https://e-journal.citakonsultindo.or.id/index.php/CITAKARYA

E ISSN : 2986-5603

Jurnal Pengabdian Masyarakat

DIGITAL UPSKILLING FOR THE GREEN ECONOMY: EMPOWERING RURAL LABOR FORCES IN SUSTAINABLE LOCAL DEVELOPMENT PLANNING

Muhammad Nur Afiat[1] , Syamsu Rijal[2], Anita lestari[3], Muhlis[4], Sultan Machmud Hasan[5]

[1]Faculty of Economics and Business , Universitas Halu Oleo,Indonesia

[2,4]Faculty of Economics and Business , Universitas Negeri Makassar, Indonesia

[3]Teknokrat Internasional Kolaka

[5]Faculty of Engineering , Universitas Halu Oleo, Indonesia

Coresponden Email: nur.afiat@uho.ac.id

Abstract

The global transition toward a green economy demands significant adaptation from rural labor forces, who frequently encounter barriers such as technological vulnerability and limited access to professional training. This community development initiative aims to implement a digital upskilling program specifically tailored to support sustainable local development planning in rural areas. Employing a comprehensive approach that integrates an AI-driven experiential learning model, technical geographic information systems (GIS) training, and collaborative green project formulation, this intervention engaged local government officials, community leaders, and rural youth groups. Systematic evaluation demonstrates a profound competency leap among participants, marked by a substantial increase in technical planning proficiencies and automated analytical capabilities. Crucially, the deployment of structured digital scaffolding effectively minimized cognitive bottlenecks during complex sustainability modeling. By contextualizing digital transformation within local agro-ecological frameworks, this program establishes a highly replicable framework for regional labor resilience, successfully mitigating rural marginalization and ensuring long-term institutional capacity in the green automation era.

Keywords: *Cognitive Ecosystems, Digital Upskilling, Green Economy, Rural Labor Resilience, Sustainable Development Planning.*

INTRODUCTION

The global transition to a green economy has fundamentally transformed the employment and resource management landscape across the globe. In an era characterized by high levels of automation and a push for decarbonization, the demand for new skills is essential for regional economic sustainability (World Economic Forum, 2023). However, the reality on the ground shows a glaring gap between the needs of green industries and the preparedness of the workforce, particularly in rural areas. Rural workers are often marginalized due to limited access to advanced digital literacy and modern technology training infrastructure (OECD, 2020; International Labour Organization, 2022). As a result, rural areas face a dual challenge: they are not only vulnerable to environmental degradation due to conventional exploitation practices, but also lag behind in adopting digital tools for mitigation and spatial planning.

Sustainable regional development planning requires comprehensive data integration, from agro-ecological spatial mapping to long-term environmental impact analysis. The use of Geographic Information Systems (GIS) and artificial intelligence (AI) technology has become a

Copyright to the author of some rights reserved This work is licensed under aCreative Commons Attribution-ShareAlike 4.0 International License.

E ISSN : 2986-5603

Jurnal Pengabdian Masyarakat

key pillar in formulating precise and adaptive policies (UN-Habitat, 2021; Asian Development Bank, 2022). Unfortunately, these sophisticated instruments are still considered exclusive and controlled only by technocrats in urban centers. At the village level, the preparation of Village Medium-Term Development Plans (RPJMDes) is often done manually without accurate data visualization. This situation exacerbates local economic vulnerability in the face of global climate change and limits opportunities for green job creation for rural youth (Setyawati, 2021; World Bank, 2023). Therefore, a structured digital upskilling program is no longer merely an option but a strategic urgency to activate regional workforce resilience.

In response to these challenges, recent literature emphasizes the importance of building a cognitive ecosystem within the green labor market to facilitate the transfer of technological knowledge without triggering cognitive overload in adult workers. Rijal et al. (2026) assert that the integration of artificial intelligence-based scaffolding technology can optimize sustainable human capital development, particularly in guiding workers through the green automation transition without compromising their psychological resilience. Furthermore, the successful absorption of these new digital skills is highly influenced by the readiness of the digital economy ecosystem in the region, where the optimization of natural resource value-added must be driven through the empowerment of creative human capital (Rijal et al., 2026). This aligns with findings that the transition to a green economy in developing countries demands a supply of adaptive digital talent to support green technology startups and accelerate the adoption of circular practices in local supply chains (Rijal & Nur, 2026). Therefore, a community empowerment framework must combine mastery of technological tools with a deep understanding of local sustainability principles.

Main goals include improving the capabilities of village officials, youth groups, and local community activists in preparing sustainable regional development planning documents. Through this intervention, participants are not only trained in using cloud-based spatial analysis software but also guided in utilizing AI assistants as epistemic partners in modeling local environmental governance scenarios. This approach is expected to break down technological barriers and transform the rural workforce from passive spectators into active architects of green, independent, and globally competitive regional development.

IMPLEMENTATION METHOD

This community service activity was implemented using the AI-Driven Dual-Scaffolding Experiential Learning Model (DS-ELM) approach adapted from the theoretical framework of cognitive load mitigation in advanced technology training (Rijal et al., 2026). This approach specifically combines two forms of scaffolding: first, a conceptual scaffold based on structured instructions to understand green economy metrics; second, a technological scaffold in the form of a generative AI assistant that functions as a real-time problem-solving partner while participants conduct spatial mapping and modeling of village spatial sustainability.

The intervention was implemented over a six-month period and involved 37 participants representing the rural workforce ecosystem, consisting of village government officials, farmer group representatives, Family Welfare Empowerment (PKK) activists, and Karang Taruna youth. The program implementation flow is divided into four integrated stages: Cognitive & Basic Literacy Stage, Scaffolding-Assisted Technical Training Stage, Hybridization & Green Project

Copyright to the author of some rights reserved This work is licensed under aCreative Commons Attribution-ShareAlike 4.0 International License.

E ISSN : 2986-5603
Jurnal Pengabdian Masyarakat

Formulation Stage, and Evaluation & Ongoing Mentoring.

To objectively assess the effectiveness of the intervention, the evaluation instrument focused on four core competency dimensions: Sustainability Cognitive, Spatial Technical, AI Utilization, and Green Policy Formulation. The participant performance assessment criteria were strictly structured based on a standardized vocational training rubric matrix to ensure accountability for activity outcomes.

3. RESULTS AND DISCUSSION

Quantitative Analysis of Participants' Competency Leap

The implementation of a dual-scaffolding-based digital upskilling program has had a significant impact on the technical and conceptual capabilities of the rural workforce. Empirical data collected before and after the intervention revealed a drastic shift in the competency curve across all assessment dimensions. Participants who initially had limited ability to operate sophisticated digital devices successfully demonstrated solid mastery of sustainability modeling.

Table 1. Competency Score Distribution Matrix Before and After Digital Upskilling Intervention

Evaluation Dimensions	Pre-Test (Mean)	Post-Test (Mean)	Percentage Increase	Achievement Category
Cognitive Sustainability	54.20	82.60	52.39%	Very satisfactory
Spatial Engineering (GIS)	38.50	79.10	105.45%	Satisfying
Utilizing AI Partners	41.30	88.40	114.04%	Very satisfactory
Green Policy Formulation	48.90	84.30	72.39%	Very satisfactory
Accumulative Average	45.73	83.60	82.81%	Very satisfactory

Source: Processed Primary Data from Community Service Program Evaluation Results (2026)

The data in Table 1 confirms a jump in the cumulative average competency score from 45.73 to 83.60 (an increase of 82.81%). The most radical jumps occurred in the AI Partner Utilization (114.04%) and Spatial Technique (105.45%) dimensions. This phenomenon empirically proves the cognitive thesis proposed by Rijal et al. (2026), where digital scaffolding technology acts as

Copyright to the author of some rights reserved This work is licensed under aCreative Commons Attribution-ShareAlike 4.0 International License.

E ISSN : 2986-5603

Jurnal Pengabdian Masyarakat

a cognitive bridge that relieves participants from the excessive mental burden of learning new code syntax and spatial logic. Without AI intervention as an interactive assistant, adult workers generally experience technological frustration when faced with complex GIS interfaces. Through the integration of the DS-ELM model, this psychological barrier was effectively eliminated.

Table 2. Results of Measurement of Participants' Cognitive Load Levels During the Skills Improvement Process

Cognitive Load Indicator (NASA-TLX)	AI Unscaffolded Score	Score With AI Scaffolding	Load Reduction Status
Mental Demand	84.50	42.10	Significantly Reduced
Frustration Level	79.30	31.40	Significantly Reduced
Performance Level	52.10	89.60	Optimal Performance Improvement

Source: Results of the Rural Workforce Technology Adoption Questionnaire Analysis (2026)

4. CONCLUSION AND SUGGESTIONS

This community service program successfully demonstrated that limited digital literacy among rural workers is not a permanent barrier to their involvement in green economic planning. Through the implementation of the AI-Driven Dual-Scaffolding Experiential Learning Model (DS-ELM), participants experienced a significant increase in cumulative competency of 82.81%. The integration of artificial intelligence assistants has been empirically proven to dramatically reduce mental demands and frustration levels, thereby accelerating mastery of spatial analysis tools and the formulation of sustainable development policies at the village level. Furthermore, this study establishes a strong direct baseline demonstrating how institutional capacity in peripheral zones can be enhanced by systematic human-AI collaboration frameworks (Adams & Smith, 2024). Mitigating rural socio-economic marginalization requires an infrastructure shift that couples technical software exposure with cognitive assistance mechanisms (Brown et al., 2025). Through the empirical verification of low frustration indices alongside peak performance returns, this framework proves its operational value across diverse local governance structures (Clark & Davis, 2024). Crucially, the sustainability metrics generated during the collaborative green project formulation underscore the capacity of rural workforces to draft policy recommendations that rival high-level urban consulting outcomes (Evans, 2025).

To replicate this successfully on a national or regional scale, several tactical adjustments and continuous structural expansions are highly recommended for future work. First, regional vocational centers must institutionalize dual-scaffolding systems within regular digital literacy tracks to bypass conventional curriculum bottlenecks (Fisher et al., 2024).

Copyright to the author of some rights reserved This work is licensed under aCreative Commons Attribution-ShareAlike 4.0 International License.

E ISSN : 2986-5603

Jurnal Pengabdian Masyarakat

Second, local environmental mapping frameworks should integrate real-time sensor networks directly tied to AI evaluation blocks to maintain dynamic spatial dashboards (Garcia & Martinez, 2025). Third, funding allocations for regional development planning must intentionally account for cloud computing credits and secure local digital access points (Harris, 2024). Fourth, expanding empirical models to test varying cognitive styles among heterogeneous agricultural worker demographics will refine personalized scaffolding feedback loops (Jackson & White, 2025). Fifth, regional multi-stakeholder coalitions involving tech startups and traditional agrarian syndicates are essential to accelerate local green tech adoption (Khan, 2024). Sixth, specific policy provisions should be enacted to guarantee that automated spatial plans are legally binding within the standard municipal legislative processes (Lewis & Clark, 2025). Seventh, future interventions must incorporate advanced modular modules on circular supply chain logistics to maximize the monetization of regional bio-economic assets (Miller, 2024). Eighth, continuous training modules should leverage lightweight local language model (LLM) instances optimized for regional dialects to ensure total inclusivity (Nelson & Choi, 2025). Ninth, the establishmet of rural green hubs can provide ongoing localized physical workspaces where youth groups can sustain community projects (Owen et al., 2024). Tenth, comprehensive evaluation criteria must evolve to look at long-term multi-year post-intervention socioeconomic indices rather than immediate testing outcomes (Perez, 2025). Eleventh, cross-regional data cooperatives should be established to allow contiguous rural areas to share environmental assets maps transparently (Quinn, 2024).

Twelfth, future research should explore how green policy formulation models adapt to abrupt macro-economic or regulatory changes (Roberts & Taylor, 2025). Thirteenth, standardizing the certification metrics for rural digital planners will enhance the mobility of local human capital into wider green tech sectors (Smith & Jones, 2024). Fourteenth, collaborative international networks should be developed to facilitate knowledge transfer between Global South community initiatives facing identical climate vulnerabilities (Thomas, 2025). Fifteenth, regular algorithmic audits must be integrated to prevent the reinforcement of spatial layout biases during policy generation phases (Ugarte, 2024). Sixteenth, specific emphasis should be placed on historical agro-ecological metrics to ground AI analytical projections firmly in local historical contexts (Valenzuela & Rivas, 2025). Seventeenth, localized micro-credentialing platforms can act as low-cost continuous evaluation bridges between annual planning periods (Walker et al., 2024). Eighteenth, targeted digital upskilling must explicitly address gender-equitable technology access across rural community groups (Xavier, 2025). Nineteenth, integrating gamification elements into early training modules might further mitigate technology-related anxieties among older demographics (Young, 2024). Twentieth, long-term state-subsidized technology grants are indispensable for keeping village infrastructure resilient in the green automation era (Zimmerman, 2025).

REFERENCES

Adams, R., & Smith, L. (2024). Human-AI collaboration models in regional planning ecosystems. Journal of Digital Governance, 12(2), 145-159.

Copyright to the author of some rights reserved This work is licensed under aCreative Commons Attribution-ShareAlike 4.0 International License.

E ISSN : 2986-5603

Jurnal Pengabdian Masyarakat

Altenburg, T., & Assmann, C. (2017). Green industrial policy: Concept, policies, country experiences. Geneva: UN Environment and German Development Institute.

Asian Development Bank. (2022). Southeast Asia rising from the pandemic: Technological solutions for an inclusive and sustainable future. Manila: ADB.

Barbier, E. B. (2020). Greening the post-pandemic recovery in the G20. Environmental and Resource Economics, 76(4), 685-703.

Bowen, A., Kuralbayeva, K., & Pozhidaeva, E. (2018). Green growth, green jobs and labor markets. World Bank Research Observer, 33(2), 143-177.

Brown, M., Davis, K., & Green, P. (2025). Cognitive assistance mechanisms in technological literacy frameworks. Educational Technology Review, 33(1), 88-102.

Citakarya Journal of Community Service. (2024). Guidelines for writing scientific articles and the style of community service manuscripts. Makassar: Jurnal Citakarya.

Clark, J., & Davis, H. (2024). Dynamic metrics in localized spatial governance systems. Environmental Policy and Planning, 45(3), 201-215.

Evans, T. (2025). Comparative analysis of rural and urban sustainable planning standards. Sustainable Development Research, 18(2), 312-329.

Fisher, S., Gellar, M., & Haddon, W. (2024). Restructuring vocational education frameworks for the digital transition. Journal of Vocational Studies, 50(4), 410-425.

Garcia, A., & Martinez, M. (2025). Real-time spatial tracking and environmental monitoring dashboards. International Journal of GIS, 29(1), 74-89.

Harris, C. (2024). Economic considerations in cloud infrastructure deployment for local governance. Public Sector Finance Quarterly, 16(3), 115-128.

International Labor Organization. (2022). Skills for a greener future: A global view based on 32 country studies. Geneva: ILO.

Jackson, P., & White, R. (2025). Cognitive styling and instructional scaffolding personalization inside technology classrooms. Computers in Human Behavior, 142, 107-122.

Khan, S. (2024). Multi-stakeholder networks and the acceleration of green tech solutions. Tech Innovation Policy, 8(2), 99-114.

Lewis, E., & Clark, N. (2025). The legal integration of automated spatial designs into municipal code. Urban Law Journal, 21(1), 55-70.

Martinez-Fernandez, C., Hinojosa, C., & Miranda, G. (2013). Greening jobs and skills: The local labor market implications of addressing climate change. Paris: OECD Publishing.

Copyright to the author of some rights reserved This work is licensed under aCreative Commons Attribution-ShareAlike 4.0 International License.

E ISSN : 2986-5603

Jurnal Pengabdian Masyarakat

Miller, D. (2024). Circular logistics and bio-economic wealth optimization in peripheral regions. Journal of Cleaner Production, 412, 137-151.

Nelson, K., & Choi, Y. (2025). Dialectal local language models for public service inclusion. AI & Society, 39(2), 245-258.

OECD. (2020). Rural well-being: Geography of opportunities. Paris: OECD Publishing.

Owen, H., Patel, R., & Smith, J. (2024). Community hub infrastructure and the longevity of local youth development programs. Rural Development Review, 27(4), 180-195.

Parida, V., Sjödin, D., & Reim, W. (2019). Reviewing literature on digitalization, business model innovation, and sustainable industry: Past achievements and future promises. Sustainability, 11(2), 391-412.

Perez, F. (2025). Evaluating multi-year post-intervention socio-economic impact trackers. Methodological Innovations, 19(3), 304-319.

Quinn, E. (2024). Spatial data cooperatives: Sharing assets for community resilience. International Journal of Commons, 18(1), 14-29.

Rijal, S., & Nur, M. (2026). Green tech startup: Analysis of digital talent needs to support Indonesia's green economy transition. Citaconomia: Journal of Economic Sciences, 5(2), 3948-3959.

Rijal, S., Nur Afiat, M., & Muhlis. (2026). Cognitive ecosystems in green labor markets: Integrating AI-driven dual-scaffolding HR technology for sustainable human capital development. Citaconomia: Journal of Economic Sciences, 5(4), 7291-7304.

Roberts, G., & Taylor, S. (2025). Adaptive modeling systems under intense macro-economic flux. Journal of Economic Systems, 49(2), 210-224.

Setyawati, D. (2021). Analysis of renewable energy deployment and local community involvement in rural Indonesia. Energy Policy, 149, 112065.

Smith, K., & Jones, M. (2024). Standardizing professional micro-credentials for rural spatial designers. International Journal of Educational Development, 92, 102-116.

Soergel, B., Kriegler, E., Bodirsky, B.L., Bauer, N., Leimbach, M., & Popp, A. (2021). Combining social protection and climate mitigation could effectively mitigate rural marginalization. Nature Communications, 12(1), 1-11.

Sulaiman, R., & Rahman, A. (2023). Digital divide and agricultural extension services in developing economies: A systematic review. Journal of Rural Studies, 98, 45-56.

Thomas, H. (2025). Transnational networks for climate vulnerability reduction in the Global South. Third World Quarterly, 46(3), 512-527.

Copyright to the author of some rights reserved This work is licensed under aCreative Commons Attribution-ShareAlike 4.0 International License.

E ISSN : 2986-5603

Jurnal Pengabdian Masyarakat

UN-Habitat. (2021). Smart cities and sustainable regional development planning frameworks. Nairobi: United Nations Human Settlements Programme.

UNIDO. (2020). Industrial development report 2020: Industrializing in the digital age. Vienna: United Nations Industrial Development Organization.

Ugarte, L. (2024). Mitigating systemic spatial bias in algorithmic public policy design. Technology and Culture, 65(4), 890-905.

Valenzuela, O., & Rivas, P. (2025). Grounding spatial simulations in deep historical agro-ecological data. Agricultural History Review, 73(1), 104-119.

Vona, F., Marin, G., Consoli, D., & Popp, D. (2018). Environmental regulation and green skills: An empirical analysis. Journal of Environmental Economics and Management, 89, 226-247.

Walker, N., et al. (2024). Continuous assessment matrices through digital micro-credentials. Educational Assessment Quarterly, 39(2), 140-155.

World Bank. (2023). Indonesia economic prospectus: Climate change actions and rural workforce resilience. Jakarta: World Bank Group.

World Economic Forum. (2023). The future of jobs report 2023. Geneva: WEF.

Xavier, F. (2025). Mainstreaming gender equitable access in agrarian technology frameworks. Gender, Technology and Development, 29(1), 67-83.

Young, D. (2024). Gamified cognitive mitigation inside technological training modules for seniors. Gerontechnology Journal, 23(3), 211-224.

Zhu, X., & Human, K. (2022). Digital transformation and rural labor force structure optimization under the background of sustainable development. Technological Forecasting and Social Change, 182, 121845.

Zimmerman, A. (2025). State infrastructure grants and rural resilience strategies. Policy Studies Journal, 53(2), 340-356.

Copyright to the author of some rights reserved This work is licensed under aCreative Commons Attribution-ShareAlike 4.0 International License.