

Table 1. Summary of the analytical cases and qualitative assessment of multisectoral interactions within the Philippine innovation ecosystem. Note: The table summarizes the 31 analytical cases included in the qualitative evidence synthesis, comprising 20 studies (2013–2018) and 11 studies (2020–2025). Fully included cases met the analytical inclusion criteria for the Triple Helix Innovation Model (THIM) and/or emerging Quadruple Helix Framework (QHF) interactions, whereas conditionally included cases provided complementary evidence of partial helix engagement. Structural, Functional, and Relational dimensions were qualitatively rated as Strong, Moderate, or Weak based on institutional integration, collaborative functionality, and the sustainability of multisectoral relationships. See Supplementary Tables S3–S6 for bibliographic and screening details.

Study ID	Author(s), Year, Title, DOI	Innovation Domain	Government	University	Industry	Community	Structural	Functional	Relational
<i>Analytical Inclusion: Fully include (n=4); Policy Period: 2013-2018</i>									
SID-a90	Sarmiento, C. (2018). Enhancing the Demands of ZAMPEN-SUCs AFNR Graduates Through Curriculum Intervention Using Modular Approach with High S & T Content. JPAIR Multidisciplinary Research. https://doi.org/10.7719/jpair.v32i1.583	AFNR education and entrepreneurship	DOST–PCAARRD (Funding, policy coordination, infrastructure support)	State Universities and Colleges (SUCs) (Knowledge production, curriculum enhancement, capacity building, implementation)	Agribusiness partners and enterprises (Mentoring, enterprise incubation, commercialization support)	Local communities and enterprise beneficiaries (Technology adoption, community-based enterprise development)	Strong – Institutionalized governance with clearly defined actor roles, formal funding mechanisms, and coordinated multisectoral collaboration.	Strong – Integrated technical training, entrepreneurship, capacity building, and enterprise development generated measurable innovation and employability outcomes.	Strong – Sustained partnerships supported mentoring, knowledge exchange, networking, and long-term collaboration among Quadruple Helix actors.
SID-a133	Real, R. R., Concepcion, S. B., Montiflor, M. O., Axalan, J. T., Lamban, R. J. G., Apra, D. I., ... & Rola-Rubzen, M. F. (2013). Impact of collaborative marketing on vegetable production systems: The case of clustering in the Southern Philippines. <i>Acta Horticulturae</i> , 1006, 303-308. https://doi.org/10.17	Agricultural cluster development	National and local government agencies (Technical guidance, policy coordination, production support)	Higher education institutions (HEIs) (Technical extension, farmer training, capacity building)	Institutional buyers, development partners, microfinance institutions, and NGOs (Financing, market access, enterprise support)	Farmer clusters and local communities (Technology adoption, collective production, collaborative marketing)	Strong – Coordinated cluster governance with clearly defined institutional roles and complementary support across Quadruple Helix actors.	Strong – Integrated technical extension, capacity building, production support, and market linkages strengthened productivity, enterprise development, and market access.	Strong – Sustained partnerships supported technical assistance, shared decision-making, knowledge exchange, and collaborative marketing beyond the project period.

	660/ActaHortic.2013.1006.38								
SID-a177	Aquino, M. C. G. (2014). More hours, more areas, better practicum training....?. Procedia-Social and Behavioral Sciences, 144, 264-272. https://doi.org/10.1016/j.sbspro.2014.07.295	Tourism workforce development	CHED, DOT, and international development partners (Regulation, policy coordination, quality assurance)	Higher education institutions (HEIs) (Curriculum implementation, experiential learning, competency development)	Tourism establishments and industry partners (Workplace training, mentorship, experiential learning)	Professional associations and community-based tourism organizations (Practicum coordination, stakeholder engagement, quality monitoring)	Strong – Institutionalized practicum governance with clearly defined actor roles, regulatory standards, and coordinated multisectoral collaboration.	Strong – Integrated academic preparation, experiential learning, industry mentorship, and regulatory oversight strengthened workforce competency and graduate employability.	Strong – Sustained partnerships supported stakeholder coordination, continuous mentoring, knowledge exchange, and institutional learning across Quadruple Helix actors.
SID-a180	Blanco, A. C., Tamondong, A., Perez, A. M., Ang, M. R. C., Paringit, E., Alberto, R., ... & Villar, R. (2016). Nationwide natural resource inventory of the Philippines using LiDAR: strategies, progress, and challenges. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 41, 105-109. https://doi.org/10.5194/isprs-archives-XLI-B6-105-2016	Geospatial innovation and resource mapping	National government agencies (NGAs) and local government units (LGUs) (Funding, policy coordination, implementation oversight)	Higher education institutions (HEIs) (LiDAR and GIS development, technical implementation, capacity building)	Private sector organizations (Technology application, product validation, innovation adoption)	LGUs, NGOs, and local communities (Knowledge sharing, map validation, local application)	Strong – Institutionalized governance with clearly defined actor roles, coordinated implementation, sustained government investment, and active multisectoral collaboration.	Strong – Integrated geospatial technologies, research, technical training, and collaborative workflows strengthened decision support, human capital, and resource management.	Strong – Sustained partnerships supported technical mentoring, collaborative mapping, knowledge exchange, and long-term adoption of geospatial innovations across Quadruple Helix actors.
Analytical Inclusion: Conditionally include (n=16); Policy Period: 2013-2018									
SID-a12	Makinano-Santillan, M., Santillan, J. R., Morales, E. M. O., Asube, L. C. S., Amora, A. M., Cutamora, L. C., &	Disaster risk reduction and geospatial decision support	MDRRMO and DOST (Technical coordination, geospatial resources,	Cagayan State University (CSU) (LiDAR and GIS development,	None documented	Local communities (End users of hazard information)	Moderate – Clearly defined government–university collaboration supported	Moderate – Integrated geospatial technologies, technical expertise, and	Moderate – Sustained government–university collaboration supported

	Makinano, R. M. (2016). Academic-local government partnership towards effective application of geospatial technologies for smarter flood disaster management at the local level: An example from Mindanao, Philippines. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 41, 109-115. https://doi.org/10.5194/isprs-archives-XLI-B8-109-2016		capacity building)	hazard mapping, technical training)			technical implementation, but limited industry and community participation constrained broader multisectoral integration.	local governance strengthened disaster preparedness and decision support, with innovation remaining focused on hazard mapping applications.	technical training, knowledge exchange, and project implementation, although engagement with industry and community actors remained limited.
SID-a23	Lim, C. S., Jolkifli, Z. H., Jair, A., Karim, N., Wahab, R. A., Desai, D. V., Krishnamurthy, V., ... & Anil, A. C. (2018). An inter-site study of biofouling recruitment on static immersion panels in major ports of South East Asia and India. ASEAN Journal on Science and Technology for Development, 35(1), 167-176. https://doi.org/10.29037/ajstd.496	Marine biofouling monitoring and environmental management	Philippine port authorities and the ASEAN Secretariat (Program coordination, technical guidance, logistical support)	University of the Philippines (UP), National University of Singapore (NUS), and CSIR–National Institute of Oceanography (Research, scientific implementation, capacity building)	None documented	Port personnel (Technical implementation, operational support)	Moderate – Clearly defined government–university collaboration supported scientific implementation, but limited industry and broader community participation constrained multisectoral integration.	Moderate – Collaborative research generated baseline biofouling data, standardized monitoring protocols, and strengthened technical capacity, with innovation remaining focused on environmental monitoring.	Moderate – Government–university partnerships supported joint fieldwork, technical training, and knowledge exchange, although limited engagement with industry and community actors restricted long-term multisectoral collaboration.

SID-a24	Mohammed, A. J., Inoue, M., Shivakoti, G. P., Nath, T. K., Jashimuddin, M., De Zoysa, M., Kaskoyo, H., Pulhin, J. M., & Peras, R. J. (2016). Analysis of National Forest Programs for REDD+ Implementation in six South and Southeast Asia countries. <i>Forest Systems</i>, 25(2), e061. https://doi.org/10.5424/fs/2016252-08801	Sustainable forest management and REDD+ governance	National government agencies and LGUs (Policy development, regulation, coordination, implementation)	Universities and research institutions (Environmental research, biodiversity assessment, policy analysis)	None documented (Limited project-specific participation)	Local communities, Indigenous Peoples, and CBFM organizations (Forest stewardship, conservation, local governance)	Moderate – Government-led governance with strong community participation and research support, but limited industry involvement and a peripheral university role constrained broader multisectoral integration.	Moderate – Integrated environmental governance, community-based forest management, and scientific assessment strengthened conservation outcomes, although innovation remained focused on resource management rather than technology development or commercialization.	Moderate – Government–community partnerships supported participatory forest management and knowledge exchange, but limited university integration and minimal industry participation constrained broader collaboration and innovation diffusion.
SID-a29	Evangelista, E. V., & Morales, M. P. E. (2015). Are We There Yet?- Exploring On-The-Job Training of The Philippine Pre-Service Biology Students. <i>International Journal Of Biology Education</i>, 4(1), 44-62. https://doi.org/10.20876/ijobed.58001	Research training and experiential learning	Government research agencies (Research infrastructure, operational support, professional supervision)	Philippine Normal University (PNU) (OJT coordination, academic supervision, experiential learning)	None documented	Limited community participation (No direct role in innovation activities)	Moderate – Government–university collaboration supported structured research training, but the absence of industry participation and minimal community engagement limited broader multisectoral integration.	Moderate – Structured OJT, research training, and experiential learning strengthened workforce preparation and capacity building, although innovation remained focused on educational outcomes rather than technology transfer or commercialization.	Moderate – Sustained government–university partnerships supported practical training, supervision, and knowledge exchange, but limited industry involvement and minimal community participation constrained broader cross-sector collaboration.

SID-a33	Gatbonton RRG. Assessment of educational experiences on professional nursing practice. Nurs Palliative Care Int. (2018);1(1):26-31. https://doi.org/10.30881/npcij.00007	Nursing education and graduate tracer studies	Commission on Higher Education (CHED) (Institutional guidance, tracer study framework)	College of Nursing (Tracer study implementation, curriculum evaluation, graduate outcome assessment)	None documented	Alumni (Graduate feedback, employment outcome reporting)	Weak – University-led curriculum evaluation with limited government involvement and minimal participation from industry and community actors resulted in weak multisectoral integration.	Moderate – Tracer study findings supported curriculum evaluation, program improvement, and graduate outcome assessment, although innovation activities remained primarily academic.	Weak – University–alumni interactions supported institutional learning and curriculum enhancement, but limited engagement with government, healthcare employers, and broader community stakeholders constrained sustained multisectoral collaboration.
SID-a34	Almazan, C. V., & Vargas, D. (2016). Assessment of Fisheries Governance: The Case of the Barangay Fisheries and Aquatic Resources Management Council (BFARMC) Empowerment in Tadalac, Los Baños Laguna. CLSU International Journal of Science & Technology (2016), 1(2), 34-44. https://doi.org/10.22137/ijst.2016.v1n2.05	Community-based fisheries governance and resource management	LLDA, BFAR, and Municipal Government (Policy direction, technical assistance, funding, governance)	University of the Philippines Los Baños (UPLB) (Technical advice, limited research support)	None documented	BFARMCs and local fishing communities (Resource stewardship, community-based fisheries management)	Weak – Government-led governance with limited university engagement, no meaningful industry participation, and weakly institutionalized community involvement resulted in limited multisectoral integration.	Weak – Collaboration supported fisheries governance, environmental stewardship, and community resource management, but demonstrated limited innovation, technology development, or cross-sector knowledge integration.	Weak – Government–community collaboration supported local resource management and capacity building, but limited university participation and the absence of industry engagement constrained sustained multisectoral partnerships and knowledge exchange.
SID-a47	Sylim, P., Liu, F., Marcelo, A., &	Blockchain-enabled	Food and Drug	University of the Philippines	Pharmaceutical	Consumers (Product	Moderate – Government	Strong – Integrated	Moderate – The

	Fontelo, P. (2018). Blockchain technology for detecting falsified and substandard drugs in distribution: pharmaceutical supply chain intervention. JMIR research protocols, 7(9), e10163. https://doi.org/10.2196/10163	pharmaceutical traceability	Administration (FDA) (Regulation, system oversight, compliance monitoring)	(UP) and National Institutes of Health (NIH) (Blockchain development, technical research, system validation)	manufacturers, wholesalers, and retailers (Product traceability, supply chain implementation, transaction verification)	authentication, post-market verification)	coordinated system governance, universities provided technical expertise, and industry supported operational implementation, while community participation remained limited to end-user verification, resulting in partial Quadruple Helix integration.	blockchain technology, smart contracts, GS1 standards, pharmaceutical traceability, anomaly detection, and consumer verification into a coordinated innovation platform demonstrating strong technological integration.	blockchain platform enabled structured information exchange and transaction verification among participating actors, although collaboration was demonstrated primarily through simulation with limited evidence of sustained real-world multisectoral implementation.
SID-a55	Bayudan-Dacuycuy, C., & Lim, J. A. (2014). Chronic and transient poverty and vulnerability to poverty in the Philippines: Evidence using a simple spells approach. Social Indicators Research, 118(1), 389-413. https://doi.org/10.1007/s11205-013-0409-5	Poverty analysis and socioeconomic policy research	Philippine Statistics Authority (PSA) (National data infrastructure, statistical data provision)	Research team (Data analysis, evidence generation, policy research)	None documented	Surveyed households (Survey participation, data provision)	Weak – Government provided data infrastructure while the research team generated knowledge, but the absence of industry participation and community involvement beyond data provision resulted in weak multisectoral integration.	Moderate – Analysis of national survey data generated evidence on poverty patterns and socioeconomic determinants to inform policy, although no collaborative intervention, technology development, or cross-sector innovation activities were documented.	Weak – Interaction was largely limited to the use of government-generated datasets for academic analysis, with little evidence of sustained collaboration, knowledge co-production, or long-term multisectoral partnerships.

SID-a58	Calva, J. C. (2018). Community-based organizations: Role on coastal resource management in the Sarangani Bay area. <i>Journal of Health Research and Society</i> , 1, 1-1. https://doi.org/10.34002/jhrs.v1i0.7	Community-based coastal resource management	LGUs, BFAR, DENR, DOLE, and CENRO (Technical assistance, funding, capacity building, environmental governance)	Mindanao State University–General Santos City (MSU-GSC) (Research, program evaluation, evidence generation)	None documented (Limited support from private foundations)	Community-based organizations (CBOs), coastal communities, and NGOs (Coastal resource management, environmental stewardship, livelihood development)	Moderate – Community organizations, supported by government agencies and academic institutions, formed the core of the governance structure, but limited industry participation constrained broader multisectoral integration.	Moderate – Collaboration strengthened coastal resource management, environmental conservation, community participation, and livelihood development, although there was limited evidence of technological innovation or formal knowledge co-production.	Moderate – Community–government partnerships supported collective action and knowledge sharing, but sustained university–government–industry collaboration remained limited, restricting broader innovation-driven collaboration.
SID-a59	Baticados, D. B., Agbayani, R. F., & Qunitio, E. T. (2014). Community-based technology transfer in rural aquaculture: the case of mudcrab <i>Scylla serrata</i> nursery in ponds in northern Samar, Central Philippines. <i>Ambio</i> , 43(8), 1047-1058. https://doi.org/10.1007/s13280-014-0528-5	Sustainable mud crab aquaculture	LGUs and BFAR (Regulatory oversight, implementation support, institutional coordination)	SEAFDEC/AQD and academic partners (Technology development, technical training, program evaluation)	None documented	People's Organizations (POs), smallholder mud crab growers, and NGOs (Technology adoption, aquaculture management, livelihood development)	Moderate – Universities provided technical leadership, government supported implementation and regulation, and community organizations served as primary adopters, but limited industry participation constrained broader multisectoral integration.	Moderate – Collaboration strengthened sustainable aquaculture, technical capacity, environmental stewardship, and community livelihoods, although there was limited evidence of technology commercialization, policy innovation, or innovation scaling.	Moderate – Partnerships among researchers, government agencies, NGOs, and community organizations supported training, technical assistance, and knowledge exchange, but weak industry linkages limited broader innovation diffusion and sustained multisectoral collaboration.

SID-a69	Aranas, R. K. D., Jiao, B. J. D., Magallon, B. J. P., Ramos, M. K. F., Amado, J. A., Tamondong, A. M., & Tupas, M. E. A. (2016). Design of a Free and Open Source Data Processing, Archiving, and Distribution Subsystem for the Ground Receiving Station of the Philippine Scientific Earth Observation Micro-Satellite. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 41, 909-911. https://doi.org/10.5194/isprs-archives-XLI-B7-909-2016	Geospatial cyberinfrastructure and digital research platforms	DOST–PCIEERD (Research funding, strategic oversight, capacity building)	University of the Philippines Diliman and Hokkaido University (System development, technical research, digital infrastructure)	None documented	Government agencies, GIS practitioners, researchers, and the general public (Platform utilization, geospatial data access)	Moderate – Universities led technical development while government provided funding and institutional support, but limited industry participation and end-user involvement beyond platform use constrained broader multisectoral integration.	Moderate – Collaboration developed digital research infrastructure, strengthened technical capacity, and expanded access to geospatial information through open-source technologies, although technology commercialization and broader innovation adoption remained limited.	Moderate – Collaboration developed digital research infrastructure, strengthened technical capacity, and expanded access to geospatial information through open-source technologies, although technology commercialization and broader innovation adoption remained limited.
SID-a71	Weeks, R., Aliño, P. M., Atkinson, S., Beldia, P., Binson, A., Campos, W. L., ... & White, A. T. (2014). Developing marine protected area networks in the Coral Triangle: good practices for expanding the Coral Triangle marine protected area system. Coastal Management, 42(2), 183-205. https://doi.org/10.10	Marine protected area planning and coastal biodiversity conservation	National, provincial, and local government agencies (Regulatory oversight, policy implementation, marine protected area governance)	Universities and research institutions (Biodiversity assessment, conservation planning, technical advice)	Fisheries and tourism operators (Resource utilization, regulated participation)	Local communities, People's Organizations (POs), and NGOs (Participatory planning, resource monitoring, community-based conservation)	Moderate – Government agencies, universities, and community organizations formed the core governance structure, while private-sector participation remained peripheral, resulting in partial Quadruple	Moderate – Collaboration strengthened participatory governance, biodiversity conservation, scientific planning, and capacity building through the integration of scientific and local knowledge, although	Moderate – Government, universities, NGOs, and local communities collaborated through participatory planning, conservation, and knowledge exchange, but limited private-sector engagement constrained

	80/08920753.2014.877768						Helix integration.	innovation remained focused on environmental governance rather than technology development or commercialization.	broader innovation diffusion and sustained multisectoral collaboration.
SID-a76	Spangenberg, J. H., Heong, K. L., Klotzbücher, A., Klotzbücher, T., Nguyen, Q. A., Tekken, V., ... & Settele, J. (2018). Doing what with whom? Stakeholder analysis in a large transdisciplinary research project in South-East Asia. Paddy and water environment, 16(2), 321-337. https://doi.org/10.1007/s10333-018-0634-2	Ecological engineering and participatory agricultural innovation	Municipal, provincial, and national government agencies (Regulatory support, stakeholder coordination, implementation on facilitation)	Universities and research institutions (Ecological engineering, participatory research, capacity building)	None documented	Farmers, farm workers, local communities, and community-based organizations (Knowledge co-production, participatory implementation, ecological practice adoption)	Strong – Government agencies, universities, and community actors were well integrated through structured participatory mechanisms, although limited industry participation prevented full Quadruple Helix integration.	Moderate – Collaboration strengthened knowledge co-production, participatory learning, ecological engineering, and local capacity building, but evidence of technology commercialization, policy innovation, and broader economic innovation remained limited.	Moderate – Universities, government agencies, and community actors developed strong partnerships through participatory research and continuous knowledge exchange, but limited private-sector engagement and weaker coordination across governance levels constrained broader innovation diffusion and sustained multisectoral collaboration.
SID-a93	Roxas Jr, N. R., Fillone, A. M., & Roquel, K. I. D. (2018). Estimating the environmental	Transport modeling and decision-support systems	DOST–PCIEERD, DOTr, and MMDA (Research	University research team (Transport modeling, data analysis,	None documented	Private vehicle users (Travel behavior data provision)	Moderate – Government and universities collaborated through	Moderate – Collaboration developed transport models,	Weak – Universities primarily generated research

	effects of the car shifting behavior along EDSA. GEOMATE Journal, 14(44), 8-14. https://geomatejournal.com/geomate/article/view/1712		funding, transport data, institutional support, policy alignment)	decision-support system development)			research funding and data sharing, but limited industry participation and community involvement beyond data provision resulted in partial multisectoral integration.	analytical tools, and decision-support outputs for transportation planning, although operational deployment, technology transfer, and broader innovation adoption remained limited.	outputs for government use, with limited opportunities for sustained knowledge co-production or meaningful engagement with industry and community actors, resulting in weak multisectoral collaboration.
SID-a99	Patacsil, F. F., & Tablatin, C. L. S. (2017). Exploring the importance of soft and hard skills as perceived by IT internship students and industry: A gap analysis. Journal of Technology and Science education, 7(3), 347-368. https://doi.org/10.3926/jotse.271	Internship-based workforce development	Commission on Higher Education (CHED) (Regulatory framework, practicum standards)	University (Survey implementation, curriculum evaluation, workforce competency assessment)	Industry partners (Internship provision, workplace supervision, competency feedback)	Students (Internship participation, workforce preparedness feedback)	Moderate – Universities and industry partners collaborated through structured internship programs supported by a government regulatory framework, but limited community participation resulted in partial Quadruple Helix integration.	Moderate – Collaboration generated evidence to support curriculum improvement, workforce preparation, and university–industry alignment, although broader innovation outcomes, technology transfer, and sustained multisectoral innovation remained limited.	Weak – Interactions centered on internship implementation and feedback collection, with limited opportunities for long-term knowledge co-production, collaborative curriculum development, and sustained multisectoral partnerships.
SID-a276	Blanco, A. C., Tamondong, A. M., Perez, A. M. C., Ang, M. R. C. O., &	Nationwide geospatial mapping and	DOST–PCIEERD, national government	University of the Philippines Diliman (UPD) and 15	None documented	Research assistants, local communities,	Strong – Government and universities established a	Moderate – Collaboration produced standardized	Moderate – Universities, government agencies,

	Paringit, E. C. (2015). The Phil-LiDAR 2 program: National resource inventory of the Philippines using LiDAR and other remotely sensed data. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 40, 1123-1127. https://doi.org/10.5194/isprsarchives-XL-7-W3-1123-2015	digital infrastructure	agencies (NGAs), and local government units (LGUs) (Research funding, policy support, geospatial data access, implementation on coordination)	partner universities (Geospatial methodology development, technical coordination, capacity building)		and LGUs (Field data collection, validation, implementation support)	coordinated nationwide network through shared research infrastructure, clearly defined institutional roles, and multi-university collaboration, although limited industry participation prevented full Quadruple Helix integration.	geospatial workflows, national mapping datasets, methodological innovations, and substantial capacity building, but evidence of technology commercialization, large-scale policy transformation, and broader socioeconomic innovation remained limited.	research assistants, and LGUs engaged in sustained knowledge exchange, technical training, and collaborative research, but limited private-sector engagement and indirect community participation constrained broader innovation diffusion and long-term multisectoral collaboration.
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Analytical Inclusion: Fully include (n=5); Policy Period: 2020-2025

SID-b100	Lu, J. L., & Marcelo, P. G. F. (2021). Assessment of the Context for eHealth Development in the Philippines: A Work in Progress from 1997 to 2020. Acta Medica Philippina, 681-692. https://doi.org/10.47895/amp.v55i6.3208	National telehealth and digital health systems	DOH, DOST, PhilHealth, LGUs, ASTI, and PREGINET (Policy development, funding, ICT infrastructure, system implementation)	National Telehealth Center (UP Manila), UP-Philippine General Hospital, and Ateneo de Manila University (Technology development, eHealth research, system integration, capacity building)	SMART Communications, SHINE OS+, technology developers, hospitals, and healthcare providers (Digital infrastructure, technology deployment, clinical implementation)	Patients, healthcare professionals, local health workers, and partner healthcare institutions (Telehealth adoption, service delivery, referral support)	Strong – Clearly institutionalized roles, coordinated governance, dedicated funding, interoperable digital infrastructure, and active participation from all Quadruple Helix actors established a highly integrated innovation ecosystem.	Strong – Collaboration integrated policy development, research, digital infrastructure, technology innovation, financing, capacity building, interoperability, and healthcare service delivery, enabling nationwide implementation	Strong – Sustained partnerships among government, universities, industry, healthcare providers, and communities supported continuous knowledge exchange, joint technology development, interoperable digital platforms, and coordinated implementation
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								n of telehealth innovations.	n, demonstrating a mature multisectoral innovation ecosystem.
SID-b171	Garcia, Y. T., Garcia, M. E. T., & Garcia, A. G. (2020). Commercializing the Milkfish Hatchery-Bred Fry Industry in the Philippines: A Welfare Analysis. <i>HOLISTICA–Journal of Business and Public Administration</i> , 11(3), 25-45. https://doi.org/10.2478/hjbpa-2020-0030	Sustainable aquaculture and hatchery technology commercialization	DOST–PCAARRD, BFAR, PSA, and NIFTDC (Research funding, policy coordination, technology dissemination, capacity building)	SEAFDEC–Aquaculture Department (SEAFDEC-AQD) and University of the Philippines Visayas (UP Visayas) (Technology development, collaborative research, technology transfer, technical assistance)	Hatchery operators, grow-out operators, fry suppliers, and aquaculture enterprises (Technology commercialization, innovation adoption, aquaculture production)	Fish farmers, local aquaculture practitioners, and consumers (Technology adoption, aquaculture practice implementation, innovation diffusion)	Strong – Clearly defined institutional roles, coordinated research partnerships, formal funding mechanisms, technology transfer arrangements, and active participation from all Quadruple Helix actors established a highly integrated innovation ecosystem.	Strong – Collaboration integrated research and development, funding, technology transfer, regulatory support, workforce training, commercialization, and large-scale aquaculture production, generating measurable economic and livelihood benefits.	Strong – Sustained partnerships among government agencies, research institutions, industry, and aquaculture communities supported continuous knowledge exchange, technical assistance, technology transfer, commercialization, and widespread innovation diffusion, demonstrating a mature multisectoral innovation ecosystem.
SID-b247	Milagroso, M. I. (2020). Development and Evaluation of Internet-based Geographic and Environment Biodiversity Information System in Nueva Ecija. <i>CLSU International</i>	Biodiversity information systems and environmental monitoring	PENRO–Nueva Ecija, DENR, and the LAWIN System (Environmental governance, biodiversity monitoring,	Tarlac State University (TSU) and Central Luzon State University (CLSU) (Technical support, system development,	ICT specialists (System evaluation, technical validation, usability improvement)	Government personnel, biodiversity committee members, environmental practitioners, and community users (System utilization,	Strong – Institutionalized governance, integrated information systems, clearly defined operational roles, and active participation from all	Strong – Collaboration integrated digital technologies, biodiversity monitoring, system development, technical evaluation,	Strong – Sustained collaboration among government agencies, universities, ICT specialists, and community users

	Journal of Education and Development, 1(1), 36-48. https://ijeds.clsu.edu.ph/index.php/clsuijeds/article/view/ijeds.2020.v1n1.04		system coordination)	capacity building)		environmental monitoring, decision support)	Quadruple Helix actors established a highly integrated environmental innovation ecosystem.	capacity building, and evidence-based decision support, strengthening environmental governance and operational effectiveness.	supported continuous system evaluation, knowledge exchange, institutional coordination, and iterative system improvement, demonstrating a mature multisectoral innovation ecosystem.
SID-b694	Valenzuela, R. V. (2022). Significant Contributions of University Business Incubators in Enhancing the Business Graduates' Employability and Technopreneurship. International Journal of Multidisciplinary: Applied Business and Education Research, 3(7), 1-1. https://doi.org/10.11594/ijmaber.03.07.18	Technology business incubation and technopreneurship	CHED, DOST, DTI, IPOPHL, Land Bank of the Philippines (LBP), Cooperative Banks, and LGUs (Policy development, funding, intellectual property support, financing, institutional coordination)	Cagayan State University (CSU), Isabela State University (ISU), and Nueva Vizcaya State University (NVSU) (Business incubation, entrepreneurship education, technology transfer, research commercialization)	Start-ups, technopreneurs, incubatees, financial institutions, private enterprises, and commercialization partners (Technology commercialization, enterprise development, financing, innovation scaling)	Students, graduates, cacao growers, local entrepreneurs, and community-based enterprises (Entrepreneurship, technology adoption, enterprise development)	Strong – Institutionalized policies, university-based incubators, financing mechanisms, intellectual property support, and active participation from all Quadruple Helix actors established a highly integrated innovation ecosystem.	Strong – Collaboration integrated entrepreneurship education, research and development, business incubation, intellectual property protection, financing, technology commercialization, and enterprise development, generating measurable innovation and regional economic outcomes.	Strong – Sustained partnerships among government agencies, universities, industry, financial institutions, and community stakeholders supported mentoring, funding, incubation, commercialization, and continuous knowledge exchange, demonstrating a mature multisectoral innovation ecosystem.
SID-b695	Hernandez, J., & Reyes, J. (2022). Situational Analysis	Science- and technology-based social	DOST, DSWD–SLP, LGUs, CDA,	Benguet State University (BSU),	MSMEs, social enterprises,	Community-based organizations,	Strong – Institutionalized funding	Strong – Collaboration integrated	Strong – Sustained partnerships

	of Selected S&T-Based Social Enterprises in Batangas Province, Philippines toward a Policy Framework. International Journal of Management and Development Studies, 11(03), 01–15. https://doi.org/10.53983/ijmds.v11n03.001	enterprise development	SEC, FDA, DOLE, FNRI, PTRI, and partner agencies (Research funding, technology transfer, regulatory support, enterprise development)	University of Baguio (UB), and SEARCA (Technical training, capacity building, research support, innovation diffusion)	and private-sector market partners (Product development, commercialization, marketing, enterprise operations)	cooperatives, local associations, producers, and beneficiary groups (Technology adoption, enterprise development, livelihood generation)	mechanisms, regulatory systems, technology transfer programs, and coordinated enterprise development initiatives supported active participation from all Quadruple Helix actors, establishing a highly integrated innovation ecosystem.	research funding, technology transfer, technical training, regulatory support, enterprise development, commercialization, and community livelihood generation, producing measurable economic and social outcomes.	among government agencies, universities, enterprises, cooperatives, and community organizations supported continuous funding, technology transfer, capacity building, marketing assistance, enterprise mentoring, and knowledge exchange, demonstrating a mature multisectoral innovation ecosystem.
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Analytical Inclusion: Conditionally include (n=6); Policy Period: 2020-2025

SID-b110	Santos, A. B. G., Balba, N. P. & Rebong, C. B. (2021). Attendance Monitoring System of Schools in the Philippines with an Inclusion of Optimization Query Algorithm. International Journal of Innovative Technology and Exploring Engineering (IJITEE), 10(8), 142–146. https://doi.org/10.35240/ijitee.v10i8.142146	ICT-enabled educational administration	Department of Education (DepEd), Commission on Higher Education (CHED), school administrators, and partner educational institutions (Policy direction, governance, institutional oversight, system	Researchers, teachers, and participating higher education institutions (System development, implementation, validation, educational integration)	None documented	Students and parents (System utilization, attendance monitoring, communication support)	Moderate – Government, universities, and community actors established clearly defined institutional roles supporting system implementation, but the absence of private-sector participation limited broader Quadruple	Moderate – Collaboration developed and implemented an ICT-enabled attendance monitoring system that improved educational administration, classroom management, and reporting, although innovation remained	Weak – Collaboration was primarily operational, with government providing oversight, universities leading system development, and community actors serving as users, resulting in limited knowledge co-
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	940/ijitee.H9149.0610821		implementati on)				Helix integration.	confined to the education sector without evidence of technology commercializa tion or broader cross-sector innovation.	production, sustained knowledge exchange, and long-term multisectoral partnerships.
SID- b209	Durango, D. B. . (2022). Crops pests and diseases management system using android and GIS platform for the department of agriculture, province of samar. South Florida Journal of Development, 3(2), 2546–2553. https://doi.org/10.46932/sfjdv3n2-076	GIS-enabled agricultural pest surveillance	Department of Agriculture (DA), Agricultural Technologists (AT), Provincial Agriculturists (PA), and the Regional Crop Protection Center (RCPC) (Pest surveillance, data coordination, regulatory oversight, decision support)	Cagayan State University– College of Information Technology (CIT-U) and agricultural scientists (GIS system development, technical support, scientific analysis)	None documented	Farmers (Field data provision, pest reporting, agricultural surveillance)	Moderate – Government agencies, and farming communities established clearly defined institutional roles within a government-led surveillance system, but the absence of private-sector participation limited broader Quadruple Helix integration.	Moderate – Collaboration developed and implemented a GIS-enabled monitoring system that strengthened pest surveillance, data management, and evidence- based decision- making, although innovation remained focused on operational monitoring without evidence of commercializa tion or broader technology diffusion.	Weak – Government agencies coordinated surveillance, universities provided technical expertise, and farmers contributed field data, but collaboration remained largely operational with limited knowledge co- production, reciprocal learning, and sustained multisectoral partnerships.
SID- b318	Macaraeg, E. C., Rivera, C. G., Rosa, D., Dominguez, R., & Dizon, J. R. C. (2021). Establishment of An Academic Makerspace at the Bataan Peninsula	Makerspaces, innovation hubs, and technopreneurshi p	DOST, DOST– PCIEERD, CHED, DTI, and the City Government of Balanga (Policy development,	Bataan Peninsula State University (BPSU), Saint Louis University (SLU), Miriam College,	MSMEs, SM Group, and private-sector collaborators (Prototyping support, infrastructure assistance,	Students, faculty members, aspiring entrepreneurs, innovators, and local technology users	Moderate – Government, universities, industry, and community actors established coordinated innovation	Moderate – Collaboration established makerspaces, fabrication laboratories, and technopreneurs hip hubs that	Weak – Government provided policy and funding, universities managed innovation facilities,

	State University: Prospects and Challenges. Advance Sustainable Science, Engineering and Technology, 3(2), 372085. https://doi.org/10.26877/asset.v3i2.9655		funding, innovation infrastructure, ecosystem facilitation)	AMReL, MakerLab, and the SLU TechHub ecosystem (Makerspace management, prototyping, entrepreneurship education, innovation support)	technology collaboration)	(Innovation participation, prototype development, entrepreneurship, capacity building)	infrastructure and clearly defined institutional roles, although collaboration remained primarily infrastructure-driven with limited sustained industry integration.	strengthened research, prototyping, innovation education, and entrepreneurial capacity, but evidence of sustained commercialization, innovation scaling, and long-term cross-sector innovation remained limited.	industry offered limited technical support, and community actors primarily served as users, resulting in collaboration centered on resource provision rather than sustained knowledge co-production and long-term multisectoral partnerships.
SID-b469	Valleser, V. C., Dayondon, G. R., Arbes, J. L., Melencion, A. B., & Cosrojas, K. D. J. (2020). Is Sociodemographic Profile of Project-Cooperator Essential on the Success of Cacao Plantation Establishment?. Agricultural Socio-Economics Journal, 20(2), 97-106. https://doi.org/10.21776/ub.agrise.2020.020.2.2	Cacao production and agricultural technology transfer	DOST–PCAARRD and LGUs (Research funding, program coordination, agricultural extension support)	Central Mindanao University (CMU) (Technology transfer, technical training, agricultural extension, capacity building)	None documented	Farmer-cooperators and local farming communities (Technology adoption, cacao production, agricultural practice implementation)	Moderate – Government agencies, the university, and farming communities established clearly defined roles through coordinated funding, technical assistance, and extension services, but the absence of private-sector participation limited broader Quadruple Helix integration.	Moderate – Collaboration strengthened cacao production through technology transfer, technical training, input provision, field monitoring, and extension services, although innovation remained focused on technology dissemination without evidence of commercialization or value-	Weak – Government coordinated project implementation, the university provided technical expertise, and farming communities adopted recommended practices, resulting in predominantly one-way knowledge transfer with limited knowledge co-production and sustained

								chain integration.	multisectoral partnerships.
SID-b582	Marciana, M., Lou, C., & Perpetua, A. (2021). Philippine halal food export industry: life cycle, trends, and global outlook. In E3S Web of Conferences (Vol. 316, p. 02044). https://doi.org/10.1051/e3sconf/202131602044	Halal certification and industry development	Government of the Philippines (GOV_PH), Philippine Accreditation Board (PAB), Halal Certification Bodies (HCB), Islamic Da'wah Council of the Philippines (IDCP), and national regulatory agencies (Regulation, accreditation, policy development, compliance oversight)	None documented	Halal producers, exporters, suppliers, certification organizations, tourism enterprises, and private-sector stakeholders (Halal production, certification compliance, market development, export facilitation)	Consumers and Muslim communities (Market adoption, demand generation, community engagement)	Moderate – Government agencies and industry actors established clearly defined roles through structured certification, accreditation, and regulatory mechanisms, but the absence of university participation limited broader Quadruple Helix integration.	Moderate – Collaboration strengthened halal certification, accreditation, quality assurance, regulatory compliance, and export facilitation, although innovation remained primarily regulatory and commercial with limited evidence of collaborative research or technology development.	Weak – Government agencies established regulatory standards, industry implemented certification requirements, and community participation remained primarily demand-driven, resulting in limited knowledge co-production and sustained multisectoral collaboration.
SID-b590	Abales, J. M. A., Dandoy, V. M. A., Pipino, R. O., & Sobradil, M. (2023). Policy capacity and e-governance: Assessment of the e-government services of Valencia City, Bukidnon. Journal of Governance and Development (JGD), 19(1), 115-132. https://doi.org/10.32890/jgd2023.19.1.6	E-government and digital public service delivery	LGU of Valencia City, LGULEAD, GOVAG, and NATLEG (Digital governance, policy development, regulatory oversight, service coordination)	None documented	Businesses and ICT service providers (ICT infrastructure, digital service support, business transactions)	Citizens and government employees (Digital service utilization, e-government participation)	Moderate – Government agencies, industry stakeholders, and community users established clearly defined roles within a structured digital governance framework, but the absence of university participation limited broader	Moderate – Collaboration strengthened digital public service delivery, administrative efficiency, inter-agency coordination, and ICT-enabled governance, although innovation remained focused on operational	Weak – Government directed service delivery, industry provided technological support, and community actors primarily functioned as service users, resulting in transactional interactions with limited

							Quadruple Helix integration.	improvements with limited evidence of collaborative research or technology co- development.	knowledge co- production and sustained multisectoral collaboration.
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Note: The table summarizes the 31 analytical cases included in the qualitative evidence synthesis, comprising 20 studies (2013–2018) and 11 studies (2020–2025). Fully included cases met the analytical inclusion criteria for the Triple Helix Innovation Model (THIM) and/or emerging Quadruple Helix interactions, whereas conditionally included cases provided complementary evidence of partial helix engagement. Structural, Functional, and Relational dimensions were qualitatively rated as Strong, Moderate, or Weak based on institutional integration, collaborative functionality, and the sustainability of multisectoral relationships. See Supplementary Tables 3–6 for bibliographic and screening details.