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Assessment of Solar-Powered Irrigation Systems (SPIS) for CY 2025 in NIA-UPRIIS Division VI

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***Abstract*: This study assessed the performance, efficiency, and operational effectiveness of Solar-Powered Irrigation Systems (SPIS) implemented in the National Irrigation Administration–Upper Pampanga River Integrated Irrigation Systems (NIA-UPRIIS) Division VI for Calendar Year 2025. Using a descriptive-evaluative research design, data were collected from 33 respondents, including Irrigators Association members, farmers, and NIA personnel, through structured surveys. The assessment focused on technical specifications, water delivery efficiency, system performance, technical issues, maintenance practices, and comparisons with conventional diesel- or electric-powered irrigation systems. Results indicate that SPIS generally meets technical requirements, delivers consistent water supply, and operates reliably under varying conditions, demonstrating higher cost efficiency and reduced maintenance demands compared with traditional systems. Key technical challenges identified include low water output, panel shading, and limited battery capacity, which may affect performance during periods of low sunlight. Respondents recommended improvements such as incorporating backup power units, enhancing site selection, using durable materials, and implementing regular maintenance schedules. Overall, SPIS proves to be a sustainable and effective alternative for irrigation, supporting agricultural productivity while offering opportunities for further optimisation in design and operation.**

***Keywords*: Solar-powered irrigation systems.**

1. The Problem and its Background

A. Introduction

The National Irrigation Administration–Upper Pampanga River Integrated Irrigation Systems (NIA-UPRIIS) Division VI has implemented Solar-Powered Irrigation Systems (SPIS) as part of its initiative to modernize irrigation and support sustainable agricultural production (NIA, 2025). SPIS aims to provide reliable, cost-efficient, and environmentally friendly irrigation, especially in areas with limited access to conventional power sources (Department of Agriculture, 2022). Previous studies have also evaluated the performance of SPIS in local settings, such as the study conducted in Nueva Ecija, which assessed solar-powered irrigation systems through surveys of farmers and technical personnel, highlighting system efficiency, technical issues, and user satisfaction (Merciales et al., 2022).

Despite the potential advantages of SPIS, its actual performance varies depending on installation quality, site conditions, system configuration, and maintenance practices. Assessing the effectiveness of SPIS in NIA-UPRIIS Division VI for Calendar Year (CY) 2025 is critical to identifying its strengths, limitations, and opportunities for improvement. This study evaluates technical specifications, efficiency of water delivery, system performance, encountered issues, and comparative advantages over conventional irrigation systems.

B. Conceptual Framework of the Study

As shown in Figure 1, the Input–Process–Output (IPO) Model serves as the study's foundation. The survey questions, related studies, and literature will all serve as a guide for the researcher. The process shows how the researcher will gather and examine data. The output displays the outcome of the data analysis in the assessment of the collected data.

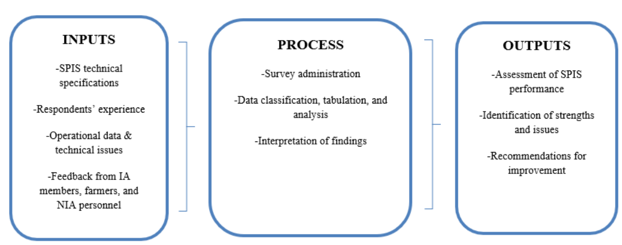

Fig. 1. Conceptual framework

C. Statement of the Problem

This study aims to assess the performance, adequacy, and operational effectiveness of Solar-Powered Irrigation Systems (SPIS) for CY 2025 in NIA-UPRIIS Division VI. It focuses on examining respondents' demographic profiles, particularly their years of experience in irrigation systems, and their assessments of SPIS technical specifications and configurations. The study also evaluates respondents' perspectives on the efficiency of water delivery, overall system performance, and the technical issues encountered during

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operation. Additionally, it considers the availability of maintenance support, system downtime, and comparisons between SPIS and conventional irrigation systems. Finally, the study seeks to gather insights that can inform recommendations for improving SPIS design, efficiency, and maintenance.

D. Scope and Limitation

The study focuses solely on Solar-Powered Irrigation Systems installed in NIA-UPRIIS Division VI for CY 2025. Respondents include IA members, farmers, and NIA engineers/personnel. The study is limited to survey-based assessment and does not include technical testing such as pump calibration, actual power output measurement, or hydraulic modelling.

E. Significance of the Study

This study will be undertaken to gather insights that can inform recommendations for improving SPIS design, efficiency, and maintenance of SPIS at NIA-UPRIIS Division VI. Benefiting the study are the various sectors as follow:

1) NIA Engineers and Personnel

The findings of this study will provide valuable insights to enhance strategic planning, optimize system design, and inform policy development for future Solar-Powered Irrigation System (SPIS) projects.

2) Farmers and Irrigators' Associations (IA) Members

The results will reflect user experiences and serve as a basis for targeted capacity-building programs, ensuring the effective and efficient operation of SPIS.

3) Local Government Units and Stakeholders

This study will inform evidence-based agricultural development planning and support the prioritization of investments in sustainable irrigation infrastructure.

4) Future Researchers

This study will serve as a foundational reference, offering baseline data for further investigations into renewable energy–powered irrigation systems and their operational effectiveness.

F. Definition of Terms

1. Solar-Powered Irrigation System (SPIS) – Irrigation system powered by solar energy to operate pumps for water delivery.
2. Irrigation – agricultural process of applying controlled amounts of water to land to assist in the production of crops, as well as to grow landscape plants and lawns, where it may be known as watering.
3. Technical Specifications – Design parameters such as pump capacity, wattage, controller type, and system configuration.
4. Efficiency – The level of output achieved relative to the expected performance.
5. System Performance – Overall reliability, stability, and operational behaviour of the SPIS.
6. Technical Issues – Operational problems affecting the system such as overheating, low water output, or pump malfunction.
7. NIA – Abbreviation, National Irrigation Administration.
8. UPRIIS – Abbreviation, Upper Pampanga River Integrated Irrigation Systems.

2. Method and Procedure

A. Research Design

The study uses a descriptive-evaluative research design, employing quantitative methods to assess respondents' perceptions of SPIS performance. Data were collected solely through a survey questionnaire, focusing on system efficiency, technical issues, maintenance support, and overall effectiveness. This approach allows for a focused evaluation of user experiences and opinions to inform improvements in SPIS implementation and management.

B. Locale of the Study

The study was conducted in the service areas under National Irrigation Administration–Upper Pampanga River Integrated Irrigation Systems (NIA-UPRIIS) Division VI, where Solar-Powered Irrigation Systems were installed and operational in CY 2025. This research was prepared by student of the Nueva Ecija University of Science and Technology as part of the requirements for the Master of Engineering Management course, specifically for the subject EnM 242: Research in Major Field.

C. Samples and Sampling Procedure

A total of 33 respondents participated in the study using purposive sampling. Respondents were selected based on their direct experience with SPIS.

D. Respondents of the Study

The researcher selected a diverse group of respondents for the study titled Assessment of Solar-Powered Irrigation Systems (SPIS) for CY 2025 in NIA-UPRIIS Division VI. The respondents include 10 Irrigators Association (IA) members, 11 farmers, and 12 NIA engineers or personnel who are directly involved in the operation and evaluation of irrigation systems. Their years of experience also vary, with 7 respondents having less than one year of experience, 6 respondents having one to three years, 13 respondents with four to six years, and 8 respondents with seven years and above. This varied level of experience ensures a comprehensive and reliable assessment for the study.

E. Research Instruments

In this study, the researcher utilized a structured questionnaire composed of seven parts to gather comprehensive and reliable data. Part I covered the respondents' profiles, while Part II focused on assessing the technical specifications of the Solar-Powered Irrigation Systems. Part III evaluated water delivery efficiency, and Part IV examined overall system performance. Part V was divided into two sections: Part V-A identified the technical issues encountered, and Part V-B assessed the maintenance practices implemented. Part VI provided a comparison between SPIS and conventional irrigation systems, and Part VII collected the respondents' recommendations for improving the system. This instrument ensured a systematic and thorough assessment of the SPIS implementation in NIA-UPRIIS Division VI.

F. Data Gathering Procedure

The researcher first obtained permission from NIA-UPRIIS Division VI to conduct the study. Surveys were administered to IA members, farmers, and NIA personnel through on-site visits and by providing a Google Form link for respondents who preferred an online format. After completion, the questionnaires, both printed and digital, were collected, tallied, and encoded for analysis. This combined approach ensured broader participation and accurate data collection.

G. Data Analysis Technique

Descriptive statistics such as frequency, percentage, and weighted mean were used to interpret the quantitative results of the study. Meanwhile, qualitative responses were examined and summarised through thematic analysis to identify common patterns, insights, and recurring themes. This combination of methods ensured a comprehensive understanding of the data collected.

3. Results and Discussion

A. Technical Specifications Assessment (Part II)

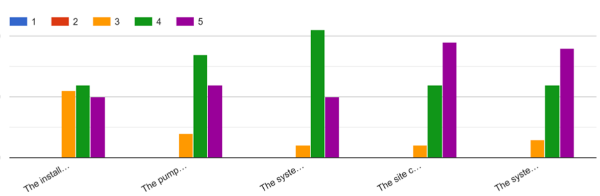

Fig. 2. Technical specifications and configurations

The survey results show in the Figure 2. that respondents generally agree that the Solar-Powered Irrigation System (SPIS) meets the required technical specifications and is installed correctly. The graph shows that most respondents rated the pump capacity, system configuration, site conditions, and adherence to project design as "Agree" or "Strongly Agree," indicating overall satisfaction with the system's performance. Statement 1, regarding the solar panel wattage, received slightly lower ratings, suggesting some variation in perception. Overall, the results demonstrate that the SPIS is properly configured and suitable for its intended operation.

B. Water Delivery Efficiency (Part III)

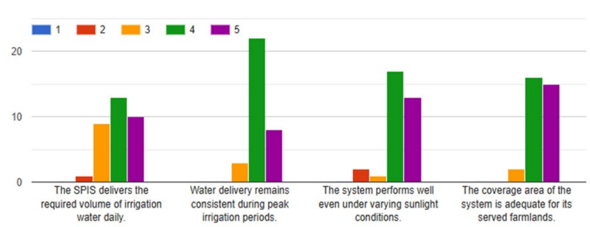

Fig. 3. Efficiency in water delivery

In Figure 3 illustrates respondents' ratings on the Efficiency in Water Delivery of the SPIS. Statement 1 shows most respondents rated 4 or 5, indicating that the system delivers the required daily irrigation volume. Statement 2 also received high ratings, with the majority agreeing that water delivery remains consistent during peak periods. For statement 3, performance under varying sunlight conditions was mostly rated 4 and 5, reflecting reliability even in less ideal conditions. Statement 4 shows strong agreement that the coverage area is adequate, with most respondents selecting 4 or 5. Overall, the chart highlights that respondents perceive the SPIS as efficient, consistent, and suitable for the farmland areas served.

C. System Performance (Part IV)

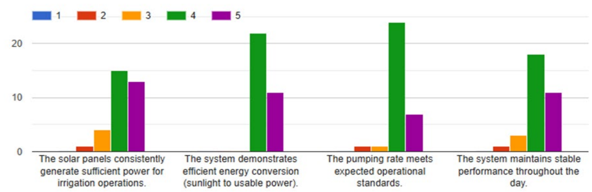

Fig. 4. System performance

The clustered bar chart in Figure 4 for Part IV presents respondents' ratings on the System Performance of the SPIS. Statement 1 shows that most respondents rated 4 or 5, indicating that the solar panels consistently generate sufficient power for irrigation. Statement 2 received similarly high ratings, reflecting efficient energy conversion from sunlight to usable power. For statement 3, the majority of respondents agreed that the pumping rate meets operational standards, while statement 4 shows that the system maintains stable performance throughout the day. These results suggest that, in addition to efficient water delivery, the SPIS is perceived as reliable, well-performing, and capable of sustaining its operations under varying conditions.

D. Technical Issues Encountered (Part V-A)

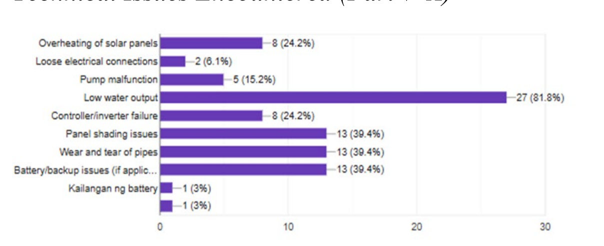

Fig. 5. Checklist of technical issues encountered

The horizontal bar chart in Figure 5 illustrates the frequency of technical issues encountered by respondents using the SPIS. "Low water output" is the most frequently reported problem, with 27 out of 33 respondents (81.8%) indicating it. Other notable issues, each reported by 13 respondents (39.4%), include "Panel shading issues," "Wear and tear of pipes," and "Battery/backup issues." "Overheating of solar panels" and "Controller/inverter failure" were each reported by 8 respondents (24.2%), while "Pump malfunction" was reported by 5 respondents (15.2%). Less commonly reported issues include "Loose electrical connections" (2 respondents, 6.1%)

and two additional minor concerns (1 respondent each, 3%). Overall, the chart shows that low water output is the primary technical challenge, followed by energy and maintenance-related issues, highlighting key areas for system improvement.

E. Maintenance and Downtime (Part V-B)

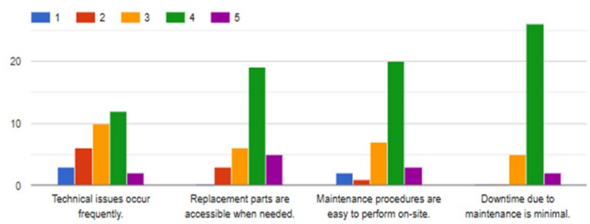

Fig. 6. Maintenance concerns

The findings in Part V-B shows in Figure 6 indicate generally positive maintenance-related experiences with the system. For the statement "Technical issues occur frequently," most respondents selected ratings 3 and 4, suggesting that while issues do occur, they are not perceived as severe or highly disruptive. Concerning the availability of replacement parts, the majority rated 4 and 5, indicating that parts are accessible when needed. Similarly, respondents showed favourable perceptions of on-site maintenance procedures, with most giving ratings of 4 and 5, reflecting that maintenance tasks are manageable and easy to perform. Lastly, ratings for "Downtime due to maintenance is minimal" were heavily concentrated at rating 4, further supporting the view that interruptions to system operation are generally limited. The overall results therefore highlight that the system is maintainable, with minimal downtime and accessible support components.

F. Comparison with Conventional Systems (Part VI)

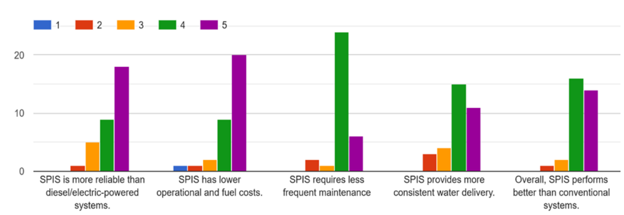

Fig. 7. Comparison with conventional irrigation systems

The results for Part VI shows in Figure 7, which assessed the respondents' comparison of the Solar-Powered Irrigation System (SPIS) with conventional diesel or electric-powered systems, show a strong positive perception of SPIS across all indicators. For the statement "SPIS is more reliable than diesel/electric-powered systems," most respondents rated 4 or 5, indicating high confidence in its reliability. A similar trend is seen in operational cost efficiency, where the majority strongly agreed that SPIS incurs lower fuel and operational expenses. Respondents also expressed favourable views regarding maintenance, with the highest concentration of ratings at 4 and 5, suggesting that SPIS requires less frequent maintenance compared with traditional systems. Moreover, water delivery performance was viewed positively, as most participants agreed that SPIS provides more consistent and dependable water supply. Overall, the collective ratings demonstrate that respondents regard SPIS as performing significantly better than conventional irrigation systems in terms of reliability, cost efficiency, maintenance, and operational consistency.

G. Recommendations for Improvement (Part VII)

For Part VII, respondents provided qualitative recommendations aimed at improving the design, performance, and maintenance of the Solar-Powered Irrigation System (SPIS). In terms of system design, many suggested incorporating batteries to store energy, using stronger and more durable materials, ensuring cost-effective components, and adding more solar panels to maintain power output during cloudy conditions. Respondents also emphasized selecting installation sites with maximum sunlight exposure to avoid shading. To enhance system performance and efficiency, the recommendations focused on reducing hydraulic losses, conducting regular monthly maintenance, upgrading both software and hardware, and ensuring proper panel placement and cleanliness. The use of energy-efficient pumps and integrating battery storage were also highlighted. Regarding maintenance and downtime reduction, respondents stressed the importance of scheduled inspections, proactive maintenance planning, daily system monitoring, and training farmers or operators in basic troubleshooting. Some also recommended creating a disaster recovery plan to ensure continuous operation. These insights collectively highlight practical strategies that can further strengthen SPIS reliability, efficiency, and long-term sustainability.

4. Finding, Conclusion & Recommendations

Based on the results of the assessment, the Solar-Powered Irrigation Systems (SPIS) installed for CY 2025 within NIA-UPRIIS Division VI have demonstrated strong reliability and overall effectiveness in supporting agricultural irrigation activities. Respondents, most of whom have 4–6 years of irrigation experience, confirmed that the technical specifications of the system are accurate and capable of delivering consistent water output suitable for field requirements. The system's energy-efficient performance and stable operation further indicate that SPIS offers a dependable alternative to conventional diesel or electric-powered irrigation systems. However, several technical concerns were observed, particularly low water discharge in some areas and limitations related to battery capacity, which affect system continuity during periods of low sunlight. Despite these issues, respondents noted that SPIS still performs better than traditional systems in terms of operational cost, reliability, and reduced maintenance demands. They also offered valuable recommendations for strengthening SPIS performance, such as incorporating batteries or backup power units to ensure uninterrupted water delivery, improving site selection to avoid shading, and using more durable materials to prolong equipment lifespan. Furthermore, respondents highlighted the importance of regular system inspections, monthly maintenance schedules, and proper training for farmers and IA operators to enhance troubleshooting capabilities and reduce downtime. With strengthened monitoring and documentation practices, SPIS can continue to improve and deliver long-term sustainability for irrigation communities in the division.

Appendix

SURVEY QUESTIONNAIRE
Title: *Assessment of Solar-Powered Irrigation Systems (SPIS) for CY 2025 in NIA-UPRIIS Division VI*
Respondents: IA Members, Farmers and NIA Engineers/Personnel

Part I. Respondent Profile
(Please tick ✓ or fill in the blank.)

2. **Position/Designation:**
   ☐ Irrigators Association Members
   ☐ Farmers
   ☐ NIA Engineers/Personnel
3. **Years of Experience with Irrigation Systems:**
   ☐ Less than 1 year
   ☐ 1–3 years
   ☐ 4–6 years
   ☐ 7 years and above

Part II. Technical Specifications and Configurations
(Research Question 1)
Please rate the accuracy, adequacy, and suitability of the system's technical setup.
Using the scale:
1 – Strongly Disagree | 2 – Disagree | 3 – Neutral | 4 – Agree | 5 – Strongly Agree

No.	Statement	1	2	3	4	5
1.	The installed solar panels match the required wattage for the pumping capacity.	☐	☐	☐	☐	☐
2.	The pump type and capacity are suitable for the water source conditions.	☐	☐	☐	☐	☐
3.	The system configuration (panels–controller–pump alignment) is installed correctly.	☐	☐	☐	☐	☐
4.	The site conditions (sunlight exposure, land area, angle) are adequate for optimal SPIS operation.	☐	☐	☐	☐	☐
5.	The system follows the technical specifications provided in the project design.	☐	☐	☐	☐	☐

Part III. Efficiency in Water Delivery
(Research Question 2)

No.	Statement	1	2	3	4	5
1.	The SPIS delivers the required volume of irrigation water daily.	☐	☐	☐	☐	☐
2.	Water delivery remains consistent during peak irrigation periods.	☐	☐	☐	☐	☐
3.	The system performs well even under varying sunlight conditions.	☐	☐	☐	☐	☐
4.	The coverage area of the system is adequate for its served farmlands.	☐	☐	☐	☐	☐

Part IV. System Performance (Energy Conversion & Pumping Rate)
(Research Question 3)

No.	Statement	1	2	3	4	5
1.	The solar panels consistently generate sufficient power for irrigation operations.	☐	☐	☐	☐	☐
2.	The system demonstrates efficient energy conversion (sunlight to usable power).	☐	☐	☐	☐	☐
3.	The pumping rate meets expected operational standards.	☐	☐	☐	☐	☐
4.	The system maintains stable performance throughout the day.	☐	☐	☐	☐	☐

Part V. Technical Issues and Maintenance Problems
(Research Question 4)
A. Checklist of Technical Issues Encountered
(You may check multiple.)
☐ Overheating of solar panels
☐ Loose electrical connections
☐ Pump malfunction
☐ Low water output
☐ Controller/inverter failure
☐ Panel shading issues
☐ Wear and tear of pipes
☐ Battery/backup issues (if applicable)
☐ Others (please specify): ___________________________

B. Maintenance Concerns

No.	Statement	1	2	3	4	5
1.	Technical issues occur frequently.	☐	☐	☐	☐	☐
2.	Replacement parts are accessible when needed.	☐	☐	☐	☐	☐
3.	Maintenance procedures are easy to perform on-site.	☐	☐	☐	☐	☐
4.	Downtime due to maintenance is minimal.	☐	☐	☐	☐	☐

Part VI. Comparison with Conventional Irrigation Systems
(Research Question 5)

No.	Statement	1	2	3	4	5
1.	SPIS is more reliable than diesel/electric-powered systems.	☐	☐	☐	☐	☐
2.	SPIS has lower operational and fuel costs.	☐	☐	☐	☐	☐
3.	SPIS requires less frequent maintenance.	☐	☐	☐	☐	☐
4.	SPIS provides more consistent water delivery.	☐	☐	☐	☐	☐
5.	Overall, SPIS performs better than conventional systems.	☐	☐	☐	☐	☐

Part VII. Recommendations for Improvement
(Research Question 6)
Please answer the following open-ended questions:

1. What improvements do you suggest for the design of the solar-powered irrigation systems?

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2. What suggestions do you have to enhance system performance and efficiency?

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3. What strategies can improve maintenance and reduce system downtime?

End of Questionnaire

References

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