Well before the development profession became aware of the volume of cash sent from migrants to their home communities, Sandra Nichols noticed a flow of ideas and equipment into the rural Mexican community where she was living, and she decided to explore it. Nichols, who describes herself as "a good nosy anthropologist type," has a doctorate in geography and is currently a research analyst with the California Institute for Rural Studies. She began her inquiry by "hanging out and asking questions" and soon discovered a pattern that had serious implications for sustainable farming.

As part of an IAF's effort to learn more about transnational community development, our task force on transnationalism invited Nichols to our Arlington offices to share her truly original research on transfers of agricultural technology to Mexican farms from California orchards and vineyards by farm workers who live on both sides of the border. After the session, we asked to publish the findings she had originally presented at the Cuarto Congreso of the Asociación Mexicana de Estudios Rurales in Morelia, Michoacán, Mexico, June 20-23, 2003. This third article in our forum series is the first to explore nonmonetary remittances. We welcome submissions on related topics for consideration for future issues of *Grassroots Development*.

Technology Transfer through Mexican Migration

By Sandra Nichols *All photos: Sandra Nichols*

Technological advances flow over the border with farm workers returning home.

The Inter-American Development Bank estimates that Mexican migrants working in the United States sent home more than $10.5 billion in 2002, representing one of Mexico's largest sources of foreign exchange. The figure for 2003 is expected to rise to 14.5 billion. The magnitude of this monetary flow — less than revenue from oil and direct foreign investment, but rivaling tourism and manufacturing export revenues — has prompted interest and debate among economists, scholars, politicians and policy-makers on the role of these remittances, the efficiency of the transfers and their potential for leveraging development.

The focus on *monetary* remittances, however, has meant that other types of return flows are often overlooked. This article defines remittances to include nonmonetary flows as well, specifically the transfer of new ideas and technologies, and examines the impact of migrant-driven technology transfers from California to the Mexican state of Zacatecas between the early 1950s and 2002. Closer attention to such transfers, and their impact, can reveal opportunities for strengthening migrant-driven development, while underscoring, in the case of agricultural technology, the need to ensure environmental appropriateness and economic sustainability.

The Jerez Valley

Zacatecas' Jerez Valley is located in the Sierra Madre Occidental and its streams and rivers drain westward to the Pacific Ocean. The elevated inland location (at 2,000 meters, or 6,650 feet, above sea level) and the intervening topography make for a semi-arid climate; annual rainfall ranges between 316 mm. to 864 mm. and is concentrated between June and October. Most agriculture is rainfed, with less than 20 percent of arable land under irrigation. Until the 1970s, agriculture was primarily household-based, for both subsistence and market purposes. Corn and beans in the summer, and wheat and fodder in the winter, were complemented by fruits, vegetables, meat, milk and eggs. In the 1980s and 1990s this traditional diversity was replaced by a monoculture: high-value fruit, which farmers hoped would end their dependence on non-farm employment.

Low prices for agricultural products, unreliable rainfall and periodic drought have made off-farm employment a feature of farm life in this region since at least the 19th century. Initially men left their fields for the mines, the railroads and the haciendas; more recent migrants opt for seasonal work on U.S farms. The mechanism that set this cross-border process in motion was a series of formal labor agreements, popularly known as the Bracero Program, between the U.S. and Mexican governments between 1942 and 1964. In time, migrants from Jerez who had become familiar with U.S. job markets opened the way for relatives, friends and neighbors, spurring the transnational flow of people and money, as well as goods, ideas and technologies. By the 1980s the *municipio* of Jerez had one of Mexico's highest rates of out-migration, and many villages became identified with the U.S. towns and cities where migrants had gained a foothold. While some migrants chose to settle in the U.S., others have continued their circular route, maintaining households in Jerez and subsidizing and modernizing their farms with money, ideas and innovations from the U.S.

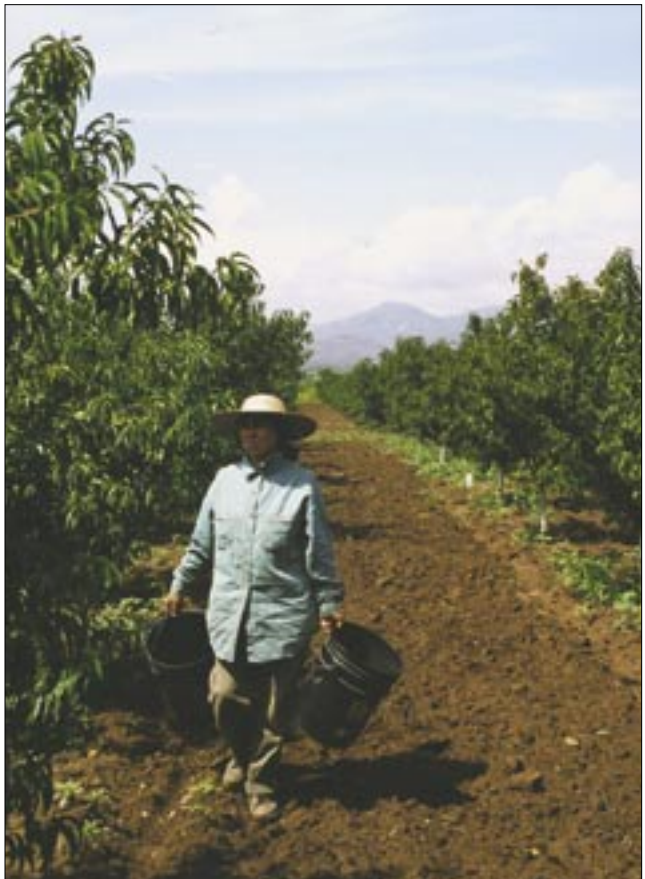
Peach fever

In the 1970s, as out-migration gained momentum, small farm systems began shifting toward commercial peach production. By the 1980s, growing numbers of small farmers replaced their corn and bean fields with orchards, often financing the investment with their U.S. earnings. Within a few years a peach boom was underway. Whereas Jerez had virtually no commercial orchards in the 1950s, by 1978 approximately 1,800 hectares had been planted in peaches; 15 years later, the area had grown six-fold to 13,000 hectares. This expansion became known locally as *la fiebre del durazno*, "peach fever." In less than two decades peaches transformed the valley's agricultural landscape and accounted for half the value of all agricultural production in the *municipio*. Why?

El loco Valdez

Jesús Saldívar Valdez is widely credited as the first farmer to plant peaches on a commercial scale in the *municipio*. Valdez had worked in California on numerous occasions and, according to one account, he returned with peach seedlings and knowledge of how to raise them. Valdez himself tells a different, more nuanced story of inventiveness, risk-taking and perseverance. To begin with, he claims he never worked in California's peach orchards nor did he bring back peach plant material or even the knowledge of peach cultivation.

Below and opposite, bearing peach orchards in Jerez in 1999.



Spanish priests had brought the first peaches (*prunus persica*) to the New World where cultivation was confined to haciendas and missions because the prized fruit was so difficult to grow. Jerez became famous for a small, firm and very sweet cling peach known as *criollo*. Farmers produced moderate quantities in the 1890s, but the Mexican Revolution of 1910-1920 and the subsequent land reform program disrupted agriculture, and recovery was slow. By the 1950s many families had just a few peach trees adjacent to their fields or mixed among other trees in family gardens. A few farmers with more trees sold their surplus to buyers from Mexico City.

What Jesús Valdez brought back to Jerez was the key to making *criollo* peaches a profitable crop. In the early 1950s Valdez decided to plant the unheard-of number of 1500 peach seedlings. For this he became the target of such ridicule that he resorted to transporting his seedlings from the nursery to his orchard by burro under cover of darkness. These efforts at secrecy notwithstanding, his neighbors dubbed him *el loco Valdez*, and for the first eight years he did indeed appear to be engaged in a quixotic venture as spring freezes destroyed the buds and his trees failed to produce a crop. Valdez would travel to California to support his family and pay off the debt incurred from planting peaches. Working in the citrus groves, he saw something he believed could be the answer to his problem: smudge pots. If American farmers could protect their oranges and lemons from frost by heating the air, he reasoned, it might also work for his peaches back home. Using discarded two-liter metals cans, he improvised small heaters fueled with spent engine oil. When frost threatened his orchard, his sons and hired laborers helped keep the makeshift heaters going through the night. After a couple of years, he got it right and produced a crop. Fruit dealers in the area to purchase apples were happy to buy his peach harvest, and with the proceeds Valdez paid off all his debts and bought himself a truck. With his profits the following year, he purchased an even larger truck and a tractor and built a new house. That was in the early 1960s and his neighbors were so impressed that they began addressing him as Don Jesús.

Peach boom

Many of the same neighbors who had ridiculed Valdez quickly set about gathering all the discarded peaches they could find and planting the pits. Valdez acquired several thousand second-hand smudge pots from the U.S. both for himself and for resale. Profits fueled peach fever, and some farmers set up nurseries to meet the demand for peach seedlings, accelerating the rate at which migrants with money to invest could plant orchards of their own. The increased production drew buyers from the major wholesale markets in Mexico City and Guadalajara.

With orchards averaging between two and 10 hectares, many farmers now had a significant source of income, and some chose to forgo migration in favor of tending their orchards. While average yields were fairly low, overall production in the municipality was such that Jerez became Mexico's leading peach-producing region, and cultivation of the local *criollo* variety spread within the state of Zacatecas and beyond. The boom prompted the Mexican government to fund research projects, technical assistance and credit programs, and it established several producer cooperatives with financing from the World Bank. By 1993 a third of the municipality's agricultural land was in

peaches and the crop accounted for 52 percent of the municipality's agricultural production.

It was a classic case of transfer and diffusion of innovation: Valdez returned from the U.S. with a technological solution to a problem; once his efforts proved successful his skeptical neighbors, won over by his example, copied him and became early adapters. Their success led to wider application in the 1970s and 1980s until, by the early 1990s, a majority of farmers had planted at least a portion of their land in peaches. A peach orchard became an attractive investment, offering a viable alternative to departure. For migrants already settled in the U.S., it produced an income stream for relatives back home. Some looked forward to an orchard as a retirement activity after years of migrating. Migrants working in California fruit orchards and vineyards soon discovered additional technologies and practices that could be applied in Mexico. Many learned pruning and irrigation techniques and taught them to others. And when the need arose, they turned to pesticides, fungicides and commercial fertilizers. But how sustainable would this new style of agriculture prove for Jerez over time?

Peach bust

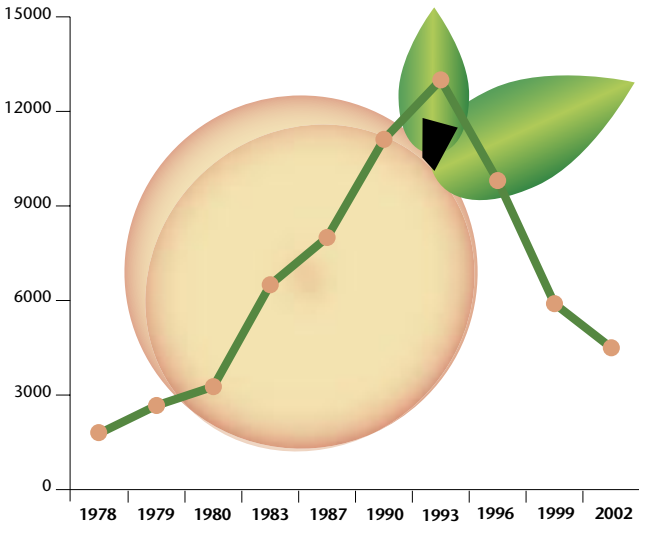
By the mid-1990s Jerez became a patchwork of dead and abandoned orchards, and the government agricultural office began offering farmers subsidies to pull out their old trees. By 2002, the area in planted peaches shrank to 4,500 hectares. The explanation for the collapse lies in a convergence of environmental and economic factors. Lack of rainfall, low prices and rising costs of production drove many farmers to abandon their orchards and migrate. That this happened so quickly and that the farmers had so little resilience bears closer scrutiny.

The landscape of small farms had become a vast monoculture, comparable to the high-input, industrial-style orchards of California. With so much contiguous land in the same crop, the region was ripe for pest infestations (from spider mites and the peach twig borer) and diseases (such as brown rot, peach leaf curl and shot hole) which spread quickly. Agro-chemicals to control pests, often applied too late and in overly concentrated doses, damaged trees and reduced the population of beneficial insects that help keep the pest population in check.

Additionally, the "bare floor" — common to California orchards and vineyards until quite recently — contributed to a deterioration of the environment. This was produced through regular use of a tractor-drawn disk to keep the alleys free of vegetation and had several adverse effects: It left the soil vulnerable to wind and water erosion; it eliminated habitat for beneficial insects; and the dry, dusty orchards created a favorable setting for one of the most prevalent pests, spider mites. In time, frequent tractor passes compacted the soil and reduced its capacity to absorb and maintain moisture. Both intense tractor cultivation and pesticides involved the purchase of inputs, especially fuel and agro-chemicals, which the collapse of the Mexican peso in 1994 put beyond the reach of many farmers. With no alternative, they abandoned their orchards and went back to work in the U.S. Dead and dying orchards became additional sources of disease and pest infestation, posing further problems for neighboring farmers trying to maintain healthy orchards.

Added to these problems was a factor beyond anyone's control: the weather. A periodic cycle of reduced rainfall, a feature of semi-arid environments, began in the mid-1990s, further exacerbating already stressed

JEREZ, Zacatecas: Hectares in peaches, 1978-2002



Sources: Chan (1988); Departamento Agropecuario, Jerez; INEGI (1994, 1998); Ruiz Lujan et. al. (1993); Salvador Rodriguez Barrientos, Jefe del Distrito de Sagarpa (2002).

Dead and abandoned peach orchard, Jerez, 1999.

conditions. Yields declined and many orchards simply withered. Even those within the government-built irrigation district began to feel the effects. The reservoir level fell so low that by the summer of 2000 severe water rationing was in place and many farmers were faced with the prospect of loosing their orchards altogether.

The search for alternatives

Yet in spite of the drought and setbacks, a committed core would not give up. Just as Jesús Valdéz had seen a possible solution to his frost problem in Southern California's citrus groves of the 1950s, farmers from the small community of Los Haro found more efficient ways to use water in the vineyards of Napa Valley four decades later. Los Haro, a major peach-producing locality within the Jerez *municipio*, also has one of the area's highest migration rates. Its population of fewer than 900 doubles when migrants return for

Samuel Félix in 2000 next to the valves, above, and, a drip line, left, of the system irrigating the Napa, California, vineyard where he works. Applying this technology to his orchard in Los Haro, Félix installed the most sophisticated drip irrigation system in Mexico.

the annual fiesta and winter vacations. For nearly 50 years men, women and entire families from Los Haro have found work in Napa Valley's vineyards, wineries and tourist industry. While many have now settled in Napa, a significant number have invested their U.S. earnings in peach orchards in Los Haro.

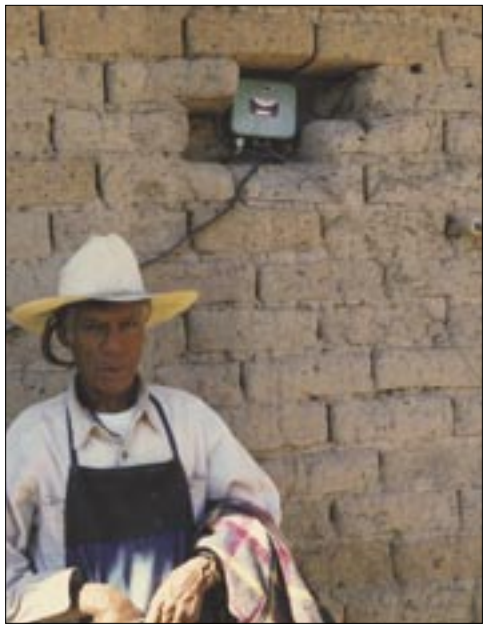
Given the value of the Napa Valley's vineyards, the agricultural technologies in use there are some of the most advanced in the world. Now, thanks to technology transfer, Mexico's most sophisticated water-conserving, drip irrigation system is located on 10 hectares of peach orchard in Los Haro. The enterprising migrant was Samuel Félix, who installed the system in 2000, modeling it on one he had helped lay out in the Napa vineyard where he has been employed for more than a decade. He spent close to $30,000, using valves imported from Israel and high quality tubing and emitters purchased from Napa suppliers. Word spread about his new irrigation system, and visitors, including engineers from Mexico City and the governor of Zacatecas, have come to have a look. By early 2001 at least five more farmers in Los Haro had installed drip systems financed with their U.S. earnings.

José Luis Acevedo (left) and a visiting farmer watch a wind machine installed to control frost in a peach orchard in Jerez.

Other technology transfers

Damaging frosts continue to threaten the peach crop, but many farmers have abandoned heaters because of fuel costs and the municipality's concern with pollution. Some farmers now try to plant orchards in higher, less frost-prone locations and hope that a freeze will not hit during the critical flowering and bud-break period. To protect their crop, U.S. growers now use wind machines that mix the lower lying cold air with the warmer air just above it, raising the temperature the few degrees necessary. At least one peach grower in Jerez, José Luis Acevedo, saw the wind machines operating in orchards in California and became determined to acquire one. Eventually he purchased a second-hand machine in Arizona, and in 1999 he installed it in his peach orchard.

The phenomenon of technology transfer by migrants is not confined to Jerez. In the guava-producing region of Jalpa, Zacatecas, about 180 kilometers south, wind machines have been in use for more than 12 years. Vidal Valenzuela was the first farmer to install one after seeing fruit protected from frost in orchards near Marysville, California. He too bought his second-hand and when he confirmed that it could save his guava crop, he had others manufactured locally in order to expand the area he could protect. In 1999 Valenzuela began looking into a system with a thermostat to switch on the engine automatically when temperatures dropped to dangerous levels, so he wouldn't have to rise in the middle of the night to turn the machines on manually. His success has drawn agricultural engineers from elsewhere in the state to visit and learn from him.



Dimas Hurtado with the control box for his electric fence in Los Haro.

Javier Félix with field equipment from Napa.

A more recent and dramatic example of technology transfer is the spraying rig that Javier Félix uses in his peach orchard in Los Haro. While working in another Napa vineyard, his brother, Samuel Félix, came across a sophisticated sprayer with multiple nozzles placed high and low, enabling the spray to reach both the top and underside of the plant foliage and to spray two rows at a time. Samuel took the design, not the equipment, back to Zacatecas where a local machine shop built a sprayer to his specifications. Javier, who

manages the family's orchards, finds the new rig faster, more effective and safer than the old system of spraying the trees by hand. Nor is the transfer of technology limited only to fruit orchards. While working on a dairy farm in California, another farmer saw electric fences used for corralling cattle and installed one in Jerez. Strung along the top of a wall, an electric fence now protects his poultry from marauding raccoons; in a nearby pasture he rigged the fence to allow for rotation of his cattle around different sections for maximum productivity. Other farmers have acquired weed eaters, roto-tillers and small field transporters. These ongoing, migrant-driven transfers from California to Mexico point to a determination to make agriculture work and a relentless search for solutions.

Sustainable development?

Farmer-migrants go to considerable expense to adapt technology observed in the U.S. agriculture, but how effective is the investment? As illustrated by the peach boom and bust, practices imported from a high-input, industrial form of agriculture can have adverse consequences for the environment and the health of humans and animals, and they can dramatically reduce a small farmer's margin of profit. Yet it is modern industrial agriculture that migrants encounter as farm workers in the United States. Furthermore this style of agriculture is currently promoted by most Mexican agronomists and agro-chemical sales representatives.

Are initiatives to catalyze development in migrant-sending regions doomed to fail? Or might there be a way to increase the likelihood that migrants can make their farms more profitable through technology transfer? What if innovative farmer-migrants encountered effective examples of profitable, low-input agricultural systems? Might they then transfer more environmentally sustainable technologies and practices back to Mexico? And, as when Jesús Valdéz introduced smudge pots, might a new wave of technology transfers stimulate the shift to a new kind of agriculture, this time one that is sound both ecologically and financially?

Interviews and conversations with Mexican farmers and farm workers in both Mexico and California suggest that sustainable agricultural practices are not foreign concepts. Indeed, the nonchemical, diversified approach is familiar to many who learned this style of farming from their fathers and grandfathers. However, in recent decades it has been derided as primitive and old-fashioned by extension agents and agricultural experts. If migrants were to see successful examples of sustainable agriculture in the U.S., and if they were to engage in farmer-to-farmer dialog with organic farmers, might they regain respect for locally-adapted, low-input systems?

After several years of exposure to sustainable agricultural practices in the Napa vineyard where he works, Samuel Félix is eager to try a more sustainable approach on the 10 hectares (25 acres) he and his brother farm in Mexico. To afford the improvements, Javier Félix remains in Los Haro looking after the peach orchards while Samuel spends close to 10 months a year working in Napa. Over time he has witnessed remarkable changes in the vineyards as the owners have introduced practices aimed at reducing their dependence on agro-chemicals and transitioning toward environmentally sustainable farming. These include a no-till approach for their hillside vineyards, drip irrigation to conserve water and cover crops to reduce erosion, increase organic matter in the soil, improve moisture retention and provide a habitat for beneficial insects. Félix has seen first-hand how this controls pests without pesticides and produces higher quality wine grapes.

In the summer of 2000 Félix's supervisor sent him to the Napa Sustainable Winegrowing Group's first-ever workshop in Spanish for vineyard workers. The discussion focused on the benefits of managing vineyards agro-ecologically, in a manner that strives to imitate nature instead of to replace it with a chemically-dependant system. The philosophy resonated with Félix who had learned to farm from his father. Without prompting, Félix and the other Mexican vineyard workers attending the workshop volunteered that the agro-ecological approach was essential to passing their land to their children. They believed it could even increase farm profits by reducing costs. Other farm workers in attendance were simply relieved not to be further exposed to toxic chemicals. Sustainable agriculture was not a hard sell with this group.

Javier Félix inspecting the cover crop he recently planted in Los Haro at the urging of his brother in California.

Félix stays in touch with his brother via regular telephone conversations, sharing with him the approaches used in the Napa vineyard. However, what works for grapes may not necessarily apply directly to peaches, so in the summer of 2002 Félix took advantage of a chance to visit Woodleaf Farm, an organic peach orchard in Northern California. Woodleaf's owner, Carl Rosato, underscored the importance of cover crops to eliminate tillage, help maintain soil health, reduce weeds and attract beneficial insects. The following year, in the summer of 2003, Samuel urged his brother to plant clover as a trial cover crop in a section of their orchard When Samuel learned a few weeks later that the seed had germinated, he was enthusiastic about the process he had set in motion. Their soil may be poor, he explained, but it was "grateful"; planting clover was like giving a gift to the soil, and the soil was encouraged to "give back." The experiment on a very small scale represented the first time anyone had planted a cover crop in the region.

While the Félix brothers are obviously enterprising and innovative, their changes are halting and somewhat haphazard. Sustainable agriculture, like an ecosystem, is very much interconnected. Samuel acknowledges that he's groping in the dark, and in his spare time he searches for reliable information in Spanish that will help him transition toward a sustainable, agro-ecological system. His goal is clear: to make farming in Jerez profitable enough so that he doesn't have to work in California. Samuel Félix's vision extends beyond growing peaches to launching a fruit-processing operation and working with others to grow and market pesticide-free fruit. Should his ideas catch on, and should he find markets, perhaps Félix will become the Jesús Valdez of sustainable agriculture, catalyzing the diffusion of a new kind of agriculture that revives a rural area plagued by abandonment and out-migration. But for now he works in Napa, looking forward to the day when he can move back to Jerez permanently.

Conclusion

The transfer of agricultural technology has been largely overlooked in the literature on migrant remittances and on migration and development. In the Jerez region of Zacatecas, Mexico, technology transfers by migrants working in U.S. agriculture have played a central role in the transformation of local agriculture and of the regional economy. However, the choice of technologies and practices transferred has been limited to what migrants have personally encountered in the course of their work, resulting in a bias toward the practices of high-input industrial agriculture. Over time, adverse environmental impacts and the high cost of inputs associated with industrial agriculture helped undermine the migrants' investment in their peach orchards in Jerez and contributed to a dramatic decline in peach cultivation and production as well as in regional income. A new generation of innovation-minded farmer-migrants is now attempting to revive peach production in the region with new transfers from the vineyards and orchards of Northern California.

The examples of technology transfers discussed here focus on Zacatecas. More research is still needed to determine how widespread migrant transfers of agricultural technology actually are: Is the phenomenon present in migration circuits elsewhere? What is being transferred? What is the context within which transfer, adoption and diffusion take place? What conditions favor transfer and what are the facilitating mechanisms? What are the impacts of these transfers on the social, economic and environmental systems of the migrants' home community? Finally, with regard to the potential of remittances to catalyze hometown development, what kind of support and technical assistance is needed to ensure that the transfers indeed result in sustainable development?