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Slum Livestock Agriculture

MT Correa, North Carolina State University, Raleigh, NC, USA

D Grace, International Livestock Research Institute, Nairobi, Kenya

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Glossary

Animal husbandry The different aspects involved in raising animals in agricultural settings.

Cold chain The transport and storage of perishable products at appropriate cold temperatures to prolong the shelf life of the product.

Coprophagia Consumption of fecal matter; pigs are coprophagic.

Food safety The proper handling of food, preparation, and storage to avoid contamination that may cause illness to humans.

Food security The access of food, the availability, and the nutritional value of the food.

Goshala Protected shelter area for cattle, a sanctuary for animals due to their religious significance; for example, *goshalas* in India for cows, calves, and oxen.

Gray water Water contaminated with waste from household use that is recycled for other use such as irrigation and flushing toilets.

Production diseases Diseases of animals affecting the production capability; for example, mastitis affects milk yield.

Reportable diseases The occurrence of a disease requiring obligatory reporting due to the importance to human or animal health.

Zoonosis Diseases transmitted between animals and humans; the biological cycle may include one or more species and humans, humans could be an accident in the cycle.

Introduction

Slums are human settlements developing in peri- and urban areas. Often not recognized as part of planned urban environments, slums continue to grow in number and size around the world. There are now 800 million to a billion people living in slums, a large percent of the seven billion worldwide. Slums are difficult to define based on a single characteristic because they are not homogeneous within cities in a country or among countries; their unique milieu depends on the geographical location of the settlement, the socio-anthropological background of the dwellers, and the history of its development. Notwithstanding the sociocultural differences, slums have some common characteristics: poor housing, often illegitimately built on private or public land with poor drainage and unfit for agriculture; overcrowded conditions; limited access to potable water; poor sanitation and lack of sewage or waste removal; high numbers of domestic pets; and clandestine keeping of livestock.

Slums originate from the need of people for a place to live after displacement due to drought, famine, or wars, and migration from the countryside into the cities by the push of rural unemployment and the pull of urban opportunities. This migration from rural to urban areas populates informal settlements in the periphery of cities and towns in many countries (United Nations, 2011). Demographic information from slums is only as good as the reports governments make. Less than 100 countries report data on slum human population, and from those, 37 indicate they have more than 50% of the population living in slums. One country reported that 94% of the population lives in slum conditions (United Nations, 2007). In the 2013 census in India, 65 million people were identified as living in slums (Government of India, 2013), which is probably an underestimate.

In lesser developed countries, the increase in the urban population dating from the 1970s is parallel to the decrease of the rural population. Demographers expect that 60% of the world's population will live in urban areas by the year 2050 and 2 billion people will be living in slums (United Nations, 2011). In Africa, the population in urban areas increased sevenfold in 50 years. Population density in some slums has reached 200 000 people per square kilometer, as in Bangladesh (Huque, 2005). With one in every seven people living in a slum, ensuring sufficient food becomes a concern; slum livestock agriculture could be part of the solution to fulfill the nutritional needs of that many people (United Nations Human Settlements Programme, 2003).

Production of food in slums is clearly different from rural, peri-urban, or other types of urban agriculture developing in many industrial countries. Urban agriculture had been characterized as a decentralized supply system composed of small and scattered production units (Mougeot, 2000). There are other classifications of urban agriculture, only some of which include slum agriculture (Egbuna, 2008). Slum livestock keeping is especially difficult to classify. The lack of basic resources to maintain and exercise good agricultural practices coupled with unsanitary slaughter is likely to render slum livestock agricultural products unfit for human consumption. However, despite all the negatives, slum livestock agriculture is a means of securing food, earning income, and supporting livelihoods of slum dwellers. Slum agriculture benefits from a large market close at hand, low transportation costs, availability of production inputs, the ability to make use of waste foods and water, and low entry costs to setting up production (Food and Agriculture Organization, 2001).

Informal markets for real estate and goods develop in slums, including markets for processed and unprocessed animal products (Potsiou and Ioannidis, 2007). Peri-urban and urban

livestock agriculture is a complex and multifaceted activity developing in an environment often unfit for human habitation. Roaming chickens, pigs, and goats are a common sight in slums, and even cows and animals used for transportation or hauling such as donkeys and horses can be seen. In different regions of the world, different animal species are popular: goats and sheep are more common in Africa and Southeast Asia, and pigs are more common in Latin American slums. Food animals in slums are a public health concern due to their potential for transmitting zoonotic diseases, unsafe food products, the risk of physical injuries and traffic accidents, and environmental contamination. Animal products processed locally enter the general population food chain through peri-urban and urban food markets. Owing to the lack of a proper waste disposal, animal and human waste mixes in the streets with leftover water from household activities. Stagnant water and waste, garbage, and other contaminants develop a foul smell and attract vermin and insects. Untreated wastewater flows into local waterways and is drunk by roaming animals. This gray water is often used for urban vegetable or crop farming.

There are few estimates of the volume of animal or vegetable products originating from slums used to supplement the family diet or entering the food chain through peri-urban or urban markets. In Ghana, 95% of the lettuce consumed in Accra is produced in urban and peri-urban areas (Amoah *et al.*, 2007). In the Chimbote slum in Lima, Peru, where 400 000 people live, it has been estimated that there are 280 swine production units (Chimbotenlinea.com, 2014). That is approximately 25% of the households in the slum assuming there are four members per household.

Livestock Production in Slums

The Food and Agriculture Organization of the United Nations has conducted technical consultations and extensive studies on urban and peri-urban agriculture. Thirty percent of the meat and 70% of eggs produced in the world is associated with urban production (Food and Agriculture Organization, 1999). It is not clear if slum agriculture production is included in these estimates. Slum livestock keeping is typically smaller scale than the peri-urban and nonslum urban agriculture. However, slum agriculture has rarely been the focus of systematic evaluations and studies. The complexity of this type of slum livestock agriculture and its implications in the social and political arena is, however, getting recognition (International Livestock Research Institute, 2012; Lemma and Rao, 2013), and some evidence is emerging on scale and importance. In Maputo (1.2 million inhabitants), Mozambique, more than one in three households in urban areas raises livestock (International Livestock Research Institute, 2013). In Ibadan in southern Nigeria, one in three urban households kept livestock, whereas in Kaduna in northern Nigeria nearly half the households kept livestock (International Livestock Research Institute, 2013).

Species of Animals and Production and Scale

Livestock production in slums is typically small to medium scale and low technology. Chickens and pigs seem to be

ubiquitous in Latin American slums, whereas goats and rabbits are favored in Africa and Southeast Asia. Cows are noticeable in India and Nepal where, for religious reasons, they cannot be slaughtered. Some animals in slums are allowed to roam and scavenge whereas others are confined in unsuitable small spaces shared with humans. The scale of this agricultural activity varies in type and size and it can range from subsistence to small- to medium-size commercial enterprises with hundreds of small animals. In more densely populated slums, fewer animals are kept and enterprises are likely to be small scale; where more land is available, livestock keeping is more common and on a larger scale (Box 1).

Smaller species: Chickens and rabbits

Chickens are animals most commonly raised in slums. One or two hens and one rooster roaming free with a few chicks is a common sight. It is not uncommon to find medium (10–30

Box 1 Livestock keeping in Dagoretti district, Nairobi, Kenya

Dagoretti District lies to the west of Nairobi city, 12 km from Nairobi city center. It is one of 8 urban districts in Nairobi and has around one-tenth of the total population. Most inhabitants live in tin-roofed timber houses with inadequate access to piped water, sanitation, and electricity. Unemployment (approximately 60%), human immunodeficiency virus-acquired immune deficiency syndrome, crime, and homelessness are persistent problems. Dagoretti was originally outside the city of Nairobi, but when the boundaries were extended in 1963, it became part of the city. Dagoretti district has both government and ancestral land. Some ancestral land has been sold to migrants, and government land has also been allocated to individuals. In some areas, squatters live on land temporarily leased out by landlords, a loose agreement, which can be revoked at any time. The population in the last available census was 240 509 up from 41 409 in 1969, a vivid illustration of the rapid growth of cities. Of the population, 42% are below 19 years of age, an age distribution that is also typical of developing countries.

A recent survey characterized livestock keeping in Dagoretti. More than half the households kept animals: in order of declining popularity: dogs (39%); poultry (39%); cats (37%); sheep and goats (14%); pigs (10%); and cattle (1%). A few households kept other animals including, rabbits, donkeys, doves, turkeys, ducks, and geese. Dogs were kept mainly for security, cats for vermin control, donkeys for work, geese for security and food production, and the other species were kept mainly for food production. In addition, cattle manure is a valuable by-product used for urban crop and vegetable production, and livestock are an easily liquidated asset that can be sold to meet urgent household needs or act as pledge enabling access to credit. Moreover, farmers report deriving social and psychological benefits from livestock keeping.

The study focused on dairy cattle kept by 1 in 80 households in Dagoretti. Farmers kept an average of three cattle. Nearly all households kept productive breeds, used artificial insemination, and zero grazing. Farms produced approximately 12 l of milk a day, and 88% of this was sold with the rest being consumed in the household. Most of the milk produced is sold in the community through informal markets. All sales of milk earn farmers in Dagoretti approximately US\$610 000 per year. Farmers reported that both demand and production are increasing.

chickens) to larger layer flocks (up to 100 chickens) in confined spaces. Chickens are the most versatile of poultry, given the value added of egg production and the worth of the animal, live or processed. In slums with limited electricity or where the cold chain is not available, chickens and eggs are a quick and easy source of protein and income generation. Chickens have an additional value because they are used in religious ceremonies and offerings (Alves *et al.*, 2009). The breeds of chickens vary from region to region and some commercial breeds are seen in slums. Scavenging chickens are fed in the morning with leftover food and possibly with added corn or poultry meal. During the day, chickens eat insects, garbage, and organic matter found in empty lots or by the side of the road. Housing is rudimentary and may consist of hay or rice husks arranged in cardboard or wooden boxes and placed off the ground for protection from dogs and predators mostly during the night. Raising chickens is considered an easy activity requiring minimal labor and is usually performed by women and children (Food and Agriculture Organization, 2001).

Backyard flocks requiring additional attention compete for space with humans and other animals and are more labor-intensive requiring feeding, watering, and pen cleaning. Noise levels and manure disposal become a problem with larger flocks and are a deterrent for keeping them in small and crowded spaces. Larger flocks are more common in peri-urban areas than slums, but broiler chickens keepers may have more than 100 birds, as in the case in the Mombasa slum in Bangladesh where a bird keeper is reported to have between 125 and 250 birds (Sabuni, 2010). Live chickens are transported in cages or burlap bags to nearby food markets. These markets are located at walking distance from the dwelling where the animals are raised, although sometimes birds are transported in cages on top of buses or trucks to other urban markets. Chickens are sold live or slaughtered on site at the buyer's request. Eggs have a longer shelf life (lasting 3–4 weeks without refrigeration depending on environmental conditions) than poultry meat. Eggs are wrapped in newspaper and kept in the shade to prolong their shelf life. They may be sold to neighbors in small numbers, as needed, for income generation or in larger numbers at markets. Other poultry kept in slums include turkeys, geese, doves, pigeons, quail, and guinea fowl.

Rabbits are gaining popularity in slums in Africa. They can be kept in small spaces in crates, either individually or in small groups. Rabbit crates are easy to build and can be kept stacked up against each other or leaned against a wall to occupy less space. These animals require more attention than scavenging or backyard flocks of chickens for feeding, watering, and cage cleaning. However, it is a profitable and uncomplicated business as evidenced by the number of rabbits a person can keep. One resident in the Kahawa Soweto slum in Nairobi has more than 400 rabbits in a shed (Kelto, 2013). Rabbits are fed greens collected locally and supplemented with vegetable leftover from markets or pelleted food. This is a small species that can reach to 4 kg of weight and can easily be processed locally as chickens for sale or family consumption. In a space of 30 × 40 feet, slum residents can raise more than 500 rabbits of different breeds. More unusual animals are also kept: a survey in Nigeria reported snails, grass cutters, and antelope among a total of 14 species kept.

Monogastrics: Pigs

Pigs adapt easily to urban conditions. One sow can produce 6–12 piglets twice or three times a year if their reproductive cycle is timed properly (pregnancy lasts 3 months, 3 weeks, and 3 days). Selling the piglets before birth is not uncommon at certain times of the year for events or festivities where pork is commonly consumed. Pigs are considered a form of saving account because piglets can be sold for cash or given in exchange for the boar's service (the piggy bank). Boars can grow tusks and become very large and aggressive, requiring confinement to protect people and other animals. This is why fewer people keep boars compared to sows. Rearing of pigs in slums in small numbers (one to five) is often done by women and larger herds by men (Food and Agriculture Organization, 2001). Piglets are easy to manage because they can roam during the day searching for food and come back to their home space at night. They can also be tethered and kept close to the dwelling, or housed in makeshift pens behind or in the confines of the human dwelling.

Nowadays pigs are ubiquitous to slums in Latin America and present even in countries with Muslim and Hindu population such as India and Nepal (Rajshekhhar, 2004). It is difficult to establish the genetics of pigs commonly reared in slums. These are smaller and more adaptable to the local conditions than large commercial breeds. Pigs revert to wild type very quickly and grow hair and tusks adapting to the environment. However, pigs kept in confined spaces in and small numbers are usually larger commercial breeds requiring more attention and feeding.

The creole pig from Haiti was an example of a small hairy dark pig well adapted to the environment, eating garbage and fallen rotten fruit. They had sociocultural value and were considered to have an important role in recycling waste. Issues associated with swine fever in the late 1970s and early 1980s prompted the United States Department of Agriculture and other international organizations to develop and conduct an eradication program. The sociocultural value of these animals was not clearly understood. People were given large commercial breeds as substitutes for the creole pig and asked to pen the pigs. The larger breeds had to be fed and cared for and were not allowed to roam, which resulted in detrimental conditions of the environment in which people lived (Ebert, 1985).

Ruminants: Goats and cattle

Goats are adaptable to urban environments. They are known for eating almost anything, including bark from trees and shrubbery, garbage from streets and land fields, or clothes hanging to dry. These animals require attention, given their inquisitive nature and destructive eating habits. Usually people keep a couple of female goats for their milk with the offspring. In slums close to peri-urban areas people keep the goats in pens or house patios during the night and walk them to pasture at different locations during the day. In the urban environment, and in particular in slums, goats roam the streets in search of food, and it is common to see them searching for food with pigs (Diogo *et al.*, 2010). Goats can decimate green areas very quickly, causing damage to vegetables growing by the side of the roads or public open spaces. They require more attention than chickens or pigs and they need shelter from the

rain. Goats' milk is nutritious and can be easily transformed into yogurt and cheese to extend the shelf life of an otherwise perishable product. In some large slums such as in Delhi, India, slum goats' sightings have become a tourist attraction and are offered as part of city tours ([News.com.au, 2013](#)).

Mixed *Bos taurus taurus* and *Bos taurus indicus* cattle are let free in search of food or water or walked to pasture in the mornings and brought back at night. In countries with a predominantly Hindu population cows are sacred and only the milk is consumed. Oxens are mainly kept for draught power; they are used for plowing and also transport. Owing to religious reasons female cattle cannot be disposed of after their productive lives have ended. Older unproductive animals may be abandoned and may die of diseases, hunger, intoxication from garbage, or get involved in traffic accidents. There are also many *goshalas* in India where abandoned cattle are looked after. Milk is a valued product that contributes to food security in slums. But it is perishable and has to be consumed quickly or transformed into a variety of cheeses, yogurt, or sour milk. Naturally fermented sour milk is popular in East and West Africa; fermenting also removes lactose, which makes it easier to digest for populations that do not have lactase enzymes persisting in adulthood.

Tending larger animals is time consuming and may involve walking long distances to find a place to feed away from the city or to cut grass that can be brought back to the animal. This is easier to do when the slum is located in the periphery of a city compared to an urban-area slum. Often cattle are confined to a small space or their mobility may be limited by tethering them close to the dwelling. Studies of peri-urban dairying in East Africa found that nearly all cattle were 'zero grazed,' that is, kept inside all the time ([Figure 2](#)).

Cow dung in India is also a valuable fuel: it is collected, reshaped into cake-like forms, and dried. In India and elsewhere cattle dung is also used as a building material mixed with mud and other substances. Livestock value is more than monetary; it is a symbol of social status and social identity both individually and collective ([Comaroff and Comaroff, 1990](#)). The value of livestock and the production parameters used elsewhere (such as in the industrial countries) need to be reevaluated because a cow or goat whose production is low may still be providing useful services ([Dutta, 2003](#)).

Production Challenges in Slums

In slums, an intricate relationship exists between poverty, food security, livestock keeping, and the environment. Enforcing livestock regulations becomes a difficult task when animal ownership is clandestine. In many countries regulations cover animal health and welfare issues, the disposal of dead animals, slaughter procedures, and environmental contamination, but in practice they are not enforced in slums. In other cases, regulations are used for 'rent-seeking' by authorities: that is police or other officials will confiscate animals and not give them back unless a bribe is paid. Keeping animals in cities undoubtedly creates environmental problems. For example, in Kisumu, Kenya, keeping animals is illegal. The city has six slums and enforcing animal farming law is a challenge. The dung of the animals becomes a problem when the rain washes

it and contaminates the city water supply. The city lacks the infrastructure to recycle the dung and 75% of it is not utilized ([New Agriculturist, 2006](#)). Yet the Draconian response of banning livestock from cities may not be the most appropriate. In Kampala, Uganda, a process lasting several years has recently led to new City Ordinances that seek to support urban agriculture as an important economic activity, while regulating against the potential adverse effects.

Burden of Disease

Animals of the same or different species in slums are in proximity with each other and with humans. Contagious diseases can spread rapidly under these conditions. Additionally, slum-raised animals suffer from malnutrition coupled with an adverse environment that makes them more susceptible to disease or injury ([Food and Agriculture Organizations, 2011](#)). Some problems are associated with animals living in areas with poor waste disposal. Pigs and goats eat plastic bags and these are common findings at slaughter or necropsy. The bags fill the stomachs impeding food digestion and nutrient absorption. Rwanda banned nonbiodegradable plastic bags in 2008, an excellent example for other African countries where plastic waste is ubiquitous.

The health of animals in slums requires attention, but estimating disease and its impact is difficult. Both zoonotic (diseases transmitted from animals to people) and non-zoonotic animal diseases need to be considered. Reportable, zoonotic, and production diseases are discussed elsewhere in this encyclopedia. Some of these diseases are of national public health interest or are of international trade importance requiring immediate reporting through specific official public health channels and to the World Organisation for Animal Health, one of the three sisters of the World Trade Organization. Reportable diseases of animals are those with the potential to cause epidemics or pandemics that cause serious disease in people, as is the case of the severe acute respiratory syndrome known as SARS, the H5N1 (pathogenic avian), and H1N1 influenza virus (known as swine influenza) ([Gauthier-Clerc et al., 2007](#); [Girad et al., 2010](#)). Public health resources and market inspections are deployed for some of these diseases, but control is often ineffective in poor countries. Determining the public health penetration of these programs in slums has been highlighted as a need ([Unger and Riley, 2007](#)). Risk communication in a crisis situation involving the livestock population in a slum may require additional resources and targeted programming. The lack of information of the size and location of the avian and swine population may impede the progress of disease control measures. Public awareness programs or the application of rigid standards for disease control without consideration of the sociocultural and economic value of the animals for people may also decrease compliance ([Box 2](#)). References to the 1920 flu pandemic are always brought to light in the media as the possible serious consequences of disease spread and death. However, public health crisis response is different today and includes emergency and disaster preparedness, first responders training programs, and damage mitigation and relief. Nonetheless robust economic estimates by the World Bank suggest that the

Box 2 The unanticipated effects of disease control

A pandemic of H1N1 influenza was declared in 2009. This disease originated in pigs but subsequently was maintained entirely by human to human transmission. In response to the pandemic, the government of Egypt ordered all of the country's pigs to be slaughtered. Because humans can only get the new flu from other humans this was not effective as a control response. It also had far-reaching and unintended consequences on the cities' waste management. Cairo's 30 000 garbage collectors used to feed the city's organic waste to pigs and their livelihood became endangered while the streets of the capital filled up with trash.

Source: Adapted from the *New York Times* article, Mona el-Naggar contributed reporting, 19 September 2009. Available at: http://www.nytimes.com/2009/09/20/world/africa/20cairo.html_r=2&scp=1&sq=michael%20slackman%20cairo%20pigs&st=cse& (accessed 30.01.14).

cost of an epidemic originating in animals could be a trillion dollars (World Bank, 2012).

There are approximately 1000 zoonoses or diseases transmitted from animals to humans. Disease transmission may be direct through contact with infected animals or its fluids, or through contaminated animal products, water, or objects contaminated with infectious material (Center for Disease Control and Prevention, CDC 24/7, 2011). Especially important for poor countries are the so-called neglected zoonoses often associated with poverty, poor hygiene, and poor understanding of disease transmission. The rest of the article discusses some neglected zoonoses that are known or likely to be a problem in slums.

Brucella melitensis, the cause of brucellosis, is very pathogenic to humans (Center for Disease Control and Prevention, 2012). It is transmitted from goats and sheep to humans through direct or indirect contact. Unpasteurized milk or contact with body fluids of infected animals are considered the most common transmission routes. There are other brucellae affecting swine, cattle, and dogs, but *melitensis* is associated with the more severe forms of the disease. Flaying and skinning sheep by blowing air through a cut in the skin exposes people to body fluids and inhalation of bacteria from infected animal, and hence is not recommended.

Cysticercosis is a disease caused by the larval stage of the tapeworm *Taenia solium*. The disease is sometimes wrongly known as the 'the pig tapeworm,' but humans are the definitive host for the adult form of the parasite, not the pig. The adult parasite releases segments daily containing thousands of eggs into the gut. These eggs pass into the environment with the feces. Humans and pigs become infected and develop cysticercosis by ingesting the parasite eggs. Pigs are coprophagic and human defecation in open spaces is one of the main forms of transmission of the disease from humans to pigs. When eaten by pigs, the eggs develop into cysts within the pig (Figure 1). If people eat meat containing viable cysts these can develop to tapeworms in the human host, thus completing its cycle. Human to human transmission occurs when people harboring the parasite contaminate food due to poor hand hygiene (Garcia et al., 2001; Carrique-Mas et al., 2001). Autoinfection can also occur following improper



Figure 1 Cysticercus in pig muscle, Bolivia.

hand washing after a bowel movement. After humans consume eggs, cysts start to develop in any organ of the body, including the brain. When cysts develop in the brain, the disease is known as neurocysticercosis. It is considered as one of the most common infestations of the brain in humans. The main manifestation of the disease is epilepsy (Garcia et al., 2001). Studies from a slum in India revealed that 25.5% of people in the studied sample who had active epilepsy had antibodies to *T. solium* (Singh et al., 2012). Cysticercosis in pigs may reach 30% prevalence or more in some countries where pigs are allowed to roam and human defecation is done in the open (Carrique-Mas et al., 2001; Fleury et al., 2012; Flisser et al., 2003). Even with low human taeniasis in the order of 1–2%, the prevalence of cysticercosis in pigs can be high. This is mainly due to the fact that only adult parasite can live in the intestine of the host for years and release thousands of eggs into the environment.

Hepatitis E virus is an enteric disease transmitted from different species of animals including pigs to humans; it can be transmitted between humans through contaminated water and food. The seroprevalence in the human population unexposed to swine is 2% whereas the seroprevalence in swine workers or other swine-exposed populations is 10% (Whithers et al., 2002). Data from a study of a pediatric population in Karachi with access to municipal piped water and nonflush toilets in a slum in India showed a high seroprevalence for hepatitis E virus (Jafri et al., 2013). The exposure to hepatitis E virus seems lower than hepatitis A (Mohanavalli et al., 2003). Hepatitis E is a disease that can cause severe gastrointestinal symptoms and has been associated with high death rates of pregnant women in lesser developed countries. In some peri-urban farms pigs are raised close to ponds where fish are kept. The pig feces are washed down to the ponds for the fish to eat. The virus seems to be ubiquitous in swine populations and undistinguishable even in samples from different countries. This was the case in hepatitis E study in two farming communities (not slum conditions), in North Carolina and Costa Rica (Whithers et al., 2002; Kase et al., 2008). Hepatitis E is a zoonosis, but the importance of animals in its maintenance and transmission has not been fully established.



Figure 2 Zero grazed cattle, Kenya.

Cryptosporidium is associated with cattle and causes diarrheal disease in humans and cattle. Although extensively studied in developed countries, it has not been diagnosed until recently in slums. Surveyed households in the Nairobi's Dagoretti district, Kenya, determined the extent of cattle keeping and the prevalence of cryptosporidiosis. With a prevalence of 20% in urban cattle, this parasite could be a major contaminant of water sources and disease that needs further consideration (International Livestock Research Institute, 2012) (Figure 2).

Antibiotics and other veterinary drugs administered to animals without proper veterinary supervision can have direct and indirect consequences for human health. After administration of an antibiotic there is a period of time when the animal product should not be consumed. This period known as the withdrawal period is to allow the drug in question to clear the animal's system because it may have harmful health effects if consumed by people who are allergic or sensitive to the drug. For example, Clenbuterol is commonly used as a growth promoter (often illegally), and several outbreaks of illness have occurred when people consume livestock products from animals treated with Clenbuterol. Of potentially greater importance than sickness as the result of consumption of residues is the risk of bacteria developing resistance to antibiotics because of their use in agriculture. As a result of these concerns, many countries require that antibiotics and some other animal health drugs should only be prescribed by veterinarians. However, this is not practicable in most slums. Veterinary services may be out of reach for many people in slums either because of distance or cost. In some cases, livestock owners may visit a veterinary office and explain the symptoms of the disease to the veterinarian, but without proper examination of the animal and the information received, the medicines may not be appropriately prescribed. The livestock owner may not fully understand how to administer the medicines and use a single dose of a medicament keeping the rest in case the animal does not improve. Getting advice from another family member or neighbors, purchasing a single dose of an antibiotic from a street vendor, or using leftover medicines from a previous case is not uncommon. Veterinary services are often expensive and out of reach of the poor (Ahuja *et al.*, 2003).

In addition, farmers may use drugs for nonhealth purposes. In Khartoum, the practice of adding antibiotic to milk to preserve it was reported, and this could have health consequences such as allergy in the people ingesting the product (Hassabo *et al.*, 2012). In China, melamine was added to milk so that it would appear to have higher protein levels. This led to one of the largest food safety events of recent years resulting in the death of six infants; the children died from kidney stones and thousands were hospitalized as a result of drinking the contaminated milk (Wei and Liu, 2012).

Markets

Slum agriculture and associated markets are part of the informal sector of the economy. It is a business model based on necessity, mostly home-based, and often clandestine. When there is no proper access to water and refrigeration, meat and eggs must be consumed rapidly, processed, and sold close to the place of origin. Markets in slums are public places where vendors congregate. Products may also be sold by hawkers moving from door-to-door or as requested. In many cities in developing countries milk is sold in this way. It is not uncommon to sell products from homes through modified window sills, from makeshift sale racks in corridors between houses, or on top of blankets or plastic sheets in the floor in open spaces. Slum dwellers acquire knowledge of who produces and sell different items. Prices vary based on perceived notions of quality, hygiene, or availability. The exchange of money is not always the norm for payment and people engage in bartering or exchanging products for services. Agricultural markets in slums differ from municipal markets where there is an operational legal framework and the state is responsible for the enforcement of public health and food safety regulations. However, the great majority of food sold in municipal markets lack any structured sanitary inspection. This does not mean that the markets in slums lack internal form of self-regulation, they have a *sui generis* operational business model. Although these markets are outside the purview of state regulation and disease control and preventative measures, the prevailing food-safety actions are based on accepted cultural norms. These norms are developed by the people who live, sell, and purchase products under these conditions or based on religious beliefs or restrictions (Rheinländer, 2006).

The number, identification of species, and location and ownership of animals in a slum is not usually performed. The lack of census data and owner identification poses a challenge for the implementation of national disease control or eradication programs. Required reporting of diseases and animal or product traceability to origin may be impossible in case of a food-related outbreak. This is contrary to the application of the Sanitary and Phytosanitary Measures of the World Trade Organization. Most countries agree to adhere to these measures when they join the World Trade Organization. Conducting an animal census in a slum is challenging but without knowing how many animals there are, vaccine campaigns or eradication programs cannot be conducted. However, the legally ambiguous position of livestock in slums mean owners are reluctant to incur official notice.

Slaughter

The inspection of animal facilities and product transformation industries destined for human consumption is highly regulated. Although in many developing countries animals must be processed in municipal slaughterhouses, at home and clandestine slaughter are common. In Bolivia, some of the municipal slaughterhouses are rudimentary and managed by the local communities. The official veterinarian is allowed to inspect the animals preslaughter and outside the facility. The inspection concerns mostly reportable diseases of national importance. Inside the slaughterhouse, skilled butchers castrate male pigs, and these and other animals bleed on the floor as part of the exsanguination process. Once the internal organs are removed the carcass is hung on a wall hook and employees rub the pigs' canal with a rag. The same rag and water stored in a bucket is used to wash several carcasses. An inquiry into the practice revealed the employees neither understood why they were doing the cleaning nor how it was supposed to be done (Correa *et al.*, 2003). In Ibadan, Nigeria facilities are even less developed. Approximately 250–300 cattle are slaughtered daily; more are slaughtered on weekends, and fewer during Muslim holidays. Cattle are kept in pens, then moved to the slaughter slab. They are tied down at the slab and killed by cutting the throat. The dead cattle are then dragged on the ground to the abattoir area. This is simply a shed with a concrete floor and open sides. Removal of the intestines and quartering is done on the floor. Portions of the carcass are then carried to the adjacent butchers' stalls where they are sold. The abattoir is under municipal management and officers collect tax and tariffs on each cow amounting to US\$1 per animal. The role of environmental sanitary officers is to inspect slaughter slabs and the general environment and ensure the area is clean. However, the filthy conditions of the market witness the challenges they face in carrying out their work. The veterinary department is supposed to check animals before slaughtering and inspect meat after slaughter, but many animals escape inspection, and even when problems are found veterinarians find it difficult to ensure condemned meat is discarded. Most butchers kill only one animal a day, and if this is condemned by veterinarians as unfit for human consumption they lose their entire day's earnings. Hence, they strongly resist attempts to condemn meat (Grace *et al.*, 2012).

Slaughter practices are probably clearly specified in pertinent regulations, but without oversight or evaluation by competent authorities, wrongly learned and applied practices may never be corrected. New employees learn from other employees and the practice is passed down, transformed, and perpetuated. The 'Trichina inspectors' in livestock markets in Bolivia are lay people trained by other people to inspect the tongue of pigs in order to detect cysts associated with cysticercosis. Trichina is a different parasite and the tongue inspection is not associated with this parasite, but *T. solium*. The wrong parasite reference has prevailed and the practice continues unchecked for efficiency in preslaughter diagnosis of cysticercosis in pigs. In Ecuador's countryside, a traveling butcher works at the community slaughterhouses at scheduled days and times of the week and processes the carcasses of mainly large species at the municipal facility. This is a trained person who can condemn carcasses from sick animals and has

an important food safety role. However, the most predominant form of slaughter in slums is the one done at home, in the streets, between or behind buildings. Usually for smaller species the head is removed using a sharp knife or axe against a hard surface like a piece of wood or the stump of a tree. The internal organs are removed swiftly; sometimes the esophagus and the rectum are tied to avoid intestinal content spillage and contamination. Animals processed in this manner are not properly exsanguinated. Raw offal may attract dogs and vermin. The meat, without refrigeration must be consumed immediately or it is left to dry on racks. Meat maybe carried to markets in small carts, buckets, or burlap bags and sold in small pieces or cut by the client's request. The meat is not inspected when sold in the slums to neighbors or at smaller slum markets. In Nepal, animal parts are sold with other identifiable body parts like a hoof or horns in order to guarantee that the species being sold is the actual species. In many cases the meat is covered in turmeric, reported to be done to decrease contamination (oral tradition reported to authors by street vendors). Interestingly, homeopathy studies suggest that turmeric can help combat bacterial infections (Krup *et al.*, 2013; Vasavda *et al.*, 2013).

Conclusions

Slum livestock agriculture interweaves its existence with the geographic location and culture of the population. People take advantage of their new environment and recreate a way of living based on their upbringing, including raising and processing livestock. The main motivations for this activity are family subsistence, income generation, and social status. Slum livestock agriculture activities range from subsistence to semicommercial production. It plays a role in the livelihood of millions of people providing animal protein and generating income. However, it lacks technical sophistication and typically operates outside regulatory purview, and its practice overlooked and tolerated by local authorities. Animals pose a risk to human health and other animals, are a public nuisance, and contribute to the waste accumulating on streets and the run off contaminating the environment and water sources. Livestock products, raw or processed are sold in street markets and may enter the urban food chain. Animal ownership is difficult to establish in slums and livestock population difficult to determine. Under these circumstances, veterinary services and disease-control programs may be hard to implement. Good hygiene, good manufacturing practices, and animal slaughter inspection turn into an impossible task to implement and enforce. Disaster and white-coat diplomacy practices combined with information and communication technologies should be considered in the planning and implementation of public awareness and outreach programs (Lemery, 2010; Lin and Heffernan, 2010).

The elimination of the slums is not feasible. The magnitude of the animal population in slums is unknown, but its food security importance is getting recognition from public and private organizations. There is a need for a community-led approach in collaboration with private and public institutions, academic, international, and nongovernmental organizations to find sustainable solutions.

See also: Agricultural Ethics and Social Justice. Animal Health: Ectoparasites. Animal Health: Foot-and-Mouth Disease. Beef Cattle. Critical Tracking Events Approach to Food Traceability. Dairy Animals. Emerging Zoonoses in Domesticated Livestock of Southeast Asia. Food Chain: Farm to Market. Food Security: Food Defense and Biosecurity. Poultry and Avian Diseases. Regulatory Conventions and Institutions that Govern Global Agricultural Trade. Small Ruminants in Smallholder Integrated Production Systems. Swine Diseases and Disorders. Zoonotic Helminths of Livestock

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