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Impacts of organizational arrangements on conservation agriculture: insights from interpretive structural modeling in Iran

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ABSTRACT

Conservation agriculture (CA) has been promoted worldwide as an approach to sustainable resource management and better productivity. Promotion and adoption of CA in Iran have been receiving increased attention from the national government over recent years. Therefore, to speed up development of CA as a basis for sustainable development, drivers that influence the development of CA need to be identified and modeled. The main aim of this study is to present a comprehensive model for CA development in Iran by identifying the institutional drivers that influence its promotion and determining the relationship between drivers. At first, the drivers identified from the literature and interviews with experts, and the relationships among the drivers were explored and clarified using Interpretative Structural Modeling (ISM). A cross-impact matrix multiplication was applied to classification (MICMAC) analysis, which was then used to categorize the drivers in four sub-groups. The results showed that creating a suitable organizational structure is a very significant driving factor for CA development in Iran. Strong driving power and weak dependence associated with this factor should be treated as a critical driver. If CA shall expand more rapidly in future, then Iran's government should invest in an appropriate organizational structure for it.

KEYWORDS

Sustainable development; participatory research; qualitative data analysis; sustainable farming; MIMAC analysis

Introduction

Agriculture aims to produce more food from less land by using natural resources more efficiently with the least environmental impact to meet the growing population of demands in the coming decades (Hobbs, Sayre., and Gupta 2008). A variety of agricultural practices have been developed and

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implemented around the world in response to concerns about food security and the depletion of natural resources in agriculture (Pannell, Llewellyn., and Corbeels 2014). Amongst them, conservation agriculture (CA) has been increasingly promoted as a sustainable cropping system for facing climate change impacts and increasing the stability of food production. CA integrates the management of soil and water resources to preserve natural resources while improving and sustaining productivity (Dordas 2015; Mrabeta et al. 2012). CA is a cultivation system based on three concepts of crop management: (i) minimum mechanical soil disturbance, (ii) permanent residual organic soil coverage and/or field coverage, and (iii) crop diversification (Hobbs, Sayre, and Gupta 2008; Kassam et al. 2009). In comparison to conventional agriculture, CA potentially conserves soil and water resources (Jat et al. 2014; Palm et al. 2013), improves productivity (Friedrich, Kassam, and Shaxson 2009), improves energy efficiency by reducing fuel consumption,decreases the machinery inputs required for tillage, and reduces production costs (Liniger et al. 2011; Ndlovu et al. 2014). Improved food security is also considered an important consequence of CA. According to Pradhan et al. (2017), increasing the yield and diversity of crop production is one of the most significant impacts of CA which should be supported as a move toward sustainable crop production to improve food security. The wide-ranging promotion of CA activities by incorporating it into the national agricultural development plan is, therefore, one of the solutions for responding to the impacts of climate change and the challenges of food security (Sapkota et al. 2015).

In Iran, various types of farming systems and land tenure can be found across the country, from commercial to subsistence farms, and both government and non-governmental organizations (NGOs) are actively involved in the farming sector. Although traditional agriculture still operates in some areas authorative statistics with public data, it has not been recognized as organic farming. Authoritative statistics on the area under different agricultural systems in Iran are generally not available (Koocheki and Ghorbani 2010). In the past, farmers relied on locally available natural resources to maintain soil fertility and to combat pests and diseases. Iran's agriculturally usable land can be divided into four classifications: 1) areas of intensive agriculture with natural irrigation that are distinguished by sufficient precipitation and natural water resources; 2) dryland farming areas are the most common ones and can be found in most parts of the country; 3) irrigation zones, typical of much of the central Iranian plateau, are characterized by relatively small patches of intensive land use in unused or neglected ecosystems and 4) pasture and rangeland constitute the most common form of land use in terms of spatial distribution; animal husbandry is carried out by both the farming and the tribal population (Koocheki et al. 2014). According to Koocheki et al. (2014), Iran is in poor condition in terms of sustainability of agricultural resources, the environment, rural communities and agricultural education, but at a moderate level in terms of sustainability of agricultural development. It therefore seems essential to take action to protect the soil in order to achieve sustainable agriculture safeguard soil quality.

In response to the increasing soil erosion and water crisis, the Government of Iran now promotes CA in the drylands and irrigated agricultural areas. Farmers play a key role in the implementation of the CA, so that if the CA principles are properly implemented in their fields, agriculture will lead to sustainability. In 2004, the Ministry of Agriculture introduced conservation tillage practices in two provinces of Iran (Khuzestan and Kermanshah). In 2007, the Ministry of Agriculture launched the first program for the development of CA in six provinces (Isfahan, Fars, Khuzestan, Hamedan, Qazvin, and Golestan) (Saei Ahan, Ghaisipour, and Mohammadi Assadi 2009). The positive results of CA in these provinces have encouraged the Iranian Government to promote CA across the country. According to the Iran's Sixth Five-Year Development plan (2016–21), the development of CA is one of the factors to achieve food security and improving the sustainability of water and soil resources. However, the government has not yet allocated any specific subsidies for the development of CA in the country, but plans are underway to make such an allocation (Ataei et al. 2019). According to the International Maize and Wheat Improvement Center (CYMMYT), the government took a CA-based Applied Research and Delivery HUB[1] approach to implement some CA projects around a few areas in cooperation with pioneer farmers and research institutes at the operational level. However, the latest political efforts have not increased the uptake of CA by Iranian farmers. With less than 5% of arable land under CA, adoption levels remain low in Iran.

Only a few studies have investigated institutional drivers of CA development. Most examined the effect of ecological, economic, and social factors on CA adoption at the farm level. (Arslan et al. 2014; Greiner and Gregg 2011; Kahimba et al. 2014; Knowler and Bradshaw 2007a; Lanckriet et al. 2014; Mazvimavi and Twomlow 2009; Ndah et al. 2014; Ngwira et al. 2014; Nyanga 2012; Rochecouste et al. 2015; Rodríguez-Entrena and Arriaza 2013). However, for CA development, not only adoption studies but also the identification of the drivers that create an enabling environment is an important priority for research. According to Lahmar (2010), CA-based systems in Europe are affected by farm and market conditions, biophysical conditions, social, cultural, technological and institutional factors that are acting as drivers or constraints on farm and off-farm levels.

Kahimba et al. (2014) identified five factors that contribute to the upscaling of CA in Tanzania: technological and economic influences, the involvement of agents of change and messages, suppliers of materials and equipment, business activities and communication infrastructure, and national and local policies and bylaws. Dhar et al. (2018) found that lack of good quality inputs and the high price of them are the major problems of CA farmers in Bangladesh. They concluded that input support and regular extension and training programs are factors that can motivate farmers to adopt CA practice.According to Giller et al. (2011), the market conditions at the regional level can enhance or impede the development, adaptation, and adoption of CA. Infrastructure, particularly communication and roads, is a major impediment to the free operation of markets (Sims, Hobbs, and Gupta 2009).

Ekboir (2003) believes that complex technologies are developed and disseminated by networks of stakeholders. According to Speratti et al. (2015), innovation systems that involve policymakers, product purchasers, input and credit suppliers, farmers, extension agents, and researchers are essential to overcome the socioeconomic and agronomic challenges of CA development. As in Brazil, Argentina and Paraguay, support from research institutions and farmers' organizations has been the key to promote adoption (Speratti et al. 2015). A wide range of stakeholders should be involved in CA's production and distribution process, including farmers, extension agents, academics, equipment manufacturers, service providers, product suppliers, traders, and policymakers(Corbeels et al. 2015).In this regard, Ndah et al. (2014) find that cultural and institutional constraints are the key barriers to CA adoption in South Africa. According to Ngwira et al. (2014), NGOs group membership is one of the most important factors influencing adoption and extent of CA. In sum, the involvement of various stakeholders is important including agricultural extension agents and local governments at national, regional, district, ward, and village levels (Kahimba et al. 2014).

CA is a knowledge-intensive and a complex system to learn and to implement. For farmers, it represents a fundamental change in conventional cropping system thinking (Friedrich and Kassam 2009; Kassam et al. 2009). Furthermore, it displays a foundation change from traditional practices because it is not an easily transferable single component technology. Hobbs and Govaerts (2010) noted that overcoming the tillage prejudice or attitude is an important factor in CA's adoption. A mental shift from soil-degrading tillage to CA is required by farmers, extension workers, and researchers (Derpsch 2001). According to Kassam and Friedrich (2011), experience and empirical evidence throughout many countries showed that CA's spread requires a change in attitude and actions of all stakeholders concerned. CA awareness, distribution of information through agents and farmers, and increased support for policies will help to change attitudes and traditional agricultural practices (Speratti et al. 2015). Wall (2007) indicates that successful adoption of CA depends on increasing awareness of soil depletion issues in the community. Farmers' attitude that tillage is important for good crop production is also crucial. A change from attitudes and conventional farming practices to attitudes and conservation farming practices at national and regional levels is necessary in order to make effective use of research results and human resources. Carmona et al. (2015) indicate that in order to overcome socioeconomic barriers to the adoption of CA, particulate research and training can promote CA among farmers' groups excluded from resources and support. Long-term work is therefore required on CA technologies and demonstrations (Li et al. 2015).There is a long and rich tradition of empirical research that seeks to explain the adoption by farmers of specific agricultural innovations. Since Ryan and Gross (1943) first demonstrated that the acceptance of agricultural technologies is usually inconsistent from farmer to farmer, researchers have focused attention on certain characteristics of farmers and their households in an effort to explain this inequality. A farm operator's level of education has often been assumed to influence adoption decisions because of the presumed link between education and knowledge. In addition, education generally correlates positively with the adoption of conservation practices in agriculture (Knowler and Bradshaw 2007b; Prokopy et al. 2008). Resistance to change and personality are linked: individuals who score low on openness to new experiences may be particularly reluctant to change in general. In other words, the status quo bias, whereby people systematically prefer to maintain their current practices because they see any change as a threat is also inherently linked to resistance to change.

A recent meta-analysis of the role of status quo bias in agri-environmental policy has shown that a high percentage of farmers systematically reject change (Barreiro-Hurle et al. 2018). Because rigidity is strong among farmers (Rodriguez et al. 2009), it is probably one of the main reasons why more sustainable practices are not adopted. Moreover, risk tolerance is a key concept in (behavioral) economics, which has been found to influence farmer behavior across a wide range of areas, such as the signing of crop insurance contracts and crop innovations (Hellerstein, Higgins, and Horowitz 2013).

According to most literature, the development of CA requires an enabling environment. An enabling environment reflects a set of interrelated conditions including political, regulatory, institutional, economic, and social ones that provide desirable conditions for CA adoption at the local level (World Bank 2012). This environment must both motivate and enable farmers so that they are in a better position to take it up. Therefore, understanding different drivers that impact CA development and their interdependence is essential to createa fully functional and effective environment for the development of a country's resource base. The development of CA will require committed attention to the drivers that currently impede adoption. A clear definition of CA creation and relationships among drivers also allows top leadership to make appropriate decisions to solve the problem of low CA adoption.

Previous studies on the CA development in Iran focused on identifying the factors affecting the adoption of CA principles at farm level (Haghjou, Hayati, and Momeni Choleki 2014; Rafiei 2016; Sarikhani Khorami et al. 2018) and analysis of the barriers to its development (Latifi et al. 2017). Although some studies already argued the various aspects and impacts of CA as a new technology, creating an enabling institutional environment for CA development received less emphasis in previous studies. Thus, there is a need for research to define which institutional arrangement should be targeted for increased CA promotion (Nhamo and Lungu 2017). In order to fill this gap, this study attempts to investigate the institutional drivers of CA development, as well as the relationships between drivers, in order to develop measures and strategies for the promotion of CA practices. Accordingly, the purpose of this study is to identify the most influential drivers of CA development to present a comprehensive model that provides a guideline for CA promotion programs in Iran. This study contributes to the emerging field of CA and would improve the policies associated with CA development in Iran.

Methodology

Research process

A qualitative multi-method analysis consisting of semi-structured interviews and focus groups was carried out to model the drivers influencing CA adoption. First, the drivers from the literature and interviews with experts were identified and then the relationships among the drivers were clarified by using Interpretative Structural Modeling (ISM) approach. ISM was developed by J. Warfield in 1973 to analyze complex socio-economic systems (Warfield 1974). ISM's basic idea is to classify and evaluate the relationships between different variables that define a problem or issue by using the knowledge and experience of experts to create order and guidance on the nature of relationships between system elements (Sage 1977; Warfield 1974). ISM has been used in a wide range of fields, including the analysis of interactions between energy-saving barriers (Wang, Wang., and Zhao 2008), analysis of drivers and barriers influencing the implementation of green supply chain management (Diabat and Govindan 2011; Mathiyazhagan et al. 2013), and the analysis of interactions between smart grid technology barriers (Luthra et al. 2014). In this study, the main approach involved two distinct stages: literature review and interviews. At first, by exploring relevant journal articles, government documents, and CA project reports, CA development drivers were identified. In the next step, semi-structured interviews were conducted to finalize identified drivers with experts and other key stakeholders from nine pioneering provinces. In other words, the main sources of data were the literature study and the interviews with experts. During the model development phase, a diversified group of experts with more than 10 years of experience in CA promotion activities was selected to ensure the appropriate coverage of all aspects of CA development.

The various steps of ISM technique are (Kannan and Noorul Haqa 2007; Kannan, Pokharel, and Sasikumar 2009; Ravi and Shankar 2005): (1) the identification of the variables relevant to the subject matter of the study, (2) the establishment of a structural self-interaction matrix (SSIM) by examining pair relationships between the variables identified on the basis of expert opinions, (3) building the SSIM reachability matrix, (4) examining the reachability matrix for the contextual relationship transitivity which is a basic assumption made in ISM, (5) dividing up the reachability matrix obtained in the previous step into different levels, (6) designing a directed graph based on the achievement matrix result and eliminating transitive links, and (7) transforming this digraph into an ISM model by replacing variable nodes with statements and checking the model for conceptual inconsistency and necessary adjustments.

Moreover, a Matrix Impact Cross-Reference Multiplication Analysis (MICMAC) is done to identify the key drivers that drive the system. MICMAC was developed in 1973 by Duperrin and Godet (Wang, Wang, and Zhao 2008). This method of analysis was used to define and analyze the variables' dependency and driving force (Mandal and Deshmukh 1994; Ravi and Shankar 2005). The drivers will be grouped into four clusters according to the driving power and dependencies. The first cluster (I) is made up of autonomous drivers with poor driving ability and heavy dependency. They are fairly disconnected from the network, with which they have just a few relationships, which can be powerful. The second cluster (II) is made up of dependent drivers with low driving capacity but strong dependency. The third cluster (III) involves contact drivers with strong driving power and high dependence. The fourth cluster (IV) consists of autonomous drivers with good driving power but low dependency (Ravi and Shankar 2005).

Sampling and data collection

A systematic samplingprocess was applied to obtain the list of drivers for CA development. The process involved two distinct stages: literature review and interviews. In the first phase, by exploring relevant journal articles, government documents, and CA project reports, drivers to CA development were identified. Then, semi-structured interviews were conducted to finalize identified drivers with farmers, researchers, and other key stakeholders from 9 provinces of Iran during 2015. The 32 experts were identified through snowball sampling. Based on the literature (Emmel 2013; Patton 2015a, 2015b), snowball sampling is considered as a sequential and emerging sampling strategy during fieldwork. It is important to note that this method is a nonrandom sampling method that is used in qualitative studies and therefore, is a biased method. Nevertheless, through this method, multiple cases of a phenomenon are selected to create generalizable findings that can be used to inform changes in practices, programs, and policies. In the next step, we will build a fieldwork sample. Then one case leads to the next, in sequence, as the investigation unfolds. In the last step, we follow the new directions that emerge during the study (Kendall, Kerr, and Gondim et al. 2008). It is worth mentioning that the main basis, i.e. "how many cases", should be chosen in the qualitative sampling method to arrive at "data saturation", where adding more cases will not add to the information provided by the participants Staniford et al., 2011). In other words, when we arrived at 32 cases, our data set got saturated, and when we added more cases, we did not get any new information and just got the repeating information (what other cases had already told us).

The interviews focused on understanding the factors that can drive CA development with respect to the Iranian agricultural section conditions. The participants were asked open questions such as: What is your opinion about the current state of CA development at local and national levels? What challenges are there for transitions to CA in Iran? Does the current CA institutional arrangement represent an efficient outcome? What factors can influence CA promotion? What should the government do at national and local levels for CA promotion?

Interviews were conducted in 2015 and they lasted between 20 and 70 minutes. All interviews were tape-recorded and transcribed. In developing the contextual relationship among the variables of the experts in developing structural self-interaction matrix (SSIM), the ISM methodology builds on expert opinions based on different techniques, such as focal groups, nominal techniques, etc.(Luthra et al. 2014; Ravi and Shankar 2005). In the second phase, two focus groups, including 10 subject matter experts (policymakers, advisors, and researchers) with more than ten years of experience in CA promoting activities, were interviewed in 2015. Participants were selected from different parts of Agricultural Organizations and agricultural research institutes in order to account for the diversity of comments. Each of the two focus group interviews took from 35 to 50 minutes and included 4–5 participants per group. As shown in Table 1, during focus group discussions all participants were asked to determine the relationship between identified CA development drivers by using below symbols:

Symbol V means that driver 'i' will help to achieve driver 'j'.
Symbol A means that driver 'j' will help to achieve driver 'i'.
Symbol X means that driver 'i' and driver 'j' will help each other to be achieved.
Symbol O means that driver 'i' and driver 'j' are not related to each other.

To facilitate the information-gathering process, we developed and used a structural self-interaction matrix (like Table 2). Moreover, all comments made by participants were written and used in the data analysis stage.

Table 1. Structural self-interaction matrix for the drivers affecting conservation agriculture in Iran.

Drivers (i and j)	D8	D7	D6	D5	D4	D3	D2	D1
Creating an organizational structure (D1)	V	V	V	V	V	V	V	-
Policy-making and planning at national and local scale (D2)	V	V	V	V	V	X	-	
Monitoring and assessment at national and local scale (D3)	V	V	O	V	V	-		
Financial support (D4)	V	V	V	A	-			
Inputs markets and infrastructures (D5)	V	V	O	-				
Creating the culture of CA at national and local scale (D6)	A	A	-					
CA extension and education (D7)	X	-						
CA research and development (D8)	-							

Table 2. The initial reachability matrix for the drivers of conservation agriculture in Iran.

Drivers	D1	D2	D3	D4	D5	D6	D7	D8
Creating an organizational structure (D1)	1	1	1	1	1	1	1	1
Policy-making and planning at national and local scale (D2)	0	1	1	1	1	1	1	1
Monitoring and assessment at national and local scale (D3)	0	1	1	1	1	0	1	1
Financial support (D4)	0	0	0	1	0	1	1	1
Inputs markets and infrastructures (D5)	0	0	0	1	1	0	1	1
Creating the culture of CA at national and local scale (D6)	0	0	0	0	0	1	0	0
CA extension and education (D7)	0	0	0	0	0	1	1	1
CA research and development (D8)	0	0	0	0	0	1	1	1

If the (i, j) entry in the SSIM is V, the (i, j) entry in the reachability matrix is set to 1 and the (j, i) entry is set to 0; if the (i, j) entry in the SSIM is A, the (i, j) entry in the reachability matrix is set to 0 and the (j, i) entry is set to 1; if the (i, j) entry in the SSIM is X, the (i, j) entry in the reachability matrix is set to 1 and the (j, i) entry is set to 1; and if the (i, j) entry in the SSIM is O, the (i, j) entry in the reachability matrix is set to 0 and the (j, i) entry is set to 0

Data analysis

During the first point, thematic analysis was used to analyze transcripts for the interviews and documents. Coding processes include (1) familiarization with data, (2) initial code formation, (3) codification thematic search, (4) subject analysis, (5) the identification and naming of themes, and (6) final report preparation (Braun and Clarke 2006). The qualitative data was analyzed by ATLAS.ti 6 software. Thematic analysis identified eight main drivers affecting the development of CA in Iran. To enhance reliability, data were collected from different sources (key stakeholders of CA in different parts of Iran and relevant published articles and documents) and compared. In the second phase, the frequency of each symbol in the structural self-interaction matrix was calculated by analyzing the focus group data, and finally,the type of relationship of drivers was determined.

Model development

The focus group discussions resulted in the following SSIM to discover relationships among drivers (Table 2). Indeed, this process involves determining whether a relationship exists between two infrastructures, including i and j. This matrix indicates the pairwise relationships among the drivers affecting CA development.

The SSIM is converted into a binary matrix known as the initial accessibility matrix. The initial accessibility matrix is built using SSIM(Table 3).

Table 4 constructs the final reachability matrix from the initial reachability matrix, taking account of the transitivity rules.[2] In addition, the driving power and dependence of each driver are estimated for the final accessibility matrix. The MICMAC will continue to use these driving power and dependencies.

In the next stage, each driver was reached by the final accessibility matrix and the preceding sets. Each driver has its own accessibility package and the other drivers to help achieve it. The background set includes the drivers themselves and the others that can contribute to the achievement of this. The intersection of these sets has been derived for all drivers. The driver for which the reachability and intersection sets are equivalent is given the top-level driver in the ISM hierarchy, which would not support any other drivers above their own level. Iteration 1 is completed with this partition. The same method is then used to determine drivers at the next level. The process was repeated until each driver's level had been determined. The method was completed in six iterations in this study, and six driver rates were obtained for the production of CA. Table 4 displays the driver's final level.

From the final reachability matrix, the final structural model of the various drivers important to CA development is constructed (Figure 1). The developed ISM model consists of six levels (Figure 1). The drivers creating the culture of CA at national and local scales (D6) were positioned at the top of the model because they

Table 3. The final reachability matrix for the drivers.

Drivers	D1	D2	D3	D4	D5	D6	D7	D8	Driver power
D1	1	1	1	1	1	1	1	1	8
D2	0	1	1	1	1	1	1	1	7
D3	0	1	1	1	1	1*	1	1	7
D4	0	0	0	1	0	1	1	1	4
D5	0	0	0	1	1	1*	1	1	5
D6	0	0	0	0	0	1	0	0	1
D7	0	0	0	0	0	1	1	1	3
D8	0	0	0	0	0	1	1	1	3
Dependence power	1	3	3	5	4	8	7	7	-

For driver 1, Driving power = $\sum_{j=1}^{8} a1j$ and Dependence power = $\sum_{i=1}^{8} ai1$

Table 4. Level partition of drivers – final iteration.

Iteration	Drivers	Reachability Set	Antecedent set	Intersection	Level
6	D1	D1, D2, D3, D4, D5, D6, D7, D8	D1	D1	VI
5	D2	D2, D3, D4, D5, D6, D7, D8	D1, D2, D3	D2, D3	V
5	D3	D2, D3, D4, D5, D6, D7, D8	D1, D2, D3	D2, D3	V
3	D4	D4, D6, D7, D8	D1, D2, D3, D4, D5	D4	III
4	D5	D4, D5, D6, D7, D8	D1, D2, D3, D5	D5	IV
1	D6	D6	D1, D2, D3, D4, D5, D6, D7, D8	D6	I
2	D7	D6, D7, D8	D1, D2, D3, D4, D5, D7, D8	D7, D8	II
2	D8	D6, D7, D8	D1, D2, D3, D4, D5, D7, D8	D7, D8	II

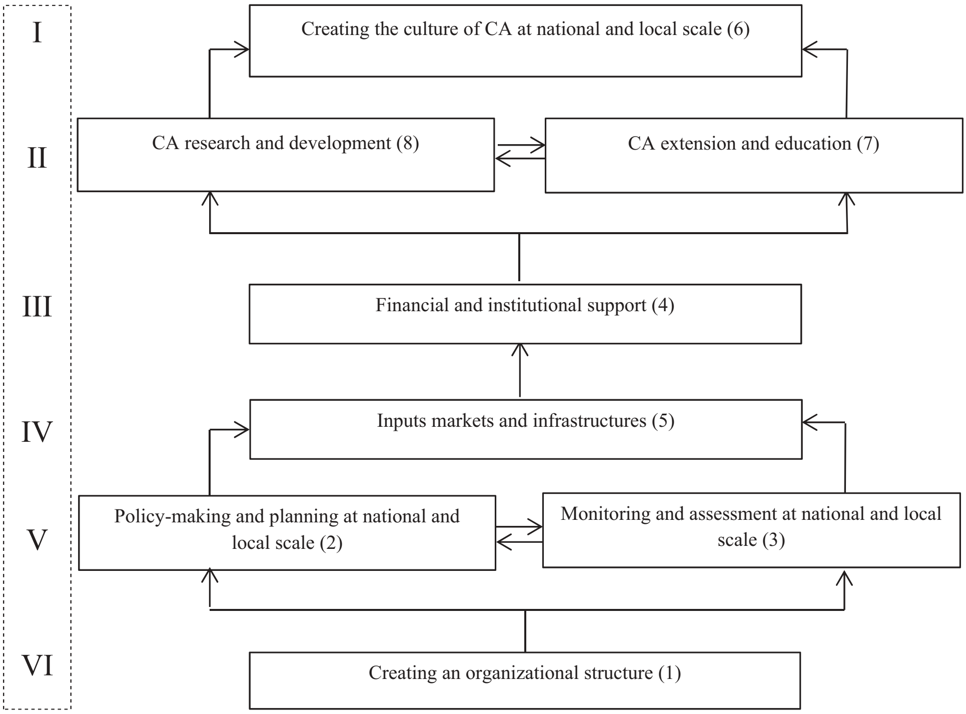

Figure 1. ISM model for the drivers affecting the development of CA.

belong to the first level. At the second level, we have CA extension and education (D7) and CA research and development (D8) which can help achieve the top driver with the help of other drivers. Moreover, these two drivers indeed help each other to achieve the top driver. The driver financial support (D4) was laid at the third level, which can be achieved with the help of driver inputs markets and infrastructure (D5). This driver can only be achieved when policy-making,planning,monitoring, and assessment at national and local scales are dealt with. These drivers (D2 and D3) are required to achieve institutional arrangement (D1). The driver creating an organizational structure (D1) was positioned at the basis of the ISM model, which is a crucial driver of CA development. Thus, creating an organizational structure-should be considered at the root levelsof CA development.

Results

Identification of various CA development drivers

Drivers of CA development are key factors and activities required for ensuring the achievement of CA high level adoption, which are required to be identified. In total, 47 drivers were identified from the literature review and interviews (Table 5). Based on their meaning and similarities, we further categorized these drivers into eight groups.

Table 5. Thematic analysis of CA development drivers.

Themes (drivers)	Initial codes
Creating an organizational structure	- Evaluating of existing organizational structure of CA development and reforming it; - Increasing cooperation between governmental and non-governmental organizations related to CA; - Interact with international organizations and institutions related to conservation agriculture (CIMMYT etc.); - Using the capacity of local organization such as rural councils and administers for CA development; - Creating and developing CA farmers' groups, such as CA associations in each province; - Organizing and enhancing communication among researchers, extension workers, farmers and manufacturers for sharing experiences and lessons learned.
Policy-making and planning at national and local scale	- Have a strategic vision on CA development at national level; – Formulating operational plans for the mainstreaming of CA at local level; - Using of experience of CA leading countries in planning for CA development; - Involving key stakeholders in the process of designing CA promotion plans and projects; - Allocating more budgets for the implementation of CA promotion plans and projects; - Coherence between CA development policies and other agricultural policies; adopting policies to CA based on all stakeholders needs; - Adopting policies to enhancing human resources capacities for CA promotion.
Monitoring and assessment at national and local scale	- Monitoring on the implementation of CA promotion plans and projects; - Assessment of CA promotion policies, plans and projects at national level; - Using of farmers' organizations in assessment of CA promotion plans and projects at local level; - Monitoring on the production process of CA equipment by local manufactory; - Monitoring on the correct implementation of the CA principles by farmer; - Regular monitoring on CA farms to identify of best operation for each region, especially in the early years of the implementation of the principles.
Financial support	- Financial Support of small farmers for reducing probably risks in first years of the implementation of conservation agriculture; - Organizing government financial support and tax of domestic manufacturers of CA equipment and machinery; - Facilitating farmers' access to services and technical advices in the field of adaptation and change existing equipment; - Facilitating farmers' access to financial credits for buying CA machinery; and creating insurance schemes to support of CA development.
Inputs markets and infrastructures	- Strengthening information and communication infrastructure to facilitate access to market and transmit CA knowledge; - Improvement of CA machinery and equipment in response to a range of crops and regions; - Localization of production of CA machinery in accordance with the agro-ecological condition of each region; - Creating and strengthening CA instruments and inputs market; - Make arrangements for facilitating sale of CA farmers production; - Initial investment by the government with the participation of farmers in soil amendments.

(*Continued*)

Table 5. (Continued).

Themes (drivers)	Initial codes
Creating the culture of CA at national and local scale	- Raising awareness of non-agricultural policy makers about the advantages of CA and need to develop it; - Organizing workshops and training programs to familiarize managers and experts of Agricultural Organizations with the concepts, principles and short and long-term benefits of CA; - Providing TV programs to familiarize wide range of farmers with the concepts, principles and short and long-term benefits of CA; - Using of potentials of pioneer farmers in CA cultural programs at local level.
CA extension and education	- Using of the "learning by doing" approach in CA extension programs; - Using of the participatory extension program such as farmer-to-farmer extension approach to CA promote; - Organizing training course about technical and management aspects of CA implementation for advisors and extension agents; - Providing training programs to enhance agricultural students' knowledge about CA; - Establishing demonstration plots with pioneer farmers' cooperation; - Organizing appropriate training programs based on farmers' information needs.
CA research and development	- Creating feedback loops between researchers and other stakeholders to identify CA research priorities; - Formulating systematic research plans on CA in accordance with the agro-ecological condition of each region; - Interacting with international research institutes forsharing experiences and lessons learned; - Implementing on-farm research with cooperating farmers to generate more appropriate CA system under farmers' conditions; - Increasing engagement of farmers in CA research; - Focus on solution-oriented research in CA research.

Creating an organizational structure

All interviewees asserted that setting formal and informal organizational structures, rules, or agreements shared among all stakeholders is a precondition for planning, supporting, and implementing CA development programs and practices.

> *Interviewee 4 and 10*: Without clear cooperation and linkage between the agricultural ministry and other stakeholders, informed decision making about CA development would be impossible.

Interviewees further suggest that the institutional environment for CA must be strengthened by strengthening existing organizational structures or creating new ones. The development of CA requires an innovative strategy that calls for new ways of working together. The Government does not govern CA development alone, and other stakeholders play important roles too. In this regard, the involvement of key stakeholders in policy preparation and implementation, interaction and coordination between all stakeholders, linkage of stakeholders with farmers, and participation of the private sector will be neededfor CA development. Two of the interviewees expressed his view on collaboration as follows:

> *Interviewee 7 and 22*: It is essential to ensure the interaction between all stakeholders and the linkage between them. These factors should be considered as a part of the structure of a CA development project from the beginning.

Policy-making and planning at national and local scales

Interviewees indicated that policy-making and planning play a vital role in the adoption and spread of CA. To increase the adoption of CA in Iran, there is a need for clear and consistent political commitment and adequate government policies that enable the farmers to meet their risks. Interview transcripts also showed that besides the suitable government CA policies, strategic planning at national and local levels is needed. Formulation of programs atnational and local levelsfor the mainstreaming of CA could be the most effective way of CA development, and it should start with a thorough understanding of farm level conditions.

> *Interviewee 13*: I (expert) believe that planning is the most important step for CA development because of its specification of the CA development goals. It is essential for the government to have long-term and short-term plans to meet those goals.

Monitoring and assessment at national and local scales

Most interviewees indicated that monitoring and assessment should be an important part of CA development efforts. Monitoring and assessment at national and local levels help the government to achieve effective implementation of CA programs. Continuous monitoring and evaluation of institutional performance should be an important component of the national program of CA. According to the experts, there is no effective monitoring system for applying CA principles to the farms. Therefore, monitoring CA implementation in farms at the local level is a key activity required for ensuring the success of the exact implementation of CA principles.

> *Interviewee 30*: To promote CA, it is important to focus on monitoring and assessment of CA promotion projects. Multilevel monitoring and assessment processes at national and local scales should be considered.

Financial support

Farmer representatives believe that CA equipment and inputs are often expensive for most farmers. While experts interviewed at the Agricultural Organizations argue that financial support should focus on the provision of CA machinery, tax relief and subsidies for the production of CA machinery, facilitation of access to credit and finance options, and creating insurance services, farmer representatives believe that direct payment and subsidies are a crucial element.

> *Interviewee 8, 14, and 20*: CA machineryis expensive, and small farmers do not have enough money to buy such equipment. Providing credit for farmers to buy the CA equipment and inputs through credit agencies is a necessary factor for the adoption of CA.

Input markets and infrastructure

According to all interviews, we found that the availability of CA inputs and equipment markets at an affordable cost has been a constraint to the adoption of CA technologies. Ten participants explained that based on past experiences, without existing suitable markets and infrastructure for present CA machinery and inputs, CA adoption would not happen. Therefore, strengthening market and communication infrastructures for markets' accessto CA inputs and investments in improved lands are essential components of efforts targeted at the upscaling of the CA.

> *Interviewee 15*: The important thing for the successful development of CA is the need forenhancing farmers' access to markets to buy the equipment, machinery, and inputs by strengthening rural infrastructure.

Creating the culture of CA at national and local scales

The interviewees maintained that CA involves changing the mindset of all stakeholders about conventional farming practices. Where practices such as plowing and clearing the land are embedded in the local culture, changing the mind-set of the farming community is difficult. However, CA development depends strongly on a deep mindset change. Increasing information dissemination and awareness among all CA stakeholders, especially farmers and policymakers, about CA benefits is an essential factor to overcome cultural biases toward conventional farm management. It is important that all stakeholders come to a full understanding of the implication of the CA system.

> Interviewee 3: CA is not common in the agricultural community because most farmers believe that plough is still an essential part of successful farming.

CA extension and education

Most interviewees indicated that lack of technical knowledge about CA principles is an important factor that limits CA adoption. Therefore, motivated and continuous extension and education services are prerequisites for CA development. The most essential element of CA's extension is

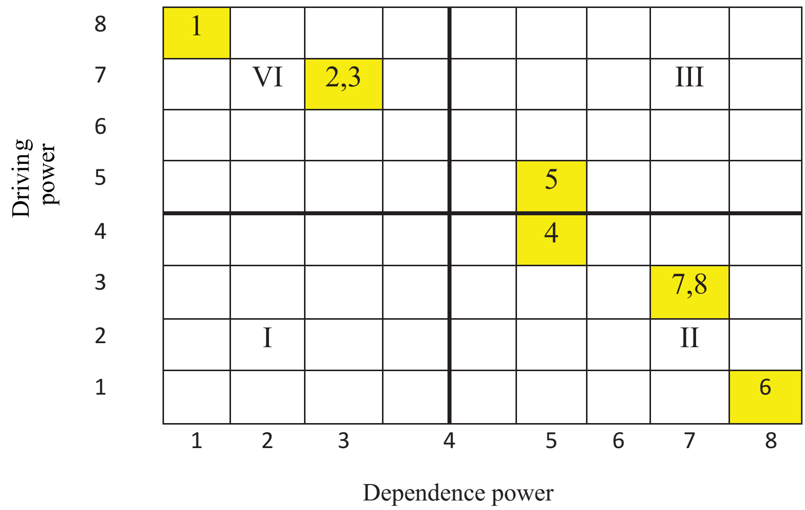

Figure 2. Driving power and dependence power.

that extension activities should be able to provide farmers with up-to-date information by exchanging visits with farmers and informal farm-to-farm interactions. The public sector has a key role to play in ensuring that the extension service provides farmers with high-value information.

> *Interviewee 8*: To adopt and implement CA principles, farmers need to observe the performance of CA in the farm situation. CA demonstration plots can provide an excellent opportunity for farmers to observe the performance of CA.

CA research and development

To achieve a high level of CA adoption, CA research and development programs are essential. With regard to a new technology such as CA, a strong communication about progress and problems between farmers, researchers, and manufacturers is an important activity that the public sector should support. CA's R&D services should also be closely coordinated with other stakeholders to identify needs and select appropriate solutions. The main role of CA research and development programs should be technology adaptation to local conditions. Farmer participatory research can enable CA scientists to identify problems and use both indigenous and scientific knowledge to solve problems and adapt CA to local conditions.

> *Interviewee 18 and 9*: For CA development, agricultural research centres in each region must focus on participatory long-term research. It can create an opportunity for the identification of CA problems in farms by involving farmers in the research program. Moreover, it can facilitate the process of adapting the principles of CA to the conditions (Interviewee 25). Research in farmers' fields and

cooperation with innovative farmers allow other farmers to see the result in the farmers' conditions. It also provides a great opportunity for the identification of problem areas and researchable issues.

MICMAC analysis

After the final ISM structure, the MICMAC analysis of the variables is done based on their driving and dependence power. All drivers are categorized into four distinct clusters based on their driving power and dependency (Figure 2). As an example, driver 1 (creating an organizational structure) has the driving power of 8 and dependence power of 1 and therefore has been placed accordingly in the MICMAC diagram at the top left of the diagram. None of the driver categories was classified in sector I. The absence of such drivers indicates that all considered drivers play a significant role in the model. Financial support (D4), creating the culture of CA at national and local scales (D6), CA extension and education (D7), and CA research and development (D8) were placed in sector II as dependent drivers. These drivers have weak driving power and strong dependence power. Markets of inputs and infrastructure (D5) were placed as a connection driver in Sector III. Linkage drivers have a powerful driving force and a strong dependence. This driver is unstable because any action on this driver affects the others and can also have an impact on itself. Categorized national and local policy and planning (D2) and monitoring and evaluation (D3) fell into the fourth cluster, which includes independent categories with strong driving power but poor dependence.

Discussion

The objectives of the research were to identify the drivers affecting the development of CA and finding their contextual relationships to develop a hierarchy of drivers for CA development in Iran. The contextual relationships between identified drivers and the development of a structural model of these drivers for CA development have been achieved using the ISM methodology.

In this model, creating an organizational structure (D1)has been identified as the root driver for CA development and helps all other drivers for effective function. Similarly, the results of Rai et al. (2011) and Dougill et al. (2017) indicate that institutional arrangements have a significant effect on CA adoption and promotion. CA development, like any other novel agricultural practice, relieson the formal and informal organizational structures, rules, and informal norms in form ofinstitutional arrangements for creating an enabling environmentto facilitate CA adoption and diffusion. These institutional arrangements need to be dynamic so that they can respond to the varied and changing needs of farmers (Friedrich, Kassam, and Shaxson 2009).

The culture of CA at national and local scales is showing at the top of the structural model (D6). This driver has the highest dependence power and is strongly dependent on other drivers. Development of CA increasingly needs initiatives for cultural domination practices among farmers and stakeholders regarding this phenomenon. This because a major challenge to the widespread adoption of CA across Iran is the tillage mind-set. Soil tillage, particularly the plow, has become part of the culture of crop production in most countries (Friedrich and Kassam 2009). In addition, policymakers are not aware of CA in most cases, and many of the existing policies work against CA adoption (Friedrich, Kassam., and Shaxson 2009). Therefore, there is an essential need for farmers and all stakeholders to change their mind-set (Singh et al. 2015). Increasing awareness and knowledge concerning CA through the formulation of extension and education programs are needed for creating the CA culture. CA should be included in curriculum agricultural schools and colleges (Bhan and Behera 2014). At the local level, pioneer farmers can play an important role in this way by changing farmers' norms and values. Research and development programs can also help improve knowledge gaps and available technology and gain scientific evidence of CA's many advantages in gaining public acceptance. Based on the result of MICMAC analysis, institutional drivers of CA development can be categorized into two major groups: Independent drivers and dependent drivers.

Independent drivers of CA development

This study showed that creating an organizational structure (D1) with policy-making and planning (D2) and monitoring and assessment scale (D3) at national and local levels are independent drivers of CA development. Strong driving power and weak dependence associated with these drivers require treating them as critical drivers. A facilitating environment for policy making and planning can,therefore,be an important deterrent to whether or not CA is adopted. In the same way, the studies by Farooq and Siddique (2015) and Kassam et al. (2014) showed that sustained governmental policies and institutional support play a key role in the promotion of CA. Kassam et al. (2014) also found thatin cases where policies to support CA have been ineffective, the successful diffusion of CA has not occurred. CA policy should be compatible with other policy initiatives and should be part of a coherent national agricultural policy (Sims, Hobbs, and Gupta 2009). The results also showed that CA is a typical composite technology. As such, its development and promotion rely on a large number of complementary actors. Developing and encouraging these linkages between farmers, researchers, extension workers, the private sector, consumers, and policymakers are critical for policymaking and planning toovercome complex agronomic and socioeconomic constraints to CA development. Corbeels et al. (2015) and Kahimba et al. (2014) also found that a broad range of stakeholders needs to be involved in the diffusion process of CA.

Dependent drivers of CA development

As the MICMAC analysis indicates (Figure 2), financial and institutional support (D4), CA research and development (D8), CA extension and education (D7),and creating the culture of CA at national and local scales (D6) have been identified as dependent drivers to CA development. These drivers are dependent on other drivers, such asinput markets and infrastructures (D5), policy making and planning at national and local scales (D2), and monitoring and assessment at national and local scales (D3). Providing suitable financial supports has a crucial role in implementing and financing CA research,development and CA extension, and education programs. Furthermore, providing financial support forframers to purchase CA equipment and inputs has played a key role in creating CA adoption incentives (Dhar et al. 2018; Friedrich, Kassam., and Shaxson 2009). Small-scale farmers often attribute more value to immediate benefits than future ones(Giller et al. 2011; Nkala, Mango, and Zikhali 2011), and many benefits of CA are only incurred in the longer term. In the short term, the adoption of CA may entail costs and risks for farmers, particularly smallholders. Therefore, financial supports such as direct payment and subsidy can affect their decision for adoption or continuous CA practice.

Conclusion

CA is an important agro-ecological approach for achieving sustainable production intensification. However, this approach is not well developed in the Iranian agricultural sector. There are various drivers affecting the development of CA. Understanding what drivesthe uptake of CA is critical for policymakers to develop more appropriate strategies to encourage the adoption of CA principles by farmers. In this paper, eight drivers to CA development in Iran have been identified, and relationships among them have been found in the form of the structural model. Creating an organizational structure is coming at the bottom of the model, and creating a culture of CA is coming at the top of the model. It is also evident that creating a suitable organizational structure supporting CA would have the biggest leverage effect for creating a culture of CA at national and local levels by helping the appearance of other drivers at the bottom level in the model and creating an enabling environment. In fact, all other drivers can help to create a culture of CA at national and local levels that is the desired objective of CA development.

Public support for CA development should emphasize creating an appropriate organizational structure to strengthen collective processes to ensure the implementation of policy objectives and activities for CA development. Based on the results, bringing all relevant stakeholders to a common platform to forge strategies and create anappropriate learning process would enhance knowledge exchange and generate new information for public CA programing. Moreover, such platforms would ensure that all stakeholders are aware of and fulfill their obligations in view of CA development. Therefore, there is a need to enhance the effectiveness of the existing CA organizational structure to ensure that allinvolved stakeholders understand their duties and responsibilities.

In this study, a set of influenced drivers on CA development were structured into a comprehensive systematic model. This model could be used by decision-makers for designing new strategies and taking effective implementation for increasing the promotion and adoption of CA at the local level.

Since there are a number of drivers that can influence CA promotion, and only eight critical drivers are identified in this study, further investigation is necessary to determine the drivers of CA promotion. In this study, the relationships between the various drivers of CA development have been identified only based on Iranian experts' opinions.Therefore, the results may be limited by experts' level of knowledge and experience in this area. Since the developed model is not statistically validated, future investigationsare required to test and validate thismodel using the SEM approach. This method has the capability of testing the validity of such hypothetical models. However, the results of this study can help policy makers come up with effective decisions to guide future efforts in the implementation of CA development programs.

Furthermore, this study revealed that although there is significant research conducted on CA adoption, more studies are critical to understand how governments can create an enabling institutional environment for CA promotion by considering various challenges and opportunities associated with current institutional arrangements. These can lead to a better understanding of the institutional structures and processes that are necessary for the development of useful strategies for CA adoption by farmers.

Notes

1. In Mexico, CIMMYT has developed the concept of the CA-based Applied Research and Delivery HUB. This approach involves researchers working in a multi-disciplinary manner together with farmers, agriculture leaders, private sector members, and other needed partners to ensure the development, testing, fine-tuning, and delivery of suitable CA-based technologies to farmers (Sayre 2014).
2. which states that if the variable 'A' is related to 'B', and 'B' is related to 'C', then 'A' is necessarily related to 'C'.

Conflicts of interest

The authors declare no conflicts of interest.

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