International Journal of Agricultural Management and Development
Available online on: www.ijamad.iaurasht.ac.ir
ISSN: 2159-5852 (Print)
ISSN:2159-5860 (Online)

Research Paper *https://dorl.net/dor/20.1001.1.21595852.2022.12.1.1.0*

Analyzing Interventions Affecting the Development of Nutrition-Sensitive Agriculture Production using the Analytical Network Process (ANP)

Maryam Movarej [a], Hossein Shabanali Fami [b,], Zhila Daneshvar Ameri [c] and Ali Asadi [b]*

Received: 15 January 2020,
Accepted: 02 February 2020

Abstract

Nutrition is recognized as both an input to and a result of sustainable development, where agricultural production also plays an undeniable role. Alborz, one of the major provinces of Iran, faces several issues that have been adversely affecting its food security over the years and the implementation of nutrition-sensitive agriculture been has deemed to be a necessity to alleviate these problems. The research in hand investigates the interventions affecting the implementation of nutrition-sensitive agriculture production in Alborz Province and structures a multiple-criteria decision making (MCDM) analysis to prioritize these interventions, as well as identifying the best implementation strategy to be followed in the area of the study. To achieve this goal, the Analytical Network Process (ANP) has been employed. Based on library and documentary studies and interviews with experts and authorities, the structure of the ANP model has been developed and pairwise comparisons have been made. Results indicate that income generation for nutrition was the most important intervention, followed by nutrition-sensitive post-harvest handling, storage and processing. Decision makers and authorities should dedicate more attention to these aspects in the implementation of nutrition-sensitive agriculture in Alborz Province. Also, a long term (6-20 years) implementation strategy has been found to be a better alternative to target and plan for by the decision-makers and authorities.

Keywords:
Analytical Network Process (ANP) ; food security; food systems; nutritional interventions; Multi-Criteria Decision Making (MCDM); Nutrition-Sensitive Agriculture production

[a] *Ph.D. In Agricultural Development, Department of Agricultural Management and Development, College of Agricultural Economics and Development, the University of Tehran, Karaj, Iran*
[b] *Professor, Department of Agricultural Management and Development, College of Agricultural Economics and Development, the University of Tehran, Karaj, Iran*
[c] *Assistant Professor, Department of Agricultural Management and Development, College of Agricultural Economics and Development, the University of Tehran, Karaj, Iran*

Corresponding author's email: hfami@ut.ac.ir

INTRODUCTION

Conquering malnutrition around the world calls for action on many fronts. Achieving this goal entails multi-stakeholder participation and extensive contribution to the health sector (Haddad et al. 2015).

FAO defines nutrition-sensitive agriculture as "an approach that seeks to ensure the production of a variety of affordable, nutritious, culturally appropriate and safe foods in adequate quantity and quality to meet the dietary requirements of populations in a sustainable manner" (FAO 2017). Nutrition-sensitive agriculture has been discussed in the *Feed the Future* initiative, which tries to address the root causes of hunger, poverty, and malnutrition around the world. The Initiative is established by the Department of State and is coordinated mainly by the U.S. Agency for International Development (USAID). USAID missions are focused on a wide range of joint interventions among different sectors, including agriculture, education, health and hygiene to ultimately address the underlying nutritional issues of the member countries (Klein 2016). Nutrition-sensitive agriculture not only supports the production and supply of healthy food for the population, it also identifies vulnerable groups in local, regional and national communities (i.e. tribal groups, women, children, patients and the elderly), who often suffer from inadequate access to healthy and proper foods. While the focus of food security programs is often the number of calories offered, nutrition-sensitive agriculture also considers the quality of these calories and the amount of vitamins, minerals and other nutrients provided (Rights 2010). In this regard, nutrition-sensitive interventions play a decisive role in making food systems and agriculture nutrition-sensitive (HerforthHarris 2014). Nutrition-sensitive interventions refer to strategies or developmental efforts seeking to enhance the overall nutritional status of the society (Alderman et al. 2013). These interventions are needed all over the food system, from production to consumption. Interventions are also needed in other relevant sectors such as health, education and waste management in order to properly address the problem of malnutrition. Governments should integrate nutrition-sensitive goals into their policies to ensure relevant programs are properly funded and successfully implemented. In general, nutrition-sensitive agriculture production may be implemented in three main areas (FAO 2014):

Making food more available and accessible: A prerequisite for proper nutrition, and one of the goals of nutrition-sensitive agriculture, is reducing the gap between available and accessible food to obtain a healthy and balanced diet throughout the community. In the realm of food security, availability encompasses the supply side of the chain and anticipates adequate amounts of quality nutrients from imported or domestic production and is dictated by the amount of food production, net trade and also stock levels. On the other hand, food accessibility addresses the demand side of the chain and refers to the access by people to enough assets to obtain necessary amounts of food for a nutritious eating regimen, either through own production or from the marketplace. Accessibility deals with whether people have enough assets to obtain appropriate amounts of nourishments (for themselves or their family), therefore, it depends on their salary, expenditure and purchasing limit (Sneha et al. 2018). A prerequisite for proper nutrition, and one of the goals of nutrition-sensitive agriculture, is reducing the gap between available and accessible food to obtain a healthy and balanced diet throughout the community. In the realm of food security, availability encompasses the supply side of the chain and anticipates adequate amounts of quality nutrients from imported or domestic production and is dictated by the amount of food production, net trade and also stock levels. On the other hand, food accessibility addresses the demand side of the chain and refers to the access by people to enough as-

sets to obtain necessary amounts of food for a nutritious eating regimen, either through own production or from the marketplace. Accessibility deals with whether people have enough assets to obtain appropriate amounts of nourishments (for themselves or their family), therefore, it depends on their salary, expenditure and purchasing limit (Ebo-Sciences 2017).

Making food more diverse and production more sustainable: Food diversity refers to the consumption of various foods in the required amounts. Consumption of diversified meals helps in preserving a healthy and exciting diet which provides a range of different nutrients to the body. In this regard, producing diverse foodstuffs can be effective in the dietary regiment of the household (Roche et al. 2008; Kuhnlein et al. 2009; Frison et al. 2011). Lack of food diversity is more and more being recognized as the underlying cause of micronutrient deficiencies, especially zinc, iron and vitamin A (Sibhatu et al. 2015). Consequently, the level of food diversity has been found to be in many cases a proper gauge of nutritional status (Ruel 2003; Arimond et al. 2010). Furthermore, increasing agricultural yield and focusing on proper nutrition both contribute to addressing hunger and poverty. However, conventional agricultural methods are in many cases subject to ineffective usage of fertilizers, pesticides, soil, water and other resources along with deforestation and constant urbanization, and generally, result in compound environmental pressures like land deprivation and water pollution that can greatly endanger human well-being and economic growth (Sibhatu et al. 2015). To address hunger and poverty, FAO promotes increasing agricultural yield through sustainable production practices. There is a consensus on the idea that sustainable agricultural intensifications are needed in small and large farms to achieve this goal (Cassman 1999; Montpellier 2013). The concept focuses on generating more products (food and other agricultural goods) per unit of resource, whilst avoiding current and future destruction of natural resources and ecosystem services crucial to human health (Smith 2013). Among the key premises of sustainable agricultural intensification, is the need to generate more nutritious food by obtaining higher yields whilst focusing on methods that result in a reduction of environmental impacts and conversion of forests. The strategies developed for sustainable agricultural intensification aim to improve social and economic development in rural regions, which in turn requires concurrent and transformative interventions throughout the whole food chain. Some of the sustainable production methods are conservation agriculture, water management and integrated pest management that may also help in reducing costs of productions, saving time, higher yields through timelier planting and reduction in diseases and pests (Hobbs 2007). All these benefits result in higher margins and sustainable income growth, as in the United States for example, the top quarter of farmers who applied sustainable agriculture methods reported greater net profits and higher yields versus the top quarter of conventional farmers (Strange et al. 1994).

Making food itself more nutritious: WHO[1] defines nutrition as "*the intake of food, considered in relation to the body's dietary needs*" (WHO 2020). It has been known for many years that proper nutrition, which entails a proper diet, along with daily physical activity, significantly contribute to human health and wellbeing. On the other hand, poor nutrition will result in lower immunity, higher vulnerability to diseases, reduction in productivity, and impaired psychomotor and physical growth. One of the focus areas in the implementation of nutrition-sensitive agriculture is identified as making the food itself more nutritious, which can be achieved through a process called food fortification (FAO 2020b). In food fortification, micronutrients are added to the processed foods and can result in a fairly quick enhancement of the micronu-

[1]. World Health Organization (WHO)

trient status of a population. Many countries add nutrients to staple food like flour and rice to improve the nutritional status of their citizens. Zinc, iron, folic acid and B vitamins are common additions to prevent micronutrient malnutrition and lessen the risk of infants with severe brain and spine birth defects (DaryHurrell 2006). To implement the nutrition-sensitive agriculture production in these three general areas, FAO has categorized twenty nutrition-sensitive interventions in five main categories, where four of the categories represent the four main functions of the food system and one category is comprised of cross-cutting issues (FAO 2017). These categories and respective interventions are presented in (Table 1) and each intervention is explained briefly later.

Obviously not all the above interventions have the same impact on achieving the final goal of making agriculture and food systems nutrition-sensitive. Each intervention, with regards to its interrelationships with other elements, will have a different implementation and funding priority, especially when the timeframe of the execution varies. In the current study, we consider two main execution timespans, namely a short (1 to 5 years) versus long (6 to 20 years) attainment period. Ultimately, it is desired to figure out which execution timespan should be followed to achieve the goal of making agriculture and food systems nutrition-sensitive in the area of the study (Alborz province, Iran), and which interventions have priority over the others. The ANP model can provide us with the ranking of the interventions, as well as identifying the preferred execution timeframe to be considered. The structure of the ANP method along with obtained results will

Table 1
Main Functions of the Food System and Their Nutritional Interventions

Main functions of the food system	Interventions
Food production	Biodiversity for food and nutrition
	Bio-fortification
	Diversification and sustainable intensification of agricultural production
	Nutrition-sensitive livestock and fisheriesUrban and peri-urban agriculture
Food handling, storage and processing	Food fortification
	Nutrition-sensitive post-harvest handling, storage and processing
	Food labelling
Food trade and marketing	Food marketing and advertising practices
	Food price policies for promoting healthy diets
	Trade for nutrition
	Income generation for nutrition
Consumer demand, food preparation and preferences	Nutrition education and behavior change communication
	Nutrition-sensitive humanitarian food assistance
	School food and nutrition
	Nutrition Sensitive Social Protection
Cross-cutting issues	Food loss and waste: prevention, reduction and management
	Food quality, safety and hygiene
	Nutrition-sensitive value chains
	Women empowerment and gender equality

Source: (Uccello et al. 2017)

be discussed later in the paper. The remainder of the paper is as follows: first, we introduce the area of the study and the nutrition and health issues it faces. Then, we briefly explain each intervention recommended to achieve nutrition-sensitive agricultural production. Following that, what the ANP model is and how it can help in prioritizing the interventions and identifying the best implementation strategy to follow. Finally, the results of modeling the ANP model for Alborz province are presented and further discussed in the Conclusion and Suggestions section.

Area of the Study

Almost half of Iran's provinces fall in the range of moderate to high food insecurity, perceptibly a sign of gradual deterioration of food security status in this country. The data is consistent with the World Map released in 2008 (Sundaram 2012). Limited agricultural production along with rising malnutrition and obesity poses a challenge to Iran's long-term food security. International sanctions have also imposed high inflation and reduced access to food. Inadequate income opportunities have affected many sectors of the population both in urban and rural areas (Marvi et al. 2018). Consequently, micronutrient deficiencies are widespread in Iran, especially iodine and iron deficiency. Due to its dependence on international trade and feeble agricultural sector, Iran is considered nutritionally insecure at the year 2025. Currently, food supply is inadequate in Iran and with rising prices, people cannot afford enough foodstuff (Heslot 2014). On the other hand, even with resolving the issue of food inadequacy, Iran still faces the problem of nutrient quality. Based on the global ranking of countries in terms of food and diet quality, Iran ranked 80 in 125 countries (Heslot 2018). Iran's position in the ranking of food and diet quality indicates that the country needs lots of progress in this respect. Increased access to chemical and non-organic inputs to boost agricultural production has led to a surge in a variety of diseases. For example, irregular application of low-quality pesticides for various reasons such as being cheap, farmers' lack of knowledge and being available from unauthorized stores, has led to agricultural pesticide residues in crops that adversely affect health and increase diseases such as cancer (Damari et al., 2015). In the field of livestock production, there are some cases of contamination of livestock products such as milk and meat due to toxins present in animal feed (Oveisi et al. 2007). Also, feeding cattle on contaminated plants, moldy bread and other low quality and unhealthy cattle food has resulted in the reduced nutritional quality of livestock products, especially in rural areas (Abasi et al. 2009). Iran also faces high volumes of agricultural waste. Sources have reported about 29 million tons of horticultural crops being wasted in Iran per year (Hosseini et al. 2013). Often the global nutritional standards of horticultural crops are not met in terms of quality as well. There is also the problem of irrigation of crops with sewage in some parts of the country (BigdeliSeilsepour 2008; Qishlaqi et al. 2008; AsgharipourAzizmoghaddam 2012) resulting in various acute and chronic diseases.

These nationwide problems are expectedly present at Alborz province, the second most popular immigration destination in Iran, as well. With a population of around 2.7 million people and an area of 5,833 square kilometers, Alborz province is considered one of the major agricultural and food supply hubs in the country. Of the total area of the province, 93.6 percent is allocated to agriculture and natural resources. Also, about one-tenth of the total employed population of Alborz work in the agricultural industry. Nevertheless, research suggests that 17.2 percent of the Alborz population are in the "not-hungry" state of food insecurity, 10.3 percent in moderate hunger and 8 percent are in a severe hunger state. In the aggregate, 36.6 percent of the households living in Karaj, the capital of the province, live in food insecurity conditions (Kian et al. 2015). The nationwide problems

mentioned earlier extend to Karaj province as well. For example regarding the pesticide residues issue, a study conducted on crops sold in 26 fruit and vegetable markets in Alborz province, the residues of chlorpyrifos has been found higher than acceptable levels in 6 markets (24%), as well as 14 markets (56%) for deltamethrin, based on the food code system (MohammadiImani 2012). Also, the problem of pesticide residues in agricultural products of Alborz has been emphasized in various studies (Jamshidi et al. 2015; Jamshidi et al. 2016). Considering the above, in order to alleviate the problem of nutritional security, implementation of nutrition-sensitive agriculture seems to be the best path to take.

Nutritional interventions

FAO has identified various nutritional interventions by analyzing the main functions of the food system (Uccello et al. 2017). In this section, we explain these main functions and their respective nutritional interventions.

Food production

One of the main functions of the food systems is Food Production, which deals with various actors and activities like urban and rural crop productions, forestry and livestock rearing. Food production heavily relies on managing natural resource bases like water, soil, animal breeds and plants seeds as well as supporting infrastructures like water supply network. The respective interventions of the Food Production function are as follows:

Diversification and sustainable intensification of agricultural production

Diversification methods are designed to improve the availability and accessibility of diverse foods. If implemented in large-scale, diversification can improve the availability of diverse foods in the marketplace and hence nutritious foodstuff would be available at a lower cost to the public. Many studies suggest that a diverse diet could help in preventing various diseases. For example, investigate the link between food diversity and breast cancer risk in Italy and find a meaningful relationship between the role of dietary habits and incidents of breast cancer. Another example is presented by where the impact of food diversity during the first year of life and allergic diseases until the age of 15 and suggests that early introduction of highly allergic food prevents food allergy later in life. Therefore, enhancing dietary diversity is considered as a critical strategy in improving nutritional status and general health. Also, sustainable intensification is defined as strategies and approaches with the goal of improving productivity and environmental sustainability at the same time. This can be reached by increasing diversity in agricultural systems or ecosystem-based approaches like conservation agriculture, integrated pest management and water management. Some integrated farming systems like crop rotation and legume-based cropping systems aim at both diversification and sustainable intensification. Diversification and sustainable intensification of agricultural production can: A) improve availability and accessibility of diverse foods throughout the year to ensure a healthy and balanced diet for everyone, B) Raise climate resilience and improve providing of ecosystem services, and C) Establish a sustainable income stream at small scale farmhouses if implemented at farm level. Moreover, if diversification and sustainable intensification programs are implemented with regards to women empowerment and gender-sensitivity, they would be more likely to have a higher nutritional impact at farming households (Rockström et al. 2017).

Nutrition-sensitive livestock and fisheries

The livestock sector plays an important role in the global food system and security. Based on FAO, 40 percent of the global value of agricultural output is contributable to the livestock sector as well as supporting the livelihoods and nutrition security of around 1.3 billion people (FAO 2020a). The fishery sector encompasses both wild capture and

aquaculture fish farming. The most-traded food commodity of developing countries is Fish products. In 2013, fish was the world's highest traded food commodity with around $130 B in export value. Sustainable fishing can assist in achieving food security and nutrition goals both as a food source and as an income basis. Prompting integrated farming systems (for example mixed crop/livestock/aquaculture systems) can significantly improve availability and accessibility to nutritious and diverse foods.

Biodiversity for food and nutrition

Biodiversity is defined as "*the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems*" (HerforthHarris 2014). Systems with a higher level of integrity and diversity such as agriculture, forestry, integrated flood management offer remarkable nutrient alternatives, as they stand as a shield against the effects of climate change (JaenickeVirchow 2013). Finally, production diversity may also offer protection against the external and internal market disturbances and thus support and maintain the diet of consumers. WHO also recognized biodiversity as a contributor to support improved health outcomes worldwide and a way to ensure food security and health (Romanelli et al. 2015). The subdivision of biodiversity that contributes to agriculture and foodstuff production is called in turn Biodiversity for Food and Agriculture (BFA). In this definition, agriculture incorporates fisheries and aquaculture, crop production, livestock and forestry. FAO identifies BFA as a critical element to food security, sustainable development and continuation of various ecosystem services. WHO also recognized biodiversity as a contributor to support improved health outcomes worldwide and a way to ensure food security and health (Romanelli et al. 2015). Evidence suggests that diversity can be effective in sustainability (Thrupp 2000; Kuhnlein et al. 2009), quality of production (Kuhnlein et al. 2009), availability and access to food (Sundar 2011), food safety and the storage and processing of products (PAR 2011).

Biofortification

World Health Report (WHO 2000) has identified micronutrient malnutrition as being one of the world's most grave health risk factors, and contrary to popular belief, this problem is not solely the issue of underprivileged countries. For example, iodine deficiency in Europe and iron deficiency affecting many of the nations. Consuming a balanced diet with the proper content of each nutrient would be the best ways to fight micronutrient malnutrition. However, this obviously is not achievable due to food accessibility in many regions and based on different dietary habits. One of the best strategies to face this issue is biofortification which can deliver more nutrients to a vast portion of the population without a need for fundamental changes in dietary patterns. The procedure by which the vitamin and mineral substance (i.e. Iron, zinc, etc.) of staple crops raise is called biofortification. This becomes possible through the application of micronutrient fertilizers, traditional plant breeding and sometimes genetic alterations (Khush et al. 2012). Biofortification is considered as one of the new effective and economical methods to deal with the incessant issue of micronutrient malnutrition in poor countries (Garcia-Casal et al. 2017). While traditional biofortification needs artificial substances, biofortification includes synthesis or amassing of supplements by plants at source, and evidence suggests that it can improve yields and micronutrient substance of crops (De Valença et al. 2017).

Urban and peri-urban agriculture

Nutritious and fresh foodstuffs are sometimes not accessible to the urban poor. Most of the time, cheaper energy-dense and low nutrition commercialized food are consumed by those who find fresh foodstuff too expen-

sive. Also, some products may be hard to find and out of reach in Urban areas. In this context, (Intra) urban and peri-urban agricultural products may present an opportunity to improve the availability and accessibility of fresh and nutritious foodstuff in neighborhood markets. Mougeot defines Urban Agriculture as "*an industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grows or raises, processes and distributes a diversity of food and non-food products, (re-)using largely human and material resources, products and services found in and around that urban area, and in turn supplying human and material resources, products and services largely to that urban area*" (Mougeot 2000). Urban Agriculture is hence considered as a strategy to fight disorders like undernutrition and obesity, as well as a sustainable income source for urban poor and middle class.

Food handling, storage and processing

In order to preserve food, we need to be able to handle, process and store it effectively (at household, community and commercial levels) to improve the shelf-life, decrease food loss, make food safe and tasty and also provide more options for consumption throughout the year. The interventions for this function are as follows:

Nutrition-sensitive post-harvest handling, storage and processing

Post-harvest handling encompasses each and every phase that crops go through to get to the market. These steps include activities such as handling of the harvested crops, packaging and transportation and distribution. Storage is the process of keeping products in a way that preserves their value and prevents them from being wasted. Processing refers to both initial and final processing. Initial processing deals with basic preparation (i.e. cleaning, peeling, dicing, etc.) of the products to be used in final processing steps which transform fresh or initially processed foods into the final product to be consumed by the individuals. One of the methods used in initial processing is food preservation which aims to stop or slow down the deterioration of food. Freezing, fermentation, canning and pickling are among the most common food preservation techniques used around the world.

Food fortification

WHO defines food fortification as the "practice of deliberately increasing the content of an essential micronutrient, i.e. vitamins and minerals in food, so as to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health" (WHO_a ; WHO 2018) . Food fortification can range from the national scale (i.e. iodized salt, Omega-3 enhanced cooking oil, etc.) to consumption time enhancements (i.e. adding micronutrient powders). Fortification differs from biofortification in the sense that biofortification aims to improve the nutritional value of crops during the growth period of the plants; whereas fortification tries to do so by the means of manual interventions during the processing of the food. Biofortification, therefore, has the potential to reach areas where conventional fortification may not be readily feasible.

Food trade and marketing

The next function of the food systems is Food Trade and Marketing. The Trade part of this function encompasses exchange activities at domestic, regional and international levels with the goal of providing foodstuff to the population from available sources. Food Marketing, on the other hand, deals with actors and activities related to infrastructures and regulations on the sale and promotion of the commodities. The interventions pertaining to this function are:

Trade for nutrition

Trade is defined as "the act or process of buying, selling, or exchanging commodities, at either wholesale or retail, within a country or between countries". A network that provides the foundation for trade is usually called a market. Food trade supports the

availability and accessibility of food for the population and is one of the oldest forms of trade in human history. Food trade is possible at domestic, regional and international levels. From the nutrient point of view, countries sometimes impose tariffs and subsidies on imports and exports, sign trade agreements and enforce trade policies to moderate the supply and demand fluctuations, improve the availability and accessibility of food, and achieving nutritional targets and food security in general. Carefully designed policies on food trade play an important role in supporting proper nutrition throughout the nation.

Food marketing and advertising practices

In modern urban dwellings, food advertisement plays an important role in the diet choices of the growing middle class. Food marketing encompasses all the activities, parties, infrastructure, regulations and policies involved in the sale of the food. Many may choose cheaper, more convenient but usually low in nutrients (generally referred to as Junk Food) products in lieu of healthier options which are usually more expensive and time-consuming. This may increase the rate of obesity, malnutrition and other non-communicable diseases in society. Consequently, the design and implementation of adequate food policies and regulations to support both traditional and modern food sectors demand proper investigation and consideration of the impacts of advertisement and marketing on the target population.

Food price policies for promoting healthy diets

Countries may design and implement strategies to promote the consumption of healthier and more nutritious products by enforcing taxes, subsidies and other forms of financial incentives/penalties. These programs usually target vulnerable populations where the price of foodstuff is more likely to affect diet choices. An example of a food policy implemented to fight obesity and non-communicable diseases is the Pacific Obesity Prevention in Communities (OPIC) project (Thow et al. 2011). OPIC is a multisectoral food policy with interventions spanning sectors like health, education, taxation, agriculture, trade and communications. Food price policies like taxation of soft drinks and subsidizing healthier foodstuff are advised to have a positive impact on the diet choices of the Fiji and Tonga population.

Food labeling

A label can be found on most packaged products these days and it typically conveys pertinent information regarding ingredients, energy value, and nutrient contents of the product. This kind of information, accompanied by basic nutritional knowledge, may help consumers to choose healthier options. (Thow et al. 2011) argue that providing nutritional education and behavioral change campaigns to the general public is the key to the effectiveness of the labeling strategy.

Consumer demand, food preparation and preferences

Consumer demand is the key topic that dictates what foods will be produced, processed and traded. Purchasing power and individual preferences are the main drivers of the demand at household level. Food preservation, preparation and cooking methods all influence the level of individual food consumption. Also, to support consumer demand and consumption, various social protection schemes like subsidies and school feeding programs may be introduced into the food system. The interventions pertaining to this function are classified in the following five categorize:

Nutrition education and behavior change communication

Nutrition education aims to ensure that increased food production and revenue results in enhanced diets and better nutritional status. It has been identified as one of the important factors affecting food security and nutritional interventions, with a focus not only on diets with healthier nutrient profiles

but also covering topics like healthy lifestyle, physical activities, everyday hygiene and other health-oriented behaviors.

Income generation for nutrition

Over the years, agriculture and food systems have evolved dramatically and nowadays, income plays an extra important role in nutrition and surpasses own farming production to feed the family. To achieve suitable nutritional goals, the population should have a decent, stable and adequate income to enable not only the procurement of nutritious foodstuff but also access to healthcare and education. Food system activities (i.e. farming, fishing and any other agribusiness related activity) have the potential to generate income through either sale of the products or compensation for labor. Strategies should be devised to target both leveraging income generation through agricultural production and providing necessary education and behavioral change campaigns to promote spending the extra money on the procurement of extra money on nutritious products.

Nevertheless, enough food supply does not directly translate into food security at individual and household levels; it is also essential that the low-income and vulnerable people have economic and physical access to food. The concept of food accessibility is deeply interlaced with the income levels of population and from an economic perspective it may be interpreted as being able to obtain food either from own crops and productions or by procuring it from available markets; all without forfeiting other basic needs (BalasubramanianCole 2002). A high percentage of the population in low-income countries reside in rural areas and rely on agricultural products to generate income. For small farmers, increasing agricultural production means an increase in income and hence it is a crucial element in improving food security. Adopting sustainable agriculture methods has proven to have a major redistributive impact on productivity, and data indicates that in terms of yields, the current low-income countries would benefit the most out of implementing these methods (KruzslicikaDevelopment 2014).

Nutrition-sensitive social protection

Many social protection programs like health insurance and social assistance, target nutritional consumption, access to the healthcare and proper education of the poor, while keeping an eye for construction of their productive assets to ensure ongoing and long-term support of the nutritional goals. This can be achieved through making provision of the aid (i.e. cash, in-kind, child support, etc.) contingent upon partaking in programs like nutritional education, child school enrollment and public work programs.

School food and nutrition

Children are the future generation of any nation and paying close attention to their nutritional needs is of utmost importance to ensure proper mental and physical growth. School food interventions aim to provide proper nutrition, education and skillset to school-aged children, especially adolescent girls who will be the forthcoming mothers of the nation. These programs not only answer the immediate need for a balanced and healthy diet but also contribute to the overall health of the nation in the future.

Nutrition-sensitive humanitarian assistance

During an estate of emergency (like a war, earthquake or another kind of crisis) that affects the lives of many people, humanitarian support can alleviate some of the nutritional needs of the affected population by providing cash or in-kind foodstuff to the groups in need of the assistance. This support can be direct or indirect, conditional or unconditional, and general or targeted. Many a time, due to the nature and urgency of a crisis, little attention is given to the nutritional needs of the affected people. Nutritional sensitive humanitarian assistance support should identify different groups (like pregnant women, elderly, infants, sick, etc.) and try to cater to their nutritional needs respectively. In addi-

tion to nutritional needs, humanitarian assistance programs need to integrate with health and hygiene intervention to maximize the impact and avoid future complications that may arise from improper sanitary conditions.

Cross-Cutting Issues

There are several interventions that do not fall directly under any of the aforementioned main functions. Nevertheless, integrating then into the food system is deemed important and beneficial. These Cross-Cutting interventions are explained below:

Nutrition-sensitive value chains

From the farms to the marketplace, products go through a multitude of steps to become available to the consumers. These steps create a supply chain where the value of the product increases in each step, with a traditional focus on increasing revenue by improving efficiency. The focus of a nutrition-sensitive value chain, on the other hand, is more on enhancing the nutritional value of the product at each step. This can be achieved through optimizing the processing and storage techniques and adding nutritional value-adding steps (like fortification) to the process.

Women's empowerment and gender equality

One of the main factors affecting the success of nutrition, health and agricultural production programs is devising and implementing strategies aiming to improve the state of gender equality and women's empowerment in society. Women's empowerment, a prerequisite for gender equality, refers to strengthening women in every aspect to enable them to control their lives. Gender equality, the state of having equal rights and opportunities for both men and women, in turn, follows the successful empowerment of women in all facets (i.e. social, economic, political, etc.). (Pretty et al. 1996) argue that resources and income managed by women are more probable to be spent on foodstuff, health and education, resulting in a positive impact on nutritional status.

Food loss and waste: prevention, reduction and management

FAO report published in 2011 states that about one-third of the food produced for human consumption in the world (approximately 1.3 billion tons per year) goes to waste (RogersYoussef 1988). Food waste is disposal or alternate use of nutritious and safe food. Reducing food waste is considered to have a significant impact on increasing food availability, security and safety. Waste can occur at any stage of the food supply chain: from production, postharvest handling and storage to processing, packaging, distribution and consumption. In many middle and high-income nations, the majority of food waste happens in distribution and consumption stages, whereas in low-income countries, it is more dominant in production and postharvest stages. Food loss covers a broader spectrum than food waste and is defined as any reduction in quality and quantity of nutritious and safe food available and accessible for human consumption. Some of the main causes of food loss are insufficiency, inadequacy or non-existence of storage facilities, infrastructure, means of transportation and refrigeration, market facilities, packaging, quality standards, environmental conditions during display, planning and focus on waste, and leftovers from consumption (FAO 2011).

Food quality, safety and hygiene

Food risk is defined as the likelihood of contracting a sickness as a result of consuming a specific food. Food Safety, on the other hand, can be defined as the exact opposite of food risk. In this regard, the idea of food safety is built on the assessment of the risk associated with the consumption of specific food by food experts and specialists (Gustavsson et al. 2011). Safe food can keep consumers from the hazards of food poisoning and acute or chronic illnesses. Unsafe food can result in many health complications like diarrhea, cancers and many viral diseases. Food safety can be considered as one aspect of food quality, as safety is with no doubt a desirable charac-

teristic of the food. Processing, storage, distribution and handling of food all contribute to food safety and by enforcing common standards on each area, along with proper education of parties involved, the overall food safety of the products will improve. Water safety is also another major topic that affects the population and also the food industry. Whether intended for drinking, food processing or agricultural purposes, safe and clean water is essential in safeguarding the health of the public (Grunert 2005).

METHODOLOGY

Before presenting the analytical technique and findings of this study, it is necessary to explain the chosen research method to answer questions about the type of research, how the data was collected and analyzed, tools and materials used and the rationale for choosing this method. The development of nutrition-sensitive agricultural production in Alborz province is achievable by focusing on proper nutritional interventions affecting the overall food system of the province. These interventions have been identified and explained in section 3 (Nutritional Interventions). Considering the ever-present limited budget and resources available in any project, it is necessary to understand which interventions have the highest priority and greatest effect on achieving the goal in the specific area of the study. The statistical population of the study is comprised of subject matter experts in a variety of fields related to agriculture (including gardening, promotion, education, and animal science) who were also familiar with Alborz Province conditions and status. A total of fifteen experts were selected who had a comprehensive view of the subject under study due to their participation in nutrition-related projects and research areas. Among the experts, eight are from the local government and seven are academics. Most of the experts have 15 to 25 years of experience in this field and 47 percent of them have at least a M.Sc. degree in a relevant subject.

To prioritize the interventions presented in this study, a qualitative method is implemented through the deployment of surveys to gather experts' opinions for pairwise comparisons. The process chosen for performing the pairwise comparisons and the software used is explained in more detail in the following section.

Overview of the Analytic Network Process (ANP) Method

Two of the most renowned tools for multi-criteria decision making are Analytic Hierarchy Process (AHP) and its extension, Analytical Network Process (ANP), both developed by Thomas L. Saaty (Saaty 2005; Lin et al. 2009). The AHP method is comprised of one goal, along with its respective criteria and alternatives, all arranged in a hierarchical structure in a way that elements on the lower level influence elements on the higher level. In real-world situations, however, this is rarely the case and any decision-making problems may also contain dependencies among alternatives, same level criteria dependencies, and/or dependency between elements from different levels (Saaty 1987). To cope with these complications, Saaty developed the ANP method which does not impose a structure. The Nine-Point Scale of Saaty has been employed to demonstrate the relative importance, where a score of 1 represents the same importance and going up, scale 9 represents very strong importance of one factor over another.

The steps of the ANP

Step1. Structuring the problem: Clearly state the problem and decompose it into a network-like structure.

Step2. Pairwise comparisons: Do a pairwise comparison of the decision factors at each cluster by considering their importance with respect to the control criteria. Do the same for interdependencies between each criterion of a cluster. An eigenvector will signify the impact of each factor on other factors. Pairwise comparisons should be done by ex-

perts in the field.

Step3. Formation of Supermatrix: Enter the local priority vectors in the columns of a matrix to get global priorities. This will produce the unweighted supermatrix; a partitioned matrix where each segment signifies the relationship among two clusters. Weights attained by pairwise comparisons on the cluster level are multiplied into the blocks of the unweighted supermatrix, producing the stochastic (weighted) supermatrix. The limiting supermatrix is, according to Saaty methodology obtained by elevating the weighted supermatrix up to 64 stages so all its columns become equal.

Step4. Selection of the best alternatives: In this step, the values of the limiting matrix are chosen as the final weights of the decision model and the criteria and alternatives are ranked based on their final weights, respectively.

The Framework of the ANP Analysis Model

Based on the review of the literature and considering the opinions of the experts, the structure of the model and the interrelationships between the interventions are developed in *SuperDecision software Version 2.6.0 RC-1*. A total of fifteen experts from the university and the local government have been interviewed and useful suggestions have been used to revise the model. The final schematic of the ANP model is presented in (Figure 1). The goal of the final model is to find out key interventions in implementing Nutrition-sensitive Agriculture, as well choosing between a short time strategy (1-5 years) versus a long term (6-20 years) implementation period.

Pairwise comparisons and calculation of the model

The pairwise comparison of each intervention was done after the ANP model has been developed. Fifteen experts were invited to form the pairwise comparison matrix. Each expert was engaged with nutrition-sensitive agriculture and its interventions for more than five years and could provide first-hand information. As needed, group decision-making techniques were employed to prevent bias in the process of decision making. Based on the ANP method, the pairwise comparison matrices were then formed. As explained earlier, the relative importance values are identified with the help of the Nine-Point Scale of Saaty, in which a score of 1 signifies equal importance among the two factors and scale 9 implies a very high importance of one factor over another (Table 2).

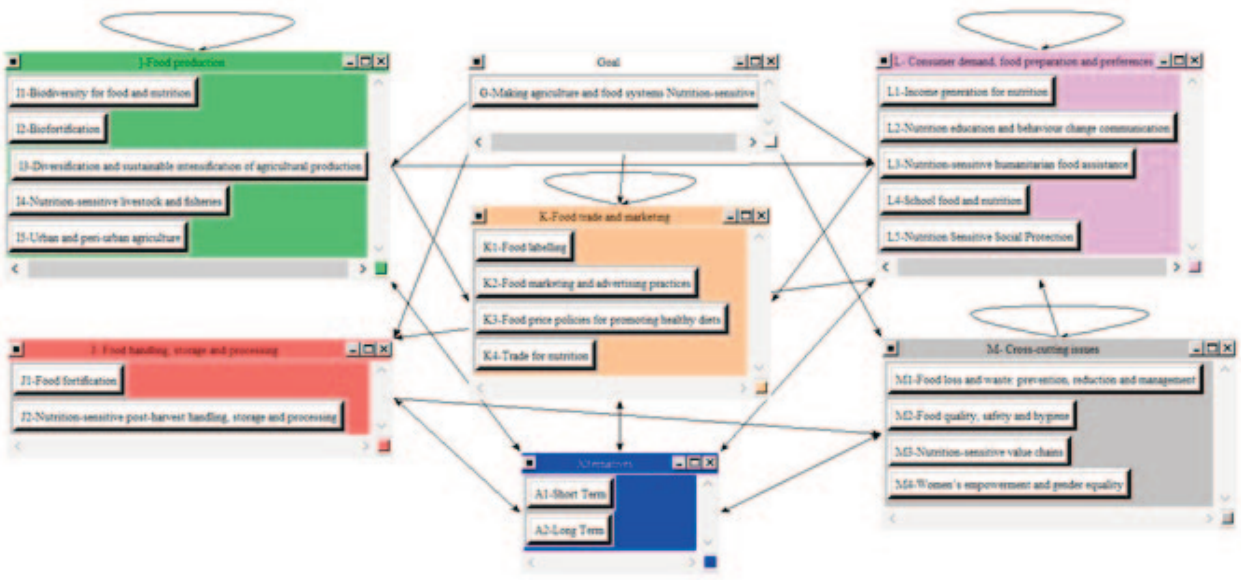

Figure 1. Schematic of the ANP Model in SuperDecision Software

Table 2
The Nine -Point Scale of Saaty

Definition	Intensity of importance
1	Equal
2	Between Equal and Moderate
3	Moderate
4	Between Moderate and Strong
5	Strong
6	Between Strong and Very Strong
7	Very Strong
8	Very Strong and Extreme
9	Extreme

The Consistency Ration is employed to evaluate the consistency of pairwise comparisons. If the Consistency Ration drops below 0.1, the comparison is considered satisfactory. After implementing the ANP model, the results are obtained and presented in (Table 3). A Consistency Ration of 0.001 is obtained which indicates the validity of the judgments' consistency of the pairwise comparisons matrices.

The first intervention with the highest priority for Alborz province is identified as "Income generation for nutrition" which belongs to the Consumer demand, food preparation and preferences function of the food system with a priority weight of (0.081226). The second alternative, "Nutrition-sensitive post-harvest handling, storage and processing" belongs to the "Food handling, storage and processing" function with a priority weight of (0.067795) and third place goes to "Nutrition-sensitive value chains" which resides in "Cross-cutting issues" function of the food system. Further discussion on these interventions is presented in the Conclusion and Suggestions section of this paper.

Finally, between the two alternatives of a short term (1-5 years) and long term (6-20) strategic planning to implement these alternatives, the long-term option has been chosen (Table 4) with the priority weight of (0.637306) which will also be discussed in the following section.

CONCLUSION

In the present study, interventions affecting the production of nutrition-sensitive agriculture have been prioritized using the ANP method for Alborz province, along with identifying the proper implementation timeframe. Analysis suggests that "Income Generation for Nutrition" to be the most important intervention among all for Alborz province. A very important factor not to be neglected regarding income growth is investing in women and empowering them to help the family buffer against economic turmoil. With regards to the high participation of women in agricultural production and given that an increased income for women can greatly assist in facing malnutrition, investing in women in small farming households proves to be critical. Smaller farming households would have a better chance of feeding their families, educating their children and investing in their farms when both men and women farmers grow more products and earn a higher income. Reducing waste and loss is another important area to focus on when it comes to income growth. Proper waste reduction will increase the food consumption and income of the family as well.

Table 3

Prioritization of nutritional Interventions for Alborz Province, Iran

Interventions	Limiting	Rank
L1-Income generation for nutrition	0.081226	1
J2-Nutrition-sensitive post-harvest handling, storage and processing	0.067795	2
M3-Nutrition-sensitive value chains	0.03868	3
J1-Food fortification	0.03805	4
I1-Biodiversity for food and nutrition	0.037706	5
K4-Trade for nutrition	0.035494	6
M1-Food loss and waste: prevention, reduction and management	0.035094	7
L2-Nutrition education and behavior change communication	0.032847	8
M4-Women empowerment and gender equality	0.032314	9
I3-Diversification and sustainable intensification of agricultural production	0.026272	10
K2-Food marketing and advertising practices	0.024842	11
K3-Food price policies for promoting healthy diets	0.024614	12
M2-Food quality, safety and hygiene	0.01877	13
K1-Food labeling	0.017546	14
L4-School food and nutrition	0.017115	15
L3-Nutrition-sensitive humanitarian food assistance	0.01409	16
I2-Biofortiï¬cation	0.011793	17
I4-Nutrition-sensitive livestock and fisheries	0.011237	18
L5-Nutrition-sensitive Social Protection	0.009569	19
I5-Urban and peri-urban agriculture	0.007682	20

Table 4

Prioritization of the Implementation Alternatives

Alternatives	Ideal	Normal	Raw
A1-Short Term	0.569106	0.362694	0.151339
A2-Long Term	1	0.637306	0.265924

Low-income and developing nations should invest more and more in their main area of losses (i.e. post-harvest), whereas more developed nations should focus on decreasing food waste (Saaty 1987). Extensive amounts of investment in infrastructure and enhanced technology are usually required for effective interventions in waste and losses, especially for managing postharvest losses, which requires substantial investments to enhance storage and systems of transportation. Nevertheless, there are several less expensive methods where we can expect a reduction in losses at various stages of the supply chain. Use of enriched fertilizers with the goal to extend the shelf life of vegetables and fruits, improved packaging methods, enhanced harvesting techniques, and inexpensive drying solutions are a few of these methods that could be employed to reduce waste and losses (Biggs et al. 2015).

The second place goes to "Nutrition-sensitive post-harvest handling, storage and processing" intervention. It is noteworthy that Although less processed products are generally considered to be safer (Monteiro 2009; Monteiro et al. 2010; Dobermann et al. 2013), proper processing and storage is a way to prevent corruption as well as improving the quality of manufactured products, which overall contributes to reduction of agricultural waste as well as boosting availability

and accessibility to nutritious and diverse foods (Dobermann et al. 2013). For reasons such as being costly and time-consuming, many waste management methods are not applicable to small-scale farming entities. Food storage and processing is a preferred strategy to reduce overall food waste as well as ensuring access to a diverse diet throughout the year. Processing and storage techniques such as drying meats, fruits and vegetables, or making cheese can reduce the level of mycotoxin contamination and provide required nutrients outside the season for domestic consumption and sales in local markets (Keding et al. 2013; HerforthHarris 2014).

The third most important intervention to be considered is "Nutrition-sensitive value chains". In designing the value chains, first and foremost it is of utmost importance to make sure that the generated value be dispersed evenly and the weakest link of the chain, which is usually the farmers receive reasonable compensation and benefits. Additionally, it should be noted that the value chain intervention may not be implemented in isolation and they are always reliant on other interventions such as expanding the business environment, especially in developing countries and with the help of both the public and private sectors. Finally, emphasizing that the implementation of required interventions in the province needs to be considered as a long-term strategy, the authorities and decision-makers must carefully study and plan for each intervention in the light of available and feasible facilities, develop a long-term integrated plan and dedicate required funds and resources with the involvement of all relevant and involved bodies to successfully achieve the objectives of nutrition-sensitive agriculture production.

ACKNOWLEDGMENTS

The authors wish to thank the experts and scholars of the Alborz Organization of Agriculture for their help and support.

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How to cite this article:
Movarej, M., Shabanali Fami, H., Daneshvar Ameri, Z., & Asadi, A. (2022). Analyzing interventions affecting the development of nutrition-sensitive agriculture production using the Analytical Network Process (ANP). *International Journal of Agricultural Management and Development, 12*(3), 227-243. **DOR: 20.1001.1.21595852.2022.12.1.1.0**