



FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

Technology Profile

Type of Technology:
Tangible or Physical

Chimney Solar Dryer

September 2019

This technology profile was compiled by Lauren Howe, University of California, Davis

As a low-income country, Nepal has concerning levels of malnutrition, manifesting in childhood stunting rates of 35.8% and 40.8% of women with any anemia (Ministry of Health - MOH/Nepal, New Era Nepal, & ICF, 2017). Chronic malnutrition may inhibit optimal physical growth, as well as impair cognitive development, leading to long-term economic consequences from reduced productivity.

Maternal and child undernutrition has many causes. In rural Nepal, low dietary diversity results from mainly consuming staple foods (e.g. rice and lentils), with very limited amounts of fruits and vegetables and animal source foods because of lack of availability and/or affordability. However, horticultural crops like fruits and vegetables have great potential to ameliorate undernutrition and provide needed income to farming families.

Cultural Practice, LLC (CP), as a consortium partner of the Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES) project, developed a methodology to assess whether agricultural technologies are gender-responsive and nutrition-sensitive in terms of design, use, and dissemination. The Chimney Solar Dryer Technology profile was compiled by Lauren Howe, based on her Master's Thesis research, using this technology assessment approach. This technology profile aims to improve the dissemination of gender-responsive and nutrition-enhancing technologies and inputs to improve women's agricultural productivity and enhance household nutrition. The technology profiles identify issues and opportunities to make technologies more attractive for men and women farmers or other value chain actors, to increase men's and women's benefits from using the technologies, and to design distribution models for extension agents, input suppliers, and mobile devices to get the technologies into men's and women's hands.

Although fruits and vegetables are excellent sources of micronutrients, in Nepal, their quantities vary throughout the season, based on climatic zone. Common vegetables grown in the study area, Dadeldhura district in the far west of Nepal, include leafy greens, tomato, radish, cauliflower, carrot, beans, peas, pumpkin, potato, onion, garlic, balsam apple, coriander, and taro, as well as fruits like citrus, guava, and banana, depending on the altitude and temperatures. In some communities in Dadeldhura, farmers are producing more than enough produce, but may lack awareness and/or access to technology to properly handle and store it after harvest. In fact, postharvest losses of fruits and vegetables are exceedingly high in Nepal, with rates ranging from 20-50% (Gautam & Bhattarai, 2006 as cited in Devkota, Dhakal, Gautam, & Dutta, 2014) or 15-35% (Kaini, 2000; Paudel, 2006), which is consistent with the popular statistic that roughly one third of all food produced for human consumption is lost or wasted (Gustavsson, Cederberg, Sonesson, Van Otterdijk, & Meybeck, 2011).



USAID
FROM THE AMERICAN PEOPLE

**HORTICULTURE
INNOVATION LAB**

UC DAVIS
UNIVERSITY OF CALIFORNIA

This technology profile is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of the author and do not necessarily reflect the views of USAID or the United States Government.

In lower-income countries, it is widely understood that postharvest losses of fresh fruits and vegetables occur earlier in the supply chain because of lack of proper storage technology and scant awareness of postharvest management, with loss typically involving surplus product that cannot be immediately consumed by the household or sold in the market (Gustavsson et al., 2011). It has been estimated that for major crops, more than 25% of produce may be lost after harvest in Dadeldhura, mainly due to saturated markets, price fluctuations, and poor postharvest practices, including lack of knowledge and suitable technology (e.g. cold storage) (A. Shrestha, personal communication, February 28, 2018).

In many places around the world, including Nepal, drying has traditionally been done outside in open air, either on the ground or on rooftops (Chua & Chou, 2003). Drying is already a popular and widespread postharvest activity practiced by farmers in Dadeldhura, with the current practice of open-air sun drying done commonly by women who learned from their mothers and grandmothers in villages where drying has been practiced for generations. Dadeldhura is a productive district for vegetable crops, so it makes sense that the popular products for drying include common vegetables such as chili pepper, radish, leafy greens, cauliflower, balsam apple, pumpkin and taro. Women here are using a variety of materials for drying produce including bamboo (e.g. *nanglo* or *supo* baskets), as well as plastic tarps, cloth, or even on rooftops without any drying material under the product. Because they will leave the food outside and uncovered for several days at a time, sometimes through the nights without bringing it inside, this practice leaves the product exposed to the elements like dirt, dust, rain, flies, animals and children. Open-air sun drying is relatively unhygienic, because it leaves product vulnerable to contamination by debris such as rocks, dirt, insects and other pests and can also have moisture issues through hardening of the product skin or unexpected rainstorms (Chua & Chou, 2003). These practices are not only unhygienic, but can lead to spoilage due to slower drying (especially under cloudy conditions), as well as quality loss.

Technology design and dissemination

Although drying in Nepal has typically been done through open air methods using bamboo containers like *supo* or *nanglo*, this process can also be achieved using improved solar dryers like the University of California, Davis-designed chimney dryer. An improved postharvest technology, the chimney dryer is an efficient model that is small-scale and relatively affordable.

BOX 1 DATA COLLECTION

Data collection took place from October to December of 2018 in Dadeldhura district in far west Nepal. First, a three day training of trainers (TOT) workshop was held for NGO partners, government officials, local carpenters, and village model farmers (VMFs) to learn how to build and use the chimney dryer. Then at the community-level in Bagarkot and Belapur, local carpenters constructed one chimney dryer on the demonstration plot of a VMF, to serve as an example in each village. Community members were then trained on how to use the chimney dryer, as well as the benefits of drying fruits and vegetables, measuring product dryness, safe and effective storage containers and conditions, and the nutrition of fruits and vegetables dried in the chimney dryer. In addition to the training workshops, staff from the *Suaahara II* program helped coordinate individual and group interviews. In total, 47 women participated in baseline and endline focus group discussions, including twenty-one 1,000 days mother-farmers, 19 general group members, four village model farmers (VMFs), and three community health volunteers. In addition to these women, six men farmers and two men carpenters were involved in the construction, training, and interview activities to promote additional buy-in and long-term sustainability of the technology at the village level. Additionally, fourteen key informant interviews were conducted with a variety of stakeholders, including the chimney dryer designers based at UC Davis; Dadeldhura-based ward-level and district-level government representatives; partner NGOs; produce collectors; carpenters; and the first chimney dryer users.

The chimney dryer was designed by researchers at the Horticulture Innovation Lab who had extensive experience in drying operations for many years and observed that all commercial dehydrators have good airflow, a critical element of fast drying, and most existing dryers for smallholders lack good airflow. They also wanted to bring the product up off the ground to avoid sanitation issues and keep flies and dirt away from the product. The resulting chimney solar dryer design, tested on farms in California and around the world, is more efficient and higher capacity than many existing cabinet dryer designs.

The chimney solar dryer is an example of a passive dryer that traps heat with its large drying table, which is covered with heat-absorbent black cloth or plastic. The chimney design promotes moisture removal through constant airflow and high air speeds around the product, as the warm, less dense air moves across the trays, up and out of the chimney, accelerating the drying process more than cabinet-style dryers. A benefit of the chimney dryer is that it can be constructed with local materials such as wood, bamboo, plastic, and cloth. It can also achieve more uniform drying through its utilization of the stacked trays lined with mesh, which promote airflow around all sides of the product, resulting in good air-particle contact. The trays can also be repositioned during drying to promote more uniform final product moisture content.

In 2018, the USAID-funded and UC Davis-led Horticulture Innovation Lab published a manual and instructional videos, which provide background information, building instructions and tips for troubleshooting the dryer.

The main components of the chimney solar dryer include:

1. A drying table covered with black plastic or fabric
2. A chimney covered with clear plastic with an opening at the drying table
3. Mesh drying trays to hold the produce
4. Clear greenhouse-grade polyethylene (PE) plastic film that covers the trays and the drying table and is sealed to the chimney, which allows air to enter the dryer at the front, removing moisture as it flows over the product, and then warm moist air escapes up and out of the chimney



Built with widely available materials, the chimney solar dryer combines a table for drying fruits and vegetables with a chimney. Photos by Lauren Howe/UC Davis, 2018

In addition to the faster drying time, there are several other intended benefits of the chimney dryer. These benefits include more hygienic drying as a result of plastic covering the food and the table elevating it off the ground, which can ultimately lead to safer food that is not contaminated by the elements such as flies, dirt, animals, and rain. Another facet of improved solar drying using the chimney dryer includes improved quality of dried products, including color, texture, and presumably nutrients.

Prior to the research conducted in Nepal, the chimney dryer was built and tested by NGO partners and smallholder farmers in several countries, including Zambia, Guinea, Tanzania, Rwanda, Guatemala, Honduras, Thailand, and Cambodia. Research in Bangladesh shows the profitability of the chimney dryer, particularly for fish and high-value crops including chili pepper, peanut, and mung bean.

Gender analysis

In Nepal, the dissemination process was through the *Suaahara II* Good Nutrition Program, being implemented by Helen Keller International (HKI) and local partners, including Vijaya Development Resource Center (VDRC). Through these partners, chimney dryer dissemination efforts targeted women as the main members of their households engaged in drying activities. Training participants included village model farmers (VMFs) within the *Suaahara II* Program, who are women generally selected from “1,000 days” households (homes that have either pregnant women or children under the age of two) based on their agricultural performance, leadership, and their central location. VMFs already have land, irrigation systems, and a supportive family environment, which allows them to create a demonstration plot on their property. VMFs from each community participated in the training and interview activities. This project also targeted other “1,000 days mother-farmers” and general homestead food production (HFP) group members who are currently receiving training from HKI on how to grow fruits and vegetables and raise poultry. In addition to women, a few men farmers and men carpenters were involved in the construction and training activities to promote additional buy-in and long-term sustainability of the technology at the village level.

Per selection by HKI based on current project activities and priorities, this research was carried out in Dadeldhura district, a hilly district in the remote far-western part of Nepal. Although the far west is well known for being underdeveloped compared to other districts in the country, it is also known for being highly productive in vegetables. This research was conducted in two communities in Dadeldhura district, pre-selected by HKI: Bagarkot and Belapur. In Bagarkot, there are still high amounts of surplus produce after household consumption, with relatively easy access to local markets to sell agricultural products. In contrast, Belapur is a municipality in the upper belt of the mountain region where vegetable production is not possible throughout the year.

Although we only worked with a small number of women farmers in the pilot phase, there is the potential to introduce chimney dryers to many more farmers who are currently participating in *Suaahara II*, as well as those farmers who interface with partner organizations, government extension workers, and other individuals we trained. In the long-term, this type of intervention could make a substantial contribution to reducing postharvest losses, increasing access to fruits and vegetables year-round, and improving dietary diversity and micronutrient intakes among women and young children.

TIME AND WORKLOAD

Stakeholder interviews revealed that drying is a gendered activity that is traditionally performed by women. During a seasonal calendar activity in Belapur, we learned that women have much larger workloads than men. The main responsibilities of men are around tillage, field preparation, and dry-land irrigation, only during two months of the year. While both men and women participate in the harvest, women are additionally responsible for planting, weeding, drying, and all household work, which takes place year-round. The unequal distribution of work is common in this community, especially because many husbands are outside the home working so women simply have no other option but to fill the

labor gaps, which may include taking on roles traditionally held by men such as land preparation and irrigation. This trend is consistent with the literature, which points to large-scale rural migration, especially among Nepali men, many who work outside the home, traveling to India or Gulf countries, and send remittances back to their families in Nepal (The World Bank, 2018).

The chimney solar dryer makes the drying process more efficient than current sun drying, as demonstrated by drying experiments in Dadeldhura. Moreover, women can leave their product in the dryer all day with minimal stress. They might only need to devote 5-10 minutes a day to shuffle the trays, which we expect will only add minimum tasks to women's existing workload. Furthermore, the chimney dryer may actually save time because of the mesh trays, which allow air to circulate on all sides of the product. This air circulation helps ensure uniform drying, preventing users from having to turn or flip the food products piece by piece as they might with current sun drying on a solid surface where product does not receive airflow from the bottom.

However, because the time between baseline and endline was so limited in this research project, we mainly assessed people's *perceptions* of time and workload effects. Related to gender, multiple people, including men and women, farmers and NGO staff, thought that women would benefit more than men from the reduced workload because women are the primary dryers.

Surprisingly, women did not perceive time savings as the most significant benefit of the chimney dryer. While the chimney dryer is objectively faster than sun drying, depending on the crop and season, and saving time is arguably critical for women farmers who may already be overburdened, time and labor savings were deemed less important than expected. This finding can be attributed to the fact that drying is a relatively passive activity that does not require a significant amount of active time or arduous labor. Women may leave their product out for 7-10 days and only check on it once or twice, not even bringing it inside overnight (which is not recommended for food safety reasons and risk of mold growth overnight). As a result, any time saved may not significantly impact their current drying practices.

FOOD AVAILABILITY, QUALITY AND SAFETY

However, faster drying does reduce the risk of product developing mold or otherwise spoiling, especially if left out for days at a time under cloudy or suboptimal drying conditions. As a result, time saved is directly related to improved product quality and thus quantity through reduction in spoilage. At endline, farmers felt there would be increased food available during the lean season due to decreased spoilage as a result of utilizing the chimney dryer, making vegetables available year-round, in some form. This increase in food availability is crucial for these communities in Dadeldhura district, where dried foods are consumed weekly or even daily, especially in the dry or lean season when fresh produce is limited. In Dadeldhura, the relative importance of dried foods means that improving the method, quality, and quantity of dried foods available may have a significant impact on the nutrition and diversity of the household diet, and the importance of dried food products should not be underemphasized.

In addition to time saved and losses prevented, it is critical to emphasize the other benefits of the chimney solar dryer, including improved hygiene, sanitation and food safety, plus color, taste and quality retention. Food safety and quality are intrinsically linked to food availability because if food is not safe or nutritious, it will ultimately be less available for bodily absorption. The perceived hygiene, health, and food safety benefits of improved solar drying using the chimney dryer ended up being a key finding among farmers. It should be noted, however, that this realization came early on in the research during the baseline focus group discussions, even before the women saw the chimney dryer in person. Clearly, health, sanitation, and food safety appear to be important driving factors that motivate farmers' desire to utilize the dryer, but this motivation could have reflected social desirability bias early on, as participants may have wanted to please or gain approval from the NGO program staff.



Orange-fleshed sweet potato (OFSP) dried in the open sun (left) compared to OFSP dried in the chimney solar dryer (right). Color is often an indicator of food quality and nutrient content, and in the case of orange, we can assume beta-carotene (precursor to vitamin A) is more retained in the chimney-dried product. This OFSP was dried during a community training in Dadeldhura. Photo by Lauren Howe/UC Davis, 2018.

Another important finding from this research was that after the introduction of the chimney dryer through community-level construction and trainings, some farmers felt that the vegetables dried in the chimney dryer tasted better and were more nutritious than those dried in the open sun, so consumption will naturally increase. These claims were not validated by actually measuring nutrients or palatability, but regardless, if farmers believe it to be true, then this is an unexpected benefit of this technology. In fact, this quantification may actually be less important compared to farmers' perceptions in the context of technology adoption.

INCOME GENERATION AND MARKET OPPORTUNITIES

If product is adequately dried after harvest, dryness is measured as sufficient for long-term storage without mold growth, and proper storage is maintained, then a logical next step beyond household consumption would be marketing the dried foods. In fact, drying can facilitate the storage, transport, and marketing of fruits and vegetables, especially during the lean season, because the process reduces the product weight and bulk by removing water (Barrett, 2002). This research sought to assess whether farmers in Dadeldhura were currently selling their dried produce or if this potential existed.

Although home consumption could potentially take priority, especially within the context of nutrition-specific programs, one of the desired short-term outcomes in the project was to increase the desire to sell surplus dried product and raise awareness of potential markets. We observed that some dried foods are already being sold in major cities, especially at Nepali superstores like *Bhatbhateni*, but the farmers we spoke with in Dadeldhura were not currently participating in these supply chains, though many were interested in selling dried foods. This new market opportunity would allow them to dry small quantities at a time, then wait and store it until they have enough dried quantity to aggregate or until market prices increase. Red chili peppers are one key example in Dadeldhura (and across Nepal), as many farmers are producing this crop on a relatively large scale, which leads to low prices.

Many stakeholders agree that drying is an effective alternative to product spoilage when prices are low, especially for commercial farmers growing in bulk. Moreover, produce collectors and collection centers may often have higher postharvest losses than individual households, so there may be more potential for the chimney dryer to benefit them. Furthermore, partially damaged or overripe produce is typically unsellable but can be dried and provide additional income for anyone willing to invest the resources into drying.

Successful sales, however, are dependent upon consumer demand and a reliable customer base or market. We learned about possible market opportunities for dried foods in Nepal, such as a rising middle class of health-conscious consumers in cities like Kathmandu and Pokhara. Other sales outlets include direct sales to government workers, restaurants, hotels, and even tourists. Nepal has a large trekking industry where tourists come from all over the world to hike in the Himalayan mountains. Thus, selling dried foods to trekkers is a promising option, given the lightweight, portable, and convenient nature of dried foods. For this outlet to be promising, however, there needs to be transportation or traders to bring the dried foods from Dadeldhura to the trekking hotspots.

Another potential marketing opportunity could be promoting dried foods as specialty, value added products that are culturally familiar or significant. For instance, consumers may be less likely to accept plain dried fruits and vegetables, and would prefer fresh produce. However, consumers enjoy specialty dried foods like *gundruk* (dried and fermented leafy greens) and *sinki* (dried and fermented radish or cauliflower), an important processing distinction. These well-known specialty foods are already sold in superstores and small wet markets and can be further promoted as traditional and value-added foods. In contrast, making plain dried foods palatable for a wider audience necessitates consumer marketing and education on the nutritional benefits and culinary uses, as well as taste testing and recipe development.

Several other components of marketing could be considered to scale up the production and sales of dried foods. These additional ideas include media campaigns, partnering with agricultural entrepreneurs, and seeking investment and buy-in from super stores like *Bhatbhateni*. Farmer cooperatives are another option that could be pursued for collective drying and marketing of dried products.

If a market is developed, then selling dried product has the potential to increase household income. However, multiple interviewees shared that men will get involved in the selling of dried foods (even if they are not drying themselves), if it becomes profitable. Currently, male migration outside Nepal is common, and men generally have more social freedom and decision-making power compared to women, especially in public and economic spaces. Husbands or in-laws tend to be the primary decision makers and heads of household in Dadeladhura, and as such, they often control the income. For women to dry commercially, they will need support from their husbands and families.

The most immediate and tangible employment gain, however, may be felt by local carpenters, who are men, as this project can support them in the long-term with the knowledge and skills to construct chimney dryers for other farmers in their villages.

Issues and opportunities

In terms of the chimney dryer's gender-related impact, stakeholders including men and women farmers, NGO partners, and government officials all agreed that women would tend to benefit more from this technology as the primary individuals practicing drying in the community, but that men would benefit from the commercialization of drying. This pilot study revealed that the chimney dryer certainly has the potential to benefit women in terms of time and workload. However, for the advantages to extend into the area of income and asset generation, women need to be better integrated into value chain development for dried foods. Thus a gender-sensitive approach to value chain development is necessary, one that identifies and analyzes the root causes of gender-based systemic constraints to participation in economic activities and links these to structural change (FAO, 2016). For example, efforts could be made to facilitate women's participation in the dried foods value chain by targeting and customizing training and providing them with better access to "infrastructure services, information, credit, and other business development services" (Ragasa, 2012). These strategic efforts would help enable women to purchase, rent, or otherwise finance a chimney dryer and associated "dry chain" technologies, as well as provide them with gender-specific training and information about transporting and pricing their products. In addition to access to information, resources, and services, additional measures, such as policies and regulations (e.g. around rural finance), may be required to guarantee that women maintain control over income-generating assets when men attempt to take charge following profitable commercialization (Ashby et al., 2008).

During this research, we received frequent comments on the size of the chimney dryer, though the feedback did not have explicit gender dimensions. Several stakeholders in Nepal expressed desire for a smaller chimney solar dryer than the standard size described in the construction manual (with a 12-foot-long table). They emphasized that farmers in Nepal have very small plots of land, and they feel the chimney dryer in its standard dimensions is both too large for individual household drying needs and would occupy too much space on farmers' property. However, related to a smaller size is portability, enabling women to easily move the dryer in the event of hazardous weather conditions. As a result, for the subsequent community-level dryers, we shortened the table to 8 feet instead of 12 feet after the Training of Trainers workshop.

In comparing the chimney solar dryer to the current method of sun drying, one potential drawback is drying capacity. The current method has a virtually unlimited capacity as it really just depends on how many bamboo mats, plastic tarps, or roof space a farmer has on their land. In contrast, the chimney solar dryer has a fixed capacity (6-10 trays), depending on the size of the drying table. Compared to the essentially unlimited capacity of sun drying, the limited capacity, especially of the smaller chimney dryer, is a valid concern for farmers who are interested in commercial drying. For commercial or shared use, the consensus is that the original size (12-foot-long table) is better. However, for many women who intend to use it for limited household use, the reduced size (8-foot-long table) will likely work well. After learning early on that one size does not fit all in this situation, we tried to emphasize that the chimney dryer construction manual does not have to be followed exactly and size can be adjusted based on preference.

Through the pilot project design, constructing a few chimney dryers on the land of women village model farmers in Bagarkot and Belapur was intended to promote the trialability of the technology, "the degree to which an innovation may be experimented with on a limited basis," which "represents less uncertainty to the individual who is considering it for adoption, as it is possible to learn by doing" (Rogers, 1995). It was our hope that by constructing one chimney dryer in each village, women would take advantage of the opportunity to try the technology, and if they are satisfied with the results, they would ideally invest in their own. Trialability can be especially important for farmers who do not have the resources (e.g. financial, land, time, social capital, etc.) or desire to take risks without ample support. Furthermore, piloting the chimney dryer on the land of village model farmers was a key strategy because VMFs are opinion leaders in the community, who are well-regarded and can "influence other individuals' attitudes or overt behavior informally in a desired way with relative frequency" (Rogers, 1995). However, it should be noted that communal dryers, even when centrally located, may require some women to travel far (e.g. walking up to an hour) from their homes. This distance can add additional time to women's already full workloads of household and farm responsibilities. Future projects should take into account the number, location, and distance of community resources, like solar dryers, to reduce the burden on women farmers.

Cost and affordability of a technology are key components to long-term adoption. The Horticulture Innovation Lab considers the chimney dryer a low-cost technology as it can typically be built for less than \$200 in different countries. Affordability, however, is relative and highly contextual. In Dadeldhura, the current sun drying method is essentially free and unlimited, not requiring a significant investment of capital or materials, with the exception of bamboo baskets or plastic tarps. However, we calculated that the total material costs for a smaller chimney dryer (8-foot-long table) were about 10,000 NPR or around \$90 USD. Once carpenter labor is factored in, the cost increases to about 14,000 NPR (~\$125 USD). Skilled labor may only be required for one day to cut the wood. Otherwise, anyone can construct the dryer, which will keep costs down, though employing a carpenter is likely more efficient and less frustrating for the novice builder.

However, are families willing to invest this amount of money into a chimney dryer? When we interviewed women in Belapur, many agreed that they could not estimate their household's willingness to pay or commit to constructing their own dryer, as they needed the input and approval from their husbands or in-laws as the primary decision makers. Overall, the general consensus from the research was that farmers, regardless of gender, would be willing to spend about 7,500 NPR (~\$67 USD) on average, up to about 10,000 NPR (~\$90 USD) for a chimney dryer. This dollar amount could increase if financial support was available. For instance, besides subsidies from the local government or NGOs, women discussed pooling resources from their women's groups or sharing the dryers in groups of 3-6 households. Besides maximizing the use of the chimney dryer through households sharing, constructing dryers as a small group makes the technology more affordable.

References

- Ashby, J., Hartl, M., Lambrou, Y., Larson, G., Lubbock, A., Pehu, E., & Ragasa, C. (2008). *Investing in women as drivers of agricultural growth*. Retrieved from http://siteresources.worldbank.org/INTARD/Resources/webexecutivesummaryARD_GiA_InvstInWomen_8Pg_web.pdf
- Barrett, D. (2002). Processing of horticultural crops. In A.A. Kader (Ed.), *Postharvest technology of horticultural crops* (Third, pp. 465–479). Oakland, CA: University of California Agriculture and Natural Resources.
- Chua, K. J., & Chou, S. K. (2003). Low-cost drying methods for developing countries. *Trends in Food Science & Technology*, 14, 519–528.
- Devkota, A. R., Dhakal, D. D., Gautam, D. M., & Dutta, J. P. (2014). Assessment of fruit and vegetable losses at major wholesale markets in Nepal. *International Journal of Applied Sciences and Biotechnology*, 2(4), 559–562. <https://doi.org/10.3126/ijasbt.v2i4.11551>
- FAO. (2016). *Developing gender-sensitive value chains - a guiding framework*. Rome. Retrieved from www.fao.org/3/a-i6462e.pdf
- Gautam, D., & Bhattarai, D. (2006). *Post harvest horticulture*. Kathmandu, Nepal: Public Printing Press.
- Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., & Meybeck, A. (2011). *Global food losses and food waste: Extent, causes and prevention*. Düsseldorf, Germany. Retrieved from <http://www.fao.org/3/a-i2697e.pdf>
- Kaini, B. R. (2000). Country paper on post-harvest techniques for horticultural crops in Nepal. In *APO seminar on appropriate technologies for horticultural crops* (pp. 11–218). Bangkok, Thailand.
- Ministry of Health - MOH/Nepal, New Era Nepal, & ICF. (2017). *Nepal demographic and health survey 2016*. Kathmandu, Nepal. Retrieved from <https://dhsprogram.com/pubs/pdf/FR336/FR336.pdf>
- Paudel, K. B. (2006). Nepal. In R. S. Rolle (Ed.), *Postharvest management of fruit and vegetables in the Asia-Pacific region*. Rome, Italy: Asian Productivity Organization. Retrieved from http://www.apo-tokyo.org/00e-books/AG-18_PostHarvest/AG-18_PostHarvest.pdf
- Ragasa, C. (2012). Gender and institutional dimensions of agricultural technology adoption: A review of literature and synthesis of 35 case studies. In *International Association of Agricultural Economists*. Foz do Iguaçu, Brazil: International Association of Agricultural Economists. Retrieved from <https://ideas.repec.org/p/ags/iaae12/126747.html>
- Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). New York: The Free Press. Retrieved from <https://books.google.com/books?hl=en&lr=&id=v1ii4QsB7jIC&oi=fnd&pg=PR15&ots=DLXvylVncT&sig=YHCcVyyinwtkwGqU980tcCr5Yn8#v=onepage&q&f=false>
- The World Bank. (2018). *Male outmigration and women's work and empowerment in agriculture: The case of Nepal and Senegal*. Washington D.C. Retrieved from <http://documents.worldbank.org/curated/en/653481530195848293/pdf/127755-REVISED-Male-Outmigration-and-Women-s-Work-and-Empowerment-in-Agriculture-The-Case-of-Nepal-and-Senegal.pdf>