Grain Moisture Meter in Nepal

Allison Bailey

December 1st 2015

AGR 1100

Word Count: 4102

Part 1: Product Information and Canada

Food Losses

Food losses are problematic for numerous reasons, both from the perspective of food security and environmental wellbeing. In developed countries, food losses are most often the result of food waste- disposal of viable food products- and in developing countries, losses are more commonly the result of post harvest losses or in-field losses (Aulakh & Regmi, 2013). *Figure 1* outlines some of the common sources of post-harvest losses in agriculture. This paper will focus primarily on storage based losses relating to moisture content.

In terms environmental concerns arising from this, it is estimated that 6-10% of human greenhouse gas emissions is the result of food waste (Aulakh & Regmi, 2013). This is largely caused by the decomposition of this organic material in landfills, which releases methane into the atmosphere (Aulakh & Regmi, 2013). Another concern associated with food losses is the wastage of land, and water resources. One estimate suggests that 1.47-1.96 Gha of arable land is wasted, as well as 0.75-1.25 trillion cubic meters of water, and 30-50% of all food produced (Aulakh & Regmi, 2013). All in all, as land and water are finite resources and food security is a pressing issue worldwide. Therefore, steps need to be taken to reduce these losses as it is beneficial from both an environmental and humanitarian perspective.

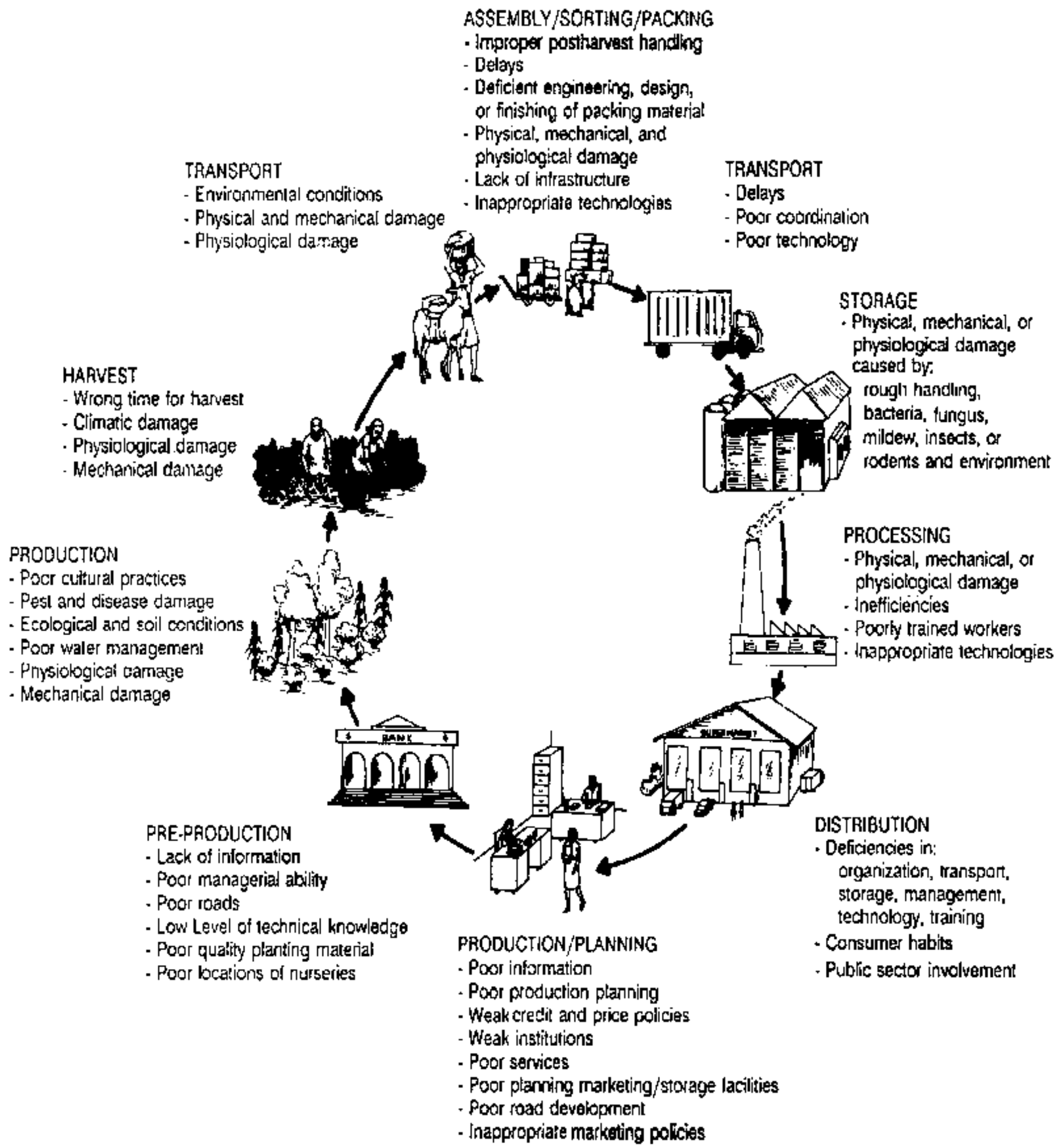


Figure 1: Causes of Post Harvest Losses (http://www.fao.org/wairdocs/x5405e/x5405e04.htm)

i) <u>Grain Drying</u>

Drying is an essential step in storage of grains. When grains are harvested, they are generally have a moisture content of around 18-25% moisture content ([FAO], 2011). Ideally this value leans towards the lower end of this range. However, this is not the content that grains are ideally stored at, and the goal of the producer is to have the grains reach their equilibrium moisture content or EMC. The EMC is the point where a hygroscopic material, such as a grain, has reached an equilibrium between the moisture content of the grain and the humidity of the air ([FAO], 2011). This value fluctuates depending on the humidity of the air, and the temperature, and it is appropriate to store grains within 1-2% of the ideal moisture content ([FAO], 2011). The ideal storage values for wheat, maize and rice are all around 13% ([FAO], 2011; Ganesh, 1992; "On-Farm Stored Grain Management: Insect Management for Farm-Stored Grain," 2009).

ii) Grain Moisture Content and Problems Relating to High Contents

The moisture content of grains and cereals is extremely important for grain producers. This is because a high grain moisture content, or a grain that is harvested prematurely creates conditions that are more favorable to spoilage ([FAO], 2011; Mills, 1989). This is the result of the increased biological activity, specifically anaerobic respiration, in grains with high moisture levels and of those harvested prematurely (FAO, 2011; Mills, 1989). The products of this respiration are carbon dioxide, water, and energy- liberated as heat, and these products create an environment where molds, bacteria and insects can thrive (FAO, 2011; Mills, 1989). When these pests are present in grain, they render them unfit for consumption or usage as seed (FAO, 2011). Another problem associated with increased moisture content is premature germination of seeds ([FAO], 2011). It is important to note that spoilage is not only result of the moisture contents of grains, but it is a substantial contributing factor.

In Canada, there are many strategies producers use in an effort to prevent spoilage of grains. *Table 1* shows these strategies as outlined by the Canadian Grain Commission. The strategies identified in this table revolve largely around maintaining a low moisture and heat level, as well as aerating stores to avoid localized areas of high levels (Mills, 1989). Although these strategies are centered around industrialized Canadian agriculture, the general themes and ideas are applicable to agriculture world wide. Grain drying before storage, followed by storage in waterproof, tightly sealed containers have tremendous impacts of preventing spoilage ([FAO], 2011; Mills, 1989).

Table 1: Prevention of Spoilage and Heating Problems in Stored Products

Grain crop in fields	• Air-dry small grains in swaths to safe moisture content levels. • Provide special binning or artificial drying for moist or immature grains
Binning	• Obtain advice on suitability of bin system for required purpose. • Provide adequate site drainage. • Clean interior and surroundings to remove pest harborages. • Keep in good repair and inspect regularly for leaks. • Spray with insecticide, and fumigate if required. • Refuse loads of doubtful keeping quality on entry. • Know history of material. • Get pre-binning samples and test for spoilage mold invasion. • Remove debris before binning. • Use a properly adjusted grain spreader or stirring device in the bin to evenly distribute fines; some spreaders may worsen fines distribution. • Sample and determine range of moisture content of material throughout binning. • Turn over stocks periodically. This procedure, however, is expensive, labor intensive, and may create more broken material, e.g., in corn. It is better to aerate
Aeration	• Know principles of aeration and likely problems. • Obtain advice on floor design and fan size. • Remove debris before aerating stocks. • Aerate to cool or warm the product (see Friesen and Huminicki 1986).
Drying	• Obtain advice on most suitable system. • Clean stocks except corn before drying; clean corn after drying because broken corn and foreign material (BCFM) must be dried for storage and feed use. • Remove accumulations of dust and fuzz from walls and burner area. • Use wind deflectors to keep airborne material and moisture from entering burner. • Check for leaking propane tanks and lines. • Inspect electrical wiring and circuit breakers. • Check for uneven drying. • Use proper air-to-grain ratios on stirring devices to prevent stagnating drying fronts. • Be careful of excess drying temperatures. • Cool after drying. • Check electric moisture meters for accuracy.

High moisture grains	
Chemical preservatives	• Clean material before treatment. • Use correct dosage rate for a particular grain moisture content. • Use sufficient chemical on all or part of the bulk. • Aerate material to prevent moisture migration. • Protect concrete or steel surfaces with plastic or acid-resistant paint when using propionic acid preparations.
Ensiling green material	• Cut green material at correct stage of development and pay special attention to any stock that is wilting, the percentage of dry matter, and the length of the cuts. • Fill silos quickly to ensure good compression for air exclusion. • Use distributor to pack material along silo wall. • Ensure doors and walls are tight (top unloading). • Keep top and bottom hatches closed to prevent chimney effect (bottom unloading). • Know the minimum percentage of moisture content for safe storage of material. • Put a green plug of moist material at top of filled silo (unsealed silo). • Remove material quickly. • Partially unload immediately after filling to prevent bridging of auger (oxygen-Iimiting silos).
Processed products	• Remove metal fragments to prevent foci for hot spots. • Cool off ground material or artificially dried material in small quantities before binning. • Vibrate bin walls to prevent bridging. • Avoid contamination with liquids liable to self-heat. • Avoid storage in close proximity to heat sources, for example hot ducts, engines, or bin lights. • Avoid overdrying. • Ensure that bin conveyors do not become sources of frictional heat or electrical sparks.
Education	• Educate staff on storage characteristics of different commodities. • Ensure staff are aware of moisture content ranges and moisture migration. • Stress the importance of regular inspections and a proper reporting system

(Mills, 1989)

iii) <u>Grain Moisture Detector</u>

The strategies designed to keep moisture levels down require a way to detect the moisture level. This is where the grain moisture detector becomes useful. There are numerous different types of detectors with different sizes, accuracies and price points. The ideal detector to export to a developing country, such as Nepal, would be a portable model with a relatively low price point. Shimana, a Canadian company, makes a model that fits these criteria ("Process Instruments," 2015). The model made by Shimana follows a probe design, and consists of a probe attached to a monitor. In addition, this particular model also comes with a carrying case designed to protect the sensor("Process Instruments," 2015). An image of this product can be seen in *Figure 1.* The specific name of this product is Grain Moisture Meter, with the part number SHGLMM017 and can be purchased online from the company's direct retailer Process Instruments ("Process Instruments," 2015).

This meter works with a wide variety of grains and grains in different conditions. Some examples of detectable grains are soybean (whole and ground), rice (paddy-whole, paddy-ground and milled) and many more ("Process Instruments," 2015). The entire list of these is shown in *Table 2.* The grains on this include the major grain crops grown in both Canada and Nepal.

The device is rather simple to use and displays information clearly. Therefore, it would be easy for almost any individual to operate. For starters, to use the device, it first must be powered on. After this the correct grain code for the type of grain being tested must be inputted into the device- the codes are the same as those found in *Table 2*. Next, then the probe can be placed into the grain sample. The moisture level will be detected then displayed on the screen. In addition, for simplicities sake an LED light attached will produce a colour based on the content (“Process Instruments,” 2015). A green light indicates the moisture level is below the alarm limit, this is factory set to 13%. A red light indicates the moisture level is above the alarm limit, which is factory set to 18% and a yellow light indicates it is between the alarm limits (“Process Instruments,” 2015). A green light is the ideal colour to detect. These alarm limits are able to be changed to the user’s preferences. The device is able to detect the moisture percentage of grains within an accuracy of 0.5% between a range of 6-30% moisture content (“Process Instruments,” 2015).

Figure 2: Shimana's Grain Moisture Meter (“Process Instruments,” 2015)

The cost of this product is $238.00 CDN from the Shimana’s direct retailer Process Instruments. In addition to this cost, four AA batteries need to be added to power the device. The location of production is unknown as the company never returned attempts to contact them, and no information was offered online.

Shimana is a branch of Digital Measurement Metrology (DMM), a Canadian company. DMM is based out of Brampton, Ontario and has been in operation since 1989 (“Digital Measurement Metrology,” 2015). The primary work done by this company involves the sale, calibration, repair and installation of precision measurement equipment ("Digital Measurement Metrology," 2015). The company has a large and diverse product line of different measurement devices and gauges. Furthermore, this company currently exports items, but no information has been provided as to the scale and location of this. Even still, with this company already involved in foreign trade, expanding into Nepal or another country could be more easily done.

code	grain	code	grain	code	grain
cd01	Wheat/Rye (Whole)	cd13	Coffee (Whole)	cd25	Flax (Whole)
cd02	Wheat/Rye (Ground)	cd14	Coffee (Ground)	cd26	Peas (Progreta) (Ground)
cd03	Paddy (Whole)	cd15	Coffee Green (Ground)	cd27	Peas (Ground)
cd04	Paddy (Ground)	cd16	Cocoa Beans (Whole)	cd28	Ground nuts Hulled (Whole)
cd05	Rice (Milled)	cd17	Linseed (Whole)	cd29	Grass Seed/Rye grass (Whole)
cd06	Semolina	cd18	Lentils (Ground/ Whole)	cd30	Grass Seed/Cocksfoot (Whole)
cd07	Maize/Corn (Whole)	cd19	Oilseed Rape (Ground)	cd31	Flour/Soft Wheat
cd08	Maize/Corn (Ground)	cd20	Mustard Seed (Whole)	cd32	Clover/White Seed (Whole)
cd09	Soya Beans (Whole)	cd21	Sorghum/Milo (Whole)	cd33	Clover/Red Lucerne Seed (Whole)
cd10	Soya Beans (Ground)	cd22	Sorghum/Milo (Ground)	cd34	Buckwheat (Ground)
cd11	Barley/Oats (Whole)	cd23	Sunflower seed (Whole)	cd35	Brassicas/Brussels Sprout (whole/ground)
cd12	Barley/Oats (Ground)	cd24	Sugarbeet Seed (Whole)	cd36	Beans/Tic/Winter (Ground)

Table 2: Grain Codes for Shimana Moisture Meter ("Process Instruments," 2015)

iv) Market in Canada

The grain moisture meter has a demand in Canadian agriculture, but this particular product has large competition in this market. For starters, with more industrialized farms moisture detectors, there are other options of moisture detection that are more convenient to the producer. Many combine harvesters come with a on-board moisture detector, for example all new Case IH combines come with moisture sensors (“Axial-Flow Combines,” 2015), Furthermore, Canadian producers can afford to buy a product that is more accurate and comes at a higher price. These alternative products are often made by a company that has more brand recognition such as Agratronix or Dickey-John. Both of these companies specialize in the production of agricultural instruments (“Agratronix,” 2015, “Dickey-John,” 2015) and are well known among the agricultural community.

v) Benefits to Canada

The benefits to Canada do not rival the benefits of this product to Nepal, however, they still are notable. For starters, the export of this to Nepal would benefit the exporting company. This would allow for them to expand the market of their product into Nepal. In addition to this, if the product does well in Nepal, they could extend more parts of their product line into this country. Finally, this would also make it easier to expand into more similar developing countries. Overall, all of these would help the company generate more revenue as well as improved brand recognition. Ultimately increased income would allow for them to hire more Canadian workers and improve their product line. This company’s product line consists of many items that are useful in construction. Developing countries are lacking in infrastructure, but are continually trying to improve this ("Infrastructure," 2012). The construction of improved infrastructure could make use of many of these products, and further benefit the company.

Another benefit that could come is improved relations between Canada and Nepal. Currently, trade goes on between Canada and Nepal, but of relatively small magnitude. According to the Government of Canada, in the years 2012-2013, Canadian exports to Nepal totaled about $7.1 million and imports from Nepal totaled $11.7 million ("Canada-Nepal Relations," 2013). With Nepal a developing economy, this will likely grow in upcoming years. Therefore, it is beneficial for Canada to develop a strong healthy relationship with Nepal in an effort to become a larger trading partner with them in the future.

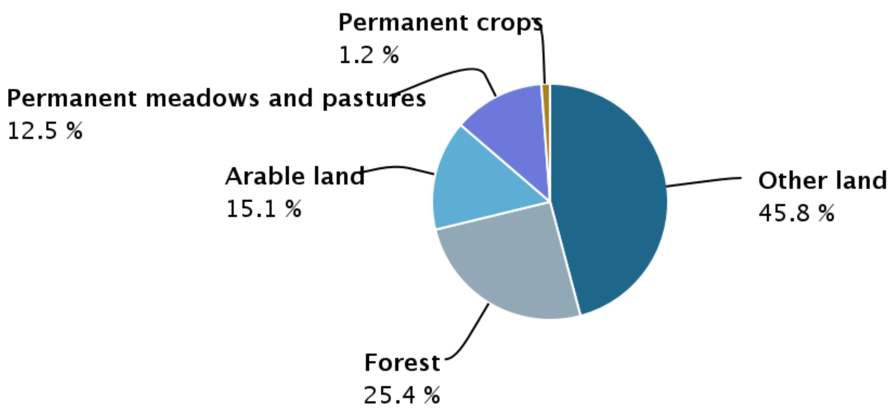
Part 2: Grain Moisture Detector in Nepal

i) Nepal

Landlocked between China and India, lies the small country of Nepal. The population of Nepal is 28 121 000 ("Nepal," 2015a), which lower than Canada's; however, due to the small area of this country it has a population density is 191.1 people per square kilometer ("Nepal," 2015a), which is much higher than Canada's 3.6 people per square kilometers ("Canada," 2015). This number has serious implications for food security in this country, as there is are more people to feed per acre of land. Furthermore, only 28.8% of land is used for agricultural usage

("Nepal," 2015b), meaning there are many people to feed on a relatively small area of land. The breakdown of land usage is shown in *Figure 3.*

Figure 3: Land Useage in Nepal ("Nepal," 2015b)



Moreover, Nepal has a low gross national income (GNI) per capita at a value of $730.0 USD in 2014 ("Nepal," 2015c). This value is slightly above the average of $625.6 USD for low income countries, but substantially lower than the average in South Asia of $1501.6 USD ("Nepal," 2015c). *Figure* shows a graph displaying the GNI per capita of these three groups, as well as the trend over the past eight years. All of these groups have shown a trend upwards over this period ("Nepal," 2015c). Even still, all of these values are tremendously low when compared to Canada's GNI per capita of $51158.6 USD ("Canada," 2015).

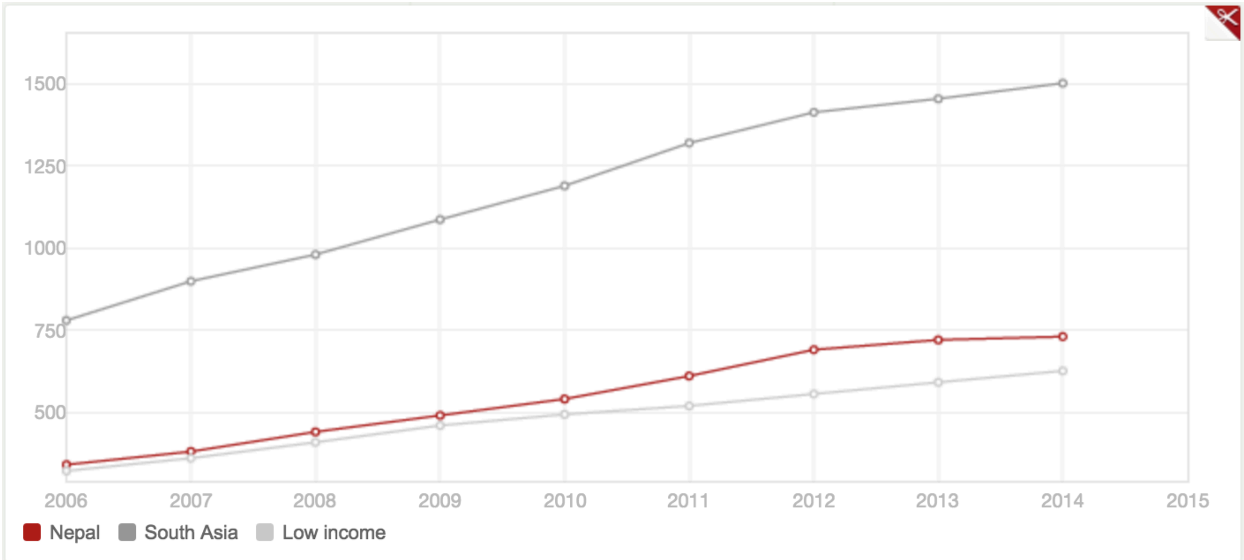


Figure 4: GNI per Capita of Nepal, South Asian and Low Income Countries ("Nepal", 2015c)

ii) <u>Agro-Ecological Regions</u>

Nepal is comprised of three major agro-ecological regions, the Mountain, Hill and Terai regions (Pariyar, 2008). The locations of these regions are shown in *Figure 5.* These regions have been classified based on their production methods and altitude (Pariyar, 2008). The Hill region is the largest of these regions taking up 43% of Nepal's area, followed by the Mountain regions at 35% and the Terai at 23% (Pariyar, 2008). *Table 3* shows some more physiographic features of the regions on Nepal. This table divides Nepal into five different regions, but still gives valuable information on the climate, topography, infrastructure and production in these regions.

The types of commodities produced in these regions is largely based on the climate. In the Terai region, the primary crops are legumes, rice, wheat and oilseeds ; in the Hill region, the primary crops are wheat, maize and rice; and finally in the Mountains the primary crops are potato, barley and buckwheat (Jayawardane & Weerasena, 2001; Pariyar, 2008). In all of these regions there is a type of grain that can be used by Shimana's moisture detector.

Table 3: Characteristics of Physiographic Regions of Nepal (Pariyar, 2008)

Table 12. Characteristics of physiographic regions of Nepal

Features	Terai	Siwaliks	Middle Mountain	High Mountain	High Himal
Geology	Quaternary alluvium	Tertiary sandstone, siltstone, shale and conglomerates	Phyllite, quartzite limestone and islands of granites	Gneiss, quartzite and mica schists	Gneiss, schist, limestone and Tethys sediments
Elevation	66-300 m	200-1 500 m	800-2 400 m. Relief 15 00 m with isolated peaks to 2 700 m	2 200-4 000 m. High relief 3 000 m form valley floor to ridges.	4 000 m above
Climate	Sub-tropical	Sub-tropical (but warm temperate in higher hill spurs)	Sub- tropical, warm temperate, cool temperate on high ridges	Warm to cool temperate, alpine	Alpine to arctic (Snow 6-12 months)
Moisture regime	Sub humid in FW+MWDR; humid in W+C and EDR	Sub-humid in most of the area, humid in N-aspect of W+C+EDR and dun valleys	Humid, per humid above 2000 m	Sub humid to per humid	Semi and benid Himal
Rainfall intensity	High	High	Medium	Low	Low
Vegetation	Sal +mixed hardwoods	Sal + mixed hard woods + pine forest	Pine forest+mixed hardwood and oak forest	Fir, pine, birch and rhododendron	Open meadows +tundra vegetation
Soils	Ustochrepts, haplustolls, haplaquepts, haplustalfs, ustifluvents & ustorthents	Ustochrepts, haplustolls, Rhodustalfs, ustothents, Dystrochrepts, Haplaquepts and Ustifluvents	Ustochrepts, haplustalfs, rhodustalfs, haplumbrepts, ustorthents and ustifluvents	Eutrochrepts, dystrochrepts, haplumbrepts, cryumbrepts, cryorthents and ustorthents	Cryumbrepts, cryorthents and rock
Crops	Rice, maize, wheat, mustard Sugar cane Jute, Tobacco, Cotton and Tea	Rice, maize, wheat, millet, radish, potato, ginger, tea.	Rice, maize, wheat, millet, barley, pulses, sugar cane, ginger, cardamom	Oat, barley, wheat, potato, buckwheat, yams, amaranthus, medicinal herbs	Grazing (June to Sep)
Horticulture	Mango, litchi, pineapple, jackfruit, imli, potato, tomato	Mango, papaya, banana, potato	Mango,papaya,banana, orange,lime,lemon, peach, plum, potato,cauliflower	Chestnut, walnut, apple, peach, plum, apricot, potato	Apple, walnut, vegetable seed, potato
People	Tharus, Brahmins, Chetris,	Tharus(dun valley) presently all hill tribes displaced/immigrated from middle mountains	Gurung, Magar, Tamang, Newar, Brahmin, Chetri, Damai, Sarki, Sunar, Kumal, Rais, Limbu.	Khas Chetri, Tibetan related groups - Thakali, Bhotiya, Sherpa, Tamangs, Ghale	Temporary herders Sherpa and Bhotiya
Transport	Good road linkage	Good road linkage within dun valleys	Road linkages around major centres	Very few road linkages	No road linkages

Figure 5: Agro-ecological Regions of Nepal (Pariyar, 2008)

iii) Food Security

The issue of food security can be seen by looking at this country's food deficit. The World Bank uses the term food deficit to describe the number of kilocalories that would be needed to have the undernourished become properly nourished ("Nepal," 2015c). This is measured in kilocalories per person per day. In Nepal, the overall trend has been the food deficit decreasing, but the current value in 2014 was 87.0 kilocalories per person per day ("Nepal," 2015c). This is shown by the graph in *Figure 6.* This graph shows a decreasing trend overall in food deficit. Furthermore, 29.1% of children in this country are underweight, according to 2011 statistics ("Nepal," 2015c). These statistics show that this country has a need to produce more food for its citizens, or alternatively reduces losses of foods.

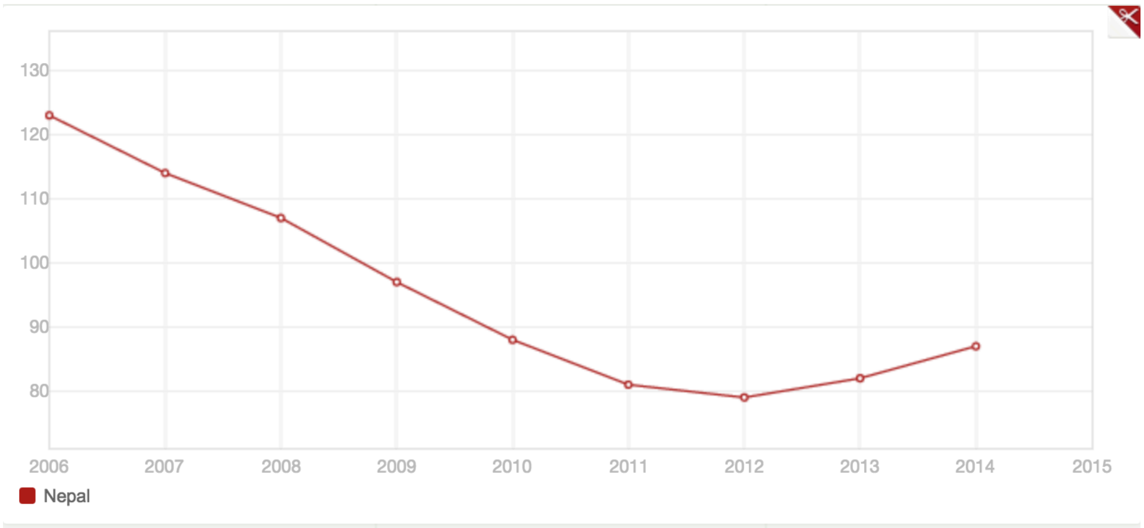


Figure 6: Food Deficit in Nepal ("Nepal", 2015c)

iv) Brief Overview of Grain in Nepal

Grains are important commodities in Nepal. Rice (paddy), maize, wheat and millet are all in the top ten crops in Nepal in terms of production by weight ("Nepal," 2015b). The production of these grains in metric tons in 2013 is shown in *Table* . These grains are staple food crops to many citizens in this country ("Nepal at A Glance," 2015). In fact, it is estimated that rice accounts for 40% of an average Nepalese person's daily calorie intake (Joshi & Bauer, 2006)

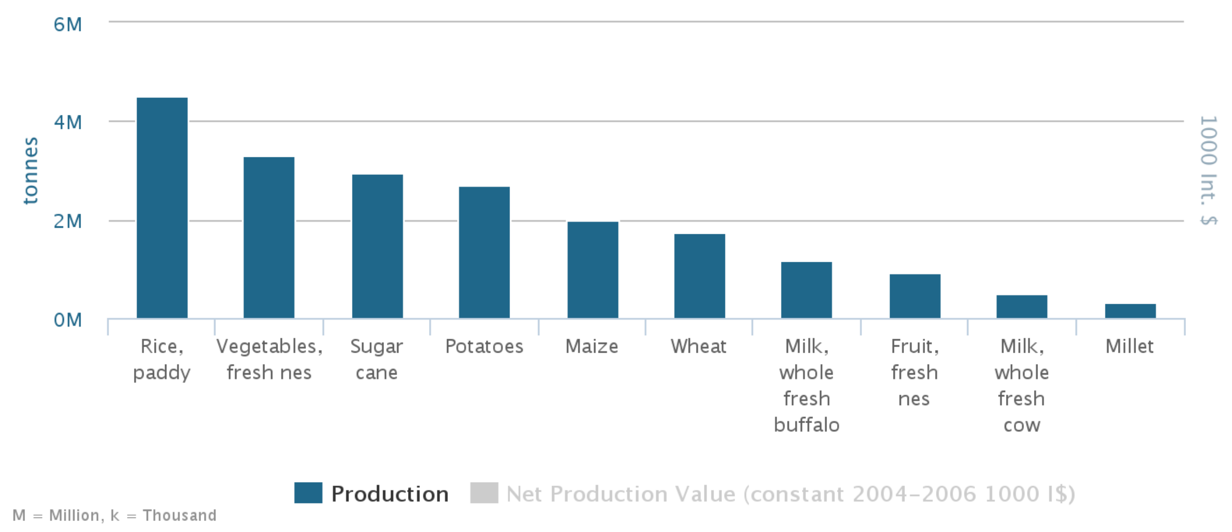


Figure 7: Production of Agricultural Commodities in Tonnes ("Nepal", 2015b)

v) <u>Grain Drying and Storage in Nepal</u>

The majority of farmers in Nepal are subsistence farmers, and thus the majority, or all of their produce for their family's own usage. The degree to which this happens depends on the area of the country the farmer lives in. In the Terai region, 70-80% of a farmer's grain harvest is stored for the family, and in the Hill and Mountain region this number is almost 100% (Ganesh, 1992).

In order to have this food viable throughout the year, it must be stored effectively. In Nepal, traditional methods are often used to store grains, although amongst larger producers metal bins are becoming more common (Ganesh, 1992). There are numerous methods of storing grains traditionally; some of these for paddy (rice) and wheat are the Bharkai, Dhukiti, Kothi or the mud Dehari (Ganesh, 1992).

Grains are not harvested at a moisture content that allows them to be safely stored and in order to do this, grains must be dried. The most common method of grain drying in Nepal sun drying (Ganesh, 1992). This is often done by placing harvested grains on a mat, or piece of ground especially prepared for the drying process (Ganesh, 1992). *Figure 8* shows a group of women drying grains in a market square. Another important way of keeping moisture contents low is harvesting grains at an appropriate time where they are mature, and have a low existing moisture content (Grolleaud, 2002). This results in less drying needed and reduces the likelihood of spoilage.

Figure 2: Women drying grains (http://www.alamy.com/stock-photo-newar-drying-grain-nepal-kathmandu-11569494.html)

vi) Food Losses in Nepal

In Nepal, post harvest losses make up the majority of food losses. Pests cause major losses in Nepal, leading to recorded losses of 6.22% in paddy, 7.3% in wheat, and 5.92% in maize stores (Ganesh, 1992). As before mentioned, there are a variety of factors that can allow for these damages due to pests including inadequate storage facilities and high moisture contents during storage ([FAO], 2011; Aulakh & Regmi, 2013). High moisture contents create conditions desirable by many insects, micro-organisms, mycotoxins and other pests (Mejia, 2003; Mills, 1989).

The issue of reducing post harvest is one that has been identified in the SakNepal project. The SakNepal project is one that is trying to study how distributing low-cost sustainable agriculture kits will benefit the people of Nepal as well as the environment in this country ("SakNepal," 2015). The problem of post harvest losses is explained as losses in grains after harvest caused by insect damage and fungal infections. This primarily stems from poor storage ("SakNepal," 2015). Sak Nepal has attempted to reduce this problem by selling specialized storage bags that prevent build up oxygen in the stores and creates an inhabitable environment for insects and fungi ("SakNepal," 2015).

vii) <u>Benefits to Nepal</u>

Being able to check moisture contents in grains allows for correct steps to be taken to safely store and harvest grains. In Nepal, this product could be used to help farmers determine moisture contents at these important steps along the production chain. The two primary times this would need to be used is during harvesting and when drying. By taking a small sample of grains at the beginning of harvest, the farmer could determine whether the grain is at a good moisture content to harvest, or whether waiting before harvest is a more viable option. This is a practice commonly used in Canadian agriculture, where a farmer will harvest a strip of a field to test the moisture content and determine whether it is an appropriate time to harvest (D.Bailey, personal communications).

The moisture meter could also be used to test the moisture content during drying. It has been shown the respiration rate changes depending on the size of grains, and therefore different drying times may be needed for different types of grain or depending on kernel size from year to year (Bailey, 1940). The moisture meter would allow for the farmer to test grains before putting it into storage and ensure the grain is at an appropriate moisture content.

Overall, these would allow for the producer to ensure their grains are at lower moisture levels before putting them into storage, or would give them information on whether or not steps are needed to lower the moisture content. The result of this could be lower post harvest production losses, and more produce available.

viii) Transportation

As Nepal is a land-locked country shipping from Canada cannot be done by ship, and therefore, the simplest method of transport is by air freight. No direct measurements as to the size of this package are given, but from the photos and the dimensions of the probe a reasonable guess is the product is 20 x 15 x 10 cm. The weight of the device is given as 320g ("Process Instruments," 2015). If a box with a size 100 x 90 x 90 cm is shipped, 270 individual meters could fit. The total weight of this would be 86.4 kg.

A1 Freight Forwarding is a company that ships from Toronto, Canada to Kathmandu, Nepal. The cost to send a box of the specifications before mentioned by air freight is estimated at $635.75 CDN ("A1 Frieght Forwarding," 2015). This adds an additional charge of $2.35 per meter. This would bring the overall cost of this product to $240.35 CDN for the product, or 19188.83 Nepalese Rupee, any taxes and tariffs would have to be added to this total.

ix) <u>Target Audience</u>

The price point of this product is rather steep, and therefore the average Nepalese farmer is not the ideal consumer for this product. As this is the case, there are two ideal targets for this product. The first being larger farmers, and the second being groups of smaller farmers wanting to purchase this product to share. The Terai region of Nepal is a region where commercial agriculture is starting to become more prevalent (Joshi & Bauer, 2006). In this region 70% of farmer's now sell their rice commercially (Joshi & Bauer, 2006). The result of this is more income, and therefore more money to invest into their operation. This increases the likelihood that these people would purchase this product. In regards to this product being purchased in a community, the product has unlimited usage and therefore can be used by many people at no added cost. This means if shared amongst many people the initial purchase price per person could be reduced and the benefit would still exist.

x) <u>Competition</u>

China and India are Nepal's two biggest trading partners in terms of imports, with them providing 9.4% and 63.6% respectively ("Nepal," 2015a). With imports of this magnitude there is likely already transportation systems developed to move products from country to country. Therefore, the costs of shipping would be lower. In addition, both of these countries are known for producing products at lower prices, this means that moisture detectors from these countries would be more affordable to the Nepalese consumer.

The cost of Shimana's product is extremely high when compared to other similar products. There are many moisture meters for sale through Alibaba for a fraction of the price, three of which are the Vetus tester, the Hedao and the MD7822 tester. All of these follow the same probe design as Shimana's detector. The Vetus tester is able to test wheat, maize, rice and paddy, and comes at a price of $62-70 USD ("Alibaba," 2015). The Hedao tester works with barely, corn, hay, oats, rapeseed, rice, sorghum, soybeans and wheat, and only costs $ 42-48 USD ("Alibaba," 2015). Finally, the MD7822 tester is the cheapest only costing $20-30 USD and is able to test wheat, paddy, rice and corn ("Alibaba," 2015). These detectors do not have the same breadth of testing capability as the Shimana model, but the prices are much more viable to the average consumer in Nepal.

xi) <u>Recommendation</u>

This is not the ideal product to be exported to Nepal, and is not even a viable product to export. The reason for this primarily stems from the price of the product. Given a GNI per capita of $730.0 USD ("Nepal," 2015c), this product would take about 24% of the average person's yearly income. The product does not provide enough benefit to justify spending of this magnitude. However, the product does have some benefit, so the more economical competitors may be viable options. Furthermore, the average farmer would probably see more benefit from investing their hard earned income into better storage facilities, as a grain moisture detector cannot prevent spoilage only indicate it may become a problem.

References

[FAO], F. and A. O. of the U. N. (2011). Grain crop drying , handling and storage. *Rural Structures in the Tropics: Design and Development*, 363–385.

A1 Frieght Forwarding. (2015). Retrieved from http://www.a1freightforwarding.com/

Agratronix. (2015). Retrieved from http://www.agratronix.com/

Alibaba. (2015). Retrieved from http://www.alibaba.com/

Aulakh, J., & Regmi, A. (2013). Post-harvest food losses estimation-development of consistent methodology, *2050*, 1–34. Retrieved from http://www.fao.org/fileadmin/templates/ess/documents/meetings_and_workshops/GS_SAC_2013/Improving_methods_for_estimating_post_harvest_losses/Final_PHLs_Estimation_6-13-13.pdf

Axial-Flow Combines. (2015). Retrieved from http://www.caseih.com/northamerica/en-us/products/harvesting

Bailey, C. H. (1940). Respiration of Cereal Grains and Flaxseed. *Plant Physiology*, *15*(2), 257–274. http://doi.org/10.1104/pp.15.2.257

Canada. (2015). Retrieved from http://data.un.org/CountryProfile.aspx?crname=Canada

Canada-Nepal Relations. (2013). Retrieved from http://www.canadainternational.gc.ca/india-inde/bilateral_relations_bilaterales/canada_nepal.aspx?lang=eng

Dickey-John. (2015). Retrieved from http://www.dickey-john.com/

Digital Measurement Metrology. (2015). Retrieved from http://www.ic.gc.ca/app/ccc/srch/nvgt.do;jsessionid=0001TKrgr7Qu1EPkGB-8y2VXI-s:11VIIVT17Q?lang=eng&prtl=1&sbPrtl=&estblmntNo=234567138221&profile=cmpltPrfl&profileId=1921&app=sold&searchNav=F

Ganesh, K. C. (1992). Farm Level Grain Storage Pest Management in Nepal. In *Towards Integreated Commodity and Pest Management in Grain Storage*. Retrieved from http://www.fao.org/docrep/x5048e/x5048e12.htm

Grolleaud, M. (2002). *Post-Harvest Losses: Discovering the Full Story*. Italy. Retrieved from http://www.fao.org/docrep/004/ac301e/ac301e00.HTM

Infrastructure. (2012). Retrieved from https://www.usaid.gov/what-we-do/economic-growth-and-trade/infrastructure

Jayawardane, S. S. B. D. G., & Weerasena, L. A. (2001). Crop Diversification in Nepal. *Crop*

Diversification in the Asia-Pacific Region, 80–94. Retrieved from http://www.fao.org/3/a-x6906e.pdf

Joshi, G. R., & Bauer, S. (2006). Determinants of Rice Variety Diversity on Household Farms in the Terai Region of Nepal Association of Agricultural Economists Conference , Gold Coast , 1–17.

Mejia, D. J. (2003). An Overview of Rice Post-Harvest Technology. In *Proceedings of the 20th Session of the International Rice Commission*. Bangkok, Thailand. Retrieved from http://www.fao.org/docrep/006/y4751e/y4751e0o.htm

Mills, J. T. (1989). Spoilage and Heating of Stored Agricultural Products, 97.

Nepal. (2015a). Retrieved October 18, 2015, from http://data.un.org/CountryProfile.aspx?crName=Nepal

Nepal. (2015b). Retrieved October 18, 2015, from http://faostat3.fao.org/browse/area/149/E

Nepal. (2015c). Retrieved from http://data.worldbank.org/indicator/SN.ITK.DFCT

Nepal at A Glance. (2015). Retrieved from http://www.fao.org/nepal/fao-in-nepal/nepal-at-a-glance/en/

On-Farm Stored Grain Management: Insect Management for Farm-Stored Grain. (2009). Retrieved from http://www.omafra.gov.on.ca/english/crops/pub811/11insect.htm

Pariyar, D. (2008). *Country Pasture/Forage Resource Profiles*. Retrieved from http://www.fao.org/ag/agp/agpc/doc/Counprof/PDF files/Nepal.pdf

Process Instruments. (2015). Retrieved October 18, 2015, from http://www.processinstruments.ca/store/moisture-meters/grain-moisture-meter.htm

SakNepal. (2015). Retrieved from http://saknepal.org/