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**Biochar: The Key to Keeping Food on The Table**

As someone who originates from Mexico, I am able to look through the eyes of the country's people and see where many issues lie. Mexico is a highly agricultural country, it produces enough food to export to others throughout the world. It doesn't sit right with me, therefore, that Mexico cannot feed many of its own people. That is why I was compelled to consider how Mexico can make its farming more sustainable for the rural subsistence farmers.

Mexico's government is a democratic federal republic. "Mexico covers 1,972,550 square kilometers (761,610 sq mi), making it the world's 13th-largest country by area" ("How"). Also, "its current population is 131,242,552" ("Mexico population"). "20.6 percent are boys and girls under the age of 12 years, 30.7 percent are young people from 12 to 29 years, 37.4 percent are adult people from 30 to 59 years and 11.3 percent are people of 60 years and more." (Consejo). The Organization for Economic Co-operation and Development reports that approximately 80 percent of Mexican land is rural and home to around 36 percent of the Mexican population which is the equivalent of about 37 million people. "Mexico has a segmented farm structure, and a great deal of rural poverty. Two-thirds of Mexico's poor people live in rural areas, as do three-fourths of the very poor" ("Mexican"). The topography of Mexico varies between tall mountains, canyons, and plains and its climate zones include deserts, steppes, and tropical rainforests (Vegara). According to Trading Economics, 54.99 percent of Mexican land was reported to be used for agriculture in 2018. Mexico exports many different agricultural products but it is number one worldwide in avocado production, harvesting 994 thousand tons in the past year (Secretaria). A source named "The Pattern of Farm Sizes in Mexico: Is There a North-South Divide?" states that "It is very clear that larger farms are concentrated in northern Mexico. All the states along the US border have average farm sizes in excess of 100 hectares. At the other extreme, a ring of states in central Mexico (centered on the Federal District) have average farm sizes that are below 5 hectares" (Burton). While this information is accurate, it is important to realize that it is not rare for many impoverished subsistence farmers to own less than half an acre of land.

The size of the typical Mexican family has indeed shrunken over the years. The average size of a Mexican home is 3.6 people. The head of the house usually averages 49.8 years of age and 88.1 percent of all Mexican homes are family homes. If the newer generations do not have the funding to build their own homes, they reside with the elders of the family (Consejo Nacional de Población).

The type of home that a family lives in depends on where they are located, but even more importantly on the socioeconomic status that they hold. More crowded cities have apartments available for rental and their size and luxury varies, but all usually always have access to utilities. In more rural areas of Mexico, people usually live in houses that have been built by the families themselves as opposed to having bought finished homes from others as is common in the United States. It isn't uncommon for homes to have been in the families for generations. Families that have steady and well paying jobs often have indoor bathrooms, flooring, and direct access to water. Poorer families live in smaller homes made of bricks with thin metal shingles or sometimes concrete roofs. The flooring in these homes is often just dirt. Impoverished individuals such as this often find themselves using outdoor toilets with no plumbing. The tap water in Mexico isn't safe for consumption; people instead purchase big jugs of water that are often delivered to their homes or are found in stores.

A recent study reveals that 50 percent of the poorest population only takes 9.2 percent of the national income. It also reveals that these people make approximately \$179.42 USD a month or \$2,153.35 USD a year (Imagen). This income must be enough for an entire family. In order to earn this money, Mexicans work almost any job that may be available due to the lack of employment opportunities. This is especially true in the more rural areas where a considerable percentage of the highly impoverished reside. Traditionally, the tougher and more physically demanding jobs are reserved for the man of the household. However, it is not rare to see women participating in fieldwork. An impoverished person in Mexico often has more than one occupation. Children in poverty begin working from an early age which can start during primary school. These children are balancing school and work. This can end in many ways, but severely impoverished children commonly drop out of school and begin working full time. The typical diet for a poorer family revolves largely around grains such as maize, rice and beans accompanied by onions, chiles, lard, and herbs. Tortillas, a flat, corn side dish, are always present at the table. The use of electric stoves remains more common in upper middle class urban families. Lower middle class urban and rural families use gas stoves. The poorest demographic of the Mexican rural population have makeshift outdoor stoves which are usually fueled on wood. Getting access to nutritious food is often a challenge to those living in smaller areas who don't have a reliable source of income.

The availability of healthcare and education varies for a person in Mexico. Wealthier individuals with stable employment usually have their children go to school for far longer than someone on the other side of the wealth spectrum. Public schools are technically free, but there are many hidden costs that discourage parents and students from attending school, including the cost of a uniform or materials. When a person is faced with the choice of having themselves and their family eat for the week or having to spend their savings on exorbitant objects, the decision they make usually favors survival. Ironically, the lack of education of the people sentences them to lifelong economic distress. There are those in Mexico who live by making just barely enough and who struggle to keep their children in school up until high school. At the same time there are those who can easily send their children off to pursue higher education.

For those living in more urban areas, health insurance programs are available as long as you hold enough income. "It is estimated that over 50% of the Mexican population is uninsured"(Salinas). This especially impacts the rural elderly. "In 2006, Mexico had a population of approximately 107 million people, mostly urban (75.7%). Mexicans aged 65 and over live in towns with populations of 14 999 people or fewer, a greater proportion than any other age group. Given the elevated levels of poverty and lack of services in smaller towns and villages, older Mexicans are at greater risk for experiencing the negative health consequences associated with material disadvantage"(Salinas). The smaller rural areas of this country lack a properly developed medical infrastructure. Even if medical facilities are near, it may not always mean they are accessible. It is common for someone who may be able to physically access a healthcare facility to avoid it and rely on home remedies for a cure to their illness simply because of the expense.

A large portion of Mexicans living in rural areas depend on sustenance farming. This means that the quality and quantity of the yield will determine the type of life that those individuals will be able to live. Regrettably, there are many obstacles that persist in interfering with the crops being grown by the people. "Campesinos typically grow native varieties of maize, beans, squash, and chili peppers, primarily to feed their own extended families. At least 20 million Mexicans rely on rain-fed maize, which is imperiled by worsening drought, a consequence of climate change. By the end of this century, production of rain-fed maize could drop by as much as 30% in parts of Mexico"(Zuidema). Here we see how the native crops grown by these people hold such an importance over their well being. But how do we know if this is an issue that truly affects many instead of few? "The largest group in rural Mexico are subsistence farmers. These 1.5 million farmers, concentrated in the north central and southern states, produce the corn and beans on which their families depend" ("Mexican"). Ultimately, it is apparent why a bad yield leaves so many without food on the table.

Now, it is time to mention a key component of the lack of complete success for so many farmers. Fertilizer--more specifically the inability to access it. Anyone, whether they are large corporate farmers or a simple plant hobbyist, knows that in order to increase the chances of better crops a good fertilizer must be added. Hewitt de Alcántara discusses the increase in power that the agri-food commercial industry has gained throughout the decades along with the disproportionate and unregulated control the the agencies of machinery and fertilizer hold. With large fertilizer companies only thinking of profit, prices are raised beyond the reach of those who need them the most. "Since the end of 2021 fertilizer has undergone a dramatic price increase, rising from from the equivalent of \$403.49 USD to \$1,210,471.20 USD per ton" (Precio). This is a situation that doesn't seem like it will end soon, whatsoever since "Russia, the first producer of fertilizers in the world and the main supplier of this input for the countryside in Mexico, has stopped its sea freight, causing a shortage in the market that has generated an increase in prices above 24,000 pesos per ton" (Suarez). Due to the current invasion of Ukraine that Russia has operated, it is only natural that fertilizer prices continue to skyrocket.

This is a situation that large crop companies can withstand at the price of lower profit, but for the people whose survival depends on growing crops things cannot go well as they are. This is why a solution is needed. Fertilizer is indispensable for sufficient crop yield but the prices are unachievable for many. A new method of agriculture must be introduced immediately. The people of Mexico could benefit by learning about biochar. "Biochar is carbon rich material obtained by pyrolysis of biomass with little or no oxygen. Pyrolysis of plant biomass normally results in highly alkaline biochar. However, alkalinity varies with respect to feedstock properties used for the biochar production. Greater the alkalinity of biochar, greater is the reduction in acidity" (Basavarajappa). Therefore, since acidic soil is less than ideal for crop production, biochar can be used to improve soil quality as well as add nutrients to the soil. Biochar is also incredibly cheap since it comes from burning any type of biomass with the process of pyrolysis. Sustenance farmers wouldn't need to make a single purchase, instead they would simply have to gather dried out plant matter. "Biochar is known to enhance plant growth by increasing soil fertility. Addition of biochar to nutrient poor soil has been reported to enhance nutrient availability and increase plant biomass" (Shetty). The porous nature of Biochar even makes it able to retain water, which additionally will help with areas going through dry seasons.

Making biochar through the process of pyrolysis is a fairly simple procedure. Pyrolysis requires burning under high heat and low oxygen. Such conditions can easily be achieved by digging a hole in the ground, setting fire to the biomass, and covering the hole loosely with soil in order to limit the amount of air coming in. The biomass used can range from a mixture of dried out weeds and wood to the dried out corn plants of the very field they are trying to fertilize.

Introducing biochar as an agriculture practice in Mexico is feasible. The people of rural Mexico often burn trash and dried out weeds. It is common for the older generation of Mexican sustenance farmers to be familiarized with the use of ash in their soil. Henceforth, the idea of burning plant matter and getting it to a carbonized state in order to use it to better the fields should not be an outlandish one to Mexican people. It would only be a matter of educating them on the specific process and benefits of making biochar. Murals on walls are a common method of reaching out to the public. Even smaller rural towns usually have designated space for murals where information about things such as election candidates and vaccines are shared. These towns usually have representatives from their own people get together to deal with town issues and events. This small group of people is later responsible for informing their fellow townspeople. Groups teaming up with universities of Mexico and going into towns to communicate will inevitably grasp the attention and curiosity of the people. The representing group of higher educated individuals will automatically earn a degree of authority and trust on the subject and will encourage villagers to listen. Since the process of making biochar goes along with cultural norms of Mexican people, it will be accepted by the community leaders of the towns who will then spread the

word. Part of Mexican culture is spreading information verbally and it is common for individuals to be familiarized with the comings and goings of all the townspeople. Therefore, the idea of biochar will spread like wildfire. Additionally, as results are shown by the increased crop yield of those first to incorporate biochar into their farming practices, the effectiveness of biochar will effortlessly begin to expand beyond into neighboring villages.

The sustenance farmers of Mexico are struggling due to the lack of fertilizer available for their fields. This leaves countless families throughout the rural areas of Mexico impoverished. Biochar has been studied by many sources and its agricultural benefits are significant. The price of biochar is virtually nonexistent as the farmers can burn any dried biomass, something present in abundance all over rural regions of Mexico. The simplicity of the process of making biochar allows common people to make and use it. Therefore, biochar would prove to be an effective method of keeping soils fertile and the crop yield high.

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