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Technical, economical and social actions of farmers to mitigate water deficit in Tamaulipas, Mexico

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ABSTRACT

The present study was carried out in the Third Unit of Technical Assistance (TUTA) of the Irrigation District 026, in Tamaulipas, Mexico. Since the beginning of the construction and operation of the dam "El Cuchillo-Solidaridad" in Nuevo León in 1994, the decrease in available water resources was manifested in the study area; besides, there was a prolonged drought (1995–2003), an increase of input prices, and a low market price for maize. Nonetheless, the district was able to maintain the totality of its cultivated surface. The objectives were to study the actions farmers carried out to mitigate the impacts of water deficit and abandonment of land, and to determine the level of communication and organization among farmers. A total of 90,500 pieces of information (plot number, irrigated surface, crop sown, crop surface, and crop yield) were collected by the TUTA from 1994 to 2006, and were organized into a GIS environment. The farmers mitigated water deficit impact by modifying the crop pattern in a drastic way, from maize to sorghum because the latter requires less irrigation to maintain its productivity, and distributing the water in equal form. Therefore, they were able to avoid migration, and abandonment of the land. Under favorable water availability and international market prices for maize, a new shift in crop cultivation was done, from sorghum to maize. The drastic shifts in crop cultivation were possible because of the equal representation that each farmer has within their organization, and because of the close communication among themselves. This level of organization enabled farmers to make immediate decisions and to adapt quickly to environmental and economic restrictions within each agricultural cycle. These findings represent a new alternative to face agricultural drought in other countries with similar conditions.

1. Introduction

The Irrigation district 026 (ID-026) began its operation in 1943, using the water from the San Juan River, through the Marte R. Gomez (MRG) dam. The objective was to supply an initial irrigable area of 100,000 gross ha. However, only 79,995 ha proved to be suitable for agriculture, and for the Third Unit (the study area), the total surface was 32,145 ha (SRH, 1953). Land use change in the Third Unit was inevitable, where shrub land was transformed into agricultural land. Cotton was the main crop with 90% coverage of the irrigated area (SRH, 1953) because it became a profitable commodity. However, the high agricultural production costs caused cotton to be completely replaced by maize (71.8%), sorghum (24.4%), and wheat (2.8%) in 1971 (Barbosa, 1971; SRH, 1973). With time, maize dominated the agricultural lands as a single-cycle crop until 1994.

In 1994, an increase in population and industry of the Metropolitan area of Monterrey, N.L. triggered the need to increase the storage and readiness of water resources; thus, the construction of the Cuchillo-Solidaridad (CS) dam was authorized by the government of the State of Nuevo Leon. This dam is located 80 km upstream from the MRG dam, and began its operation in October 1994 (Aguilar, 1999), effectively fulfilling the original objective. However, it restricted water flow towards to the Third Unit which impacted negatively on the productivity of the land (Flores and Scout, 1999). The decrease in water availability represented an almost 84% loss, since the water flow decreased from 269 Mm^3 in 1993 to 44 Mm^3 in 1999 (Rocha, 2004). Additionally, the prices of input increased substantially while prices for maize decreased. Due to water restrictions, increased price of input, and lower market prices for maize, an increase in the surface cultivated with sorghum was observed through field trips realized during the

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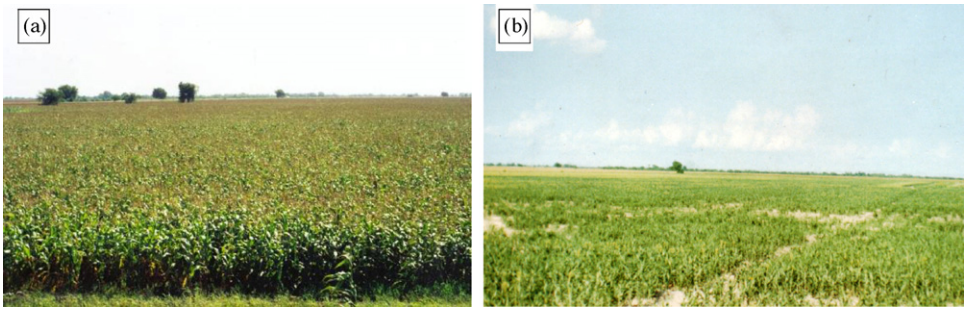

Fig. 1. Crop patterns in Third Unit of Technical Assistance. (a) Corn before the water deficit; (b) sorghum with water deficit.

period 1991–1997. Fig. 1 illustrates some land use change in the Third Unit.

During the time period between 1994 and 2002, the northern region of Mexico suffered a severe drought (Rymshaw, 1998; Schoups et al., 2006), which caused many irrigated districts to decrease their extensions. For example, in Chihuahua (Irrigation District 05, Delicias), from 107,000 ha of labor land in 1989 only 16,500 ha of labor land were preserved in 2002 (Gutiérrez et al., 2004). In other places (Yaqui Valley Irrigation District, Sonora), a conjunctive management of surface water and groundwater resources was proposed, as well as engineered improvements, and regional pumping in order to save 30% of historical water reservoir (Schoups et al., 2006).

On the other hand, in 1994, Mexico was integrated into a free trade agreement with USA and Canada (NAFTA). As a result, Barbier (2000) mentioned that the price of fertilizer rose sharply (around 50–70%), and the fall of prices for maize caused the decrease of around 10–13% in labor land area. This could have decreased the demand for rural labor, generating emigration to urban areas (Levy and van Wijnbergen, 1992).

In the case of ID 026, some studies were carried out to forecast water volumes and availability, using hydrologic models. Flores and Scout (1999) reported that storage water would not be enough to supply neither Monterrey City nor irrigation for labor land of the district. Schmandt et al. (2000) predicted that for the year 2030 these water shortfalls could reach 55% of the total water supply in the area. Návar and Téllez (2002) mentioned that the irrigation area could decrease up to 65% of its total surface by the year 2045, under the worst-case scenario if the drought period would persist in the region.

In spite of the catastrophic predictions, the increase in input prices, low market prices for grain crops, and drought seasons that lasted for eight years, the farmers of the 26th Irrigation District were able to preserve their croplands until 2006. Rymshaw (1998) reported that a drastic change in land use occurred only for the first year (a reduction of 33% in cultivated land during the season 1994–1995). However, during the next growing period the district totally recovered its initial extension. This means that farmers carried out practices to mitigate the impacts caused by water deficit, as well as those impacts resulting from elevated production costs (particularly in the case of cotton and maize).

The two outlined hypotheses were that the farmers changed the crop pattern, only under certainty and with very low risk of water deficit, to guarantee their harvest and to minimize loss; and that the level of communication among farmers contributed to drastic changes in agricultural land use.

The objectives of this research were: (a) to determine the actions that farmers carry out to mitigate the impacts of water deficit, and to avoid abandonment of their lands, during the period from 1994 to 2006; and (b) to establish the level of communication between technicians and farmers, and the level of organization and communication among farmers within the Third Unit of Technical Assistance.

2. Materials and methods

2.1. Description of the study area

The Third Unit of Technical Assistance (TUTA) is made up of five modules (III-1, III-2, III-3, III-4 and III-5); however, module III-5 was discarded, due to lack of accurate information. The remaining four modules covered an area equal to 29,761 ha (93%), within the Irrigation District ID-026.

The landscape of the TUTA pertains to the physiographic province of the "Gran Planicie Costera del Noreste" (Great North-Eastern Coastal Plain) of Mexico, with an average altitude of 34 m above sea level (SRH, 1953). Administratively, this region lies within the boundaries of the municipalities of Reynosa and Rio Bravo, State of Tamaulipas (Fig. 2). The climate is semi-arid with an annual average temperature of 18 °C (INEGI, 1995). While the total annual evaporation is near to 2011 mm, the reference of evapo-transpiration averages 1756 mm. In contrast, the annual rainfall only amounts to 570 mm, with a mainly summer rainfall distribution, during the months of August and September (Rymshaw, 1998).

The soils in the TUTA are classified into three groups: Calcisols, Kastanozems, and Vertisols (FAO/UNESCO, 1970), which are suitable for continued-mechanized agriculture. Additionally, the vegetation in the region is dominated by Tamaulipean thorn shrub, with *Cercidium* spp. and *Acacia* spp. (mesquite) as main species (SEMARNAT, 2007).

2.2. Methodology

Personnel working in the TUTA provided data corresponding to plot number, irrigated surface, crop sown, crop surface, and crop yield (90,500 pieces of information) from annual recorded statistics. With this information, a database for the modules of technical assistance (BDMAT) was built, representing the different agricultural production systems occurring in the study area, during a twelve-year period (1994–2006).

The implementation of the database with annual records required a reorganization of the information, including data "debugging" (checking for error coding), data "purging" (eliminating redundant data), and data validation (checking for data consistency). The application MS Excel 2003 was used to perform such a task. Furthermore, the agricultural plots were spatially identified and properly represented by a digital planimetric cartography of the district, which was provided by the State Bureau, covering 75% of the study area.