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# Administrative Organization of State Science and Technology Policies for Economic Development in Iraq

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This study examines the administrative organization of state science and technology policies in Iraq and their role in supporting economic development. The research addresses the persistent gap between Iraq's scientific and technological potential and the limited contribution of research, innovation, and technological capability to economic diversification and productivity. It focuses on the institutional, administrative, financial, and regulatory dimensions of science and technology policy, with particular attention to coordination among government bodies, universities, research centers, private firms, and financial institutions. The study adopts a descriptive and analytical approach to assess the principal organizational weaknesses affecting the formulation and implementation of science and technology policies in Iraq. The analysis shows that fragmented institutional responsibilities, weak inter-agency coordination, unstable research financing, limited university–industry cooperation, insufficient commercialization mechanisms, and inadequate integration between technological planning and economic policy reduce the effectiveness of the national innovation system. The study further finds that science and technology can contribute to economic development through higher productivity, economic diversification, technological learning, innovation-based entrepreneurship, improved public services, and stronger human capital. Achieving these outcomes requires an integrated administrative framework capable of linking research priorities with national development needs, coordinating sectoral institutions, strengthening innovation finance, improving technology transfer, and supporting practical scientific and technical skills. The study concludes that Iraq should establish a more coherent national governance structure for science and technology, supported by transparent financing mechanisms, innovation-oriented public procurement, stronger university–industry partnerships, adaptive regulation, improved data governance, and continuous policy evaluation. Such reforms can help transform science and technology from fragmented administrative activities into strategic instruments for building a more diversified, productive, resilient, and knowledge-based Iraqi economy.

***Keywords:*** *Iraq; Science and Technology Policy; Administrative Organization; Economic Development; Innovation; National Innovation System; Economic Diversification*

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## 1. Introduction

Science and technology have become indispensable components of contemporary economic development because economic growth increasingly depends on knowledge, innovation, technological capability, skilled human resources, and the institutional capacity to transform scientific knowledge into productive activity. The traditional conception of development as a process driven primarily by physical

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capital, natural resources, and the expansion of conventional production has gradually been replaced by a broader understanding in which technological learning, research capacity, digital infrastructure, institutional innovation, and the ability to generate and absorb knowledge determine the competitiveness of states. This transformation is especially important for countries whose economies remain dependent on a limited range of natural resources. Iraq is a clear example of such a case. Although the country possesses considerable oil wealth, a large domestic market, a significant university system, and substantial human potential, these resources have not yet been integrated into a coherent national system capable of using science and technology as sustained engines of economic diversification. The problem is therefore not simply a lack of scientific institutions or technological activities, but the absence of an administrative organization capable of connecting scientific research, public policy, economic priorities, investment, education, innovation, and productive sectors within an integrated framework.

The role of the state in this field cannot be reduced to financing universities or issuing regulations concerning particular technologies. Science and technology policy constitutes a complex domain of public administration in which the state defines national priorities, allocates resources, establishes institutions, regulates incentives, coordinates public and private actors, supports innovation, and evaluates whether scientific activities contribute to broader economic and social objectives. The importance of administrative organization becomes particularly evident in areas characterized by rapid technological change because fragmented decision-making produces duplication, regulatory inconsistency, weak accountability, and inefficient use of resources. The legal regulation of emerging technologies also demonstrates that technological development requires institutional frameworks capable of maintaining legal certainty while permitting experimentation and innovation. Karim argues that the regulation of artificial intelligence illustrates the broader need for legal and institutional structures that can respond to technological change without obstructing beneficial innovation (Karim, 2022). In the same context, Al-Khatib emphasizes that emerging technologies increasingly require legislative frameworks that connect technical innovation with administrative responsibility and clearly defined regulatory standards (Al-Khatib, 2020). These observations are relevant beyond artificial intelligence because they reflect a general principle applicable to national science and technology policy: technological progress is unlikely to produce sustained economic value where institutional responsibilities are unclear or administrative systems are unable to adapt.

For Iraq, the relationship between science and technology and economic development is particularly significant because the country's economic structure remains strongly dependent on oil revenue. Such dependence exposes public finance and economic planning to external price fluctuations and limits the development of diversified productive capacities. Science and technology policy can contribute to economic diversification by supporting advanced industrial activities, digital services, agricultural modernization, energy efficiency, health technologies, information industries, and knowledge-intensive entrepreneurship. Yet technological modernization cannot be achieved through isolated projects. It requires an administrative system that coordinates education, research, finance, industrial policy, public procurement, intellectual property, data governance, and private investment. Jabour's examination of access to knowledge in Iraqi and comparative legislation highlights the importance of institutional conditions governing the circulation and use of information (Jabour, 2022). Knowledge cannot generate economic value when it remains administratively isolated within universities or government agencies. Its developmental value depends on mechanisms that allow knowledge to move from researchers to firms, public institutions, entrepreneurs, and other economic actors.

The challenge is intensified by the growing importance of digital technologies in public administration and economic activity. Digitalization changes not only production methods but also the mechanisms through which governments design and implement policy. Modern science and technology systems depend on reliable data, interoperable government platforms, research databases, digital infrastructure, and the capacity to assess technological developments in real time. Abd al-Rahim explains that technological sovereignty increasingly involves the ability of states to govern information and digital systems in ways consistent with their institutional and political capacities

(Abd al-Rahim, 2023). For Iraq, this implies that science and technology policy must include administrative mechanisms for data governance, cybersecurity, digital standards, research information systems, and the responsible use of technological platforms. The institutional dimension is therefore as important as the financial dimension. Increasing research expenditure without building coordination, evaluation, and technology-transfer mechanisms may simply produce higher expenditure without corresponding improvements in productivity or competitiveness.

The importance of public administration also appears in the regulation of innovation-related risks. Technological development generates new forms of liability, privacy concerns, information-security problems, and ethical questions. Kouzi observes that technological development creates complex challenges for privacy protection and the regulation of information use (Kouzi, 2022). Hassan similarly stresses that the deployment of artificial intelligence must be accompanied by ethical and legal safeguards capable of preserving accountability and public trust (Hassan, 2024). These considerations demonstrate why administrative organization in science and technology must balance two requirements that can sometimes appear contradictory: encouraging experimentation and investment while preserving rights, public safety, transparency, and accountability. Excessive regulation may discourage innovation, but the absence of adequate regulation can generate legal uncertainty and social resistance. Effective public policy therefore requires proportionate, predictable, and adaptive institutions.

The Iraqi context also illustrates the importance of coordination between different levels and sectors of government. Science and technology policy crosses ministerial boundaries because research, education, industrial development, communications, finance, planning, environment, health, energy, and agriculture are interconnected. When each institution develops its own programs without an integrated national strategy, resources are dispersed across overlapping initiatives and the resulting policies may even contradict one another. Administrative fragmentation can also weaken the implementation of national priorities because ministries may pursue sector-specific objectives without considering their relationship with the national innovation system. Jafri's analysis of legal and informational security in electronic administrative relations demonstrates that administrative modernization depends on coherent institutional rules and reliable coordination mechanisms (Jafri, 2021). Although his discussion concerns electronic administration, the underlying principle applies directly to science and technology governance: institutional coordination is necessary to reduce uncertainty and establish predictable relationships among administrative actors.

The connection between technology and economic development also depends on the state's ability to create markets for innovation. In many developing economies, private demand for research and advanced technology remains weak because firms operate with limited technological capability, financial institutions are reluctant to finance intangible assets, and university research is only loosely connected to commercial applications. Under these circumstances, the state must perform a catalytic function. Public procurement can create early demand for innovative products, public research grants can reduce the initial risks of experimentation, guarantees can encourage financial institutions to support technology-based firms, and incubators can help researchers convert scientific results into commercial projects. Chakour's analysis of artificial intelligence and changes in the international system reflects the wider strategic significance of technological capability in contemporary economic and political competition (Chakour, 2024). Science and technology policy is therefore not merely a sectoral administrative concern; it is closely connected to economic sovereignty, competitiveness, and the state's long-term development capacity.

Another crucial dimension is human capital. Technological transformation requires more than university enrollment or the production of academic degrees. It requires competencies that can be transferred into productive activity, including engineering, programming, data analysis, laboratory skills, research management, entrepreneurship, intellectual-property management, and technology commercialization. Ali notes that the use of artificial intelligence in research itself requires methodological competence and awareness of technological bias (Ali, 2025). This illustrates a broader problem: technological development changes the skills required not only in

private industry but also within universities, research institutions, regulatory bodies, and government departments. Public administration must therefore treat human-capacity development as a continuous process rather than a one-time educational outcome. Training systems, professional accreditation, research mobility, industry placements, and continuing education all become part of science and technology policy.

The central problem addressed in this article is consequently the administrative organization of Iraqi state policies in science and technology and the extent to which this organization can contribute to economic development. The article seeks to analyze the institutional and administrative foundations of science and technology policy, identify the structural challenges that limit its effectiveness in Iraq, explain the economic mechanisms through which scientific and technological development can support diversification and productivity, and propose an integrated administrative approach capable of improving coordination, financing, knowledge transfer, and human-capacity development. The analysis follows a descriptive and analytical approach based on the conceptual, legal, and institutional framework developed in the underlying research. The article proceeds from the proposition that Iraq's difficulty does not arise solely from insufficient scientific resources but from the weakness of the administrative mechanisms connecting those resources to economic objectives. Accordingly, meaningful reform requires the construction of a coordinated national innovation system in which public institutions, universities, research centers, firms, financial organizations, and regulatory bodies perform complementary rather than isolated roles.

## 2. Conceptual and Administrative Foundations of Science and Technology Policy

Science and technology policy can be understood as the organized set of governmental decisions, institutional arrangements, financial mechanisms, legal rules, and administrative instruments through which a state develops scientific capacity, supports technological innovation, regulates the use of emerging technologies, and directs knowledge toward national economic and social objectives. This definition distinguishes science and technology policy from isolated research programs or sectoral technology projects. A national policy involves a comprehensive system through which government determines priorities, distributes responsibilities, creates incentives, coordinates institutions, and evaluates results. Such a system must be capable of moving scientific knowledge through several stages, beginning with education and research and continuing through experimentation, development, commercialization, diffusion, adoption, and economic utilization. The effectiveness of the system therefore depends on the strength of the institutional links connecting each stage rather than on the performance of individual institutions considered separately.

Public policymaking in this field begins with accurate diagnosis. Administrative institutions must identify the economic and technological problems requiring intervention, assess existing research capabilities, determine gaps in infrastructure and human resources, and distinguish between problems arising from insufficient finance and those caused by weak regulation, skills shortages, institutional fragmentation, or limited demand for innovation. The quality of information becomes critical because poor diagnosis leads to inappropriate policy instruments. Darwish's discussion of information circulation illustrates the broader importance of reliable access to information in public decision-making (Darwish, 2020). Where public authorities lack reliable research data, expenditure indicators, patent information, technology-adoption statistics, and assessments of university–industry collaboration, science policy may be driven by assumptions rather than evidence. Administrative organization must therefore include statistical and analytical capabilities able to transform dispersed information into policy-relevant knowledge.

The formulation of policy requires a clear distinction between objectives and instruments. Objectives may include increasing research capacity, diversifying the economy, improving productivity, strengthening technological sovereignty, supporting start-ups, modernizing public services, or increasing high-technology exports. Instruments are the mechanisms used to achieve those objectives, including grants, tax incentives, public procurement, standards, licensing regimes, intellectual-property rules, research infrastructure, training programs, and public–private partnerships. Administrative weakness often arises when governments announce broad technological

ambitions without identifying the institutional mechanisms required for implementation. A strategy may declare innovation a national priority, for example, while leaving responsibility divided among ministries with overlapping mandates and without a central institution authorized to coordinate implementation. Effective policy formulation therefore requires explicit assignment of responsibility, measurable objectives, realistic resource allocation, and predetermined procedures for monitoring and review.

Legal organization is an essential component of this process. Innovation cannot operate effectively in an environment of regulatory uncertainty because firms, universities, investors, and researchers require predictable rules concerning ownership, contracts, liability, information, privacy, and licensing. Kouzi's analysis of judicial oversight in intellectual property demonstrates the importance of legal protection for technological activity and knowledge-based assets (Kouzi, 2024). Intellectual-property regulation must create incentives for invention while also facilitating licensing, diffusion, and cumulative innovation. Where protection is weak, researchers and investors may have limited incentives to commercialize knowledge. Where protection is excessively restrictive, technological diffusion may be slowed. The role of public administration is therefore to maintain a balance that encourages investment while preventing the legal framework from becoming an obstacle to knowledge circulation.

The regulation of emerging technologies also requires institutional adaptability. Traditional regulatory models frequently assume that technologies change slowly and can be governed through stable rules. Contemporary digital technologies develop too quickly for this approach. Artificial intelligence, automated decision-making, biotechnology, digital platforms, and data-intensive services may evolve faster than formal legislation. Al-Khatib identifies the need for legal frameworks capable of responding to artificial intelligence while maintaining legal clarity (Al-Khatib, 2020). Dhiya likewise demonstrates that new technological applications create novel legal problems concerning responsibility and property interests (Dhiya, 2024). These developments support an administrative model based on regulatory learning. Governments may use pilot programs, regulatory sandboxes, temporary licensing arrangements, and periodic review procedures to allow innovation to proceed under controlled conditions. Such mechanisms are particularly relevant to Iraq because they can reduce the tension between the desire to modernize rapidly and the need to prevent legal and institutional instability.

Science and technology policy also depends on administrative coordination. Modern innovation systems are inherently networked. Universities produce research and human capital, firms convert knowledge into products and services, financial institutions provide investment, public agencies create regulation and demand, and professional bodies establish standards. None of these actors can independently generate a complete innovation system. Public administration must therefore move beyond a purely hierarchical model in which ministries issue instructions to subordinate institutions. It must also perform a network-governance function by connecting actors whose resources and competencies are distributed across organizational boundaries. Jafri's analysis of informational and legal security in electronic administrative contracts shows how complex administrative relationships require clarity of responsibility and reliable institutional interaction (Jafri, 2021). Similar principles apply to technological collaboration because joint research, public–private partnerships, and innovation procurement require stable rules governing responsibilities, information sharing, ownership, and accountability.

Policy implementation is often more difficult than policy formulation. Science and technology strategies commonly fail because administrative institutions lack the resources, expertise, incentives, or authority needed to translate general objectives into operational programs. Implementation therefore requires institutional capacity at several levels. Government agencies need personnel capable of evaluating technical projects, managing research grants, assessing intellectual property, designing procurement specifications, and measuring economic impacts. Universities need technology-transfer offices and research-management systems. Firms require access to finance and technical support. Regulatory bodies need scientific expertise to evaluate technological risks. Hassan's discussion of the ethical governance of artificial intelligence demonstrates that effective technological

regulation depends on specialized competence rather than general legal rules alone (Hassan, 2024). The same principle applies across the science and technology system: administrative structures must include technical expertise within the institutions responsible for implementation.

Monitoring and evaluation are equally important. Public expenditure on science and technology cannot be assessed only by counting research projects, publications, laboratories, or training programs. These indicators measure activity rather than development impact. A more sophisticated evaluation system should examine whether public investment improves research quality, technology transfer, firm productivity, employment, export capability, industrial diversification, and the ability to solve national problems. Ali's discussion of bias and methodological challenges in technology-assisted research illustrates the importance of evaluating not only outputs but also the reliability and quality of the processes producing them (Ali, 2025). Policy evaluation must similarly distinguish between nominal achievement and meaningful impact. A large number of funded projects may have little economic value if they remain disconnected from industry or public-sector demand.

The principle of proportionality is particularly important where technological regulation affects rights and economic freedoms. Digital innovation often depends on access to data, yet excessive data collection can threaten privacy and public trust. Al-Douri emphasizes the impact of technological developments on privacy rights (Al-Douri, 2022). Kouzi likewise discusses the growing difficulty of protecting privacy in an information-intensive technological environment (Kouzi, 2022). These concerns are directly relevant to economic development because weak rights protection can reduce public acceptance of technological systems, while overbroad restrictions can limit innovation. Effective administrative organization should therefore establish data-governance frameworks that specify lawful purposes, access conditions, security obligations, accountability, and oversight. Scientific and economic development should not be treated as objectives that justify unlimited technological intervention.

The concept of technological sovereignty further expands the administrative responsibilities of the state. Sovereignty in a knowledge economy is not achieved through technological isolation. Rather, it involves the ability to participate in international knowledge networks while retaining sufficient domestic capability to evaluate, adapt, secure, and strategically deploy imported technologies. Abd al-Rahim's analysis of informational and political sovereignty highlights the importance of state capacity in governing modern information systems (Abd al-Rahim, 2023). For Iraq, technological sovereignty would involve building domestic expertise, establishing standards, strengthening cybersecurity, developing research infrastructure, and ensuring that strategic sectors are not entirely dependent on external suppliers. At the same time, excessive localization requirements could reduce access to advanced technologies. Administrative policy must therefore combine international openness with domestic capacity building.

Economic incentives form another foundational component. Knowledge production produces positive externalities because the benefits of research often extend beyond the organizations financing it. Private firms may therefore invest less in research than is socially desirable. Government intervention can correct this problem through grants, tax incentives, credit guarantees, public research programs, and innovation procurement. However, these instruments create their own governance risks, including political favoritism, rent seeking, ineffective subsidies, and the financing of projects with little technological value. Administrative organization must therefore combine financial support with transparent eligibility criteria, competitive selection, conflict-of-interest controls, and performance evaluation. The purpose of public funding should not be to replace private initiative but to reduce market failures and stimulate investment that would otherwise be too risky or uncertain.

Finally, the administrative foundations of science and technology policy depend on institutional learning. Innovation systems operate under uncertainty, and not every intervention will succeed. Governments must therefore create mechanisms through which failed programs can be revised or terminated without treating policy adjustment as administrative failure. Evaluation results should feed back into new policy design, and public institutions should be capable of modifying priorities in response to technological and economic change. This adaptive capacity is particularly important

in Iraq, where reconstruction needs, fiscal dependence on hydrocarbons, demographic pressures, and rapid global technological changes create a volatile policy environment. A rigid administrative system is unlikely to respond effectively. A coordinated, evidence-based, legally grounded, and adaptive system provides a more appropriate foundation for aligning science and technology with economic development.

## 3. Administrative Organization of Science and Technology Policies in Iraq

The administrative organization of science and technology policy in Iraq must be examined in relation to the broader characteristics of the country's public administration. The Iraqi state possesses universities, ministries, research centers, technical institutions, regulatory bodies, and public enterprises capable of contributing to scientific and technological development, but the existence of these institutions does not automatically create an integrated innovation system. Their effectiveness depends on coordination, clear competencies, predictable financing, and mechanisms linking research to economic demand. One of the central problems is institutional fragmentation. Different government bodies may pursue technology-related programs according to their own mandates without a unified mechanism for setting priorities, sharing information, avoiding duplication, or evaluating national outcomes. As a result, science and technology activities may remain administratively dispersed even where individual organizations possess capable personnel or useful infrastructure.

The fragmentation problem is particularly important because science and technology policy intersects with almost every major area of government. Higher education institutions generate research and train scientists. Planning authorities identify development priorities. Finance authorities control expenditure. Industry-related institutions influence manufacturing and technological upgrading. Communications authorities govern digital infrastructure. Agriculture, health, energy, environment, and transport institutions create sector-specific technological demand. If these areas are governed separately, national innovation policy becomes the sum of disconnected initiatives rather than a coherent administrative system. A coordinated framework should therefore establish a central strategic mechanism capable of setting national priorities while leaving implementation to specialized sectoral institutions. The purpose would not be excessive administrative centralization but strategic coherence.

An Iraqi national science and technology coordination body could perform several essential functions. It could prepare medium- and long-term national innovation strategies, identify priority sectors, coordinate research funding, establish common performance indicators, oversee interministerial programs, and produce annual assessments of technological development. Such a body would need high-level authority because coordination mechanisms without political and administrative influence often become consultative forums with little effect on actual budgetary decisions. It should include representatives from government, universities, research institutions, industry, financial organizations, and relevant professional sectors. The inclusion of non-governmental actors would be essential because scientific policy cannot be effectively designed solely within administrative institutions. The state must understand technological demand within firms and the obstacles facing researchers and entrepreneurs.

The institutional relationship between universities and the economy is one of the most important areas requiring reform. Iraqi universities produce scientific research and skilled graduates, yet the developmental value of this capacity depends on whether research can be translated into technologies, services, processes, and enterprises. Universities traditionally reward publication, teaching, and academic advancement, while firms focus on commercial viability, cost, market demand, and speed. These different institutional incentives create a gap that administrative policy must bridge. Technology-transfer offices can perform this function by identifying commercially relevant research, assisting with intellectual-property protection, negotiating licenses, and connecting researchers with investors. Kouzi's analysis of intellectual-property oversight demonstrates the importance of legal clarity for the protection and exploitation of knowledge-based assets (Kouzi, 2024). Without clear rules concerning ownership of inventions produced through public research, universities and researchers may lack incentives to engage in commercialization.

University–industry collaboration also requires institutionalized mechanisms for joint research. Rather than expecting firms to finance academic research without incentives, government can establish matching grants in which public funds complement private contributions. Research calls can focus on problems identified by industry, public services, or national development plans. Cooperative laboratories can bring together academic researchers and technical personnel from firms. Student placements can provide industries with access to university talent while exposing students to practical problems. These mechanisms would gradually transform the relationship between universities and the economy from occasional cooperation into structured interaction. Such integration is central to human-capacity development because practical experience improves the employability of graduates and allows curricula to respond to technological demand.

Research financing is another major organizational issue. Science and technology activities require continuity because research projects often produce results only after several years. Annual budget uncertainty undermines long-term planning and discourages ambitious projects. An effective Iraqi system should therefore distinguish between institutional funding, competitive research grants, mission-oriented programs, infrastructure funding, and commercialization support. Competitive grants can encourage quality and accountability, but they should not be the sole source of funding because research institutions also require stable infrastructure and technical personnel. Mission-oriented programs can focus resources on nationally important challenges such as water scarcity, energy efficiency, agricultural productivity, health services, digital government, and environmental protection.

The financial system must also support the commercialization stage. Scientific ideas frequently fail to reach the market because conventional lenders prefer tangible collateral and predictable revenues, whereas technology start-ups possess intangible assets and uncertain prospects. This financing gap justifies specialized instruments such as seed funds, guarantees, concessional loans, venture funds, and innovation grants. Dagher's study of liability associated with robotic technologies demonstrates how emerging technologies create novel legal risks that can affect investment decisions (Dagher, 2023). Clear legal frameworks are therefore necessary alongside financial instruments because investors are unlikely to commit resources where liability, ownership, and regulatory obligations are uncertain. Public financing should be designed to share risk rather than permanently subsidize firms.

Procurement represents another administrative mechanism through which the Iraqi state can stimulate innovation. Government is a major purchaser of goods and services, particularly in infrastructure, energy, health, education, transport, and information technology. Traditional procurement often emphasizes the lowest initial price and detailed technical specifications, which can disadvantage innovative solutions that offer better long-term performance but do not fit established categories. Innovation-oriented procurement would define desired outcomes rather than predetermined technologies, allowing firms to propose new approaches. Transparent competition and objective performance indicators are essential because procurement can otherwise become vulnerable to favoritism and politicization. The administrative value of innovation procurement lies in its capacity to create an initial market for local technological firms while simultaneously improving public services.

Standards, metrology, testing, and accreditation are less visible but equally important elements of administrative organization. Innovative products cannot enter domestic or international markets unless their quality and safety can be verified. National laboratories and accreditation systems reduce uncertainty by establishing common technical benchmarks. They also help Iraqi firms participate in regional and international value chains. Administrative responsibility for standards should therefore be integrated into science and technology policy rather than treated as a separate technical matter. Technology policy must connect research, commercialization, quality assurance, and market access within a continuous system.

Digital administration provides another area in which state capacity can directly influence technological development. Government data can support research and innovation when made available through secure and standardized systems. At the same time, privacy and security safeguards must be maintained. Al-Douri's analysis shows that technological development

intensifies privacy concerns (Al-Douri, 2022), while Kouzi emphasizes that information-age governance requires stronger legal protections against inappropriate use of personal data (Kouzi, 2022). Iraq therefore requires a coherent data-governance architecture covering access, classification, cybersecurity, interoperability, and accountability. Open government data can support entrepreneurship and research, but sensitive information should remain protected through clear legal standards.

Administrative modernization also requires the development of technical expertise within government itself. Science policy cannot be effectively managed exclusively by generalist administrators. Ministries and regulatory agencies need specialists capable of evaluating research proposals, understanding technological trends, assessing intellectual property, designing innovation contracts, and interpreting performance indicators. Hassan's analysis of artificial-intelligence ethics highlights the importance of specialized competence in governing complex technologies (Hassan, 2024). Public-sector training should therefore include technology assessment, digital governance, research management, procurement innovation, data analysis, and regulatory impact assessment.

Institutional coordination between the federal government and subnational authorities also deserves attention. Economic and technological needs differ among Iraqi regions and governorates. Some areas may prioritize agricultural technology, others energy, logistics, manufacturing, or digital services. A national strategy should establish broad priorities and standards while allowing regional experimentation and specialization. Local innovation programs can connect universities, chambers of commerce, firms, and local government around region-specific economic clusters. However, decentralized initiatives should operate within a national information and evaluation framework so that successful experiments can be identified and scaled.

Transparency and accountability must accompany expanded governmental involvement in innovation. Science and technology programs frequently involve discretionary funding decisions and technical judgments that may be difficult for the public to evaluate. Transparent procedures reduce opportunities for favoritism and strengthen the legitimacy of public investment. Jabour's discussion of the right to knowledge and information emphasizes the importance of institutional access to information within Iraqi governance (Jabour, 2022). Publication of funding criteria, evaluation methods, project outcomes, procurement results, and aggregate performance indicators would allow researchers, firms, and citizens to assess whether public resources are being used effectively.

The administrative organization required for Iraq should therefore be based on coordinated specialization rather than bureaucratic expansion. Creating new institutions will not solve fragmentation if existing responsibilities remain unclear. Reform should begin with an institutional mapping of current organizations, mandates, programs, financing mechanisms, and overlaps. Responsibilities can then be clarified, redundant functions consolidated, and coordination mechanisms established. The goal is to create an innovation architecture in which each institution understands its role and has access to the information and resources needed to perform it. Such an architecture would transform science and technology policy from a collection of separate activities into an integrated component of national economic governance.

## 4. Role of Science and Technology Policies in Achieving Economic Development in Iraq

The economic importance of science and technology policy lies in its capacity to transform knowledge into productivity, diversification, employment, and new sources of wealth. For Iraq, this transformation is strategically important because dependence on hydrocarbon revenues constrains the resilience of the economy and exposes public expenditure to fluctuations in international oil prices. Science and technology policy cannot eliminate resource dependence immediately, but it can gradually expand the technological capabilities required for non-oil sectors to grow. Economic diversification should therefore be understood not simply as increasing the number of sectors in the economy but as increasing the technological and knowledge content of production. An agricultural sector that adopts precision technologies, improved irrigation, biotechnology, and digital supply chains contributes differently to economic development from one dependent on low-productivity traditional methods. The

same distinction applies to manufacturing, health, logistics, construction, financial services, and energy.

Innovation contributes to wealth creation because knowledge can generate value beyond the physical inputs used in production. Software, patents, technical processes, data, organizational systems, engineering designs, and brands are intangible assets that can increase firm productivity and competitiveness. Chakour's discussion of artificial intelligence illustrates how technological capability has become an increasingly important source of economic and strategic influence (Chakour, 2024). For Iraq, building intangible assets requires a policy environment in which research results can be protected, financed, licensed, and commercialized. The economic objective should not be simply to increase the number of inventions but to increase the capacity of Iraqi organizations to convert useful knowledge into products and services that generate domestic income.

Productivity improvement is one of the most direct channels through which technology can support development. Technologies reduce costs, improve quality, increase precision, save energy and water, and allow firms to manage complex processes more efficiently. Digitalization can also reduce administrative costs and improve access to markets. The state's role is especially important where firms lack the resources or expertise needed to adopt technology. Technology-extension services can provide technical assistance to small and medium-sized enterprises, while investment incentives can support modernization of machinery and digital systems. Public policy should distinguish between frontier innovation and technology diffusion. Not every firm needs to create new technology; many can achieve substantial productivity gains by adopting and adapting technologies developed elsewhere.

Economic development also depends on the ability to create local technological capabilities rather than permanent dependence on imported systems. Imported technology can produce immediate efficiency improvements, but long-term development requires domestic capacity to maintain, modify, and eventually improve imported technologies. This process is commonly described as technological learning. Administrative policy can support learning through local training requirements, joint research, supplier-development programs, and procurement contracts that include knowledge-transfer provisions. Abd al-Rahim's examination of informational sovereignty is relevant because technological dependence can limit a state's capacity to govern critical information and infrastructure (Abd al-Rahim, 2023). Technological sovereignty does not require self-sufficiency but does require sufficient domestic expertise to prevent dependence from becoming structural vulnerability.

The diversification of Iraq's economy should therefore identify sectors in which existing national resources can be combined with scientific and technological capability. Energy is an obvious example. Iraq's hydrocarbon resources can support research and industrial development in petrochemicals, energy efficiency, emissions reduction, environmental monitoring, and renewable-energy integration. Agriculture offers opportunities for water-saving technologies, remote sensing, improved crop management, food processing, and supply-chain modernization. Health technologies can reduce dependence on imported services and improve public health capacity. Construction technologies can increase efficiency in infrastructure development. Digital services can create employment opportunities requiring relatively limited physical capital but substantial human skills.

Human-capacity development is central to all these sectors. Technology does not independently create productivity; workers and managers must possess the competence required to use it. Education policy should therefore be closely connected to economic and technological planning. Curricula should respond to emerging skill requirements, but this does not mean transforming universities into narrow vocational institutions. Rather, education should combine scientific foundations with practical problem-solving, digital competence, communication, research ability, and adaptability. Ali's discussion of artificial intelligence in research demonstrates that even academic methodology increasingly requires technological literacy and the ability to identify bias in advanced tools (Ali, 2025). The implication for economic development is that technological competence must be treated as a general capacity across professional fields rather than the exclusive responsibility of computer specialists.

Technical and vocational education has a particularly important role because economic transformation requires technicians, operators, laboratory personnel,

engineering assistants, and maintenance specialists in addition to university graduates. Administrative policy should create recognized competency frameworks linking training to occupational requirements. Cooperation with employers can improve curriculum relevance, while apprenticeship and cooperative training systems can facilitate transitions from education to employment. Hassan's emphasis on ethical competence in artificial-intelligence applications also suggests that technical training should incorporate professional responsibility and risk awareness (Hassan, 2024). Economic development requires reliable and trusted technological systems, not merely rapid adoption.

Entrepreneurship represents another mechanism through which science and technology can generate economic activity. University researchers and graduates may possess technical knowledge but lack business experience, finance, legal support, or market connections. Incubators and accelerators can provide these complementary capabilities. However, such institutions should be evaluated according to the survival, growth, and technological quality of the firms they support rather than the number of participants or training sessions. Public programs frequently fail when administrative indicators reward activity instead of economic outcomes. A successful Iraqi innovation system should therefore measure whether supported enterprises generate employment, increase revenue, attract private investment, and introduce new technologies into the economy.

Financial reform is equally important. Conventional banking models may be poorly suited to innovative firms because research-based businesses often possess few tangible assets and uncertain short-term cash flows. State policy can respond through credit guarantees, co-investment funds, seed financing, and other instruments that reduce risk without eliminating market discipline. The objective should be to mobilize private capital rather than permanently substitute public finance for private investment. Transparent investment criteria and independent technical evaluation are necessary to prevent public innovation funds from becoming mechanisms for politically connected financing.

Intellectual property can support economic development when integrated with commercialization policy. Patents and related rights can allow researchers and firms to capture returns from innovation, but legal rights alone do not create economic value. Institutions must also provide licensing support, valuation expertise, market analysis, and mechanisms for resolving disputes. Kouzi's analysis of judicial oversight in information-technology intellectual property emphasizes the importance of reliable legal protection for technological assets (Kouzi, 2024). Iraqi universities and research institutions should therefore establish clear internal policies concerning ownership of inventions, revenue sharing, researcher incentives, and licensing. Such policies can reduce uncertainty and encourage academics to participate in commercialization.

Digital transformation of the state itself can stimulate economic development by creating demand for local technological solutions. Public agencies require software, data systems, cybersecurity, digital identity, health information platforms, educational technologies, and automated administrative services. If procurement is designed strategically, these needs can create markets for Iraqi technology firms. At the same time, digital government must be accompanied by safeguards. Kouzi notes that privacy protection becomes increasingly difficult as technological systems expand their capacity to collect and process information (Kouzi, 2022). Al-Douri similarly emphasizes the effect of technological change on privacy rights (Al-Douri, 2022). Development-oriented digitalization should therefore incorporate data minimization, security, accountability, and mechanisms for challenging improper administrative decisions.

Science and technology policy can also improve the quality of economic governance. Better data, digital systems, and analytical tools can improve tax administration, public investment management, infrastructure maintenance, and policy evaluation. However, technological solutions cannot compensate for weak institutions. Digital systems introduced into poorly designed administrative processes may simply reproduce existing inefficiencies in electronic form. Technology should therefore be combined with administrative simplification and institutional reform. Jafri's analysis of information and legal security in electronic administration demonstrates that digital transactions require clear and reliable administrative frameworks (Jafri, 2021). The economic benefits of digital government consequently depend on legal certainty and organizational redesign.

The international dimension is also important. Iraq cannot develop science and technology policy in isolation because scientific knowledge and technological markets are global. International cooperation can support researcher mobility, joint projects, access to infrastructure, technology transfer, and participation in global research networks. At the same time, cooperation should contribute to domestic capability rather than create permanent dependence. Agreements involving technology should therefore include training, knowledge transfer, and institutional learning. Iraqi researchers working abroad can also contribute through temporary appointments, joint laboratories, mentoring programs, and collaborative research networks.

Economic development requires long-term policy consistency. Research capacity, technological skills, and innovation ecosystems cannot be created within short political or budgetary cycles. Public administration should therefore protect essential science and technology programs from excessive volatility while maintaining mechanisms for periodic evaluation. Stable objectives do not require rigid instruments. Programs should be adapted when evidence demonstrates that they are ineffective. The balance between continuity and flexibility is essential because innovation requires both patient investment and the ability to respond to rapid technological change.

Ultimately, science and technology policy contributes to Iraqi economic development when it changes the underlying capabilities of the economy. The relevant measure of success is not merely the number of research institutions, digital projects, patents, or graduates. Success means increased productivity, stronger technological firms, more diversified exports, greater capacity to solve national problems, improved public services, better employment opportunities, and a more resilient economic structure. Achieving these outcomes requires the administrative reforms discussed throughout this article: coherent coordination, long-term financing, stronger university–industry relations, modern regulation, innovation-oriented procurement, human-capacity development, transparent governance, and systematic evaluation. Science and technology must therefore be treated not as an isolated sector but as an organizing principle of national economic development.

## 5. Conclusion

The administrative organization of state science and technology policies represents a central element of Iraq's capacity to achieve sustainable economic development. The principal challenge is not the complete absence of scientific institutions, technical expertise, universities, or public-sector involvement. Rather, the central weakness lies in the limited integration of these resources within a coherent national system that connects scientific knowledge with economic priorities, productive sectors, investment mechanisms, and administrative decision-making. Fragmented competencies, weak interinstitutional coordination, unstable research financing, insufficient university–industry cooperation, limited commercialization mechanisms, and gaps in technological governance reduce the developmental impact of existing scientific capacity.

An effective national policy therefore requires an administrative model based on coordinated specialization. Iraq needs a clear national framework through which major development priorities are translated into science and technology programs, while specialized ministries and institutions retain responsibility for sectoral implementation. A high-level coordination mechanism should be capable of aligning research priorities, financing programs, innovation policy, education, industrial development, digital transformation, and public procurement. Its purpose should not be to create another bureaucratic layer but to prevent duplication, resolve conflicts of competence, and ensure that separate institutional activities contribute to common national objectives.

The organization of research financing also requires substantial reform. Stable institutional funding should support essential research infrastructure, while competitive grants should reward scientific quality and relevance. Mission-oriented programs should direct multidisciplinary research toward major Iraqi development challenges, including water management, energy efficiency, agriculture, health, environmental protection, digital government, and industrial modernization. Funding decisions should be transparent and subject to independent technical evaluation. Public resources should be assessed according to measurable outcomes rather than simply the number of funded projects.

University–industry relations should become a structural component of the national innovation system. Universities need professional technology-transfer offices capable of managing intellectual property, licensing, commercialization, and partnerships with firms. Research incentives should recognize practical impact alongside academic publication. Joint laboratories, matching research grants, industrial placements, and cooperative training programs can strengthen the connection between knowledge production and economic demand. These mechanisms can also improve graduate employability by exposing students to real technological and organizational problems.

Innovation finance should be developed as a distinct component of economic policy. Technology-based enterprises face financing conditions different from conventional businesses because their most valuable assets are often intangible and their revenues uncertain during the early stages of development. A graduated financing system should therefore combine research grants, seed funding, credit guarantees, venture investment, concessional instruments, and private co-investment. The state should use these instruments to reduce market failures and mobilize private capital rather than to maintain permanently subsidized enterprises.

Public procurement can serve as another major instrument of technological development. As one of the largest purchasers in the Iraqi economy, the state can create demand for innovative products and services in sectors such as energy, health, education, water, transport, infrastructure, and digital administration. Procurement procedures should increasingly emphasize performance and measurable outcomes rather than relying exclusively on predetermined technical specifications and the lowest initial cost. Opportunities for start-ups and smaller technology firms should be expanded while maintaining strong safeguards against favoritism, conflicts of interest, and misuse of public resources.

Human-capacity development must accompany institutional and financial reform. Iraq requires scientists and engineers, but it also needs technicians, research managers, intellectual-property specialists, data analysts, technology evaluators, regulatory experts, entrepreneurs, and public administrators capable of understanding complex technological systems. Education and training policy should therefore emphasize competencies, practical learning, digital literacy, laboratory skills, problem-solving, and continuing professional development. Stronger links between educational institutions and employers can reduce mismatches between qualifications and economic demand.

The governance of data and digital infrastructure should also be treated as part of science and technology policy. Research, innovation, and advanced public administration increasingly depend on reliable data, secure information systems, interoperability, and digital platforms. The state should establish clear rules governing data access, protection, security, institutional responsibility, and lawful use. Open data can support research and entrepreneurship where disclosure is appropriate, while personal and strategically sensitive information must remain subject to effective safeguards.

Regulatory policy should become more adaptive without sacrificing legal certainty. Rapid technological change means that rigid regulatory systems can become outdated before implementation is complete. Iraq should therefore consider controlled experimentation mechanisms, pilot programs, staged licensing, and regulatory testing environments where appropriate. These tools can allow public authorities to learn from emerging technologies before imposing permanent regulatory structures. However, experimentation should always operate within defined legal limits and under transparent oversight.

Regional and local dimensions should also be incorporated into national science and technology policy. Different Iraqi governorates possess different economic resources, institutional capacities, and development needs. Regional innovation systems could support specialization in agriculture, energy, manufacturing, logistics, tourism, digital services, or other sectors according to local conditions. National authorities should establish common standards and strategic priorities while allowing local institutions sufficient flexibility to design and test region-specific initiatives.

Evaluation must become a permanent function of science and technology governance. The effectiveness of programs should be assessed through indicators connected to productivity, commercialization,

technological adoption, employment, export capacity, firm survival, research quality, knowledge transfer, and improvements in public services. Evaluation should not merely justify existing programs but should provide a basis for institutional learning. Ineffective initiatives should be redesigned or discontinued, while successful approaches should be expanded.

The long-term objective should be the creation of an Iraqi national innovation system in which knowledge moves efficiently between universities, government institutions, firms, financial organizations, and society. Such a system would allow scientific research to contribute more directly to economic diversification and would improve Iraq's ability to absorb and adapt technologies developed internationally. It would also strengthen domestic capacity in strategically important fields and reduce the vulnerability created by excessive dependence on imported expertise.

Science and technology policy should therefore be understood as an integral part of economic governance rather than a specialized field operating at the margins of development planning. Iraq's natural resources can provide financial capacity, but sustainable development will increasingly depend on the country's ability to transform financial resources into knowledge, skills, technological capability, and productive institutions. Administrative organization is the mechanism through which that transformation can occur. A coherent institutional framework, stable financing, university–industry integration, innovation-oriented procurement, human-capacity development, adaptive regulation, data governance, and systematic evaluation can together establish the conditions under which science and technology become genuine sources of economic value.

The ultimate purpose of reform is not technological modernization for its own sake. It is to create a more productive, diversified, resilient, and knowledge-based Iraqi economy capable of generating sustainable opportunities beyond oil dependence. Achieving this objective requires continuity across governments and planning cycles, because scientific capability and innovation ecosystems develop gradually. With sustained institutional commitment and an integrated administrative structure, science and technology can become central instruments of Iraq's economic reconstruction and long-term development.

## Authors' Contributions

Authors contributed equally to this article.

## Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

## Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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## Ethical Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were observed.

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