Sustainable Crop Production in Nepal

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Introduction

Over the course of the last few years, my good friend Ben has been rather obsessed with Nepal – its culture, people, economy, landscape, etc. His fixation led to his studying abroad in Nepal and then writing a senior thesis entitled, "Socio-Economic Impacts of Rural Road Development: Lessons from Mustang, Nepal." To support Ben, I attended his thesis defense, and to my delight, I found myself much more interested than I initially thought I would be. I was especially curious about Nepal's agricultural production, though Ben's thesis merely grazed over this topic. This paper allows me to explore the specifics of crop production in Nepal, specifically in relation to sustainability.

An Overview of Nepal

The Federal Democratic Republic of Nepal is in Southern Asia, landlocked between China and India. The country has an area of 147,181 sq km and is similar in size and shape to Tennessee in the U.S. Nepal's terrain consists of flat plains in the southern Terai region, hills and rivers in its center, and the Himalayan Mountains in the north (U.S. Dept. of State, 2009). Variation in Nepal's elevations is extreme, ranging from 70 m to 8850 m (Mount Everest, the highest elevation on Earth), and only 16.07 percent of its land is actually arable. Nepal's diverse topography lends itself to equally diverse climates. The southern plains are subtropical, with

hot summers and mild winters (CIA, 2010). The central hills are more temperate, and the northern mountains are practically arctic at their highest altitudes. From June to September, Nepal experiences a monsoon season, with near-daily rain showers adding up to 75 to 150 cm of total precipitation (U.S. Dept. of State, 2009).

Nepal's population is 28,563,377, and this number is growing at a rate of 1.281 percent per year. However, only 17 percent of Nepal's people live in urban areas, and this statistic neatly corresponds with the fact that agriculture is the major source of employment in Nepal (CIA 2010). The Nepal Department of Agriculture reports that agriculture employs 66 percent of the total population (2010), while the CIA World Factbook claims that agricultural workers make up 76 percent of the labor force (2010). Agriculture makes up 35% of Nepal's GDP, despite the fact that, as mentioned earlier, only 16.07 percent of its land is arable. Due to the lack of arable land, "Some people have even been compelled to earn subsistence by extending farming to unsuitable areas," which has led to deforestation and soil erosion in the hill regions (Joshi, 2006). Further complicating matters is the fact that the country's success in agriculture is rather vulnerable to the whims of the annual monsoons (U.S. State Dept., 2009).

Sustainability

The concept of "sustainability" is difficult to define and even more difficult to concretely evaluate. In 2003, the Forum for Sustainable Development in Nepal published a book on sustainability: *Sustainability: the Lasting Fuel*. The majority of the Forum's publication is devoted to the attainment of sustainable development, which is a broad concept that covers economic, social, and environmental aspects. However, the book begins with a discussion of several definitions of the word "sustainability" itself. Sustainability, it claims, always revolves

around the following three concepts: “Living within the limits; Understanding the interconnections among economy, society, and environment; [and] Equitable distribution of resources and opportunities” (Regmee, 2003). In other words, human beings ought to live, work, and produce in a manner that respects the natural world and does not exploit any group of people or the land itself in the process. The Forum goes on to cite two outside definitions of sustainability. The first, courtesy of Robert Gilman, President of Context Institute, gives sustainability as “the ability of a society, ecosystem, or any such ongoing system to continue functioning into the indefinite future without being forced into decline through exhaustion… of key resources” (Regmee, 2003). A very similar definition of sustainability, from William D. Ruckelshaus, follows the earlier two: “the [emerging] doctrine that economic growth and development must take place, and be maintained over time, within the limits set by ecology in the broadest sense – by the interrelations of human beings and their works, the biosphere and the physical and chemical laws that govern it… It follows that environmental protection and economic development are complementary rather than antagonistic processes” (Regmee, 2003). One straightforward interpretation of these rather verbose definitions might be as such: sustainability means perpetuating the livelihood of our current societies without destroying the physical environments that make such livelihood possible. As Ruckelshaus concludes, modern development and environmentalism do not need to stand in opposition to one another.

The preceding paragraph does not necessarily provide the only Nepali interpretations of sustainability, however. Another definition comes from Professor Hari Datt Lekhak, PhD, who does not have Ruckelshaus’ faith in modern industrialization. Lekhak talks about the Sustainable Earth Worldview, summarized as follows: “Earth’s resources are finites… ever-

increasing population, production, and consumption will severely stress the natural processes that renew the air, water, and soil that support all life and economics…. the key element in this life-centered approach is to cooperate with the rest of the nature to help sustain all life including ourselves. We are to do this by learning how nature sustains itself and incorporating these Earth lessons into our lifestyles and economic and political and ethical systems" (Lekhak, 2003). The Sustainable Earth Worldview emphasizes that humanity must synchronize with nature, something that seems difficult with our current technology's reliance on non-renewable resources. Though, in Nepal, many of these modern-day technologies are lacking, so returning to natural sustainability might be more attainable than it would be for a country such as the United States, for example.

Although the Nepali nation seems to have a solid grasp on sustainability as a concept, it is difficult to find many equally concrete examples of how sustainability is being implemented. However, a few examples do exist. For instance, many Nepalese food crops are dried, either by fire/smoke or industrial furnaces. However, these methods contribute to vast energy consumption, which is not sustainable. Thus, the Forum for Sustainable Development discusses the alternative of solar drying, which is environmentally-friendly. The Forum also touches on some other alternative energy sources, such as biogas, that can be used for more than just drying produce (Lekhak, 2003). Other examples of sustainable practices are addressed throughout the rest of this paper.

Historic Production Practices

Until the Nepal Department of Agriculture was established in 1955, horticultural development was rather disorganized. Luckily, along with the Department of Agriculture came

a Horticulture Development Section, which quickly began introducing and studying several new deciduous fruit tree cultivars. Cultivar performance studies and propagation activities began to occur, mostly due to assistance from the United States Agency for International Development. The Government of Nepal began to emphasize fruit development in the hilly parts of Nepal, especially after six temperate-zone stations were set up for testing cultivars, producing and distributing plant material, and training local farmers (Devkota, n.d.). Furthermore, the FAO Hill Agriculture Development Project (1977-80) increased the production capabilities of the horticultural stations. As a result of these measures, fresh fruit production has joined Nepal's top-ten list of agricultural crops (FAOSTAT, 2009); by the 1980s, several private nurseries had made fruit production nearly self-sufficient (Devkota, n.d.).

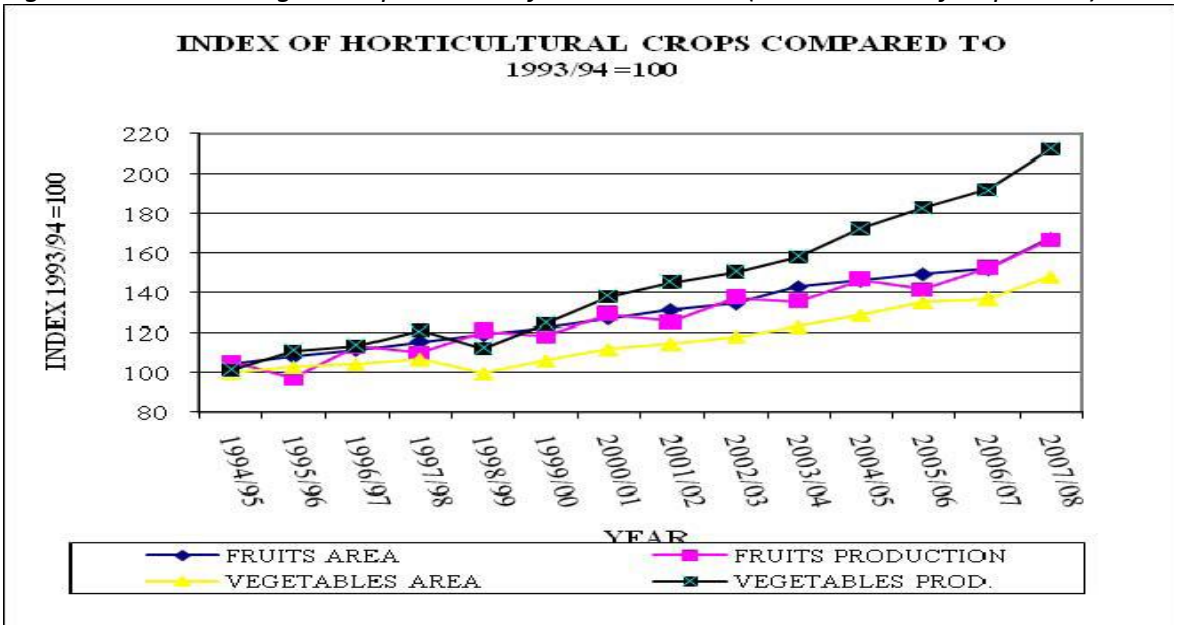
The growth of fruit production coincided with the development of plant tissue culture in Nepal. In 1976, Dr. S.B. Rajbhandari a plant tissue culture lab in the National Herbarium and Plant Laboratories in Godawari, specializing in seed and meristem culture of orchids. Other tissue culture crops included chrysanthemum, potato, banana, strawberry, cardamom, kiwi, citrus, carnation, lily, African violet, gerbera, gladiolus, and other plants. The Department of Plant Resources currently "has developed micro-propagation technique protocols for [at least] 100 economically important plant species including forest, horticultural, floricultural, and medicinal and agricultural crops" (Rajbahak, 2003). The government's work has also facilitated the foundation of several private sector tissue culture laboratories. Some of these labs have worked on developing protocol for endangered and/or endemic Nepali plants. There are still several large public sector labs at work too, such as the Nepal Agriculture Research Council, which has focused on virus-free potato production, and the Royal Nepal Academy of Science

and Technology, which has developed micro-grafting for the elimination of citrus viruses and diseases (Rajbahak, 2003).

Current Crop Production

The floriculture industry in Nepal has grown a great deal over the last few decades; the industry really began to gain ground in the early nineties. In 1992, there were only four small- and medium-sized growers in Nepal. However, due to the enthusiasm and investments of the private sector, the country now has over 500 floriculture growers. Located in 34 districts of Nepal, these growers "employing 2,600 persons (60 percent women)… have invested in 87 ha (36 ha covered) and had a turnover of USD 3.6 million in 2006. The industry is even looking to expand its cut flower export market (Yanai, 2007). The top twelve cut flower crops include white calla lily, carnation, Dutch rose, fern leaves, gerbera, gladiolus, gypsophila, lily, local rose, *Lycoris*, tuberose, and orchid. Since 2003, most likely because of the privatization of the floriculture industry, the Nepali government "has given priority to the development of high value crops, especially fruits and vegetables, honey, tea, coffee, etc." (Rajbahak, 2003). Figure 1 (see below) illustrates the increases in fruit and vegetable production from 1994 to 2008: both vegetable and fruit production are increasing, in terms of quantity produced and the amount of land used for its production.

Figure 1: Fruit and vegetable production from 1994-2008 (Government of Nepal n.d.)



In 2007, the top agricultural crops in Nepal were (listed in order of value): rice, buffalo milk, fresh vegetables, potatoes, wheat, maize, cow milk, ginger, fresh fruit, sugar cane, millet, dry chilies and peppers, mustard seed, oilseeds, lentils, mangoes/mangosteens/guavas, hen eggs, tangerines/mandarins/clementines, garlic, and goat milk (FAOSTAT, 2009.) See Figure 2 (at the end of the paper) for the monetary values and metric tonnage of the top ten crops. As evidenced by Figure 2, the majority of agricultural crops are grains and vegetables. Horticultural crops include a wide variety of fruits, vegetables, flowers, spices, and medicinal plants. In subtropical southern Nepal, crops such as mango, litchi, grape, banana, papaya, citrus, oriental pear, peach, pineapple, jack-fruit, potato, tomato, and plum are successful; the more temperate zones are more conducive to the growth of deciduous crops such as apples, pears, chestnuts, almonds, cherries, apricots, and walnuts (Jindal, 2003).

Major cereal crops in Nepal include rice (2.7 ton/ha), maize (1.8 ton/ha), wheat (1.81 ton/ha), finger millet (1.09 ton/ha), and barley (1.08 ton/ha). See Table 1 for the area (ha) and

production (ton) figures for these five crops in the year 2003. Total cereal crop production area is 3,313,681 ha; total production is 7,171,782 tons (Anonymous, 2003).

Table 1: Major cereal crops – area, production, productivity (Anonymous, 2003)

Cereals	**Area, ha**	**Production, ton**	**Productivity, ton/ha**
Rice	1,560,044	4,216,465	2.7
Maize	824,525	1,484,112	1.8
Wheat	641,030	1,157,865	1.81
Finger millet	259,888	282,852	1.09
Barley	28,194	30,488	1.08
Total	3,313,681	7,171,782	

Nepal's major cash crops are sugarcane (37.22 ton/ha), potatoes (10.18 ton/ha), tobacco (0.94 ton/ha), and oilseeds (0.7 ton/ha). Table 2 shows the area (ha) and production (ton) totals for these crops in 2003.

Table 2: Cash crops – area, production, productivity (Anonymous, 2003)

Cash Crops	**Area, ha**	**Production, ton**	**Productivity, ton/ha**
Sugarcane	59,422	2,211,781	37.22
Potato	129,019	1,313,717	10.18
Tobacco	4,226	3,973	0.94
Oilseeds	188,455	132,331	0.7

Current Production Practices: Rice

Rice is Nepal's main crop, both in terms of field area (ha) and production (tons). See Tables 1 and 2 above for the exact area and production amounts in relation to the country's other cereal and cash crops. Animal traction is the most common form of land preparation. "Manual transplanting is the dominant crop establishment method in lowland ecologies, while direct seeding of seeds to dry soils is dominant in upland ecologies" (FAO Corporate Document Repository, 2010). Furthermore, rice farmers use cattle and buffalo dung as a natural fertilizer for their crops. Up to 39 million tons of dung is available each year; this method is considered

very sustainable, even though farmers are using higher levels of fertilizer each year. Unfortunately, no research has been done on the effects of higher fertilizer levels on rice production levels in Nepal (FAO Corporate Document Repository, 2010).

Constraints and Issues of Sustainable Production

Most greenhouse and field production in Nepal is on the lower end of the modern technology scale. Although some "state-of-the-art" technology is present in the country's top facilities, most growers do not use this advanced equipment. A few of the wealthiest companies are using drip irrigation systems, but the majority of growers are unable to make the initial financial investment to install such systems. By the close of 2007, the Agriculture Development Bank of Nepal and the United States Agency for International Development were promoting drip and sprinkler technology that "have proven to have water application efficiency in an order of 75 percent or more, compared to 20 to 50 percent in other conventional surface irrigation." Water conservation is not the only aspect of sustainability that Nepali growers are taking into consideration: "As a campaign to promote sustainable agriculture, bio-fertilizers such as composts, organic materials and vermiculture easily collected from farmyards or from local farmers, are in increasing use, particularly for commercially grown vegetables, fruits, and flowers." It might be that bio-fertilizers are attractive to Nepali growers because of their low costs rather than because of their contributions to sustainability, but this fact does not decrease the value of their use (Yanai, 2007).

Because the majority of Nepal's growers reside in what we would consider "underdeveloped" rural areas, the overall state of field production practices is rather lacking. Indeed, much of the literature on Nepal's orchard and vegetable growers suggests that grower

education is sorely lagging, placing them far behind the times in terms of not only technology but also practical common knowledge regarding their crops. For example, in a collection of papers about apple farming in the Himalayas, one author noted: "In Nepal reliable maturity standards to decide the correct time for harvesting are nonexistent. The ignorant farmers are being persuaded by middlemen to harvest their fruit at the earliest to make more money before Indian apples find their way into Nepalese markets. This premature harvesting results in poor storage quality and harms crop productivity in the long run, as it affects the fruit development process." In this particular interpretation of the growing situation in rural Nepal, education is stressed as the only way to improve methodology. Specifically, the aforementioned farmers are encouraged to use ethrel, a plant growth regulator that will induce early maturity and color formation in their apple crops. This way, they can conform to the pressures of the market while also adhering to horticulturally-sound practices (Jindal, 2003).

Again, in relation to apple farming, which is very prominent in the mid-western hills of Nepal, much of the new "technology" focuses on the plants themselves, specifically the need for rootstocks that can withstand water stress. In Nepal, annual monsoons often cause severe stress on many crops as they deal with standing water during the rains from June through September. This is especially harmful because the stress occurs during the period of fruit development. As many current apple trees have been grafted on rootstocks that do not thrive under such conditions, apple production has not been optimal. However, during the majority of the year, when the monsoons are absent, crops are subject to the opposite extreme: drought. Irrigation is limited, especially in the more isolated rural areas, so several cost-effective strategies have been developed. Top strategies include: "[rain]water harvesting

through ‘kucha’ ponds with a polythene layer in drains (kholas) flowing through hill slopes, or watershed management in the community area so that stored water can be used during the summer months.” A less technologically-advanced method involves mulching the tree basins with plastic (alkathene or polythene sheeting) or organic mulches (grasses, hay, leaves) to conserve water. Some farmers also utilize high efficiency drip irrigation systems. Aside from cutting costs and increasing productivity, these water management strategies help improve the sustainability of Nepal’s orchards (Jindal, 2003).

As mentioned earlier, around 83 percent of Nepal’s population lives in rural areas. Some of these areas are very difficult to access by modern transportation methods, which makes efficient product shipping as well as necessary growing inputs (seed, fertilizer, etc.) nearly impossible at times. For example, in the district of Mustang, which is located in the Annapurna Mountains of west-central Nepal, the completion of a single rural road project has the potential to revolutionize the region’s agriculture. Ben Briese’s thesis research in Lower Mustang emphasizes this problem, specifically in relation to exporting its highly-valued apple crop. The roads from Mustang are rocky and prone to landslides, which makes them more suitable for pack mules than for motorized transport. However, pack mules are much too slow to transport apples; usually, the produce has rotted or been damaged en route before it reaches the nearest markets (Briese, 2009). For a similar reason, the floriculture industry in Nepal has been struggling in the rural areas where climates favor cut flower growth. Because cut flowers are so perishable, vast improvements in road quality would need to occur before Nepal could successfully export them (Jindal, 2003). Obviously, basic road development is absolutely vital to Nepal’s horticultural production.

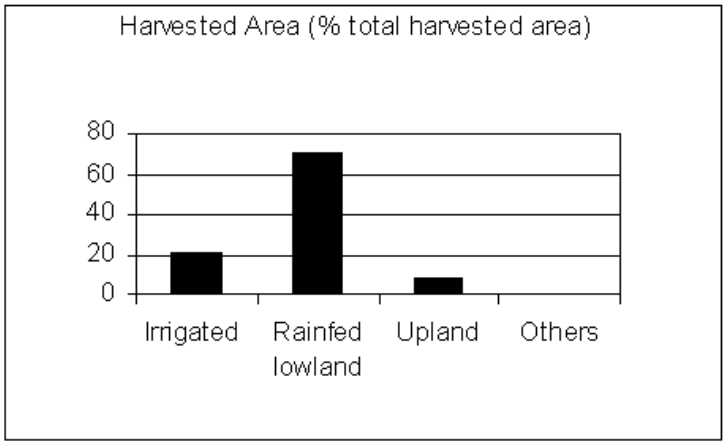
Briese believes that transportation improvements will eventually lead to changes in the crops grown in the Mustang district: “As larger markets become more easily accessible and cheaper inputs, such as chemical fertilizers, become available, many farmers are likely to shift to growing higher-value crops such as fruits and vegetables… These farmers also considered changing their seasonal planting and harvesting patterns of certain crops to coincide with the off-season of these crops at lower altitudes… Several [farmers] told me that when the road was completed, they planned to shift from their traditional crops of wheat and barley to more profitable vegetable crops… Another interlocutor believed that because of Mustang’s higher elevation and colder temperatures, farmers here could produce vegetables during the monsoon – a season where such crops are difficult to grow in much of the rest of Nepal. He is even considering building a greenhouse to cultivate outside of the normal growing season” (Briese, 2009). Increased transportation may seem to inhibit sustainability, as growers will begin growing crops that require more energy inputs. However, it only seems fair that Nepali growers be allowed to catch up with the rest of the world in terms of available technology.

Synthesis and Ranking of Production Practices

As mentioned earlier, most growers have very limited access to modern growing technology. This does not mean, however, that growing cannot improve, in terms of both productivity and sustainability. Horticultural production in Nepal mostly occurs in the fields, where 40 percent of horsepower per unit of cultivated land comes from animals and 37 percent from human labor (Anonymous, 2003). It is in the fields where production seems to be the most sustainable, as most crops grown in this environment require fewer inputs than those grown in more controlled environments such as greenhouses. However, field-grown crops are

susceptible to water stress caused by the annual monsoons, and irrigation methods are usually inadequate during the dry seasons. Rice, which is the country's largest agricultural crop, seems to be the most successful because of its high tolerance for standing water. Because the monsoon season occurs during the rice growing season, growers at lower latitudes can rely on the rains to completely irrigate their crops. Figure 3 below shows the percentages of harvested area for rice in Nepal based on irrigation and location. Around 65 percent of the total harvested area is located in lowlands that rely totally on the rains for a water source. This makes rice production very sustainable in terms of water input. Moreover, as mentioned earlier, bio-fertilizers are also often used in rice production. Other field-grown crops are also more sustainable than those grown inside facilities. For example, the climate and soil of Nepal favor cut-flower and bulb production (Yanai, 2007), and if water stress in orchards is properly managed, fruit trees are highly productive as well. By its very nature, greenhouse production requires higher inputs of light, water, fertilizer, etc.; this method of production is therefore less sustainable as a whole. Plus, the general lack of accessible technology in Nepal lends itself to sloppy growing practices in greenhouse facilities.

Figure 3: Harvested areas from different rice ecologies, from1995-2000 (FAO Corporate Document Repository 2010)



Sustainable Development Strategy

The greatest challenges facing sustainable crop production in Nepal are related to the limiting physical terrain of the country, especially when combined with the country's inadequate infrastructure. "Different parts of the country are endowed with a bewildering variety of resources. Due to the mountain nature of the terrain, the command area of a central place or activity is limited. It is difficult to reach the people. It is also difficult to make a fair distribution of development benefits… It has not been possible to establish functional links between the hills and the Terai on the basis of their interdependence" (Joshi, 2006). In other words, the roadblocks to sustainability are much more complex than just lack of knowledge or technology. Overall, Nepali authorities on sustainability are well-aware that their country is greatly lagging behind other countries that produce similar crops. However, as discussed earlier, the existing technology cannot currently spread to the outlying regions of Nepal due to poor (or even nonexistent) roads and transportation methods. Furthermore, electricity generation, communications, and even something as basic as access to drinking water are limited in all but the central region, which contains Kathmandu, the country's capital (Joshi, 2006). Many Nepali growers might be more concerned about fulfilling their most basic needs rather than making their operations sustainable.

Luckily, for Nepali growers, movement toward sustainability should mean movement toward financial stability. As growing operations increase in sustainability, the results should be an increase in productivity, which will allow for a self-perpetuating increase in profit. I truly believe that the initial investment would be worth the outcome, but it will indeed be a hefty investment – one that most Nepali growers cannot afford to make on their own. This raises the

ultimate question: how can growers overcome financial limitations? As mentioned earlier, the Nepal Department of Agriculture as well as the U.S. Agency for International Development have, in the past, taken strides to fund horticultural research. However, I think this funding, though well-intentioned, had far too narrow a focus. Rather than focusing on specific horticultural crops, these organizations should have been focusing on how to set up a nationwide infrastructure that supports agricultural activity throughout all regions of Nepal. Then, after this infrastructure was in place, they could proceed to perform crop-specific research to improve the existing infrastructure. The Nepali government should therefore begin working toward transportation and technology improvements across the country.

Roads should be the first priority. In the region of Mustang, Nepal, road construction has caused transportation costs to decrease dramatically. As transportation costs drop by 50 percent or more, agriculture is becoming more profitable. Consequently, increased profit should prompt transitions into "higher profit cash crops such as fruits and vegetables" (Briese, 2009). If rural roads are successfully constructed, horticultural productions (and markets) will become much more stable, which will produce a demand for higher quality products; this demand should induce the standardization of modern production practices throughout Nepal. Furthermore, improved transportation will facilitate the movement of technological knowledge to those parts of the country that are currently lacking it. Of course, this entire hypothetical string of events is dependent upon the ability of the Nepali government to recognize these needs and the fact that the fulfillment of said needs will benefit the country's well-being in the end. It is counterproductive to research sustainability when there is not yet a basic infrastructure in place to uphold sustainable practices.

For the sake of this paper, we will assume that the government has done as I have suggested above, and that the necessary chain of events has played out, more or less. (All subsequent suggestions are based on this assumption.) Research on sustainable horticultural crop production (for both greenhouse and field) would then need to commence in the following areas: irrigation, fertilizers, soil-based and soilless substrates, appropriate crops (down to the cultivar level), mechanized planting/harvesting and post-harvest crop storage. The most important research question is one that Nepali researchers have already been working on: which plants (and varieties of plants) are able to withstand the harsh water stress of Nepal's weather conditions? How should plants be genetically or physically manipulated to optimize their performance in times of both standing water and drought? If this particular question proves too complicated for short-term success, research should focus on proper irrigation and drainage of crop production sites so that the water stress is more negligible. (In relation to this paper, this research could concentrate on orchard and floriculture crops grown in fields.) Other research questions could investigate the effectiveness of certain "sustainable" production methods, specifically in greenhouses. For example, growers could test "sustainable" soil-based and soilless media to determine which produces the most consumer-friendly products. The same could be done with "sustainable" fertilizers, especially since Nepali growers often use animal waste as a cheap fertilizer option. It would be beneficial to test this fertilizer against manufactured "sustainable" fertilizers on the market to determine the actual cost-effectiveness of each type of input.

Sustainable Controlled-Environment Production

The future of horticultural crop production in Nepal is full of possibilities. To illustrate this presumptuous statement, this section will create a hypothetical controlled-environment production facility with fully sustainable elements. This production facility will exist to test sustainable elements of cut-flower crop production (in greenhouses), as this particular branch of horticulture seems most beneficial to Nepal's overall economy on many levels. If floriculture production is increased to 1000 ha nationwide, there is potential for 25,000 employment opportunities, which could directly decrease poverty rates in Nepal (Yanai, 2007). Furthermore, the creation of sustainable greenhouses would allow the Nepali growers to participate in the global floriculture market, which would improve the value of its exports. Also in relation to sustainability, floriculture field production would help control soil erosion and desertification (Yanai, 2007).

The test facility would be located in rural Nepal, specifically in Simikot, a small town in northwestern Nepal. It is necessary to choose a remote location for the test facility; it would be far too easy to succeed in an urban setting. The true test of sustainability in a country would be whether or not the sustainable aspects can be upheld in the country's most trying conditions. The hypothetical production facility would be 50 feet by 100 feet, with movable (rolling) metal benches for optimum use of space. The greenhouse would be even-span, with double-polyethylene as a glazing material. Fin-tube heating and pad-and-fan cooling systems would be controlled by a central computer system, with electricity supplied by hydropower from the Karnali River. (There is great potential for hydroelectricity throughout Nepal.) Irrigation would be supplied by rainwater harvested during the monsoon season (Yanai, 2007). The irrigation

systems themselves would be drip and sprinkler systems to save water; in Nepal, drip and sprinkler systems have been "proven to have water application efficiency in an order of 75 percent of more compared to 20 to 50 percent in other conventional surface irrigation" (Yanai, 2007). Bio-fertilizers, such as composts and organic manures, would be used.

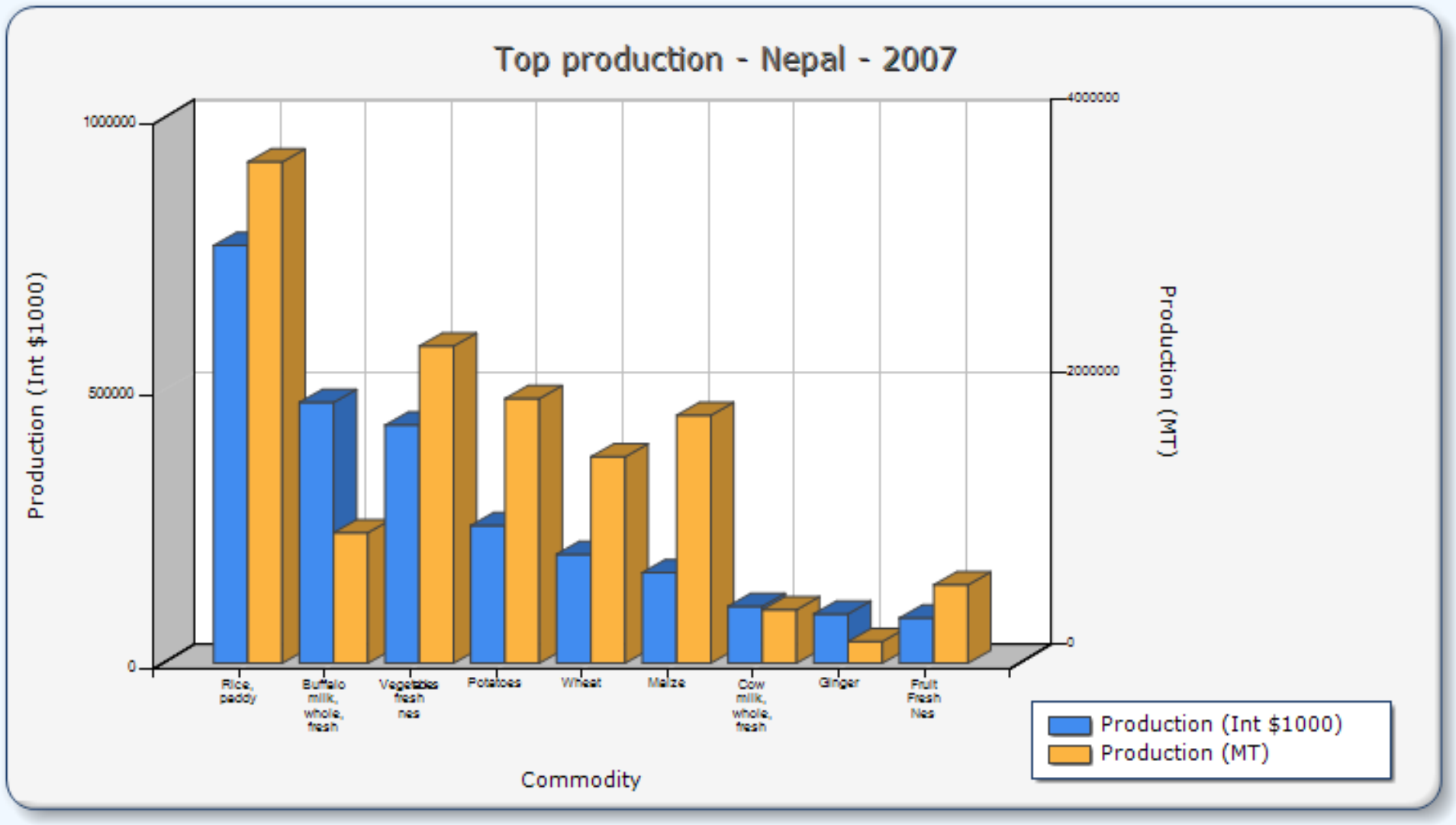
As discussed earlier, several different experiments could be conducted to evaluate sustainable components of production. Said components include: media, light, fertilizers, containers, heating, cooling, and plant growth regulators, among others. For the hypothetical test facility, experiments will be performed on the leading cultivars of Nepal's top five cut-flower crops: calla lily (*Zantedeschia spp.*), carnation (*Dianthus spp.*), Dutch rose (*Rosa spp.*), gerbera daisies (*Gerbera spp.*), and gladiolus (*Gladiolus spp.*). Because water scarcity occurs during a sizeable part of Nepal's growing season and because this facility's crops will be irrigated with rainwater, the first set of experiments will focus on irrigation needs for each plant genus. This round of experiments will take place over the course of an entire year, so that researchers can take accurate records regarding rainfall amounts throughout the different periods of drought and excess precipitation. Plants will be grown under species-specific optimum growing conditions, and the experiments will evaluate the least possible amount of water that each needs to grow in such conditions. Variables will include different "sustainable" soil types as well as different day-lengths, heat levels, and fertilizer types/levels. The ultimate outcome of these experiments should be that growers will be able to produce cut-flower crops (that are comparable to the international market standards) by using the absolute minimum amount of inputs. This is especially important because the majority of floriculture inputs need

to be imported into the country, which adds expenses for growers (Yanai, 2007). In this case, sustainability and cost-effectiveness would go hand-in-hand.

Conclusion

The Federal Democratic Republic of Nepal has made much notable progress over the course of its horticultural history; however, it still has far to go before its crop production will be considered successful by modern measures, especially in terms of sustainability. The most basic obstruction to efficient sustainable crop production is the country's general lack of infrastructure (especially roads in rural areas), which prevents efficient transport of production inputs and harvested goods. But with the right amount of government involvement and funding, an adequate infrastructure could be set up; this advancement would build a foundation upon which the Nepali horticultural community could build sustainable production facilities, both for field and greenhouse production. I am eager to see them succeed.

Figure 2: Top agricultural crops in 2007 (FAOSTAT 2009)



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