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Institutional Mapping of Nano-Technological Innovation System in the Agricultural Sector of Iran

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ABSTRACT

Nature and rate of technological change is defined inside technological innovation system, a concept developed out of Innovation System Approach. The main purpose of this study was to institutionally map nanotechnological innovation system of Iranian agriculture by investigating current state of hard and soft institutions regarding functions of the system. This study consisted of qualitative and quantitative phases. In the qualitative part, a thematic content analysis was used to compare the current and desired states of high level laws and documents. The quantitative phase was a descriptive survey. In the quantitative phase, the statistical population consisted of active researchers in the field of nanotechnology from agricultural national research institutes and centers, agricultural colleges, and knowledge-based companies. Using Krejcie and Morgan's table and stratified random sampling, 405 participants were selected. After ranking functions of the system based on their importance, current and desired functional state of hard institutions were compared through paired t-test. In the qualitative phase, current state of NanoTechnological Innovation in Agricultural (NTIA) system was investigated in terms of functions of soft institutions, i.e. 23 high level documents and laws related to nanotechnology, using ATLAS.ti software. Results showed that the functional gap between soft and hard institutions of the innovation system was very deep. This trend indicated that the capacities of various operators of NTIA system were not fully used to advance nanotechnology applications in agriculture.

Keywords: ATLAS.ti software, Functional gap, Hard institutions, Soft institutions.

INTRODUCTION

Today's economy emphasizes on knowledge-based economy and production facing challenges of the industrial era. In particular, it focuses on economizing production and creating competitive advantage by relying on human resources and using modern technologies as the main wealth factors (Zamani-Miandashti and Malek-Mohammadi, 2012; Walter *et al.,* 2014). Knowledge-based agriculture can be identified in increasing productivity and making maximum use of knowledge and technology in agricultural production (EU SCAR, 2012; Jahanshiri and Walker, 2015). Knowledge based approach to agriculture provides the opportunity for enhancing added value through innovation and maximizing productivity through application of knowledge and technology in the production of agricultural goods and services (Koutsouris, 2012). Nanotechnology may serve agriculture as the followings: increasing production (Malakouti, 2014), reducing waste (Pourrahim *et al.,* 2008), reducing chemical fertilizers usage (Zhang *et al.,* 2012; Malakouti, 2014), crops' quality (Prasad *et al.,* 2014), facilitating food processing and higher safety of the products (Sekhon,

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2010), ensuring water supply, its quality and safety (Qu *et al.*, 2013), and increasing machinery lifetime (Rai *et al.*, 2012).

Agricultural technological innovation system, as the most powerful system that encompasses -agricultural institutions and organizations, plays a very important role in development of new technologies such as nanotechnology in agriculture sector (Bagheri Moghaddam *et al.*, 2012) by providing the following seven functions: (1) Producing knowledge, (2) Disseminating it, (3) Directing research and innovation, (4) Securing and facilitating human resources, (5) Encouraging entrepreneurial activities, (6) Forming the market, and (7) Legitimating it (Carlsson and Stankievicz, 1991; Jacobsson and Johnson, 2000; Bergek *et al.*, 2008; Mohammadi *et al.*, 2013).

Capron and Cinsera (2007) divide institutions into two groups: hard and soft institutions. Organizations and actors of hard institutions involved in development of nanotechnology in agriculture are laced in the following seven levels (Ranaei *et al.*, 2006; Mohammadi, 2010; Sharifzadeh and Abdollahzadeh, 2011; Ministry of Jihad-e Agriculture, 2015): Macro policy-making institutions, executive policymaking institutions, intermediary institutions, agricultural research institutions, universities and educational centers, extension service providers, entrepreneurial and productive institutions of agricultural goods and products.

Soft institutions affect innovation in the form of formal and informal institutions (Capron and Cincera, 2007). Formal institutions are openly codified and affect innovation in terms of high level laws, rules and regulations, while informal institutions indicate norms, values, beliefs and way of thinking; and are not openly codified (Capron and Cincera, 2007) (Table 1).

A specific framework called institutional mapping is needed in order to study network of scientific and technical cooperation, formulate policies to ensure the relationship between the institutions, find the gaps and create a united view of the network (OECD, 1999; Aligica, 2006). It has been tried to prioritize their expected functions and determine functional gaps between current and desired state for each operator by modeling the process of institutional mapping (OECD, 1999). Sharifzadeh and Abdollahzadeh (2011) specified the first desired functional priority of multi-sectorial organizations. Temel *et al.* (2002) evaluated institutional relationships of agriculture innovation system in Azerbaijan Republic and considered agricultural research as one of the main components of agricultural innovation system. Bergek *et al*. (2008) studied obstacles of technological innovation systems in conditions of uncertainty, loss of legitimacy, poor communication, and ambiguous activities of existing companies and inhibiting government policies which led to failure of formation and development of technological innovation systems. Hekkert and Negro (2009) categorized the factors affecting the development of technology in technological innovation systems into factors related to the commercialization, policy instability, legitimation, learning at work, capabilities and competencies, and incorrect decision making. Maghabl *et al.* (2012) attributed barriers to nanotechnological development in Iranian agricultural sector to five factors: fiscal, structure, management, research, and information. Cristina *et al.* (2012) identified and grouped systemic problems by hierarchical factor analysis into four components: institution, network, science and technology infrastructure, and other support services. Cortes-Lobos (2013) concluded that agri-food nanotechnology subsystem has all the necessary ingredients, such as an excellent scientific community, solid institutions, competitive food industry, and social participation among others to achieve these public goals. Ali and Kunal Sinha (2014) suggest that it is necessary to develop responsible nanotechnology governance, encourage the development of appropriate products targeted to help meet critical human development needs, and include methods for addressing the safety,

Table 1. High level laws and documents related to development of science and nanotechnology in agriculture.

Row	High level laws and documents	Notification or approval entity	Notification or approval date
1	The constitution	The Cabinet	06.12.1979
2	Comprehensive scientific map of the country	Council for cultural revolution	14.01.2011
3	Iran's perspective document in 1404	Expediency council	18.10.2003
4	The fifth developmental Plan	The parliament	10.01.2011
5	Development strategy for nanotechnology's future	Council for cultural revolution	24.07.2005
6	General policies of the fifth developmental Plan	Supreme leader	10.01.2009
7	General policies of economic security	Supreme leader	10.03.2001
8	Amendments to law for partial adjusting of state financial regulations	Expediency council	16.02.2002
9	the 44th principle of the constitution law	Supreme leader	02.07.2006
10	fifth development program	Supreme leader	10.01.2009
11	The law of patents, industrial designs and trademarks	The parliament	29.10.2007
12	Protection law of knowledge-based companies and institutions as well as commercialization of inventions and innovations	Cabinet	21.11.2010
13	General policies to encourage investment	Supreme leader	18.02.2011
14	General policies of employment	Supreme leader	19.07.2011
15	General policies of industry	Supreme leader	10.01.2013
16	The law on maximum use of production and services capacity to meet the needs of the country and their reinforcement in exports, and reform the 104 Article for direct taxes	The parliament	11.09.2012
17	General policies of national production, supporting Iranian labor and capital	Supreme leader	12.02.2013
18	General policies to transform educational system of the country	Supreme leader	22.05.2013
19	General policies of resistance economy	Supreme leader	09.02.2014
20	General policies of science and technology	Supreme leader	20.09.2014
21	The law of elimination of the barriers to competitive production and improvement of the country's financial system	The parliament	11.05.2015
22	Sixth developmental plan	Supreme leader	30.06.2015
23	The amending law of the law on direct taxes	The parliament	22.07.2015

Retrieved from: New Communication and Technology Studies Office (2015).

appropriateness, accessibility, and sustainability of nanotechnology in the developing countries like India.

Reviewing the studies conducted within and outside Iran in the field of research and development of agricultural technologies reflects the fact that most of these studies investigated only a part of the continuum. This means to accept technologies and research findings based on diffusion of innovation theory, focusing on farmers as final users, and of agricultural extension as a transmitter (a linkage between farmers and researchers) (Sharifzadeh and Abdollahzadeh, 2011). Currently, development of nanotechnology is one of the country's main priorities, which has been emphasized on general policies of the fourth, fifth, and sixth Five-Year developmental plans. In this context, Ministry of Jihad-e

Agriculture along with some other executive ministries tried to do activities in the field of nanotechnology (Iranian Nanotechnology Initiative, 2015). Although nearly 15 years has passed from the introduction of nanotechnology and the formation of Nanotechnology Policy Studies Committee, in the cooperation technology office of Islamic Republic of Iran, the nanotechnology and its applications in agriculture are not fully expanded; and its benefits for the majority of agricultural stakeholders are yet to be realized (Rezaei *et al*., 2009; Iranian Initiative Nanotechnology, 2015). Despite sporadic activities and some achievements, it seems that agricultural sector is not in a favorable situation compared to other sectors involved in nanotechnology, due to many problems and challenges. One main reason is that the Responsibilities related to sectors of NTIA system are not specified, leading to a lack of functional coordination among various institutions of NTIA system.

MATERIALS AND METHODS

This study consisted of two phases: qualitative and quantitative. The quantitative phase was considered as a descriptive survey study. Using a questionnaire, respondents were asked to evaluate current and desirable state of actors in NTIA system in relation to some intended functions based on an 11 points continuum scale from zero to 10. In the qualitative phase, thematic content analysis was used and current state of high level laws and documents in relation to some functions of agricultural nano-technological innovation system was investigated by the ATLAS.ti software. The statistical population of the quantitative phase included those active in the field of nanotechnology from: (a) The national research institutes and centers (N= 290), (b) Agricultural faculty members in the field of nanotechnology (N= 190), and (c) Researchers of agricultural knowledge-based companies in the field of nanotechnology (N = 99). Using Krejcie and Morgan's Table (1970) and stratified random sampling method, 405 people were selected. In the qualitative phase, 23 cases of high level documents and laws related to agricultural nanotechnology development were analyzed. In the quantitative phase, to ensure the content validity of questionnaires, comments of researchers and faculty members were used. Also, to measure internal consistency coefficients, Cronbach's Alpha were computed that was between 0.72 to 0.91.

RESULTS AND DISCUSSION

According to the objectives of the research, the results are discussed in this phase.

Objective 1

Results of the frequency distribution of respondents i.e. researchers of the national research institutes and centers (n= 165), assistant professors of agricultural faculties (n= 170) and researchers of knowledge-based companies (n= 70), are shown in Table 2. The youngest and oldest respondents aged 28 and 62 years old, respectively, with an average and standard deviation of 38 years and 0.862. The respondents' experience in the field of nanotechnology ranged from 2 to 16 years; with an average and standard deviation of 9 and 1.08, correspondingly.

Objective 2

In order to rank functions of the NTIA based on their importance, the coefficient of variation was used. As Table 3 suggests, institutionalization and legalization for development of NTIA, with a variation coefficient of 0.066, was found as the first function, similar to the results previously reported by Sharifzadeh and Abdollahzadeh

Table 2. Demographic data (n_1= 165; n_2= 170, n_3= 70).

Personal and occupational characteristic		researchers in national research centers/institutes (n_1= 165)		Faculty in agriculture colleges (n_2= 170)		Researchers in knowledge-based firms (n_3= 70)	
		Frequency	Percent	Frequency	Percent	Frequency	Percent
Gender	Male	120	72.73	109	64.12	48	68.6
	Female	45	27.27	61	35.88	22	31.4
Age	Xi≤ 30	10	6.1	6	53.3	19	27.1
	30< Xi≤ 35	23	13.9	40	23.53	12	17.1
	35< Xi≤ 40	40	24.2	48	28.24	15	21.4
	40< Xi≤ 45	43	26.1	52	30.59	10	14.3
	45< Xi≤ 50	20	12.1	10	5.89	9	12.9
	50< Xi	29	17.6	14	8.22	5	7.1
Relevant work experience with nanotechnology	Xi≤ 5	48	29.1	26	15.3	33	47.1
	5< Xi≤ 10	83	50.3	93	54.7	29	41.5
	10< Xi	34	20.6	51	30	8	11.4
Education level	Bachelor	3	1.82	0	0	9	12.9
	Masters	23	13.94	0	0	46	65.7
	PhD	139	84.24	170	100	15	21.4
Education background	Animal Sciences	26	15.76	19	11.2	3	4.2
	Crop Sciences	32	19.39	21	12.4	9	12.9
	Gardening	25	15.15	22	12.9	0	0
	Food Industry	25	15.15	30	17.6	8	11.4
	Soil Sciences	10	6.06	20	11.8	10	14.3
	Biosystem Sciences	8	4.85	14	8.2	9	12.9
	Plant Protection	19	11.52	27	15.9	9	12.9
	Irrigation	13	7.88	11	6.5	0	0
	Other course	7	4.24	6	3.5	22	31.4

Table 3. Ranking functions of NTIA system based on their importance.

Rank	Functions	Mean [a]	Standard division	Coefficient of variation
1	Institutionalization (or popularization) and legalization for development of NTIA (G)	9.719	0.637	0.066
2	Guidance and direction of research and innovation in the field of NTIA (C)	9.510	0.763	0.08
3	Provision and facilitation of human and financial resources for development of NTIA (F)	9.486	0.788	0.083
4	Creation and development of nanotechnological innovations' knowledge in different areas of agriculture (A)	9.385	0.912	0.097
5	Dissemination of nanotechnological innovations' knowledge and formation of emerging revenues in different areas of agriculture(B)	9.274	1.047	0.112
6	Entrepreneurial activities in the field of NTIA (D)	9.232	1.065	0.115
7	Formation of market linked with the products of NTIA (E)	9.217	1.138	0.123

[a] Mean from zero to 10.

(2011) and Mohammadi *et al.* (2013). In Iran, coinciding with the introduction of nanotechnology in 1990, and forming the Nano and its Secretariat, the Strategic Planning for Nanotechnology Development and the Committee of Nanotechnology were established under the Ministry of Agriculture for legitimizing and regulating.

Once the standards and rules supported development of innovations related to production of nanotechnology in agriculture, their commercialization and marketing seemed necessary. However, out of 52 developed programs, only two paragraphs emphasized on the issue of commercialization and marketing. Certainly, it didn't have the necessary effectiveness. The Agricultural Extension Organization (AREEO), as one of the most important pillars of innovation, can create social acceptance of nanotechnology by changing social institution and aligning them with the needs of actors of the target system.

Objective 3

In this phase, overall prioritization matrix for hard institutions' functions of NTIA system was provided delineating their current and desirable state. It should be noted that in all cases, prioritization was done in terms of coefficient of variation. To compare the current and desirable states of the expected functions of hard institutions in NTIA system, the means were compared using paired t-test. Finally, desirable functional state for each institution of the innovation system was identified (Table 4). Comparing the current and desirable functions of macro policy-making and that of executive policy-making institutions, it is recommended that these institutions help in increasing integration and consensus among activists of NTIA. They should address future direction of agricultural nano-technological production by creating a powerful institution at the national level (such as the National Council for Agricultural Technology and Innovation). This institution could monitor the future of nano-technological innovation policy-making in agriculture, and prepare standards of products and services for NTIA. Comparison of current and desirable states of intermediary institutions revealed that entrepreneurship in the field of NTIA could be encouraged by: (a) Development of

Table 4. Ranking hard institutions of NTIA system based on their functional current state.

Functions \ Institutions	Macro policymaking institutions		Executive policymaking institutions		Intermediary institutions		Agricultural research institutions		Universities and educational centers		Extension-service institutions		Entrepreneurship-productive institutions	
	Current	Desired	Current	Desired	Current	Desired	Current	Desired	Current	Desired	Current	Desired	Current	Desired
A	7	5	3	7	2	3	1	1	1	1	7	5	5	3
B	5	6	1	6	3	4	3	2	2	2	5	6	7	4
C	6	4	2	5	4	6	2	3	3	3	6	1	6	6
D	1	7	7	2	5	1	5	4	5	4	1	3	1	1
E	4	2	5	4	7	5	6	7	7	6	4	2	4	2
F	2	3	4	2	1	2	4	6	4	7	2	7	3	5
G	3	1	6	1	6	7	7	5	6	5	3	4	2	7

active knowledge-based companies in the field of agricultural nanotechnology, (b) Creation of generative academic and private entrepreneurship companies in the science and technology parks, and (c) Enhancement of entrepreneurial capabilities and skills of agricultural companies and industries.

By considering the first current and desirable functions of agricultural research institutions, i.e. the universities and educational centers, it is recommended that these institutions direct and guide the research on NTIA by integrating the nanotechnological innovations' knowledge with indigenous agricultural knowledge, as well as publishing original and translated books in different areas of NTIA. Considering the functional current and desirable states of extension service institutions, it is suggested that these institutions put the following activities at the top of their priorities: (a) Creation and reinforcement of positive outlook among policy-making authorities based on promising promoters of innovations in the field of NTIA, (b) Clarification of the main users' demand for NTIA, and (c) Identification of opportunities and threats in relation to NTIA. According to the results of functional current and desirable participation of productive entrepreneurial institutions, it is endorsed that these institutions prioritize the following activities: (a) Diversifying the activity areas of agricultural production companies (such as large farms and agro-industries), (b) Enhancing entrepreneurial capabilities and skills of companies and agricultural industries, and (c) Increasing risk-taking investments for commercialization of NTIA. The findings were supported by previous studies (Mohammadi, 2010; Sharifzadeh and Abdollahzadeh, 2011; Maghabl *et al.*, 2012; Prasad *et al.*, 2014), too.

Objective 4

After inserting files related to 23 high level laws and documents, i.e. soft institutions, which addressed development of modern science and technology including nanotechnology, indicators related to the seven functions of NTIA system were defined in ATLAS.ti software as initial open codes. Then, each high level law and document was carefully studied; and those phrases and sentences which were similar to the open source code were codified. After specifying the open source codes' frequency, the key codes (families) were ranked. Each family was ranked according to frequency and mean of the families. To rank selective codes (or super families) in high level laws and documents, their frequency and mean was firstly determined (Table 5).

Finally, the first to seventh rankings of attention paid by high level laws and documents to the functions of NTIA system were in the following order (Table 6): (1) Provision and facilitation of human and financial resources for development of NTIA, (2) Dissemination of nanotechnological innovations' knowledge, and formation of emerging revenues in different areas of agriculture, (3) Institutionalization and legalization for development of NTIA, (4) Creation and development of nanotechnological innovations' knowledge in different areas of agriculture, (5) Entrepreneurial activities in the field of NTIA, (6) Formation of market for products of NTIA, and (7) Guidance and direction of research and innovation in the field of NTIA.

Later, appearance of each function in the high level laws and documents was specified and the following order was identified (Table 7): (1) The open source code and frequency of future development strategy for nanotechnology (f= 74), (2) The law of Fifth Developmental Plan (f= 72), (3) The comprehensive scientific map (f= 20), (4) The general politics of science and technology notified by the supreme leader in 2014 (f= 19), and (5) The barriers removal law for competitive production and promotion of financial system (f= 13). Almost, mentioned curriculum policy documents were repeated from previous documents, because implementation of the new policy is contextualized by the former policies.

Table 5. Ranking families (or key codes) and super families (or selective codes) based on attention currently paid to them in high level laws and documents.

Ranking initial codes in high level laws and documents			Ranking families (or key codes) in high level laws and documents				Ranking super families (or selective codes) in high level laws and documents			
Code	Frequency	percent	Family	Frequency	Mean	Rank	Superfamily	Frequency	Mean	Rank
A1-1	2	8.7								
A1-2	4	17.04								
A1-3	1	4.35								
A1-4	3	13.04								
A1-5	0	0	A1	11	1.1	3				
A1-6	0	0								
A1-7	0	0								
A1-8	1	4.35								
A1-9	0	0					A	34	2.6	4
A1-10	0	0								
A2-1	3	13.04								
A2-2	0	0								
A2-3	3	13.04	A2	16	3.2	2				
A2-4	4	17.4								
A2-5	6	26.09								
A3-1	4	17.4								
A3-2	3	13.04	A3	7	3.5	1				
B1-1	1	4.35								
B1-2	2	8.7								
B1-3	7	30.44								
B1-4	3	13.04	B1	20	3.33	3				
B1-5	2	8.7								
B1-6	5	21.74								
B2-1	10	43.48					B	47	3.69	2
B2-2	0	0								
B2-3	0	0	B2	12	4	1				
B2-4	2	8.7								
B3-1	4	17.4								
B3-2	1	4.35								
B3-3	6	26.09	B3	15	3.75	2				
B3-4	4	17.4								
C1-1	1	4.35								
C1-2	6	26.09								
C1-3	0	0								
C1-4	0	0	C1	8	1.14	1				
C1-5	0	0								
C1-6	0	0								
C1-7	1	4.35								
C2-1	1	4.35								

Table 5 Continued…

Continue of Table 5.

Ranking initial codes in high level laws and documents			Ranking families (or key codes) in high level laws and documents				Ranking super families (or selective codes) in high level laws and documents			
Code	Frequency	percent	Family	Frequency	Mean	Rank	Superfamily	Frequency	Mean	Rank
C2-2	3	13.04					C	16	0.82	7
C2-3	3	13.04								
C2-4	0	0	C2	7	1	2				
C2-5	0	0								
C2-6	0	0								
C2-7	0	0								
C3-1	1	4.35								
C3-2	0	0	C3	1	0.33	3				
C3-3	0	0								
D1-1	1	4.35								
D1-2	1	4.35	D1	4	1.33	2				
D1-3	2	8.7								
D2-1	3	13.04								
D2-2	0	0					D	23	2.25	5
D2-3	4	17.04	D2	19	3.17	1				
D2-4	0	0								
D2-5	1	4.35								
D2-6	11	47.83								
E1-1	3	13.04								
E1-2	0	0	E1	7	2.33	2				
E1-3	4	17.04								
E2-1	10	43.48								
E2-2	0	0								
E2-3	7	30.44	E2	22	3.67	1	E	30	2.11	6
E2-4	1	4.35								
E2-5	2	8.7								
E2-6	2	8.7								
E3-1	0	0								
E3-2	1	4.35	E3	1	0.33	3				
E3-3	0	0								
F1-1	5	21.74								
F1-2	5	21.74								
F1-3	3	13.04	F1	26	5.2	3				
F1-4	7	30.43								
F1-5	6	26.09								
F2-1	16	69.57								
F2-2	17	73.91					F	113	8.98	1
F2-3	13	56.52	F2	55	13.75	1				
F2-4	9	39.13								

Table 5 Continued…

Continue of Table 5.

Ranking initial codes in high level laws and documents			Ranking families (or key codes) in high level laws and documents				Ranking super families (or selective codes) in high level laws and documents			
Code	Frequency	percent	Family	Frequency	Mean	Rank	Superfamily	Frequency	Mean	Rank
F3-1	21	91.3								
F3-2	5	21.74								
F3-3	1	4.35	F3	32	8	2				
F3-4	5	21.74								
G1-1	2	8.7								
G1-2	4	17.4								
G1-3	1	4.35	G1	19	4.75	1				
G1-4	12	52.17								
G2-1	1	4.35					G	29	3.375	3
G2-2	1	4.35								
G2-3	0	0	G2	10	2	2				
G2-4	4	8.7								
G2-5	4	8.7								

Table 6. Ranking NTIA system's functions based on attention currently paid to them by high level laws and documents.

Functions (Super families)	Rank
Provision and facilitation of human and financial resources for development of NTIA	1
Dissemination of nanotechnological innovations' knowledge and formation of emerging revenues in different areas of agriculture	2
Institutionalization and legalization for development of NTIA	3
Creation and development of nanotechnological innovations' knowledge in different areas of agriculture	4
Entrepreneurial activities in the field of NTIA	5
Formation of market for products of NTIA	6
Guidance and direction of research and innovation in the field of NTIA	7

CONCLUSIONS

Institutional mapping of innovation system in Iran revealed that it suffers from a number of constraints including existence of several parallel public institutions, vaguely differentiated functions, and negligence of some very important elements such as innovative entrepreneurship in agriculture. Innovational development and nano-technological entrepreneurship are extremely vital for any NTIA system; hence, the Iranian system should also establish appropriate institutions capable of directing all scientific and technological efforts toward creation, diffusion, and application of knowledge and innovation.

Comparing current and desirable states of hard institutions' innovation system represented a significant functional gap in the roles played by all intended institutions regarding their functions. This trend indicates that the capacities of various operators of NTIA system are not fully used to advance nanotechnology applications in agriculture.

By comparing the overall rating of NTIA system' functions based on their importance and current attention paid to these functions in lower level laws and documents i.e. results of content analysis for lower level laws and documents, it is recommended that those laws and documents be formulated by policy-makers and decision makers of large organizations in line with implementation of the following operational programs. Besides, development of nanotechnology in agriculture should be administered and operationalized via implementation of these programs by other organizations:

Setting balanced and calculated regulations and custom facilities for facilitation of research as well as industrial and commercial interaction with leading countries in the field of nanotechnology

Codification and execution of laws and regulations to encourage the state and private sector to support inventors, innovators and financial and spiritual investment for commercialization of their inventions, ideas, and research designs

Legal support by shaping farmers' organizations and unions in order to enable them as efficient trading partners in the field of agricultural nanotechnology

Legal support by shaping centers of thought and future programs with the membership of macro and executive policymaking institutions in order to increase recognition and decision-making power in the field of agricultural nanotechnology;

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نگاشت نهادی نظام نوآوری نانوفناورانه در بخش کشاورزی ایران

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چکیده

نظام نوآوری فناورانه یک مفهوم توسعه یافته در چارچوب نظام نوآوری است که بر تبیین ماهیت و میزان تغییر در فن آوری تمرکز دارد. هدف کلی این تحقیق، نگاشت نهادی نظام نوآوری نانوفناورانه کشاورزی از طریق بررسی وضعیت مشارکت نهادهای سخت و نرم در ارتباط با کارکردهای نظام می باشد. این تحقیق از دو بخش کمی و کیفی تشکیل شده است. در بخش کیفی، از تحلیل محتوای تماتیک (تلخیصی) استفاده شده است و بخش کمی از نظر ماهیت توصیفی – پیمایشی بود. جامعه آماری تحقیق در بخش کمی، محققان فعال در حوزه فناوری نانو در مراکز و مؤسسات تحقیقات ملی (290 نفر)، اعضای هیئت‌علمی فعال در حوزه فناوری نانو در دانشکده‌های کشاورزی (190نفر) و محققان شرکت‌های دانش‌بنیان کشاورزی فعال در عرصه فناوری نانو (99 نفر) می‌باشد که با استفاده از جدول کرجسی و مورگان و روش نمونه گیری طبقه ای متناسب، تعداد 405 پرسشنامه جمع آوری گردید و در بخش کیفی، نهادهای نرم نظام نوآوری (23 مورد از اسناد و قوانین بالادستی مرتبط با فناوری نانو)، مورد تحلیل قرار گرفتند. در بخش کمی پس از رتبه بندی کارکردهای نظام نوآوری نانوفناورانه کشاورزی بر اساس میزان اهمیت، به مقایسه وضعیت فعلی و مطلوب کارکردی نهادهای سخت نظام نوآوری از طریق آزمونt همبسته پرداخته شد. در بخش کیفی نیز با استفاده از نرم افزار ATLAS.ti، وضعیت فعلی نهادهای نرم نظام نوآوری در ارتباط با کارکردهای نظام نوآوری نانوفناورانه کشاورزی بررسی شد. شکاف کارکردی نهادهای سخت و نرم نظام نوآوری نانوفناورانه کشاورزی بسیار عمیق بود. این روند نشان می دهد که از ظرفیتهای نهادهای مختلف نظام نوآوری نانوفناورانه کشاورزی در جهت توسعه کاربردهای فناوری نانو، به صورت کامل استفاده نشده است.