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Hydrolink

USE OF TECHNOLOGY TO MEET MEXICAN FOOD SECURITY FOR 2050 AND BEYOND

BY NAHUN HAMED GARCIA-VILLANUEVA & JAIME COLLADO

Resumen

Se estima que la población mexicana crecerá 25% en los próximos 35 años, y el promedio de ingesta diaria de calorías se incrementaría de 2 000 a 3 130. La nueva dieta contiene más productos de origen animal, por lo que serán necesarios más cereales. La producción agrícola debe incrementarse en un 70% para el año 2050, haciendo uso del agua, del conocimiento y de la tecnología. La opción es lograr el aumento en los rendimientos agrícolas (52%), en la intensidad de cultivo (18%), y en la expansión de las tierras cultivables (30%), a un costo de 2% del valor de la producción nacional de hidro- agrícola, porcentaje que asciende a unos US$450 millones por año.

The Mexican population is projected to grow by 25% in the next 35 years, and the average daily intake of calories is projected to increase from 2,000 to 3,130 (FAO, 2012). The new diet contains more animal products, so more cereals will be needed for livestock feed. The agricultural production should increase by 70% by 2050, but there is not enough arable land for such an expansion. Fortunately, there is enough water, knowledge and technology, so the best solution is to achieve the required increase in crop production through the increase in agricultural yields (52%), in cropping intensity (18%), and through the expansion of arable land (30%), with a cost of 2% of the national hydro-agricultural production value, which amounts to around US$450 million per year.

Water for agriculture

The hydro-agricultural sector includes the entire system that grows, processes and distributes food, feed, fiber, ornamental goods, genetic resources, biochemical materials, natural medicines, pharmaceutical products, and biofuels, as well as buffering freshwater runoff from springs and other sources, as an example of the link between water supply for irrigation and environmental services regulation. Consequently, this sector has an impact on the management of natural resources like groundwater and surface water, soil and forest, as well as on wildlife; on social, physical and biological environments, and on public policies and private actions related to the sector. All activities, practices and processes of the public and private sectors involved in agriculture, livestock, forestry and aquaculture are within the hydro-agricultural sector.

Food security

The amount of water required for food production is not only driven by the people but by eating habits and, therefore, the discussion of water for food should be moved to consumption as well. For example, a survival diet requires 1 m^3/person/day while a diet designed primarily with animal products needs about 10 m^3/person/day. The most balanced diets range from 2,5 m^3/person/day for a minimum intake of animal products in under-served communities to 5 m^3/person/day in the more developed regions.

Figure 1. Identified areas to be incorporated to irrigation

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The agricultural output challenge

National data and international trends show water requirements to produce food and clothing in developing countries of 4,5 m3/person/day, and the area needed for its production –under the current productivity schemes– of 0,25 ha/person. The forecast for the Mexican population is 150 million by 2050. At present, irrigators are less than 0,45% of the population, their plots occupy 15% of the total land area, and use 76,7% of the total extracted water.

The current water withdrawal for irrigated agriculture is 65 155 hm^3/year out of 84 929 hm^3/year of total withdrawals and of 447 260 hm^3/year of renewable water resources (NWC, 2015). The current withdrawal for agricultural purposes –with which about half of the food, feed, and fiber is produced– is 1,49 m^3/person/day, so it is estimated that at present about 3 m^3/person/day is used to produce the consumed food. In 2050 it will be required to extract another 8 144 hm^3/year to meet the food requirements.

The actual arable land in Mexico is around 25 Mha instead of the theoretically needed 30 Mha, and it should be expected to rise to 37.5 million hectares by 2050. However, according to the best estimates, the actual arable land could hardly be increased to a maximum of 34,7 Mha. Therefore, to meet the growth in food demand the country should advance in two fronts (FAO, 2011): to increase the productivity per land unit by 80% and to increase the cultivated arable land by 20%.

For these projections to materialize, agricultural production would have to increase by 70% during the period from 2005/2007 to 2050. The projected increase in the Mexican population in this period is expected to be 40%, which means that the production per capita should increase about 22%. Per capita meat consumption would rise from 27 kg per year in 1999-2001 to 44 kg in 2050, which implies that much of the additional production (cereals) will be used as feed for livestock production.

The technology perspective

Industrial agriculture is characterized by practices that rely on the use of external inputs to the land. Most of conventional agriculture is considered intensive in energy use –it needs 10 calories to produce one calorie of food products– whose high productivity, measured in kg/ha or in kg/m^3, is based on the extensive use of chemical fertilizers, herbicides, pesticides, fuel, water and new investments, for example, in improved varieties of seeds and machinery.

About 35% of the agricultural products consumed in Mexico –mainly for cattle feed– come from abroad. However, the sector has met the challenge of ensuring sufficient production for a basic minimum supply as well as for the generation of food, feed, fiber and ornamental crops at acceptable prices, but below the 25% FAO (2012) recommended limit, so it is urgent to increase the domestic production considering the goals set for the year 2050.

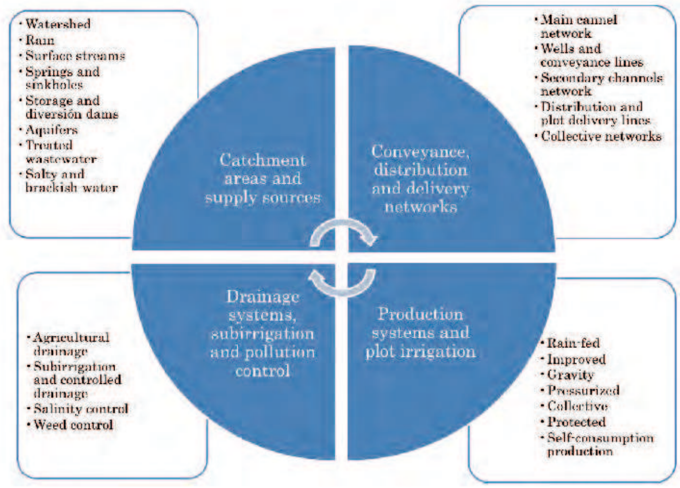

Figure 2. Basic fields of action

Table 1. Example of technology priority actions

Fields of action-Priority actions
Catchment areas and supply sources
• Reduce overexploitation in irrigation districts by improving the efficiency of water conveyance, distribution, and application • Increase arable land by introducing controlled irrigation and drainage systems • Transfer and adapt technology to generate and update inventories of ecosystems and areas in need to rehabilitation • Rehabilitate, modernize, operate and maintain the main hydro-agricultural infrastructure • Integrate micro-watersheds, for hydropower and agricultural production
Conveyance, distribution, and delivery networks
• Develop, innovate and adapt technology for the acquisition, processing, and transmission of agricultural data in real time • Measure by volume the delivered water to plots to control water rights • Estimate investments leading to tangible benefits (B/C >1) • Support the management, supervision, and decision-making in irrigation zones with drones (see figures 3 and 4)
Production systems and plot irrigation
• Increase the agricultural production by a combination of irrigation, sub-irrigation, controlled drainage, and plot drainage • Develop technology to establish design criteria for protected and precision agriculture systems • Promote entrepreneurial agriculture by integrating producers in systems of at least 1,000 ha • Combine hydropower energy generated with solar and eolic energy for small-scale agricultural and peri-urban applications
Drainage systems, sub-irrigation, and pollution control
• Reduce and control the contamination due to agrochemicals • Rehabilitate and increase the agricultural production in saline soils, which is cheaper than opening new irrigation areas • Transform technicized rain-fed zones into irrigation zones • Employ renewable-based systems to rehabilitate saline soils in zones below 5 meters over sea level elevation • Desalinate brackish waters for irrigation • Reuse drained agricultural waters as well as treated wastewaters

Experiences and the evolution of the Mexican hydro-agricultural sector –which records annualized increments of 0,85% in productivity and 0,6% in arable land– indicates that to meet the hydro-agricultural demand in 2050 a feasible scenario is to incorporate around 1,5 Mha of irrigated agriculture, Figure 1, and 4 Mha of rain-fed agriculture (Garcia-Villanueva and Collado, 2015).

This expansion of arable land should be supplemented with a 35% increase in productivity per unit of physical area, either by an increase in the yield per unit area, by the introduction of double cropping or by using improved seeds, not necessarily transgenic (Wilkinson and Wiedenheft, 2014). This way, similar results to opening 7,5 Mha to the cultivated area will be obtained. In addition, the expansion of arable land must be accompanied by more efficient water use, with the goal of increasing the overall efficiency by not less than 10%; in other words, the product of the efficiencies of conveyance, distribution and application of irrigation water should increase more than 10%.

The main areas of activity that require technological innovations in a hydro-agricultural zone are those depicted in Figure 2.

For each of the four subdivisions in Figure 2 there is a comprehensive set of technology actions that have to be taken, a sample of which are presented in Table 1.

Financing

To support and strengthen science, technology and innovation in the hydro-agricultural sector, a financing equivalent to 2% of the value of the national hydro-agricultural production is required, which represents an amount around US$450 million per year.

Indicators

Each technological product contribution must be measured by its impact on a basic set of strategic indicators: Soil, Water, Profit and Food (SWPF), shown in Figure 5, where $N denotes net profit, kgP the total weight in kilograms of hydro-agricultural products, and kgD the total weight in kilograms of demand.

The whole process must be framed and supported with a formal relationship between the scientific community and the producers involved in the hydro-agricultural sector in Mexico.

Figure 3. Ortophoto in 3D of the main channel "Humaya", in ID010, Sinaloa, Mexico

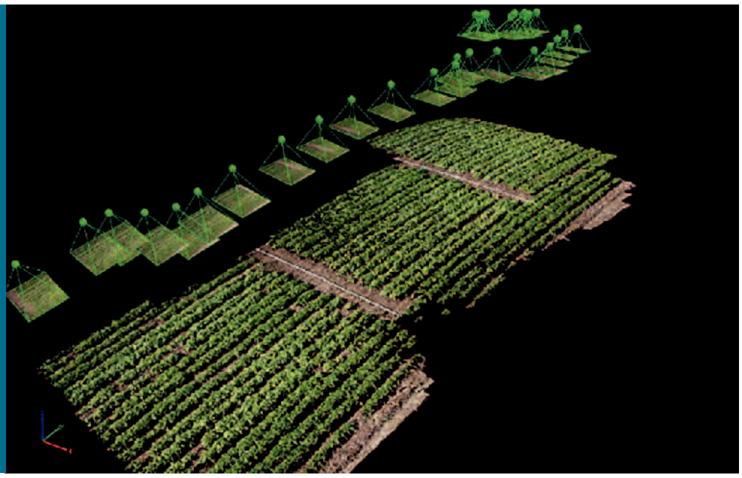

Figure 4. Estimate of bean crop production by drones

Conclusions

To meet food security for Mexico in 2050, about 70% of the required growth of crop production will come from increases in agricultural yields (52%) and in cropping intensity (18%). The expansion of arable land (30%) will remain an important factor for the growth of agricultural production, although to a lesser extent than in the past.

The technology to increase the hydro-agricultural output per unit of physical area in industrious areas involves: i) new public hybrid crops, ii) higher densities of plant population, iii) application of fertilizers based on soil analysis, iv) well-timed irrigation, and v) establishment of double crops in the same physical area. The most important issues are the accurate analysis of soil for fertilizer application and the timing of irrigation. By increasing plant population density, better use of seeds and the use of biofertilizers, farmers can increase, for instance, maize production between 35 and 70 percent (Turrent-Fernandez, et al., 2012). ■

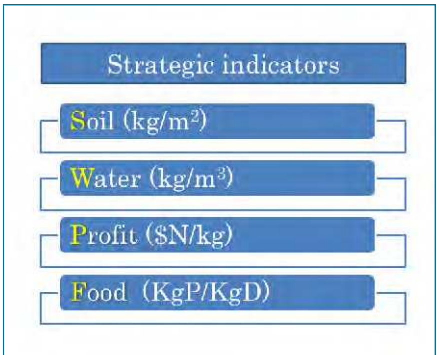

Figure 5. Basic strategic indicators, applicable by crop

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