9. Salemink, K. Rural development in the digital age / K. Salemink [et al.] // Journal of Rural Studies. – 2017. – Vol. 54. – PP. 360–371.
10. United Nations Development Programme. Human Development Report 2022/2023: Uncertain Times, Unsettled Lives. – New York: UNDP, 2023. – 384 p.
11. Kireyenka, N. V. Sustainable development of rural territories: theory, methodology, practice. – Minsk: Belarusian State Agrarian Technical University, 2019. – 312 p.

UDK 631.145:001.895

ZERO BUDGET AND ZERO INSTITUTIONAL BACK-UP: DISCIPLINED DIGITAL PLATFORM FOR AGRICULTURE IN LEBANON

Saddam Daham Maadarani *graduate student*
Educational Establishment
«Belarusian State Agrarian Technical University», Minsk

Ключевые слова: управление сельским хозяйством, инновационная экономика, транзакционные издержки, институциональный разрыв, управление с нулевым бюджетом, цифровая трансформация, Ливан, устойчивость.
Key words: agricultural management, innovative economy, transaction costs, institutional gap, zero budget management, digital transformation, Lebanon, resilience.

Аннотация: В данной статье рассматривается мировой кризис, который повлиял на эффективность функционирования сельскохозяйственного сектора Ливана. Проблема исследования возникает из-за кризиса централизованной координации и роста транзакционных издержек вследствие ослабления институциональной роли государства. Подход к решению этой проблемы включает в себя смешанные методы. Исследование предлагает подход сетевого управления с нулевым бюджетом, основанным на модели «четверной спирали», которая устанавливает синергетическую связь между исследованиями, практиками бизнеса, гражданским обществом и электронным управлением.
Summary: This article examines the global crisis that has impacted the performance of Lebanon's agricultural sector. The research problem arises from the crisis of centralized coordination and rising transaction costs due to the weakening of the state's institutional role. A mixed-methods approach is used to

address this problem. The study proposes a zero-budget network management approach based on the "quadruple helix" model, which establishes synergies between research, business practices, civil society, and e-governance.

Introduction. The world is moving towards "Agriculture 4.0", a data-based approach driven by the Fourth Industrial Revolution, IoT and cyber-physical systems [4; 13; 14]. In this information industry, information exchange and digital platforms are the main sources of competitiveness and sustainability [1; 17]. Theoretically, this process is based on Schumpeter's "creative destruction" and North's institutional economics, which highlight innovation and costs of exchange [10; 11; 12]. Moreover, the Belarusian scientific school (Gusakov and Shpak) shows that integrated state-sponsored institutions, like the Agro-Industrial Complex (AIC), are needed to ensure food security via institutional investment [6; 7; 15; 16].

By contrast, Lebanon is in a crisis that has replaced state coordination. A 98% currency depreciation, the Beirut port blast in 2020 and geopolitical tensions have resulted in USD 704 million losses since 2019 [8; 19]. The Ministry of Agriculture now has a "zero-budget" (<0.6% of the national budget), with the subsequent collapse of research and development, extension services and export quality control [3; 8; 9]. This has resulted in the creation of a "shadow ministry" comprising of international agencies

(FAO, WFP) and private clusters (Berytech) [2; 5]. This research suggests moving from vertical to horizontal networked governance to avoid further fragmentation. Through the deployment of a Quadruple Helix model (academia, private sector, civil society, residual state) and block chain registries and clusters, Lebanon can rebuild systemic coordination and export quality control without large public investments

State of the Art and Scientific Contribution Theoretical Shifts in Management. Farm management has evolved from productivity to institutional and digital. Based on institutional economics, North and Williamson [13; 14] view efficiency as based on the transaction costs, which are absent in the current crises. The Belarusian school (Daineko, Kondratenko) considers digital modernization as a new economic instrument. In fact, Gusakov [6; 7; 23; 24; 27] stresses complexes for stability and Shpak stresses innovation for crisis. This approach allows a "Strategic Substitution" of "Information Capital" for "Financial Capital" in Agriculture 4.0 [6; 7; 17]. National Perspectives and Spatial Strategy

Lebanese experts (such as LARI President Dr. Ihab Jomaa) acknowledge the presence of an "institutional gap" in Lebanon, as per Williamson's high transaction costs and information isolation theories. This could be overcome by a "Spatial Specialization" approach, emphasizing resource efficiency and regional fit. This echoes Schumpeter's search for efficiency [11; 12; 18; 20] and calls for a "New Administrative Paradigm" of decentralized digital coordination

instead of bureaucratic centralization. Field Evidences and Bounded Rationality Field observations in the Bekaa region confirms the theory of "Bounded Rationality" in which farmers are entirely in the dark when it comes to price and input information. This raises transaction costs and the need for middlemen. In agreement with North and Drucker, the main constraint on agricultural growth is the lack of "Knowledge Assets" rather than material resources. Yet the inherent resilience of the Lebanese agricultural sector is important social capital that can be institutionalized via real-time digital information networks.

Main part. This study proposes "Zero-Budget Networked Management" in response to institutional failure. This approach employs a Quadruple Helix (Academia, Private Practitioners, Civil Society, and Digital Infrastructure) to circumvent the state's bureaucratic system. Our innovation has two aspects: Strategic Substitution: Using frugal innovation to convert digital information into a resource for smallholder management [21; 26]. Institutional Bridging: Enabling a University-led innovation ecosystem to maintain business and inclusive value chains [22; 29].

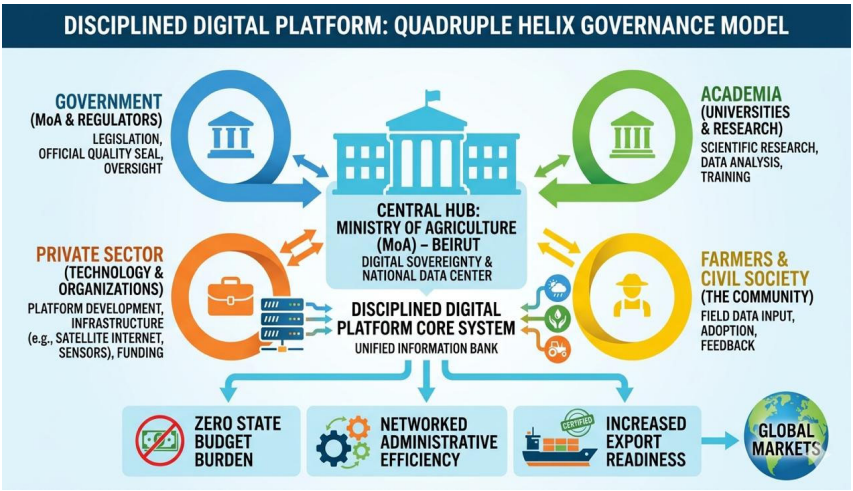

Figure 1 – The Quadruple Helix Digital Platform Model

The diagram (developed by the author) shows the horizontal interaction between:

1. Academia/Research
2. Private Practitioners
3. Civil Society/NGOs
4. Digital Infrastructure

The agricultural crisis in Lebanon is a "coordination failure" due to institutional failure. The study argues that to regain efficiency with a zero-budget, a "Zero-Budget Networked Management" model is required. By harnessing "Information Capital" and social resilience in the sector, it facilitates the sovereign resource management and loss reduction that can serve as a model for food sovereignty in difficult times [6; 21; 25; 26; 30; 31].

This study, based on expert interviews and field work, confirms a complete "institutional collapse" whereby the Lebanese state, with an agricultural budget of less than 0.6%, no longer plays its role as a "Northian" institution. As a result, the information gap has increased by 98%, farmers lack information about seed quality and world prices, and are vulnerable to exploitation by middlemen. The bureaucratic top-down approach of the Belarusian Agro-Industrial Complex (AIC) may work in subsidized economies, but it has failed in Lebanon's hyper-inflationary environment where survival is now based on horizontal peer-to-peer networks and linkages. The evidence suggests "Knowledge Assets" are the most scarce resource at present; farmers who use informal digital networks such as WhatsApp to share weather and price updates benefited from a 15-20% reduction in their transaction costs relative to their isolated peers, demonstrating the ability of Informational Capital to compensate for diminished financial capital. Also, "agricultural anarchy" due to the absence of nationwide planning can be counteracted by "Spatial Specialization". Through digital micro-climatic mapping, productivity improvements of 30% can be achieved without the need for increased use of imported fertilizers. This has resulted in a "Shadow Quadruple Helix" between LARI, Berytech and the FAO which currently operates in an ad hoc manner, but has the capability to evolve into systemic governance through structured digital information systems.

Conclusions. The New Management in "Failed State".The research provides a conclusion that agriculture in "failed-state" or "zero-budget" environments must leverage the Theory of Strategic Substitution, where quality digital information substitutes for missing financial subsidies and supports production value chains. The inherent resilience of the Lebanese farmer should be perceived not as a social emotion but as a social asset that needs "institutionalization" in a digital "Trust Protocol" to avoid reverting to subsistence farming. The Quadruple Helix (Academia, Business, Civil Society, and Digital Infrastructure) appears to be the only governance structure that will act as a "Virtual Ministry" to provide the extension and export services that the central ministry can no longer afford. Scientifically, this work promotes "Frugal Innovation" over the costly robotics and IoT seen in worldwide literature; by leveraging existing mobile infrastructure and open-source registries, Lebanon can establish a distributed "Systemic System" model akin to the Belarusian AIC without hefty investment [6; 21]. In summary, the road to food sovereignty is through a "Digital Leapfrog" that con-

verts the sector into a lean and mean export system. This model of "Zero-Budget Networked Management" provides a global blueprint for preserving vital economic sectors during periods of hyper-inflation and "failed states" where innovation is not a result of material prosperity [25; 26; 28; 32].

REFERENCES

1. Ahmed, F. Machine learning applications in precision agriculture: A review [Text] / F. Ahmed, F. Khan, M. Ali // Computers and Electronics in Agriculture. – 2021. – Vol. 189. – P. 106–115.

2. Berytech. Agrytech innovation hub and agricultural coordination reports [Text] / Berytech. – Beirut : Berytech, 2025. –45 p.

3. CREAL. Agriculture in Light of Financial and Economic Crisis: Immediate Solutions and Future Vision [Text] / Center for Research and Economic Analysis (CREAL). – Beirut : CREAL, 2021. – 48 p.

4. Das, A. Digital agriculture and Agriculture 4.0 adoption barriers: A systematic review [Text] / A. Das, M. Kamal // Journal of Agricultural Science and Technology. – 2022. – Vol. 24. – P. 150–165.

5. Food and Agriculture Organization. Agricultural sector review in Lebanon [Electronic resource] / FAO. – Rome : FAO, 2022. – URL: https://openknowledge.fao.org (date of access: 29.04.2026).

6. Gusakov, V. G. Theoretical foundations of the Agro-Industrial Complex (AIC) and food security strategy [Text] / V. G. Gusakov. – Minsk : Belaruskaya Navuka, 2021. – 256 p.

7. Gusakov, V. G. The Agro-Industrial Complex: Economics and Management [Text] / V. G. Gusakov. – Minsk : Belaruskaya Navuka, 2020. – 312 p.

8. Ministry of Agriculture. Economic losses and direct damages to the Lebanese agricultural sector [Text] / Republic of Lebanon. – Beirut, 2025.

9. Ministry of Finance. National Budget Allocations for the Ministry of Agriculture [Text] / Republic of Lebanon. – Beirut : Ministry of Finance, 2025.

10. North, D. C. Institutions, Institutional Change and Economic Performance [Text] / D. C. North. – Cambridge : Cambridge University Press, 1990. – 152 p.

11. Schumpeter, J. A. The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle [Text] / J. A. Schumpeter. – Cambridge, MA : Harvard University Press, 1934. – 255 p.

12. Schumpeter, J. A. Capitalism, Socialism and Democracy [Text] / J. A. Schumpeter. – New York : Harper & Brothers, 1942. – 381 p.

13. Schwab, K. The Fourth Industrial Revolution [Text] / K. Schwab. – Geneva : World Economic Forum, 2016. – 198 p.

14. Sharma, R. Industry 4.0 Applications in Agriculture: Cyber-Physical Agricultural Systems (CPASs) [Text] / R. Sharma, S. Parhi // Agricultural Systems. – 2023. – Vol. 198. – P. 10–25.

15. Shpak, A. P. Investment processes and the material-technical base of the AIC [Text] / A. P. Shpak. – Minsk : Institute of System Research in Agro-Industrial Complex of NAS of Belarus, 2019. – 180 p.

16. Shpak, A. P. Capital-output ratios and economic efficiency in Belarusian agriculture [Text] / A. P. Shpak. – Minsk : Institute of System Research in Agro-Industrial Complex of NAS of Belarus, 2021. – 210 p.

17. Smith, J. Sensor applications and environmental sustainability in precision farming [Text] / J. Smith, et al. // Precision Agriculture. – 2023. – Vol. 24. – P. 85–102.

18. Szukala, J. Subnational Innovation Ecosystems and Governance Capacity in the Absence of Central Fiscal Transfers [Text] / J. Szukala, et al. // Journal of Public Sector Innovation and Economic Policy. – 2024. – Vol. 12, No. 3. – P. 45–62.

19. World Bank. Lebanon Agricultural Sector Review and Damage Assessments [Text] / World Bank, FAO. – Washington, DC : World Bank Group, 2021. – 112 p.

20. Ahmed, F. The role of information capital in Agriculture 4.0 [Text] / F. Ahmed // Journal of Digital Agriculture. – 2022. – Vol. 14. – P. 112–128.

21. Pilipuk, A. V. Integrated management and food sovereignty during external shocks [Text] / A. V. Pilipuk // Proceedings of the National Academy of Sciences of Belarus. – 2023. – Vol. 45. – P. 55–67.

22. Chimnade, C. A quadruple helix framework for university-led community innovation systems in developing countries [Text] / C. Chimnade, et al. // African Journal of Science, Technology, Innovation and Development. – 2021. – Vol. 13. – P. 45–60.

23. Daineko, A. E. Digital modernization as a new economic mechanism in agriculture [Text] / A. E. Daineko // Belarusian Economic Journal. – 2024. – Vol. 22. – P. 34–49.

24. Drucker, P. F. Knowledge-Worker Productivity: The Biggest Challenge [Text] / P. F. Drucker // California Management Review. – 1999. – Vol. 41. – P. 79–94.

25. Hossain, M. Frugal innovation: A systematic literature review and future research directions [Text] / M. Hossain // Journal of Cleaner Production. – 2018. – Vol. 198. – P. 950–969.

26. Kaminski, J. Achieving inclusive digital development: A frugal strategy based on lessons from smallholder agriculture [Text] / J. Kaminski // Technological Forecasting and Social Change. – 2025. – Vol. 210. – P. 123–140.

27. Kondratenko, S. A. Directions for improving the mechanism of state regulation of agricultural production in modern conditions [Text] / S. A. Kondratenko // Agricultural Economics of Belarus. – 2023. – Vol. 18. – P. 12–25.

28. Liu, Y. Multi-objective optimal allocation and spatial distribution of water and land resources in irrigated farmland: A government-farmer duality

perspective [Text] / Y. Liu, et al. // Journal of Hydrology. – 2025. – Vol. 630. – P. 130–145.

29. Marques, P. Quadruple Helix co-creation and cities: Behavioral and institutional outcomes [Text] / P. Marques, et al. // Cities. – 2024. – Vol. 145. – P. 104–118.

30. Salman, H. The Quadruple Helix as an approach to strengthen innovation ecosystems [Text] : Ph.D. Dissertation / H. Salman. – York : University of York, 2023. – 210 p.

31. Williamson, O. E. The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting [Text] / O. E. Williamson. – New York : Free Press, 1985. – 450 p.

32. Jomaa, I. Personal communication and field interview regarding the institutional gap and spatial specialization in Lebanese agriculture [Text] / I. Jomaa. – Tal Amara : Lebanese Agricultural Research Institute (LARI), 2025.(date of interview:01.12.2025).

UDK 330

TRAINING STAFF FOR INDUSTRIAL AGRICULTURE IN THE CONTEXT OF DIGITALIZATION OF EDUCATION

Shmatko A.D.,
Шматко А.Д., Doctor of Economics, Professor
Federal State Budgetary Educational Institution of Higher Education "Baltic State Technical University "VOENMEKH" named after D. F. Ustinov", St. Petersburg

Ключевые слова: инновационное развитие, цифровизация, образовательный процесс, цифровые компетенции, предприятия, промышленное сельское хозяйство
Key words: innovative development, digitalization, educational process, digital competencies, enterprises, industrial agriculture

Аннотация: В данной статье анализируется инновационное развитие образования для предприятий промышленного сельского хозяйства в контексте цифровизации. Описывается внедрение цифровых инструментов в образовательный процесс, уровень использования информационных технологий в высших учебных заведениях и овладение цифровыми компетенциями. Проанализированы современные тенденции информатизации образования, преимущества и недостатки современного образования. От-