



## History and perspectives of the GGAVATT model (Groups for Livestock Technological Validation and Transfer)



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### **Abstract:**

In this document, the aim was to gather the experiences obtained with the GGAVATT model since its creation. The results, experiences, and impacts of the development and implementation of this model, reported in secondary sources, were evaluated. Five stages were identified: laying the foundations (1970 - 1982), model development (1983 - 1989), model validation (1990 - 1996), national expansion (1997 - 2007), and adaptation and survival (2008 - to date). Here present the results obtained in each of these stages and the participation in different projects associated with official programs in the different Mexican States. In all the projects where the GGAVATT methodology has been appropriately applied, the technical, economic, social, and ecological results have been positive. At this point, it is know the success factors that provide good results. Therefore, it has a strategy that could be very useful in improving the current situation of small and medium-scale livestock producers in Mexico.

**Key words:** Transfer model, Innovation, Livestock, Technology adoption, Impacts.

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## **Introduction**

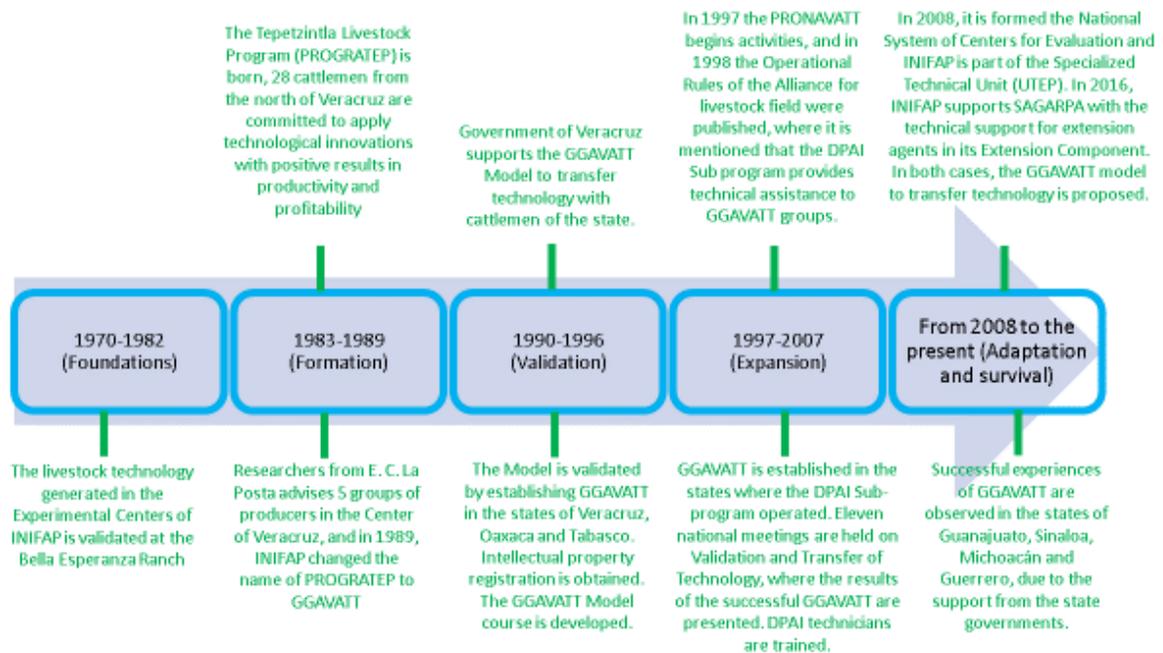
Mexico's National Institute for Forestry, Agriculture, and Livestock Research (INIFAP) and higher education institutions have developed technology that could potentially double or triple meat, milk, and honey production in the main agroecological regions in the country. Additionally, INIFAP developed and implemented a technology transfer model called

Groups for Livestock Technological Validation and Transfer (GGAVATT). This model facilitates the process of technology transfer and thus increases the productivity and profitability of the production units, improving the standard of living and quality of life of the producers and the society in general<sup>(1)</sup>.

The specific aims of this model are to group farmers with common objectives; change their attitude, behavior, and aptitude towards technology use and adoption; increase the productivity of the Livestock Production Units (LPU), so that they are profitable, competitive, and sustainable; improve the standard of living of the producers and their families; promote the conservation and optimal use of natural resources; strengthen the integration of livestock value chains; and provide feedback to research and teaching institutions through demands and technological problems<sup>(1)</sup>.

This model has proven to facilitate the transfer of livestock technology. Therefore, in this document, we aim to review the experiences obtained with the work of organized groups since 1982. For the latter, a bibliographic review was carried out with a historical perspective, identifying five stages of the GGAVAT model (Figure 1), described below.

**Figure 1:** Timeline of the GGAVATT model



## **Laying the foundations: 1970 - 1982**

The technological transformation of the farm "Bella Esperanza" (RBE), located in the Huasteca Veracruzana, started in 1970 following the recommendations provided by the Experimental Station "La Posta," in Paso del Toro (ES La Posta), Veracruz<sup>(1,2)</sup>. In the United States<sup>(3)</sup>, the use of bulls with high genetic value, obtained through artificial insemination (AI), had given positive results. Likewise, in the ES La Posta, the Holstein, Brown Swiss, and Jersey breeds could adapt to a semi-intensive system<sup>(4)</sup>. Based on this evidence, in the RBE, Brahman cattle were crossed with Holstein, cattle and paddock management were improved along with genetics, and the systematic record of the herd's productive and reproductive responses was initiated. A determining factor for this technological change's success was the producer's participation, his family, and his workers, who trusted the researchers' recommendations. By methodically adopting and applying the technology, the milk production per cow/day increased from 3.9 kg in 1971 to 6.3 in 1981 and decreased the interpartum period from 475 to 436 days. The positive change in milk production, cattle genetics, paddock conditions, and overall infrastructure motivated the first technical-practical demonstration in the RBE<sup>(5)</sup>. Several farmers from the Local Livestock Association of Tepetzintla, other farmers, researchers, professors, and authorities of the livestock sector attended this demonstration. After their approval, the integration of the Tepetzintla Livestock Program (PROGATEP) began.

## **Model formation: 1983 to 1989**

Upon learning of the RBE advances, neighboring farmers showed interest in using the same technology; this resulted in the creation of the PROGATEP, with 28 farmers from the Local Livestock Association of Tepetzintla, Veracruz. Farmers were selected based on personal conversations, visits to their farms, their interest in participating in the program, and the importance of milking in their farms. Farmers agreed to a general farm inventory, identifying their animals; record milk production, reproduction, income, and expenses; and attending a monthly work meeting<sup>(6)</sup>.

It was suggested that the program should be continuous, with gradual changes according to the producers' economic and operational possibilities and decisions. The technical assistance provided by a Zootechnical Veterinarian from the Rural Development District of Tuxpan was defined. INIFAP took responsibility for the technological innovations; the farmers appointed a Coordinator who served as a liaison between them, the Regional Cattle Union, and the municipal, state, and federal authorities. Subsequently, the transfer model was created; this

propitiated the interaction between producers, technical consultants, researchers, and government institutions. The animal and paddock activity calendar; the program of periodic visits, the calendar of monthly meetings (first Saturday of every month); the program of technical talks for the monthly meetings; and the annual technical, productive, and economic evaluation (April) were created with the participation of the producers. Producers from all over the region, researchers, academics, facilitators, various service providers, directors of various livestock associations, and government officials were encouraged to participate. Furthermore, the families and workers of the GGAVATT members were also involved<sup>(7)</sup>.

In addition to PROGATEP, INIFAP was technically responsible for six groups in the Center of Veracruz: Jamapa Livestock Program, Joaquín Livestock Program, Tres Valles Livestock Program, Jilguero Livestock Program, La Tasajera Livestock Program, and Jarocho Pig Livestock Program. In all of them, the results were similar to PROGATEP.

In 1989, in a meeting carried out at the offices of the Centro de Investigación Regional del Golfo Centro [Regional Research Center of the Central Gulf], INIFAP researchers discussed and approved that PROGATEP be called GGAVATT since it involves a group for livestock technological validation and transfer. During this meeting, the model and work methodology were also defined<sup>(2,8)</sup>. Tepetzintla is the first GGAVATT in Mexico, and it is known as the "cradle of the GGAVATT."

### **Model validation: 1990 to 1996**

In 1990, the GGAVATT model was made available to all farmers in Veracruz. The PROGATEP, as a group organization, initially adapted its structure and functions according to the official policies indicated by INIFAP and the Rural Development District. Soon, daily work dynamics and the monthly and annual meetings modified the methodology based on the country's changing economic and political circumstances. The GGAVATT model methodology proved to be versatile and adaptable<sup>(2)</sup>.

The Tepetzintla group documentation was used to support the promotion, training, and operation of other groups. The promotion was carried out at the local Livestock Associations, municipalities, ejidos, Rural Development Districts. In general, previously formed groups were used to invite interested farmers. Group formation is preceded by the static diagnosis applied directly in the farms of future associates; this is required to schedule the Constituent Assembly, where representatives (president, secretary, and treasurer) are elected. The membership of all partners is also defined during this assembly. Group components are proposed and accepted; this includes the farmer, the professional responsible for providing

technical consulting, and the institutional component. The latter is composed of the institutions or agencies that coordinate technology generation, validation, and transfer. Finally, the operation is carried out with both group activities, such as the monthly meeting, training, management, outreach, annual evaluation, and the national conference; and individual activities, such as technology validation, application of the actions agreed to in the animal and flock management calendar, keeping productive, reproductive, and economic records, and attend ranch imponderables, such as clinical cases<sup>(6)</sup>.

In Veracruz and Tabasco, other research, teaching, and operative institutions related to the federal and state governments were necessary for monitoring the GGAVATT. The Regional Livestock Unions and their corresponding Local Livestock Associations were actively incorporated. In Veracruz, the Unique Program of Groups for Livestock Technological Validation and Transfer (PROGGAVATT) was created to modernize livestock through the application of new technology and by organizing the producers to increase farm production and productivity without deteriorating natural resources and the agroecological environment. In 1990, INIFAP oversaw 11 GGAVATT in Veracruz. With inter-institutional participation, this number increased to 37 in 1991, 67 in 1992, and 79 in 1993.

State-level GGAVATT meetings started during this stage. These meetings were carried out at the port of Veracruz from 1990 to 1995. During these meetings, the participants shared their experiences and agreed to continue working in an organized manner. In Tabasco, where they observed similar results to those in Veracruz, the model was validated with two groups of producers in the Huimanguillo municipality.

Since 1990, the model methodology, so far applied and supervised by INIFAP, was released; this allowed the formation of groups under the direction or technical responsibility of whom the producers decided: Livestock Unions and Associations, Districts, municipalities, Livestock Direction, Universities, College of Zootechnical Veterinarian, and others. Therefore, by 1995, the GGAVATT were consolidated in Veracruz and Tabasco<sup>(2,7)</sup> and continued at a national level<sup>(6)</sup>.

### **National extension of the GGAVATT model: 1997 to 2007**

The GGAVATT model and its results were intensely communicated in the National Livestock Research Meetings (RNIP) organized by INIFAP. Furthermore, in 1997, the first GGAVATT National Meeting was scheduled in the Port of Veracruz; more than 1,000 producers of different Mexican States participated in this event. Simultaneously, State GGAVATT Meetings were also organized, and technological exchange tours were promoted

all over the country<sup>(1)</sup>. The extension stage of the GGAVATT model started this year when INIFAP created the National Program for Validation and Support of Technology Transfer (PRONAVATT); this was a national strategy that operated in each state. An INIFAP researcher was appointed as head of PRONAVATT. This action aimed to promote the integration of technological, intellectual, material, economic, and political resources between the public, social, and private sectors of the three levels of government. This integration would accelerate and mass technology transfer and promote sustainable development. GGAVATT considered the PRONAVATT a basic tool<sup>(9)</sup>.

The Operation Rules (OR) of the Ministry of Agriculture, Livestock, and Rural Development, published in the 1998 Official Journal of the Federation (DOF), included the operation of the DPAI, which states that DPAI technicians should preferably attend to farmers in GGAVATT groups<sup>(10)</sup>; this was decisive for consolidating the model. The GGAVATT model appeared, with some changes, in the OR of the Alianza para el Campo from 1998 to 2006, as one of the models promoted by the Comité Técnico de Ganadería (COTEGAN)<sup>(11)</sup>. At least one GGAVATT was established and operated in each state (except in Estado de México); 1,098 GGAVATT were integrated, and more than 60 State and 10 National meetings were held. Moreover, from 2004 to 2009, through INIFAP's National Network for Validation and Technology Transfer (RENAVATT), change agents continued to be trained in the GGAVATT model<sup>(9)</sup>.

### **Adaptation and survival of the model: 2008 to date**

After the rise of the GGAVATT model, its expansion throughout the country decreased due to either the establishment of new models or the lack of economic and human resources. However, in 2008, SAGARPA, within the Programa Soporte, instructed to consider the GGAVATT model among other models. SAGARPA also designated INIFAP as a Specialized Technical Unit in Livestock Matters (STU), which proposed that the Programa Soporte should apply the GGAVATT model and be trained in its methodology and take courses of Diagnostic Evaluation and Livestock Farms Administration<sup>(12)</sup>.

In 2011, SAGARPA implemented the National Strategy to provide quality technical service to the livestock producers in the country; this involved different participants, such as the State Centers for Training and Monitoring of the Quality of Professional Services (CECS). These centers include State institutions or organizations, such as Universities<sup>(13)</sup>. This action by SAGARPA significantly decreased the establishment of GGAVATT in the country; some States continued with the model for their technical assistance strategy, innovation, and training. However, no study concentrated these efforts. From the review of the reports of the

2010 National Livestock Research Meeting (RNIP)<sup>(13)</sup> to date, GGAVATT continuity results were found in some states, where the support of the PRODUCE Foundations was decisive, as is the case of Sinaloa and Guanajuato, and the support of the governments of the states of Guerrero, Michoacán, Morelos, Nayarit, Colima, Tamaulipas, Veracruz, Campeche, Nuevo León, and Chihuahua.

In 2013, given the concern of organized beef producers, the "Integration of the Beef Cattle Network Cattle Meat of Veracruz" project was established<sup>(1)</sup>. This project was based on the GGAVATT methodology and was financed from 2013 to 2014 by resources from FIRA, SAGARPA (General Livestock Coordination), and the Productores y engordadores de bovinos del Centro de Veracruz, S.A. de C.V. (Grupo Veracarne), and from 2015 to 2016 by the Programa de Innovación, Investigación, Desarrollo Tecnológico y Educación (PIDETEC) of SAGARPA. The project ended in 2017. The aim was to increase productivity, profitability, and sustainability of the production units of small and medium-size producers. This would be attained with technical assistance, training, and financing, integrating these producers into the beef value network. A total of 20 groups participated with their corresponding consultants; 202 farmers were benefited in the entire state, with an average of 12 producers per group. The project used an innovative computer platform (SIGEN-TTP Veracruz) to obtain the static diagnosis at the beginning of work. Subsequently, the productive, reproductive, economic, and use of credit information was also obtained. From 2013 to 2017, the established goals were met. The GGAVATT model operated successfully following the rules of credit institutions and private livestock organizations such as Veracarne and complying with the operating rules of official agencies.

### **Results of the GGAVATT model as a generator of information**

As part of the work methodology, information is generated in the groups from the static diagnosis (social, use of technology, productive and economic). Furthermore, technical, economic, and use of technology records are implemented parallel to the work calendars with the animals and paddocks. From these records, information is generated due to the validation, use, and adoption of technology. Thanks to the data capture directly in the farms, it was possible to know the socioeconomic characteristics of the producers, as well as the estimation of technical-productive and economic indicators.

## Socioeconomic characteristics of the producers

Characterizing producers and groups is important to implement the level of technology transfer that must be applied and to evaluate the activities' future impact. A study of 12 GGAVATT in the central zone of Veracruz<sup>(14)</sup> reported that the age of producers ranges from 20 to 80 yr, 49 on average. Of the producers, 94 % knew how to read and write, 20 % received professional education, 31 % attended secondary and high school, 43 % only elementary school, and 6 % had no school grade. The production units have an average of 45.5 ha, with an animal load of 46.6 animal units (AU) and without a rotating paddock system.

As for group characterization, a previous report indicates that in 1996 there were 79 GGAVATT in Veracruz. These GGAVATT included 1,288 farms, with 54,415 ha and around 54,000 cattle heads. Of the producers, 473 were small owners, and 815 were ejidatarios. Of the groups, 58 were dual-purpose cattle producers; seven were dairy cattle producers; ten were sheep and goat farmers; one focused on pig production; one specialized in beekeeping, and two were poultry producers<sup>(1)</sup>. Furthermore, by 2016 there were 1,165 GGAVATT at a national level; these GGAVATT grouped 17,095 producers and close to 1,000 agents of change. The groups represent the main agri-food chains: dual-purpose cattle, 41.1 %; beef cattle, 22.8 %; goats for meat and milk, 10.7 %; dairy cattle, 10.1 %; poultry, 6.4 %; sheep for meat, 6.1 %; pigs, 2.1 %; family poultry farming, 0.5 %; and aquaculture, 0.2 %<sup>(1)</sup>.

The GGAVATT model stimulated technology adoption and increased social networks and interactions. This process was influenced by socioeconomic and technical-productive characteristics<sup>(15)</sup>. Other authors report evidence that the GGAVATT has contributed to developing the technological capacities of the cooperating agro-entrepreneurs. However, the impact of innovation adoption and the profitability of the PU is low or null, suggesting that more time is needed to perceive the benefits<sup>(16)</sup>.

## Use of technology

According to the static diagnosis, the producers initially carry out 30 % of the suggested technologies, and in 5 yr, they reach 70 %. More precisely, after one year of working as a group, 126 groups in Veracruz reported a 48 % use of technology, 63 % after three years, and 73 % at the fifth year. In a further analysis of 24 groups,  $72 \pm 39$  % was reported after several years of work<sup>(6)</sup>.

Moreover, a study that aimed to evaluate the economic and productive impact of the dual-purpose bovine technology in Tabasco and Veracruz collected the annual data (1986-1997) of 139 farms incorporated into the GGAVATT. The results indicated that medium technology outperformed low technology ( $P<0.05$ ) in milk and meat production. Food supplements benefited 106 vs 44% of milk and 193 vs. 81% of meat, respectively. Breeding of dairy cattle, improved pastures, and livestock management increased milk production by 67 and 69 % and meat production by 15 and 26 % with low and medium technology, respectively. Moreover, producers that use medium technology outperform those with low technology ( $P<0.05$ ) in milk production, meat production, and benefits over variable costs by 106, 44, and 81 %, respectively<sup>(17)</sup>.

In Guanajuato, a different study evaluated the use of innovation in groups from the Programa Soporte from 2010 to 2011. This study considered 21 GGAVATT and 248 producers of family dairy systems<sup>(18)</sup>; three types of producers were compared: 1) 27 with a low technological level that apply less than 33 % of the technologies, 2) 73 with a medium technological level that apply more than 33 % and less than 66 %, and 3) 148 with a high technological level that apply more than 66 %. Results showed that group one was 2 yr old; groups two and three were three years old. The most used practices were those related to health, feeding, and management.

In Sinaloa, a study evaluated from 2010 to 2011 the use of innovations in eight GGAVATT from the Programa Soporte<sup>(19)</sup>. Eight GGAVATT and 121 producers were considered, and three strata were compared. In the first, 38% of producers had low practice implementation levels, were 3.7 yr old and used only six proposed innovations. In the second strata, 36.4 % of producers had medium implementation, were 4.5 yr old, and implemented 12.2 innovations. In the third strata, 25.6 % of producers had high levels of implementation, were 6.3 yr old, and used 22.7 innovations.

In Michoacán, the use of the technology promoted by the model was evaluated in 15 GGAVATT participating in the Program for the Development of Capacities, Technological Innovation and Rural Extensionism from 2011-2012<sup>(20)</sup>. This study reported that producers carried out on average 77 % of the activities proposed by the technician and 20 % of the technological components presented by INIFAP. The GGAVATT for goat and activities associated with disease prevention and livestock management showed the highest values. The determining factors in adopting new technologies were months with technical assistance by GGAVATT, producer age, number of localities, marginalization index, and number of women per group. In the same state, a different study evaluated the impact on the adoption of innovations. A total of 81 milk producers from the Ciénega de Chapala region were interviewed; 41 of these producers belonged to a GGAVATT from July 2008 to July 2011. The use of 22 innovations was evaluated: five related to administration/organization, four to reproduction and genetics, four to facilities/hygiene, four to nutrition, and five to health.

Results show that the farmers that belong to a GGAVATT apply 51.6 % of these innovations; those that do not belong to a GGAVATT apply 44.9 %. These results are not enough to conclude that there is a difference between both groups<sup>(21)</sup>.

In Veracruz, the use of innovations from a GGAVATT constituted in 1989 was evaluated. After 10 yr, three strata of livestock farmers were interviewed: I) active participants in this GGAVATT, II) previous participants, and III) those who have never participated. Seventeen explanatory or predictive variables of a social and productive nature were selected. The response variable, use of innovations, was also selected. Results showed significant differences regarding the use of technology between the years 1989-1990, 1990-1991, and 1993-1994. An increase in innovations was reported, mainly regarding production and financial records, deworming, mastitis and gestation diagnosis, and milk weighing. A significant increase was observed from 1990 to 1991 in milk weighing, artificial insemination, mineral and by-products supplementation, silages, haymaking, supplementation with cut and carry fodder, paddock fertilization, and sowing of cut and carry fodder. During 1993 and 1994, there was an increase in the use of the following innovations: lactation control, supplementation with a balanced diet and by-products, routine use of hormones, organized commercialization, double bucket milking, stool analysis, intensive grazing, and sowing of cut and carry fodder<sup>(22)</sup>.

Also, in Veracruz, a study evaluated the use of 17 technological components and the productive efficiency of 86 dual-purpose farms belonging to eight GGAVATT that participated in the Programa Soporte in 2010. Of these GGAVATT, 12 % received technical assistance for three or fewer years, 45 % received assistance for three years, 31 % for four years, and the remaining 12 % had five or more years of assistance. On average, these GGAVATT used 62 % of the 17 technological components evaluated; no significant differences were observed. Artificial insemination and weaning weighting were the least used components; vaccination, deworming, paddock rotation, and mineral supplementation were the most used. Significant differences were reported in milk production per cow per day. Farms that had belonged to a GGAVATT for longer were more efficient and productive<sup>(23)</sup>.

In Veracruz, a different study was carried out to evaluate the dynamics of technology adoption as a measure of success of the GGAVATT model from a social perspective. A total of 26 producers belonging to three GGAVATT were interviewed. This study observed that technology adoption was associated with the increase in the social network and interactions, with few changes in the central actors. Technology adoption is positively associated with education, is inversely proportional to the age of the producers, and is influenced by the management and production scale. The authors of this study concluded that the GGAVATT model stimulated technology adoption, increasing the social network and interactions, a process influenced by farmers' socioeconomic and technical-productive characteristics<sup>(24)</sup>.

Another study evaluated the productive and economic efficiency of dual-purpose (DPS) and family dairy systems (FDS) in Veracruz by applying the case study of four GGAVATT with different technological levels in each production system. The 1DPS GGAVATT had 12 members, 30 yr of existence, and applied 100 % of the technological package. The 2DPS GGAVATT had 16 members, 5 yr of existence, and applied 66 % of the technological package. The 1FDS GGAVATT had 12 members, 5 yr of existence, and applied 57 % of the technological package; 2FDS had nine members, three years of existence, and used 53 % of the technological package. The results reported for the DPS show that the total milk production in GGAVATT 1DPS is 84% higher than GGAVATT 2DPS. This difference results from adopting a series of technological practices with different response times and the time applying the model. Additionally, its income is higher due to the higher price of its animals due to breeding. As for the FDS GGAVATT, no significant differences were reported since both GGAVATT have a similar technological level<sup>(25)</sup>.

### **Technical, productive, economic, and ecological indicators**

In all the GGAVATT of the country, compared to traditional indicators, milk production increased by 100-200%, meat production increased by 50-100 %, reproductive and economic indicators also increased.

In Veracruz, associated with the use of 70 % of the technology,  $286 \pm 44$  milking days,  $2,159 \pm 921$  kg of milk per lactation,  $7.25 \pm 2.3$  kg of milk per cow day,  $4.7 \pm 2.1$  kg of milk per day between calving, and  $900 \pm 396$  kg of milk per hectare were reported<sup>(6)</sup>.

Tepetzintla exemplifies the possibilities of increase. Farms initially achieved 74 % use of technology and exceeded 1,000 kg per lactation. The use of technology was intensified to 95 % and exceeded the 2,000 kg of milk per lactation. The leadership of producers, technicians, and institutions allowed adopting high, complicated, and expensive technology. Subsequently, although technology use decreased to 74 %, it was possible to exceed 3,000 kg per lactation. Lastly, with 85 % of technology and using high levels of concentrated feed, 4,000 kg per lactation were achieved, and by reducing feed, it stabilized at 3,500 kg<sup>(6)</sup>.

In 2006, the economic impact of the use of technological components in animal feeding was evaluated in Sonora. Using the technology generated for the GGAVATT, the dry forage yield of the sorghum crop was 7 versus 3.9 t of DM/ha, which represented an increase of 79 %; milk production per cow per day increased 60 %, and the lactating period increased from 180 days with the traditional system to 210 with INIFAP's technology<sup>(26)</sup>. In Veracruz, the

averages of 24 dual-purpose cattle GGAVATT were analyzed. A return above variable costs (RAVC) of  $85 \pm 49$  % and a return on investment (ROI) of only  $3.5 \pm 3.6$  %<sup>(6)</sup> was observed.

Since its inception, one of the purposes promoted in the groups has been the care and improvement of natural resources. In the central zone of Veracruz, a study was carried out in 2005 and 2006 in four GGAVATT with family dairy systems (FDS) of the mountainous area and in eight with dual-purpose cattle systems (DPCS). Information for this study was obtained through interviews and field trips to sample living fences and vegetation fragments. A total of 66 tree and shrub species were inventoried. In the living fences, 37 species were reported; 33 species were identified on the banks of rivers and streams (riparian vegetation); 37 pasture species were identified. Farmers also reported introducing exotic species, crops, and fruit trees<sup>(15)</sup>; this shows that the farmers incorporated into the GGAVATT care for vegetation.

### **Successful examples of the GGAVATT model**

In 2005, INIFAP carried out a study to identify how the GGAVATT model contributed to livestock development<sup>(27)</sup> in 16 states: Veracruz, Guanajuato, Campeche, Coahuila, Tabasco, Guerrero, Sinaloa, Puebla, Yucatán, San Luis Potosí, Durango, Morelos, Sonora, Nayarit, Baja California Sur, Nuevo León. Thirty-three producers from 10 states, 19 GGAVATT advisers, and three researchers involved in developing this model were interviewed. Of the producers, 94 % agreed that the most crucial factor for success was working as an organized group, 57.6 % said technology transfer, 54.5 % mentioned the support achieved as an organized group, and 45% referred to the professional and institutional leadership. Only 27.3 % mentioned the increase in their farm production as an important factor.

Of the consultants, 37 % considered the increase in production as one of the main factors, 32 % mentioned the unity of the producers, 26 % the group organization, and 21 % the productive and economic records, the desire to work, and the interest in new technology; 16 % mentioned the application of the methodology, good relationships, and an environment of healthy competition. Only 10 % alluded to the calendar of activities, training, consulting, companionship, understanding of the benefits of adopting technology, static diagnosis, and learning.

Researchers agreed that GGAVATT is a fully replicable model that changes all participants. To a lesser extent, they mentioned that this model propitiates institutional leadership, organization, group work, social coexistence, training, obtaining technical-productive and

financial information, the use of new technology, appropriation of the model by the producers, interest, motivation, friendship, and, overall, humanism.

Producers, consultants, and researchers agreed that organized group work, training, productive information, motivation, and interest in the new technology are essential factors for success.

In Tepetzintla, the adoption of new technology increased production and income and improved the tangible capital (pastures, livestock, constructions, and equipment), partially fulfilling the initial aim<sup>(6)</sup>. However, after 25 years of work, intangible capitals emerged that motivated an important change in all participants. In principle, the "tacit cognitive capital" of the Huasteca, a region with an important inherited agricultural and livestock culture, was respected. True leaders emerged in favor of technological change: producers, consultants, and researchers. The Huasteca's "cultural capital" remained intact: traditions, myths, beliefs, language (Nahuatl), artistic manifestations; all this favored the development of the "institutional capital." In addition to INIFAP, the state and federal governments, other livestock organizations, research and teaching institutions, credit, training, development, and promotion institutions were also involved. The methodology was inclusive from the beginning. From the producer's point of view, the "psychosocial capital" increased. Thanks to its organization, the group obtained recognition and respect based on values, true friendship, work commitment, fair competition, individual and family participation (women's work stands out), and the ability to specify and solve problems. The development of "social capital" was fostered. The GGAVATT started as an associative figure "to the word," a group of friends, and, based on the circumstances and work versatility, legal and family associative figures were integrated. Without question, the "human capital" development is the most important; it increased the capacity of self-management and the security to communicate technically. A generation of university children was formed and became involved in the group (seven women and seven men, six zootechnical veterinarians among them). Lastly, producers were nationally recognized as "the cradle of GGAVATT."

Guanajuato is an example of consistency with the application of the GGAVATT model. Since its first family dairy group, "La Labor," established in the Apaseo el Grande municipality<sup>(28)</sup>, Guanajuato has maintained an average of 77 groups per year: 26 % of dairy cattle, 20.3 % of goats, 19.1 % of beef cattle, 16.3 % of sheep, 10 % of pigs, and 8.3 % of bees. An average of 1,352 livestock farmers per year have benefited from the GGAVATT model. From 1999 to date, the groups had the support of different programs. In 2002, with the support of DEPAI, 74 GGAVATT were established. DEPAI mainly contributed by paying consultants until 2006. From 2007 to 2012, the groups were supported by the Programa Soporte, and from 2012 to 2018, the Extensionism Program supported them. In 2019, the Federation withdrew its support, and the State of Guanajuato paid 100 % of the consultant's salary. Furthermore, from 1998 to 2007, farmers had the support of the

Fundación Guanajuato Produce (FGP). In addition to the support provided by the programs, the groups also benefited from the researchers from INIFAP, the Universidad de Guanajuato, the Instituto Tecnológico de Roque, pharmaceutical laboratories, and other private companies.

Mexican farmers have emerged from a deeply rooted inertia after being part of the GGAVATT model and perceiving improvement. Now they associate a government program with support: thus, producers have privileged technical support and training over equipment, infrastructure, and livestock, as evidenced by an analysis of their change in attitude<sup>(29)</sup>.

From 2002 to 2020, 14 State technology transfer meetings have been held, more than 1,000 producers attended each event. Of the information presented in these events, the GGAVATT "United Goat Farmers of Guanajuato" stands out with a production per lactation exceeding 1,100 kg. For the genetic value of their animals, these producers have supplied stallions in government support programs, benefiting hundreds of goat farmers in Guanajuato; this has undoubtedly contributed to the increase of goat milk production in the state. From 2010 to 2019, milk production increased by 68.9 %, going from 24,980 to 42,196 t. As a result, Guanajuato climbed from 3rd to 2nd place in the national goat milk production<sup>(30)</sup>.

Sinaloa also applied the GGAVATT model for a considerable period, reaching productive, technological, economic, and social impacts<sup>(31)</sup>. A total of 499 GGAVATT grouped 4,661 producers, which were advised by 185 technicians<sup>(31)</sup>. The priority chain was dual-purpose cattle. They participated in various programs: DEPAI, SINDER, PEAT, UTEP, SOPORTE, in addition to those of the state government. This work continued until 2013-2014<sup>(32)</sup>. Since 2014, without federal support, the Fundación Produce de Sinaloa took responsibility for the work and continuity of the groups.

Throughout the national meetings of PRONAVATT, GGAVATT from Sinaloa were present as "successful cases": "Zavala 1" and "El Sacrificio" in 2000 and "Chinobampo" in 2003; all GGAVATT were from dual-purpose systems<sup>(31)</sup>.

Veracruz, like the previous states, has worked intensively with the GGAVATT model. A total of 409 groups were reported from 1982 to 2006. Of these groups, 38 % remained integrated for only one year, 17 % were together for four to five years, and 14 % more than five years. The aim is for the groups is to remain together for at least four to five years. Tepetzintla is an exemplary case as it has stayed together for more than 35 yr. Other GGAVATT overcame the 10-yr and even 15-yr barriers. These groups were generally associated with INIFAP as the responsible institution<sup>(6)</sup>.

In Tamaulipas, 34 GGAVATT were formed in 2009. Each one included an average of 20 producers, served by their corresponding extensionist. Groups were in 16 of the 43

municipalities (37 %). Mante had seven groups and Aldama four; the rest had one or two. In 2010 and 2011, the STU provided training, supervision, and evaluation to the extensionist. A total of 559 producers of the different species-product participated. Specific surveys were conducted based on the type of producer: beef cattle (16), dual-purpose (7), goats (5), beekeeping (4), and sheep (2). It was possible to register 66 technologies: 18 were incorporated in the Feed and Forage area, 23.7 %; four were included in the area of Genetics, 6.1 %; seven in Animal Reproduction, 10.6 %; in Health 11, 16.7 %; three in Administration, 4.5 %; three in other complements (use of implants and additives, 4.5 %; and two in honey industrialization, 3.0 %. It may seem easy, but working with producers of five different species-product was challenging<sup>(32)</sup>.

### **Environmental, economical, productive, and social impacts of the GGAVATT model**

As for the environmental impacts, the number of living fences increased in dairy and dual-purpose farms in Veracruz<sup>(15)</sup>, which positively impacted vegetation and animal welfare. In Sinaloa, the use of technological components was promoted in the area of animal feeding: preparation and use of multinutritional blocks, establishment and management of pastures, use of living fences, new options of forage species and silages; decreasing soil and water loss by 88 % and 50 %<sup>(26,31)</sup>.

One of the technologies that the GGAVATT model promotes is the use of technical and economic records. Analyzing the information in these records makes it possible to evaluate the productive and economic impact of technology implementation in the production units participating in a GGAVATT. A study analyzed the information of 206 dual-purpose farms in Campeche, Colima, Nayarit, Sinaloa, and Veracruz; these farms received technical assistance and livestock training during 2011 and 2012. Two types of producers were identified: one with a low technological level, in which 76 % of producers apply on average 33 % of the proposed innovations, and another with intermediate technical level, in which 24 % of producers use 66 % of the innovations. After comparing the productivity and profitability variables of these two types of producers, it was found that intermediate producers obtain an additional 1.86 L of milk per cow per day and 8 % more profitability<sup>(33)</sup>.

Without a doubt, one of the most significant impacts of the GGAVATT model has been the use of technological innovations and its social implications, in which producers develop technical and organizational abilities. This is demonstrated by the studies carried out with dairy producers of Michoacán<sup>(21)</sup> and Guanajuato<sup>(18)</sup> and dual-purpose cattle producers in

Veracruz<sup>(23,24,25)</sup> and Sinaloa<sup>(19)</sup>. These studies mention that the production units that participated in the GGAVATT model increased their use of innovations.

### **Perspectives of the GGAVATT model**

The GGAVATT model has been adapted and maintained for more than 30 years, suggesting that the work dynamics between producers, professional experts, and government institutions would resurface under the same conditions and support. This assumption is based on the following: The GGAVATT model has been adapted to the great diversity of programs and projects at the three levels of government<sup>(1)</sup>. Furthermore, INIFAP has played a leading role in most of them. Chronologically, in 1986, the Technical Exchange Groups of the Rural Development Districts (RDD) stand out; INIFAP was responsible for the technological packages. From 1990 to 1995, the Agricultural and Forestry Research and Extension Program (PIEX) was established with RDD, FIRA, and BANRURAL, collateral with FIRCO. In 1995, the National Coordination of Produce Foundations (COFUPRO) was integrated into the states with their corresponding Produce Foundations. In 1996, SAGARPA remained as normative, and operating by the States; the Development Commissions were formed with the participation of INCA Rural, INIFAP, FIRCO, and the Commercialization and Development agency (ASERCA). In this same year, the Programa Alianza para el Campo, the National Training and Extension System (SINDER), and the Elementary Program for Technical Assistance (PEAT) began, with good participation of the Rural INCA; the Sustainable Rural Development Program was also established (DRS). In 1998, very important for the GGAVATT, the Comprehensive Agricultural Project Development Program (DPAI) was established to develop productive basins. In 2001, SINDER and PEAT merged into the Professional Services and Extension Program (PESPRO), which became the Capacity Development Program (PRODESCA). In 2003, all programs merged and formed the Livestock Promotion and Development of Comprehensive Projects (DPAI), in which GGAVATT continues; at the same time, the Livestock Productivity Incentive Program (PROGAN) is established with national coverage. Finally, in 2008, the General Coordination of Livestock invited INIFAP to participate in the National System of Evaluation Centers as a Specialized Technical Unit (STU), through which it continued to support farmer groups with about 1,000 PSP. As previously mentioned, the GGAVATT model was adapted to all the programs and projects, which motivates candidates to continue participating.

## Conclusions

The GGAVATT model is a process technology that granted INIFAP researchers the opportunity to participate in the farms of organized producers to validate, transfer and innovate the technologies created in experimental stations. The GGAVATT is a participatory model based on the collaboration between producers and researchers; it increases the productivity and profitability of the LPU, generates tangible and intangible capital, and increases the producers' social, intrinsic, horizontal, and vertical capital.

The GGAVATT can be successfully used in any livestock production system and agroecological region of the country; it may be an excellent conduit to enhance natural resources and reduce climate change impact. This model has an adequately documented work methodology; thus, it can be replicated in all Mexican states. The GGAVATT model may be the axis of technological transformation and integral development of national livestock.

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## Conflicts of interest

The authors declare that they have no conflicts of interest regarding the work presented in this report.

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