

Application of solar-powered borewell technology to address agricultural water scarcity among maize farmers in bontolangkasa selatan village, gowa regency

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ABSTRACT

Limited water availability is one of the main constraints on maize cultivation in rain-dependent agricultural areas. The 2026 Village Empowerment Program (program pemberdayaan desa binaan/PDB) in Bontolangkasa Selatan Village, Bontonompo District, Gowa Regency, implemented borewell technology and a solar-powered water pumping system for the Jiwa Baru Borong Kanang Farmer Group. The program aimed to improve access to agricultural water while strengthening the capacity of community partners to operate and maintain the technology. The implementation methods included socialization, training, technology application, mentoring and evaluation, as well as activities to strengthen program sustainability. The technology was implemented through a participatory approach involving site selection, installation, functional testing, operation, and maintenance assistance. Progress-stage results showed that the borewell system, solar panels, water pump, and distribution network had been installed and were functioning properly, enabling water to be pumped and distributed to agricultural areas. Farmer group members have begun to participate in system operation, network inspection, water distribution management, and basic maintenance. Quantitative impacts, including water discharge, irrigated land area, operating duration, and changes in productivity, have not yet been reported as final outcomes because measurements are still ongoing. The implementation indicates that integrating groundwater resources with solar energy represents a relevant initial solution for maize farming facing water scarcity. However, long-term sustainability requires stronger operator capacity, effective farmer-group governance, routine maintenance, and periodic performance evaluation.

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INTRODUCTION

Water and energy are two essential inputs in agricultural production. In areas with limited access to electricity or high conventional energy costs, photovoltaic water pumping systems have been widely studied as an alternative for irrigation because they utilize renewable energy sources and can be applied in rural and off-grid settings (Chandel et al., 2015) demonstrated that photovoltaic water pumping systems have promising technical and economic potential for irrigation, while (Li et al., 2017) emphasized the importance of performance evaluation, system optimization, and appropriate component selection according to water demand.

The success of technology implementation is not determined solely by technical aspects. In community-scale solar-powered water pumping projects in Indonesia, post-construction support through capacity building, technical assistance, and strengthening of local actors has been identified as an important factor in ensuring long-term system functionality (Rahmani et al., 2024) Empowerment approaches that involve farmers from the planning and installation stages through training and evaluation have also been applied in various community service programs involving solar-powered irrigation systems (Ardiansyah & Agustina, 2023).

Bontolangkasa Selatan Village, Bontonompo District, Gowa Regency, is the location of a three-year Village Empowerment Program (Program Pemberdayaan Desa Binaan/PDB). In the second year of implementation, one of the priority problems faced by the Jiwa Baru Borong Kanang Farmer Group was limited access to water for maize cultivation. The program therefore introduced a borewell system combined with a solar-powered water pump as the main technology for agricultural water provision. This intervention was accompanied by the development of maize planting equipment and strengthened technology management as part of the broader agricultural mechanization roadmap.

This article aims to describe the implementation process of solar-powered borewell technology, partner participation, functional testing results at the progress stage, and sustainability aspects that still need to be strengthened. The article does not claim quantitative improvements in productivity or efficiency because final measurement data are not yet available.

METHOD

Location and Community Partner

The activity was conducted in Bontolangkasa Selatan Village, Bontonompo District, Gowa Regency. The primary partner in the implementation of the agricultural water supply technology was the Jiwa Baru Borong Kanang Farmer Group. The program was implemented by a team from Universitas Negeri Makassar in collaboration with Universitas Islam Makassar, with support from the Bontolangkasa Selatan Village Government.

Activity Stages

The implementation method employed a participatory and application-oriented approach consisting of five stages: (1) socialization and needs identification; (2) training on system operation and maintenance; (3) technology implementation; (4) mentoring and evaluation; and (5) strengthening program sustainability. During the technology implementation stage, activities included site selection, borewell preparation, installation of solar panels and the water pump, installation of the water distribution network, functional testing, and hands-on operational practice with the community partner.

Evaluation

The progress-stage evaluation was conducted through field observation, functional testing of the technology, activity documentation, and participatory evaluation with the community partner. Initial indicators included system functionality, the ability to pump and distribute water, participation of farmer group members, and their ability to perform basic operation and maintenance procedures. Further quantitative indicators included water discharge, operating duration, irrigated land area, intensity of system utilization, and changes in crop productivity. These indicators will be completed and assessed during the final evaluation.

RESULT

Activity Results

The 2026 Village Empowerment Program (*program pemberdayaan desa binaan/pdb*) was implemented in Bontolangkasa Selatan Village, Bontonompo District, Gowa Regency, using a participatory approach with the Jiwa Baru Borong Kanang Farmer Group as the main community partner. The program consisted of five stages: socialization and needs identification, training on system operation and maintenance, technology implementation, mentoring and evaluation, and sustainability strengthening. During the technology implementation stage, the activities included site selection, borewell preparation, installation of photovoltaic panels and the water pump, installation of the water distribution network, functional testing, and hands-on operational practice with the community partner.

The target group consisted of members of the Jiwa Baru Borong Kanang Farmer Group whose maize cultivation activities were constrained by limited water availability, particularly on farmland dependent on rainfall. The program was implemented by a team from Universitas Negeri Makassar in collaboration with Universitas Islam Makassar, with support from the Bontolangkasa Selatan Village Government.

Implementation of the Solar-Powered Agricultural Water Supply System

The main achievement at the progress stage was the successful installation and initial operation of the agricultural water supply system. The system comprised a borewell as the groundwater source, photovoltaic panels as the energy source, a water pump, control components, and a distribution network connected to the agricultural area. Functional testing confirmed that groundwater could be pumped and conveyed to the farmland. This result demonstrates that the technology has reached an initial operational stage and provides the farmer group with an alternative water source to support maize cultivation.



Figure 1. The implementing team, community partners, and local residents at the agricultural water supply technology implementation site.

Community Participation and Skills Development

The program also strengthened the initial technical capacity of the community partner. Farmer group members were involved not only as recipients of the technology but also in site preparation, system operation, network inspection, water distribution management, and basic maintenance. Through this participatory process, members began to acquire practical skills in operating the solar-powered pumping system, checking the distribution network, regulating water flow, and carrying out simple maintenance procedures. These competencies are important for promoting greater independence in technology management after the formal mentoring period ends.



Figure 2. Community partner members participating in training and the implementation of agricultural technology.

Program Achievement and Initial Benefits

The program achieved its principal initial target, namely the establishment of a functioning solar-powered water supply system capable of delivering water to the agricultural area. The availability of this system provides an alternative source of agricultural water for maize cultivation, particularly during periods when rainfall is insufficient. In addition to the physical installation, the active participation of farmer group members in operating and maintaining the system indicates that the program has begun to develop local capacity for technology management.

At the current stage, quantitative indicators such as water discharge, operating duration, irrigated land area, intensity of utilization, changes in crop productivity, operational cost efficiency, and economic benefits are still being measured. Therefore, the results reported at this stage focus on system functionality, successful water delivery, community participation, and the acquisition of basic operational and maintenance skills rather than on final claims regarding productivity or economic improvement.

Sustainability of the Activity

The sustainability of the intervention requires more than the availability of physical infrastructure. Continued operation will depend on the designation of responsible operators, clear schedules for water use, routine maintenance procedures, systematic records of system utilization, and an appropriate mechanism for financing maintenance and repairs. These institutional arrangements are particularly important because the solar-powered water supply system forms part of the broader three-year PDB roadmap for strengthening maize production and agricultural mechanization. Overall, the progress-stage results indicate that the program has successfully introduced an operational solar-powered borewell system, improved access to agricultural water, encouraged active community participation, and developed basic skills in technology operation and maintenance. Further evaluation is required to determine the longer-term technical, agricultural, and economic benefits of the intervention.

DISCUSSION

The implementation results indicate that the solar-powered borewell system is technically feasible as an initial response to limited water availability for maize cultivation in Bontolangkasa Selatan Village. The successful installation of the borewell, photovoltaic panels, water pump, control components, and distribution network, followed by functional testing showing that water could be conveyed to the agricultural area, demonstrates that the intervention has reached an initial operational stage. This achievement directly addresses the priority problem identified by the Jiwa Baru Borong Kanang Farmer Group, namely inadequate access to water for agricultural activities.

Several factors contributed to the initial success of the program. First, the technology was selected according to the needs of the partner group and local agricultural conditions. The integration of groundwater with photovoltaic energy provides an alternative water supply without depending entirely on conventional electricity. Second, the implementation adopted a participatory approach involving the community partner in needs identification, site preparation, installation, functional testing, operation, and basic maintenance. This approach increased local involvement and supported the transfer of practical knowledge rather than limiting the program to equipment provision.

The results are consistent with previous studies on photovoltaic water pumping systems, which have identified solar-powered pumping as a technically relevant option for irrigation, particularly in rural and off-grid areas where conventional energy access is limited or costly (Yavuz et al., 2025). Previous community-based solar water pumping initiatives in Indonesia have also emphasized that long-term functionality depends not only on the technology itself but also on post-construction technical support, local capacity building, and effective community management (Edoun et al., 2023). Similarly, earlier agricultural community empowerment activities have shown that involving farmers in installation, training, and evaluation contributes to stronger ownership and technology adoption (Sulandjari et al., 2023).

Despite these positive achievements, several limitations remain. The current evaluation is still at the progress stage, and quantitative indicators such as water discharge, operating duration, irrigated area, utilization intensity, changes in productivity, and economic benefits have not yet been finalized (Salman et al., 2025). Therefore, the effectiveness of the intervention should not yet be interpreted in terms of increased maize productivity or cost efficiency. In addition, system performance may vary according to solar radiation, pump characteristics, water head, photovoltaic panel configuration, water demand, and maintenance practices. Continued field monitoring is therefore required to determine the reliability and efficiency of the system under actual operating conditions (Nazarychev et al., 2025).

The main impact observed at the current stage is an improvement in the partner group's capacity to manage the introduced technology. Farmer group members have begun to participate in system operation, distribution-network inspection, regulation of water delivery, and basic maintenance (Kaghazchi et al., 2022). These changes indicate the development of practical skills and greater involvement in managing agricultural water infrastructure. At the institutional level, the program has also encouraged a shift from dependence on rainfall toward the initial use of a more controllable agricultural water source. The availability of an operational borewell and solar-powered pumping system provides the farmer group with an alternative for supporting maize cultivation when rainfall is inadequate (Yavuz et al., 2025). This represents an improvement in the group's technological capacity and preparedness to manage water resources for agricultural production.

The current manuscript, however, does not yet provide quantitative evidence of changes in productivity, income, operating costs, irrigated area, or other economic outcomes. Consequently, the documented impact should presently be interpreted primarily as improved access to agricultural water, increased technological exposure, greater community participation, and strengthened basic operational and maintenance capacity (Santos et al., 2023). Quantitative impacts will require confirmation through the final evaluation.

Program sustainability will be strengthened through continued mentoring, periodic monitoring, and the development of clearer technology-management mechanisms within the farmer group. A designated operator or management team should be responsible for routine operation, inspection, and maintenance of the borewell, photovoltaic panels, pump, controller, and distribution network (Rasool et al., 2024). A utilization schedule should also be established to ensure equitable and efficient water distribution among agricultural plots. Routine monitoring should include records of operating hours, water discharge, irrigated area, frequency of use, maintenance activities, technical problems, and repair costs. These records can be used to evaluate system performance and provide an evidence base for operational adjustments. The farmer group should also establish a simple financing mechanism for routine maintenance and replacement of components when necessary, thereby reducing dependence on external assistance. These

institutional requirements are specifically identified in the manuscript as important for long-term system functionality.

The sustainability strategy is also linked to the broader three-year PDB roadmap. The second year focuses on strengthening agricultural production through water provision and maize planting equipment, while the third year is planned to extend mechanization through maize harvesting technology and stronger technology and business management. Accordingly, follow-up activities should integrate the solar-powered water system with subsequent cultivation, harvesting, post-harvest, and product-processing interventions rather than treating it as an isolated technology. Continued collaboration among the farmer group, Universitas Negeri Makassar, Universitas Islam Makassar, and the Bontolangkasa Selatan Village Government will be important for technical assistance, monitoring, and institutional strengthening.

CONCLUSION

The 2026 Village Empowerment Program in Bontolangkasa Selatan Village successfully achieved its main initial objective through the installation and operation of a solar-powered borewell system for the Jiwa Baru Borong Kanang Farmer Group. The system has been functionally tested and is capable of pumping and distributing water to agricultural land, providing the partner group with an alternative water source to support maize cultivation. In addition to the technological output, the program has strengthened the partners' practical capacity through their involvement in system operation, network inspection, water distribution management, and basic maintenance. Further program development should focus on strengthening operator competence, establishing clear group-based management and maintenance procedures, maintaining systematic records of system utilization, and conducting periodic performance evaluations. The next stage should also complete quantitative measurements of water discharge, operating duration, irrigated area, productivity, operational costs, and economic benefits. These measures are essential to provide stronger evidence of program effectiveness and to support the integration of the solar-powered water system with the broader agricultural mechanization roadmap.

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Conflict of Interest

The authors declare that they have no conflicts of interest related to the implementation, evaluation, or publication of this community engagement activity.

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