	Roll Weight
MB3651 MC3651	5000' x 36"	101.30 lb/ 46.05 kg \$322.13
MB4841 MC4841	4000' x 48"	108.06 lb / 49.12 kg \$343.63
MB5041 MC5041	4000' x 50"	112.56 lb / 51.16 kg \$357.94
MB5341 MC5341	4000' x 53"	119.31 lb / 54.23 kg \$379.41
MB6041 MC6041	4000' x 60"	135.07 lb / 61.40 kg \$429.52
MB6641 MC6641	4000' x 66"	148.60 lb / 67.54 kg \$472.55
MB7241 MC7241	4000' x 72"	162.09 lb / 73.68 kg \$515.45

Table 3
Copyright Indaco Manufacturing Ltd.

Nepalese Government Finances

Government Finance		(in million Rs.)		
	2008/09	2009/10 ^R	2010/11 ^E	
Expenditure	21966.20	25968.91	29536.34	
Recurrent Expenditure	12773.89	15101.91	17029.54	
Capital Expenditure	7308.90	9023.77	10784.75	
Principal Payment	1883.41	1843.23	1722.05	
Receipts	16985.73	21849.17	24574.12	
Revenue	14347.45	17994.58	19981.90	
Foreign Grants	2638.28	3854.59	4592.22	
Overall Surplus (+) Deficit (-)	-4980.47	-4119.74	-4962.22	
Sources of Financing Deficits				
Foreign Loan	996.89	1122.34	1207.56	
Internal Loan	1841.71	2991.40	4251.58	
Cash Balance(-) Surplus	2141.87	6.00	-496.91	

Source: Ministry of Finance R: Revised Estimate, E: Estimate.

Table 4
Copyright Government of Nepal: Central Bureau of Statistics
http://cbs.gov.np/wp-content/uploads/2012/Nepal%20in%20figure/Nepal%20In%20Figures%202012_English.pdf

Expenditure in Agriculture Sector and Food Production

FY	Expenditure (NRs. 10 mil.)	Production (MT, 000)	Expenditure Growth	Production Growth
2000/01	244.07	6690		
2001/02	475.09	6889	94.65%	2.97%
2002/03	196.4	6965	-58.66%	1.10%
2003/04	201.62	7077	2.66%	1.61%
2004/05	233.47	7477	15.80%	5.65%
2005/06	270.29	7365	15.77%	-1.50%
2006/07	414.04	7044	53.18%	-4.36%
2007/08	626.97	7778	51.43%	10.42%
2008/09	495.89	7822	-20.91%	0.57%
2009/10	658.89	7762	32.87%	-0.77%

Source: Economic Survey, 2010/11, Ministry of Finance and Author's calculation

Table 5

Copyright Agricultural insurance products in Nepal

http://www.academia.edu/5587568/Agriculture_Insurance_Products_in_Nepal

INDUSTRY STRUCTURE IN NEPAL IN RELATION TO SEED AND AGRICULTURAL INPUTS

Region/agricultural services	Involvement of different sectors			Overall structure	
	Public	Private	Civil Society	Degree of competition	Plurality
Terai, river basins and low hills (< 1,000 m)					
Agricultural research	High	Low	Medium	Medium	High
Agricultural extension	High	Low	High	Medium	High
Seed supply	Medium	High	Medium	High	High
Fertilizer supply	High	Medium	None	Low	Low
Pesticides supply	Low	High	None	Low	Low
Machinery supply	Low	High	Very low	Low	Low
Hills and mountains (> 1,000 m)					
Agricultural research	High	Low	Medium	Low	Low
Agricultural extension	High	Low	High	Medium	Medium
Seed supply	High	Low	Medium	Low	Low
Fertilizer supply	Medium	Low	None	Low	Low
Pesticides supply	Low	Low	None	Low	Low
Machinery supply	Low	Low	Very low	Low	Low

Table 6

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http://www.ifpri.org/sites/default/files/publications/Agriculture_seed_and_innovation_in_Nepal.pdf