

G.R.O.W Project: Development of a Technical Manual for Sustainable and Educational Cultivation in Governador Mangabeira

Alessandra Cardim^{1*}, Gabriela Lopes¹, Mauro Reis¹, Nathalya Barros¹, Sara do Vale¹, Clariane Teixeira Pessoa Mamona¹, Pietro Carlos Gonçalves Conceição¹

¹SENAI CIMATEC University, Department of Biotechnology; Salvador, Bahia, Brazil

This study presents the G.R.O.W Project, an educational and technological initiative designed to strengthen sustainable agricultural practices in school and family gardens within the municipality of Governador Mangabeira, Bahia, Brazil. Addressing a socio-environmental context marked by land fragmentation, soil degradation, and limited access to agroecological knowledge, the project integrates the disciplines of geography, chemistry, and mathematics to develop low-cost, replicable solutions for food production and environmental education. Methodologically, the study employed an ethnoscientific approach, combining participatory observation, informal interviews, and bibliographic research to document local agricultural practices and integrate traditional knowledge into technical recommendations. The resulting manual details strategies for soil preparation, crop layout optimization, automated drip irrigation using Arduino-based moisture sensors, rainwater drainage systems, and ecological pest control through botanical extracts and biological competition. Experimental implementation demonstrated the technical and economic feasibility of these systems, with an estimated total cost of R\$ 338.34, significantly lower than conventional alternatives, while ensuring water efficiency and crop productivity. The proposed solutions directly support food security, promote environmental preservation, and enhance community autonomy, positioning the school as a hub for rural innovation and socio-environmental transformation.

Keywords: Sustainable Agriculture. Low-Cost Technologies. Technical Manual. Community Gardens. Environmental Education.

Family farming constitutes the foundation of rural social and productive organization in the municipality of Governador Mangabeira, located in the Recôncavo Baiano region, where more than 90% of properties have less than 30 hectares. This fragmented land structure reveals an agrarian landscape deeply marked by small-scale production, scarcity of resources, and a continuous search for survival strategies. In this context, tobacco monoculture, carried out through integration contracts with large companies, represents the main source of income for farming families. However, this integrated production tends to intensively exploit family labor, imposes high production costs, and compromises food security, as it prioritizes the cultivation of a single crop destined for export [1].

Received on 22 March 2026; revised 10 June 2026.

Address for correspondence: Alessandra Cardim. Av. Orlando Gomes, 1845 - Piatã, Salvador – BA – Brazil, Zipcode: 41650-010. E-mail: ale.acardim@gmail.com.

As a consequence, farmers face numerous difficulties in reproducing socially within their own agrarian space, being forced to seek off-farm employment, especially in the services sector and public service positions, as a way to supplement their income [2]. Production for self-consumption, including vegetables, roots, and small animal husbandry, has been a recurring and strategic practice to mitigate food insecurity and ensure a minimal diet for families, even in a context of precariousness [3].

In view of this scenario of structural vulnerability and limited qualifications for family farming production in Governador Mangabeira, the G.R.O.W Project, developed by technical students from Universidade SENAI Cimatec, in partnership with Educandário Construir, emerges as an educational initiative aimed at strengthening sustainable cultivation practices in school and family gardens in the municipality. The project is set within a territory marked by soil degradation, excessive use of chemical inputs in conventional agriculture, and a growing detachment of youth from rural life and agricultural work [4,5].

In order to help reverse this situation, the project integrates knowledge from geography, chemistry, and mathematics to create low-cost solutions that optimize food production, preserve the environment, and promote critical environmental education [6].

Among the proposed solutions, the following stand out: the implementation of an automated irrigation system based on Arduino boards, the use of rainwater, and the production of natural extracts for pest and disease control in crops. These measures directly align with the principles of agroecology, which prioritize productive autonomy, the rational use of natural resources, and the appreciation of traditional knowledge [5].

Furthermore, the project acknowledges the transformative role of schools in strengthening the connection between youth and rural spaces, encouraging student protagonism and the production of knowledge applicable to the local reality. The choice of Educandário Construir as the pilot site is justified by its commitment to an interdisciplinary pedagogical approach and its presence in a community historically linked to family farming [6].

This work aims to develop a technical manual with practical instructions and guidelines for improving and optimizing the stages of cultivation and harvesting in the school garden, following the QSMS&RS management system (Quality, Safety, Environment, Health, and Social Responsibility), and for specific objectives: develop accessible technologies to optimize soil preparation, irrigation, drainage, and crop protection processes, ensuring proper management of the agricultural space; promote effective agroecological practices for pest control, integrated soil management, and sustainable reuse of water resources; encourage educational actions within the school community that reinforce the importance of safety protocols in agricultural management; systematize the knowledge produced in a technical manual to support sustainable and safe agricultural practices, facilitating its application by rural families. These objectives provide a comprehensive foundation for understanding the problems and recommending practical actions that

contribute to environmental preservation and the subsistence of the populations that depend on this garden in Governador Mangabeira.

G.R.O.W Project offers a concrete response to a context of exclusion and invisibility of family farming in the Recôncavo Baiano, reinforcing the role of schools as spaces for social and environmental transformation.

Materials and Methods

Study Area

The research was conducted in the municipality of Governador Mangabeira, located in the state of Bahia, Brazil (12°36'07"S, 39°02'34"W). The study area encompasses the surroundings of the Educandário Construir School, situated in a region characterized by the predominance of small rural properties, with agricultural practices based on family farming. The municipality is part of the Recôncavo Baiano identity territory and stands out for its historical, cultural, and productive relevance in the regional agricultural context.

The Educandário Construir School, where the actions of the G.R.O.W Project are concentrated, is embedded in a socio-environmental context of vulnerability, in which access to sustainable cultivation practices and environmental education is still limited. The institution serves as a training hub and a space for experimenting with agroecological techniques aimed at strengthening food security and fostering ecological awareness among students.

The area around the school (Figure 1) consists of soils typical of the Atlantic Forest biome, with secondary vegetation and the presence of small productive backyards traditionally used for growing vegetables, roots, and fruits intended for self-consumption.

Ethnoscience

The reality of the Educandário Construir garden (Figure 2) was analyzed through an approach grounded in ethnoscience, using photographic

Figure 1. Area surrounding the Educandário Construir School.



Source: Retrieved and adapted from Google Earth: <http://earth.google.com/2025>.

Figure 2. Garden of the Educandário Construir School.



Source: Retrieved and adapted from Google Earth: <http://earth.google.com/2025>.

records, videos, oral accounts, and exchanges of experiences with the management team, staff, and students of the institution. To this end, informal interviews and participatory observations were carried out to understand local practices related to soil preparation, organization of the productive space, agricultural planning, pest and disease control, as well as safety measures adopted during handling. This active and sensitive listening allowed

the project's actions to reflect the knowledge and habits rooted in the local agricultural culture. In this way, the aim was to value the traditional knowledge of the residents of Governador Mangabeira, strengthening the connection between science, community, and territory.

Scientific Axes

Geography

The content of the manual within the geography axis was structured around soil preparation, organization of the agricultural space, crop selection, and sustainable management practices.

Soil preparation was described considering the sandy-clay composition of the terrain and its slightly acidic pH, typical of the Atlantic Forest biome in which the region is located. Guidelines were also included on organic fertilization, enrichment with natural compounds, and practices for conserving soil fertility after understanding soil layers, in order to support agronomic decision-making (Figure 3).

The garden layout was designed (Figure 4) to optimize space use, suggesting the division of beds by crop type (roots, vegetables, and fruits) and

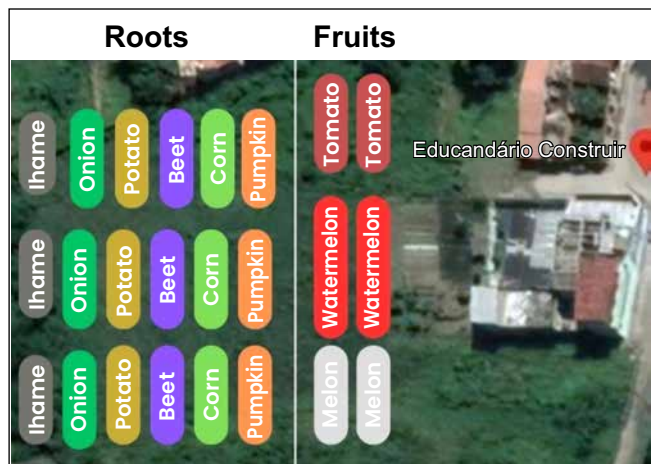
Figure 3. Development of soil profile layers.



detailing the spacing, depth, and average harvest time of each plant.

Species selection prioritized foods with high nutritional value, good acceptance among children, and cultivation cycles adapted to local climatic conditions.

Figure 4. Mapping and layout of the Educandário Construir School garden.

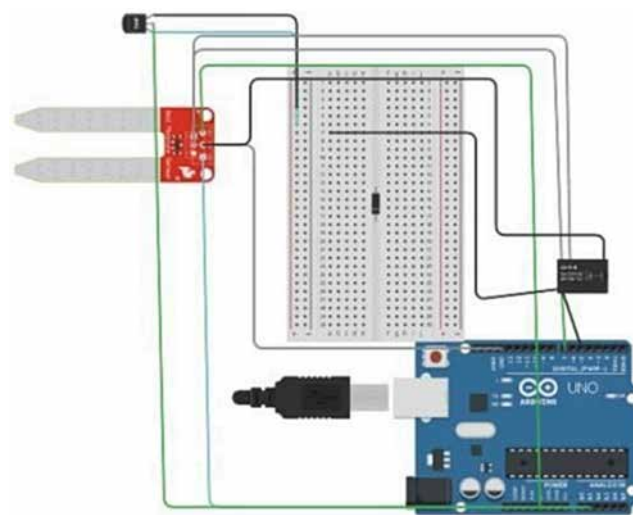


Mathematics

Regarding automated irrigation, a proposal was developed based on the use of the Arduino Uno R3, an open-source electronic prototyping platform widely used in educational projects (Figure 5). The functioning of the system was described step-by-step, beginning with soil moisture readings taken by an analog sensor connected to the A0 pin of the Arduino, followed by the activation of a water pump via a 1-channel relay when the soil moisture level falls below a pre-programmed threshold value (300). The system was designed to take measurements every 12 hours, using intervals defined in C++ code, and ensuring irrigation only when necessary, thus promoting water resource conservation.

The manual also provides detailed guidance on installing a drip irrigation system built with PVC hoses, connectors, and regular perforations. The main hose is placed along the beds and connected to a perforated secondary hose, with holes positioned near plant roots, respecting variable spacings

Figure 5. Representation of the Arduino board for system construction.



according to the water needs of each crop. The system layout was designed to ensure uniform coverage and optimize water absorption by plants (Figure 6).

For rainwater drainage (Figure 7), the assembly of an underground system was described, consisting of a PVC pipe 100 mm in diameter and approximately two meters in length, installed at a depth of about two hand spans in the soil. The pipe is perforated every 50 centimeters and covered with non-woven fabric (TNT) glued over the holes to prevent the entry of solid particles. The system is designed with a slope between 15° and 20°, facilitating water flow to an external area outside the school grounds, reducing the risk of waterlogging, and promoting greater water stability in the soil.

Chemistry

Based on literature reviews and interviews with school management members, a theoretical mapping was carried out of the main pest species affecting school crops, such as the leaf-cutting ant (*Atta sexdens rubropilosa*) [7], the cabbage looper (*Ascia monuste orseis*) [8], and the gamba grass (*Andropogon gayanus*) [3,5,9].

For each identified pest, natural compounds and their preparation methods were described.

Figure 6. Visual representation of the hose irrigation system in Tinkercad software.

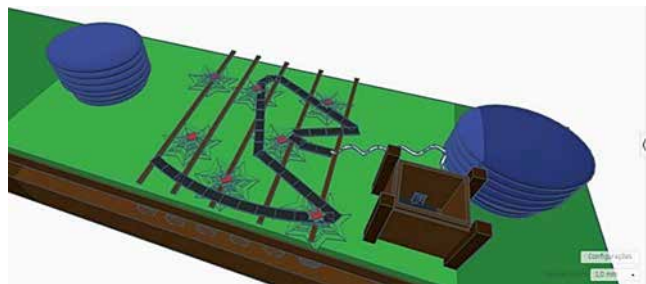
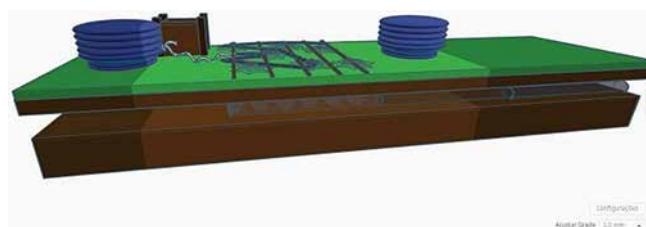


Figure 7. Illustration of the garden drainage system.

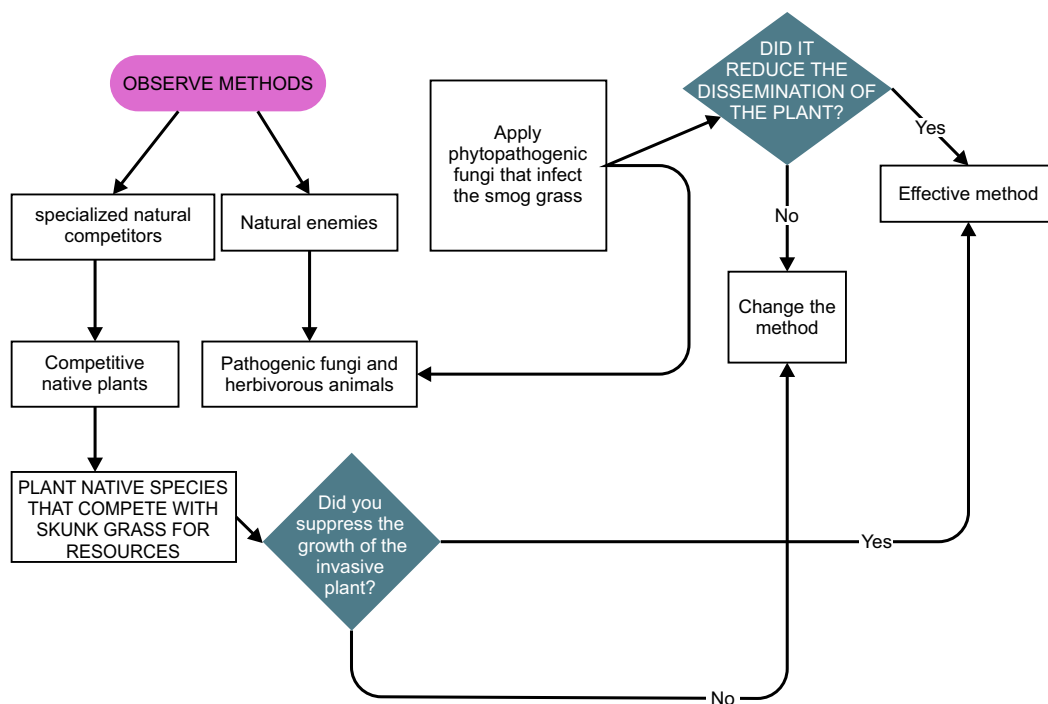


The control of leaf-cutting ants, for example, was addressed through the use of black sesame seeds, whose toxicity to the colony's symbiotic fungus (*Leucoagaricus*) represents an effective biological control method. In the case of the cabbage looper, extracts based on combinations such as lemongrass and mint, chestnut husks with *Plantago* leaves,

chrysanthemum with marigold, and garlic extract were proposed. For controlling gamba grass (Figure 8), biological competition techniques with native plant species were recommended, as well as the use of pathogenic fungi and insects.

The guidelines included details on the methods of extraction, formulation, and application of natural extracts. Essential oils were obtained from plants cultivated in the rural zone itself, such as citronella and lemongrass. Extraction followed simple processes, using alcohol as a solvent, fresh or dried leaves as raw material, and maceration periods ranging from four to eight weeks, with storage in dark bottles to preserve efficacy. Application methods were described in a standardized way, prioritizing safety and phytosanitary effectiveness. The manual also included procedures for verifying the quality of natural extracts, based on visual observations, efficacy tests, and odor control, as well as guidance on monitoring biological traps installed in the cultivated area. The recording of practices carried out and the documentation of results were also recommended for continuous evaluation and improvement of the techniques described.

Figure 8. Diagram of strategies against gamba grass.



Results and Discussion

The data gathered during the preparation of the technical manual demonstrate the feasibility of implementing sustainable and low-cost systems for school-based agricultural cultivation in Governador Mangabeira. As shown in Table 1, the total estimated budget amounted to R\$ 338.34, evidencing the cost-effectiveness of the proposed automated irrigation system with soil moisture sensors when compared to conventional market systems.

Table 1. List of materials and estimated budget for assembling the automated irrigation system.

Materials	Price (R\$)
Irrigation hose	64.00
PVC elbow (50 cm)	15.00
PVC elbow (20 cm)	13.70
Pressure pump	84.60
Main hose	32.00
TNT fabric (nonwoven fabric)	5.90
Arduino	45.00
Acrylic box	28.14
100 mm pipe	50.00
Total	338.34

It was observed that the black hose used in the proposal (Figure 9) is suitable for adapted drip irrigation systems, allowing efficient water distribution after manual perforation, with reduced cost and high availability in the local market. The combination of a main white hose with branches of perforated black hose demonstrated theoretical hydraulic efficiency for small school gardens, with potential to optimize soil moisture and reduce water waste.

Regarding pest control, the research and organization of natural alternatives highlighted the potential of extracts such as garlic, mint, citronella, and infusions of native plants for the ecological management of invasive species [1,5,9,10], with

Figure 9. Black irrigation hose installed in the garden bed, manually perforated for water release.



emphasis on controlling the leaf-cutting ant (*Atta sexdens rubropilosa*) through the use of black sesame seeds [7] and the cabbage looper (*Ascia monuste orseis*) through botanical compounds [8]. Finally, based on the mapping of the garden, it was concluded that the best crops are root vegetables (yam, potato, onion, beet, corn, and pumpkin) and fruits (tomato, watermelon, melon, and strawberry), which, in addition to being nutrient-rich, have favorable harvest times, as shown in Table 2.

Table 2. Agricultural crops and their harvest periods.

Fruits	Harvest Time
Tomato	60 to 90 days after planting
Watermelon	80 to 100 days after planting
Melon	55 to 75 days after planting
Strawberry	60 to 90 days after planting
Roots	Harvest Time
Yam	6 to 12 months
Potato	4 months
Onion	100 to 180 days after planting
Corn	60 days
Beet	60 to 70 days after planting
Squash	90 to 100 days after planting

References

1. Santos AJ, et al. O espaço agrário do município de Governador Mangabeira-BA: uma breve abordagem a partir da produção e reprodução social da agricultura familiar. *Rev Territorium*. 2024;1(1):1-15.
2. Corrêa da Silva HB, Cartes Patrício C, editors. Fortalecimento da agricultura familiar e desenvolvimento sustentável: cooperativismo, ATER e pesquisa agropecuária, ATER digital pós-COVID-19. Brasília: FAO; SEAB/PR; IAPAR-EMATER; 2022. Available from: <https://www.fao.org/documents/card/en/c/cb9932pt/>
3. Brasil. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Desenvolvimento Agropecuário e Cooperativismo. Hortaliças não-convencionais (tradicionais). Brasília: MAPA; 2010. 52 p. Available from: <https://www.gov.br/agricultura/pt-br/assuntos/sustentabilidade/tecnologias-sustentaveis/hortaliças-nao-convencionais>
4. Silva MC, et al. A escola do campo e a juventude rural: desafios para a permanência no campo e o fortalecimento da agroecologia. *Rev Educ Ruralidades*. 2023;5(2):89-107.
5. Caporal FR, Costabeber JA. Agroecologia: enfoques teóricos e estratégias de ação. Brasília: Ministério do Meio Ambiente; 2004.
6. Brasil. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Inovação, Desenvolvimento Sustentável e Irrigação. Boas práticas agrícolas para a produção de alimentos seguros: café, feijão, tomate, morango e hortaliças folhosas. Brasília: MAPA; 2022. 308 p. Available from: <https://www.gov.br/agricultura/pt-br/assuntos/inspecao/produtos-vegetal/boas-praticas-agricolas>
7. Peres Filho O, Dorval A. Efeito de formulações granuladas de diferentes produtos químicos e à base de folhas e de sementes de gergelim (*Sesamum indicum*) no controle de formigueiros de *Atta sexdens rubropilosa* Forel, 1908 (Hymenoptera: Formicidae). *Cienc Florest*. 2003;13(2):67-70.
8. Medeiros CAM, Boiça Júnior AL. Efeito da aplicação de extratos aquosos em couve na alimentação de lagartas de *Ascia monuste orseis*. *Bragantia*. 2005;64(4):633-41.
9. Gliessman SR. Agroecologia: processos ecológicos em agricultura sustentável. 2nd ed. Porto Alegre: UFRGS; 2009.
10. Lorenzi H, Matos FJA. Plantas medicinais no Brasil: nativas e exóticas. 2nd ed. Nova Odessa: Instituto Plantarum; 2008.