**Quarterly Journal of Environmental Education and Sustainable Development**
Vol. 9, No. 4, Summer 2021 (85-98)
Original Article, DOI: 10.30473/ee.2021.55718.2276

**فصلنامه علمی، آموزش محیط‌زیست و توسعه پایدار**
سال نهم، شماره چهارم، تابستان ۱۴۰۰ (۹۸-۸۵)

# Social analysis of water resources instability: Applying theory of treadmill of production (The case of Mazandaran province)

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(**Received:** 19.10.2020 **Accepted:** 01.03.2021)

# تحلیل اجتماعی ناپایداری منابع آبی بر اساس نظریه‌ی تردمیل تولید (مورد مطالعه: استان مازندران)

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**(دریافت: ۱۳۹۹/۰۷/۲۸ پذیرش: ۱۳۹۹/۱۲/۱۱)**

**Abstract**
Economic activities in Mazandaran province have been focused on agricultural and ranch products for a long time. Farmers have always exploited water resources for their activities, but after the collapse of the traditional system, capital absorption, and changing the direction of investment, aiming a new type of production has been formed alongside this traditional method, which is based on gaining profit. The purpose of this research is to investigate and explain the role of investment growth in agriculture leading to instability in water resources in Mazandaran province. Using Schneiberg's Treadmill of production theory, this study aims to respond to this basic question: "Why has the growth of investment in agriculture caused the instability of water resources in Mazandaran province?" In this research, a quantitative method and secondary data analysis strategy, as well as a comparative research method have been employed. The results of the study showed that investment in the main inputs of agricultural production and agricultural processing and services industries have been increased, and simultaneously, the amount of aquifers consumption in this province has increased from 791 million cubic meters in 2010 to 1377 million cubic meters in 2019. In addition, the results of the study indicate the growth in polluting water resources in Mazandaran. Overall, the results of the present study reveal that growth of investment affects the instability of water resources and therefore, Schneiberg's Production Cycle Theory is confirmed.

**Keywords:** Instability, growth of investment in agriculture, industrial production, water resources of Mazandaran, Treadmill of production theory.

**چکیده**
فعالیت‌های اقتصادی در استان مازندران، از دیرباز بر تولیدات کشاورزی و دامپروری متمرکز بوده است. کشاورزان همواره از منابع آبی برای فعالیت‌های خود بهره‌برداری می‌نمودند، اما پس از فروپاشی نظام سنتی، جذب سرمایه و تغییر جهت سرمایه‌گذاری، با هدف نوع جدیدی از تولید در کنار این روش سنتی شکل گرفته است که مبتنی بر تولید برای کسب سود است. هدف از انجام مطالعه حاضر بررسی و تبیین نقش رشد سرمایه‌گذاری در کشاورزی در ایجاد ناپایداری در منابع آبی استان مازندران می‌باشد. مطالعه حاضر با استفاده از نظریه تردمیل یا نظریه چرخه تولید اشنایبرگ، درصدد پاسخ‌گویی به این سؤال اساسی است: چرا رشد سرمایه‌گذاری در کشاورزی باعث ناپایداری منابع آبی مازندران شده است؟ در این تحقیق از روش کمی و استراتژی تحلیل داده‌های ثانویه و بررسی مقایسه‌ای استفاده شده است. نتایج تحقیق حاضر نشان داد که سرمایه‌گذاری در نهاده‌های اصلی تولید زراعی و صنایع تبدیلی و خدماتی کشاورزی رو به افزایش بوده و هم‌زمان، میزان مصرف آبخوان‌های استان از ۷۹۱ میلیون مترمکعب در سال ۱۳۸۹ به ۱۳۷۷ میلیون مترمکعب در سال ۱۳۹۸ رسیده است. علاوه بر این، نتایج تحقیق نشان‌دهنده افزایش آلودگی منابع آبی مازندران است. به‌طورکلی، نتایج تحقیق حاضر بیانگر آن است که رشد سرمایه‌گذاری بر روی ناپایداری منابع آبی تأثیر گذاشته و بنابراین، نظریه چرخه تولید اشنایبرگ مورد تأیید قرار می‌گیرد.

**واژه‌های کلیدی:** ناپایداری، رشد سرمایه‌گذاری در کشاورزی، تولید صنعتی، منابع آبی مازندران، نظریه چرخه تولید.

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## Introduction

Sustainable development as one of the key approaches in the field of education and environmental protection has relatively different definitions. However, the best-known statement that is the definition of sustainable development provided by the World Commission on Environment and Development (Brandt Land Report) asserts that, "the development that meets immediate needs without diminishing the ability of future generations to meet their own needs (Barbier, 2006, p. 68)". Moreover, environmental economists define sustainability based on the lack of capital reduction. However, there is an argument that we are currently consuming and depleting natural resources of the earth (Dresner, 2005, p. 18) and water is a major concern for sustainable development in the 21st century. The issue of water shortage in resources of the earth is becoming more serious every moment; on the one hand, scarcity of water resources and on the other hand, the growing global demand of various economic sector such as agriculture, industry, drinking, etc. for water, have faced this issue with major economic, social and environmental challenges. The historical experience of the development process in industrialized countries shows that agriculture has played a key role in the national development of these countries. Regardless of the industrialized countries' experience, the development of the agricultural sector of developing countries has always been emphasized. This is mainly due to the relationship between this sector and other economic sectors as well as its functions in other issues such as: providing food and food security, creating an economic surplus, providing currency for investment in other economic sectors, supplying raw materials required by industry and development, supporting dependent production activities and the completion of production loops through previous and next relationships, etc. (Shakoori, 2014, p. 1).

Iran is a developing country that 35% of its population live in rural areas and have an agricultural career and the amount of its agricultural sector's added value is about a quarter of GDP (Same: 2). This country depends on the exploitation of its natural resources for growth in economic production, and rely upon its water resources in agricultural sector. It has a dry and waterlogged climate in which the average rainfall is about one-third of the world's average rainfall. Water per capita in Iran has always been declining and according to forecasts in 2021 per capita water for Iranians will reach 1300 cubic meters in a year (Hematian et al., 2015, p. 17). Although areas such as Mazandaran province with 640 mm of rainfall per year are classified as rainy areas of the country, its rainfall is nearly 100 mm less than the mean value compared to the global average (Mazandaran Regional Water Company, 2017- b). The total potential of water resources (surface and groundwater) in Mazandaran province, is 6 billion cubic meters, of which 5.4 billion cubic meters are assigned to surface water resources and 5.1 billion cubic meters are groundwater resources. During the last decade, the potential of the province's surface water resources has decreased from 5.4 billion cubic meters to 3.8 billion cubic meters (Mazandaran Regional Water Company, 2017-a).

Nevertheless, agriculture is a vital element of the Mazandaran economy that has existed since ancient times. Today, the agricultural sector is important in Mazandaran province to ensure food security, economic growth, and job creation. This province with 70 different types of agricultural products that 22 of them has the first rank of production in the country (Mazandaran Regional Water Company - c), is known as one of the agricultural and horticultural hubs of the country. Its area is about 24,000 square kilometers that 470 thousand hectares of this area are assigned to agricultural lands (370 thousand hectares are irrigated and 170 thousand hectares are rain-fed; counting the lands under irrigated aftercrop and rain-fed cultivation, it reaches 650 thousand hectares). Nowadays, the agricultural sector is regarded vital in Mazandaran province, and after collapsing the traditional agricultural system, a new method of agriculture has emerged in addition to meeting domestic needs, and aimed to export food products. This method is assumed to be

destructive to water resources due to the high waste of water in the agricultural sector. Since in Mazandaran province like other provinces of the country, more than 90% of the water that is controlled annually is mainly used for agriculture while this rate is less than 50% in industrialized countries (Same:11). Statistics show that the rate of water wastage in irrigation in the traditional methods is between 70% and 90% (same: 27), noticing that Mazandaran is the agricultural hub of Iran, accounts for a large part of this wasting. In brief, there are many different issues and challenges related to the water issues in Mazandaran province that the most noticeable are the amount of water resources, unbalanced use of water in agriculture, and chemical pollution of water resources. Regarding the issues and challenges that arose in the field of water resources in Mazandaran province through recent years and according to the definition of sustainable development and sustainability in the report of Brandt Land and environmental economists, it seems that water resources of Mazandaran province have faced some problems in terms of sustainability. However, investment as one of the inputs of production is emphasized for enhancing agricultural production and exporting agricultural products.

The above-mentioned analysis demonstrates that water resources in Mazandaran province have gradually become unstable and various reasons for the instability of water resources have been mentioned (the effects of climate change and growth of population on water resources (Vorosmarty et al., 2000); the impact of industrialization and development (Cheevaporn and Menasveta, 2003); increasing in the use of biocides and chemical pesticides (Vryzas, 2018). Among the various theories of environmental sociology, the Production Treadmill Theory puts the major responsibility on environmental degradation and resource instability on the competitive nature of capitalism and the role of governments in facilitating industrial growth. This notion that was put forward by Schneiberg, stating that economic growth leads to an increase in environmental pollution. The main claim of this approach is that the growing level of investment and accumulation in modern capitalist economies are the main drivers of environmental disturbances. This is due to the pressures of competition and the interests of stakeholders are constantly pushing the economies of modern (capitalist) countries to increase production. Furthermore, the social processes associated with the production treadmill are highly institutionalized that it causes a 'sustained war' between the environment and society (Gould et al., 2016 & 2004).

According to the theory of the treadmill of production, the instability of water resources in Mazandaran province can be attributed to the growth of industrial production of agricultural products and we suppose that the growth of investment in agricultural processing and service industries leads to competition for more production and more profit. As a result of such a situation, there is a need for excessive exploitation of water resources that is related to the high rate of losing water in the agricultural sector and chemical pollution from fertilizers and pesticides that are released into water resources; ultimately, they cause instability in water resources of Mazandaran province. Here, this study aims to justify "why did the growth of investment in agriculture in Mazandaran province cause the instability in water resources of this province?"

Generally, to examine the empirical literature of water resources degradation, Keshavarz et al. (2016), Qudusi and Davari (2016), Heidari (2017), Attarzadeh and Pardel Noghabi (2017), Giupponiaf et al. (1999), Chapagania et al. (2006), Longo and York (2009) and Brisman et al. (2014) have explored the role of agriculture in water resources and confirmed the effects of agriculture on the quantity and quality of water resources. Langefield and Smith (2013) and Ismail et al. (2018) have examined the role of technology in water resources and the environment. Since the late of 1960s, awareness of the environment and natural resources as a determining factor in economic growth has received more attention (Toman, 2003). While the early works of environmental sociologists sought to prove the correlation between society and the physical environment, more recent research has attempted to provide a more balanced view by showing how society also affects the environment by examining the effects of the

environment on society (Grant et al., 2002).

Components of the Theory: Schnaiberg argued that a growing level of capital available for investments and its changing investment allocation together produced a substantial increase in demand for natural resources. Essentially, the major change outlined in the theory was that more capital was accumulating in Western economies and it was being applied to replacing production labor with new technologies to increase profits. These new technologies required far more energy and/or chemicals to replace earlier, more labor-intensive processes, thus producing deeper levels of ecological disorganization than ever before. New technologies emerged from the organization of scientific and technological research in universities and research institutes as well as from the new "research and development" departments of large firms. Moreover, unlike the prior use of labor, the new technologies represented forms of sunk capital. To further increase profits, managers needed to increase and sustain production levels (because worker inputs could be cut back more readily, as opposed to the fixed costs of machine operations).

## Methodology

In this study, to explain the effect of production growth on the instability of water resources in Mazandaran, the causal-comparative method, which is a kind of survey research, has been used. The key feature of causal analysis is to examine the causes after they occur. In this method, the necessary information is collected to investigate the causes of a phenomenon after the occurrence; therefore, the researcher has no involvement in its occurrence. In this case, the researcher selects one or more phenomena and by studying the previous context and conditions, tries to find the causes or correlations for the occurrence of that phenomenon (Azkia & Darban Astane, 2014, p. 350). Noticing that the destruction of water resources in Mazandaran has happened for many years and the researcher is unable to control the laboratory conditions in investigating this issue, the comparative causal method seems to be a suitable one to examine the correlation between the dependent variable of the research and other variables.

For the data analysis, a secondary data analysis method and comparative methods have been employed to explore similarities and differences (Saroukhani, 2010, p. 183) of dependent and independent variables process that this study aims to probe; some sorts of data (such as the use of machinery, distribution of seeds, fertilizers and pesticides, the number of production units related to agricultural industries and the capacity to absorb agricultural raw materials by them, areas under cultivation and salinity and nitrate in water resources) were collected by Regional Water Organization and Agricultural Organization, were collected for other purposes (Baker, 2007: 221), and were reviewed and interpreted between 2010 and 2019.

Subjects of these variables were reports and statistical yearbooks of Mazandaran Regional Water Organization, statistical yearbooks of Ministry of Energy on water issues in Mazandaran, and statistical yearbooks that were published by the Ministry of Agriculture Jihad comprised yearbooks of agriculture and agricultural products of Mazandaran province. In this study, some kinds of secondary data were drawn from all the reports and statistical yearbooks of Mazandaran Regional Water Organization and statistical yearbooks of Ministry of Energy about water issues in Mazandaran province throughout a decade (2010-2019) including agriculture and agricultural products yearbooks were prepared and utilized.

## Results

Schneiberg believed that both the increase in the level of an available asset for investment and changing the allocation of investment led to a significant increase in demand for natural resources, which in turn can destroy natural resources. Therefore, in order to examine the increase in the level of investment as well as changes in investment allocation, investment variables in agricultural activities and the growth of crop production during the last decade have been investigated.

**Qualitative results**

a) Investment in agricultural activities

To examine investment variables of agricultural activities, the status of investment and applying new technologies, agricultural

machinery, investment in agricultural processing and services industries as well as investment in the main inputs of agricultural production (including farmland, water, seeds, fertilizers, and chemical pesticides) have been examined.

1. The status of investment and utilizing agricultural machinery in Mazandaran province from 2010 to 2018

Table 1. illustrates the status of investment and utilizing agricultural machinery in Mazandaran province from 2010 to 2018. To examine investment variable and agricultural machinery including vehicles, tillage tools, planting, holding, and harvesting (comprising grain and rice combine, combine harvester, tractor, tiller, plow, disc, stalk chopper, seeder, fertilizer machines, planter machine, weeding machine, etc.) were examined in terms of their number according to the report of the statistical yearbook of Agricultural Organization of Jihad. Moreover, the mechanization coefficient was estimated to evaluate the quality and number of machines concerning the area under cultivation.

**Table 1.** The status of investment and utilizing agricultural machinery in Mazandaran province from 2010 to 2018

| | **89** | **90** | **91** | **92** | **93** | **94** | **95** | **96** | **97** |
|---|---|---|---|---|---|---|---|---|---|
| Vehicles | - | 98303 | 98303 | 98303 | 95876 | 106224 | 108822 | 100820 | 102408 |
| Tillage tools | - | 34033 | 34033 | 34661 | 56890 | 34126 | 47576 | 48255 | 48033 |
| Planting | - | 3391 | 3361 | 3362 | 3798 | 3780 | 4530 | 4850 | 4759 |
| holding | - | 35506 | 35507 | 35503 | 26999 | 24857 | 29006 | 33741 | 33877 |
| Harvesting | - | 17736 | 13380 | 9404 | 26334 | 14297 | 23093 | 23956 | 24795 |
| Collect all kinds of agricultural machinery | - | 188969 | 184584 | - | 209897 | 183284 | 213027 | 213872 | 213872 |
| Mechanization coefficient (Hp) | - | - | - | 1.66 | 76.1 | 1.81 | 2.29 | 2.41 | 2.49 |

Source: Agricultural Jihad Statistics Report from 1389 to 1397

Noticing Table 1 shows that the number of agricultural machineries has increased from 188,969 sets to 213,872 sets in 2019, which demonstrate that the use of agricultural machinery and consequently, investment in agricultural machinery has increased. Also, the mechanization coefficient (mechanization coefficient is an indicator that investigates the quality in mechanization and is the ratio of the current total tensile strength to the total area of arable land) reached from 1.66 hp in 2013 to 2.49 hp in 2018 and 2.99 hp in 2019.

2. The status of investment in the agricultural processing and services industry in Mazandaran province from 2010 to 2018

Table 2 illustrates the status of investment in the agricultural processing and services industry in Mazandaran province from 2010 to 2018. To examine this variable, the number of licenses issued in industries such as cold storage processing industries, fertilizer processing industries, industries of producing and packaging seed and grain, oil pressing industries and other related agricultural services and processing industries in the province, the amount of investment in these production units, and the amount of raw materials that these production units need for continuing their activities have been examined.

**Table 2.** The state of investment in the agricultural processing and services industry in Mazandaran province from 2010 to 2018

| Item/tons/ billion Rials | 89-90 | 90-91 | 91-92 | 92-93 | 93-94 | 94-95 | 95-96 | 96-97 | 97-98 |
|---|---|---|---|---|---|---|---|---|---|
| the number of issued licenses | 1786 | 1972 | 2136 | 2266 | 2257 | 2339 | 2377 | 2051 | 2691 |
| the capacity of absorbing agricultural raw materials | - | - | - | 13423 | 12097.1 | 19905 | 13354 | 13886 | 16631.5 |
| the amount of investment | 12567 | 13099 | 14830 | 17832 | 22124 | 22798 | 20451 | 24113 | 30541 |
| the number of units put into operation | 1008 | 1094 | 1215 | 1235 | 1267 | 1205 | 1442 | 1467 | 1552 |
| the capacity of absorbing agricultural raw materials | - | - | - | 4566.63 | 4667. 7 | 4750 | 5764 | 5951 | 6587.8 |
| the amount of investment | 4087 | 4302 | 4917 | 5603 | 5911/5 | 7035 | 7325 | 7822 | 8546 |

Source: Agricultural Jihad Statistics Report from 1389 to 1397

Examining Table 2 shows that in 2018, the number of issued licenses and the amount of investment in agricultural processing and services industries in Mazandaran province, has reached from 1786 to 2691 items and from 12567 to 30541 billion Rials, respectively. Additionally, the capacity of absorbing agricultural raw materials for this number of production units has increased from 441.6 thousand tons in 2013 to 6587.8 thousand tons in 2018 that exhibits investment conditions in the processing and agricultural services industries of Mazandaran province have been improved.

3. Investigating the condition of farmland investment in Mazandaran province during 2010 to 2018

To investigate investment variables of the main inputs of agricultural production, the situation of the area under cultivation of irrigated and rain-fed crops, investment in the exploitation of water resources, and investment in seeds, fertilizers, and pesticides have been examined.

1.3 Investigating the condition of farmland investment in Mazandaran province during 2010 to 2018

To examine this variable, the condition of the area under irrigated and rain-fed crops in Mazandaran province during 2010 to 2018 was examined. Table 3 illustrates the conditions of irrigated and rain-fed crops in Mazandaran province from 2010 to 2018.

**Table 3.** the condition of farmland investment in Mazandaran province during 2010 to 2018

| hectares | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 |
|---|---|---|---|---|---|---|---|---|---|
| the area under cultivation of irrigated | 248449 | 225041 | 249340 | 237839 | 237839 | 262252 | 268677 | 302551 | 312809 |
| the area under cultivation of rain-fed crops | 189583 | 196196 | 197888 | 198158 | 116570 | 114782 | 110116 | 88015 | 96268 |
| Total areas under cultivation of rainfed and irrigated crops | 438032 | 421237 | 447228 | 435998 | 378822 | 383458 | 412667 | 409999 | 409078 |

Source: Agricultural Jihad Statistics Report from 1389 to 1397

Table 3 indicates that the area under cultivation of irrigated crops increased from

24449 hectares to 312809 hectares in 2010, and the area under cultivation of rain-fed crops increased from 189,583 hectares to 96,268 hectares in 2010. The sum of cultivated areas of irrigated and rain-fed crops from 438,032 hectares has reached 409,078 hectares in 2018, which shows that these changes were in line with reducing the areas under the cultivation of rain-fed crops and increasing the areas under the cultivation of irrigated crops. Despite the increase in the area under irrigated crops, the total area under cultivation diminished was due to the decrease in the area under the cultivation of rain-fed crops.

2.3 Examining investment conditions of seeds, fertilizers, and pesticides in Mazandaran province throughout 2010 to 2018

To investigate the investment conditions of seeds, fertilizers, and pesticides in Mazandaran province, the distribution of the kinds of micro and macro fertilizers and the sale rate of chemical pesticides in Mazandaran province were examined from 2010 to 2018. Table 4 shows the distribution of kinds of micro and macro fertilizers (nitrogen, phosphate, potash, and complete macro fertilizers) and the sale rate of chemical pesticides (insecticides, acaricides, fungicides, and herbicides) in Mazandaran province from 2010 to 2018.

**Table 4.**The condition of investment conditions of seeds, fertilizers, and pesticides in Mazandaran province throughout 2010 to 2018

| | **89** | **90** | **91** | **92** | **93** | **94** | **95** | **96** | **97** |
|---|---|---|---|---|---|---|---|---|---|
| the amount of seed distribution wheat and barley (tons) | 4867 | 4259 | 4493 | 2385 | 3397 | - | 3586 | 2851 | 669.9 |
| Collect fertilizers and distributed toxins (liters / kg) | 1206602 | 192306 | 132024 | 83161 | 111863 | 217096 | 242377 | 244877 | 742749 |

Source: Agricultural Jihad Statistics Report from 1389 to 1397

Table 4 shows that the amount of seed distribution (wheat and barley) reduced from 4,867 tons to 700 tons in 2010; the amount of fertilizers distribution reached from 58,877 tons to 106,517 tons in 2011, the sale rate of chemical pesticides reached from 133,429 liters/kg to 636,232 liters/kg in 2011; and the total sale rate and distribution of fertilizers and chemical pesticides reached from 192,306 liters/kg in 2011 to 742,749 liters/kg in 2018. In 2010, chemical fertilizers and pesticides were distributed only by the Agricultural Organization of Jihad, but from 2011 onwards, this organization has been the only supplier of these products, and sales agents in the province meet the rest of the producers' needs for these products.

**Dependent variable**

**Instability condition of water resources**

Production Treadmill Theory indicates decreasing in social productivity of production system. This reduction in the social productivity and use of natural resource led to a change in the extent of ecosystem degradation (resource extraction) and ecosystem pollution (dumping the garbage in the ecosystem). Instability of water resources includes:

1- Water pollution is caused by discharging industrial, agricultural, and domestic wastewater into water resources. All industrial wastewater is to some degree effective in changing the quality of water flows. When this qualitative change reaches a point where we can no longer use water for normal use, the water is called polluted (Jahani Bahnemiri & Hassan Nejad, 2011, p. 16).

2- Excessive extraction out of water resources capacities yielded that these resources, especially rivers, encounter serious hurt in terms of hydraulics, morphology, environment, and economy (Water Organization, 2018, p. 4). This variable was examined through the condition of extraction from aquifers, surface waters in the province, and the amount of agricultural consumption from 2010 to 2019.

The consumption of aquifers in Mazandaran

province throughout 2010 to 2018.

**Table 5.** Status of abstraction from aquifers in the province and the amount of agricultural use from 1389 to 1398

| Million square meter | 88-89 | 89-90 | 90-91 | 91-92 | 92-93 | 93-94 | 94-95 | 95-96 | 96-97 | 97-98 |
|---|---|---|---|---|---|---|---|---|---|---|
| the consumption of aquifers | 790.95 | 691.5 | 834.35 | 852.9 | 991 | 962 | 1144 | 1195 | 1377 | 1377 |
| the amount of agricultural water consumption | 788.11 | 665.31 | 829.13 | 664.41 | 553 | 551 | 686 | 717 | 931 | 931 |

Source: Statistical yearbook of the country from 1389 to 1392 and Mazandaran regional water performance report

Table 5 shows that the consumption of aquifers in the province has increased from 791 million cubic meters in 2010 to 1377 million cubic meters in 2019 that indicates an increase in extraction of aquifers in Mazandaran province. Moreover, the information has been obtained from the statistical yearbook of Water Resources of Iran until 2013. In the second row of the Table 5, the amount of agricultural water consumption is presented based on the total drain amount of authorized and unauthorized water wells, but the report of Mazandaran Regional Water Organization only presented the drain amount of authorized wells.

– The salinity and pollution of aquifers in the province from 2010 to 2019.

Table 6 illustrates the salinity and pollution of aquifers in the province from 2010 to 2019. To investigate the pollution of water resources variable in the province, the amount of salinity and existing nitrate in aquifers were examined. Table 5 shows the maximum and minimum of salinity and nitrate in water as well as the average salinity and nitrate in aquifers.

**Table 6.** Survey of salinity and pollution of aquifers in the province from 1389 to 1398

| (µs/ s)- (mg) | 88-89 | 89-90 | 90-91 | 91-92 | 92-93 | 93-94 | 94-95 | 95-96 | 96-97 | 97-98 |
|---|---|---|---|---|---|---|---|---|---|---|
| The average salinity of aquifers | 1095 | 1172 | 1248 | 1137 | 1064 | 1144 | 1080 | 966 | 1055 | 1397 |
| the average nitrate of aquifers | Not measured | 3.2 | 12.8 | 13.7 | 16 | 13.6 | 11.6 | 21.2 | 15.4 | 21.5 |
| Average salinity of rivers | 637 | 536 | 543 | 529 | 568 | 595 | 489 | 598 | 559 | 457 |
| Average nitrate in the intestines | Not measured | 4.7 | 5.5 | 5.4 | 4.1 | 5.4 | 6.6 | 4.6 | 6.1 | 8.5 |

Source: Mazandaran Regional Water Laboratory Report from 1389 to 1398.

The reports of the lowest and highest salinity and nitrate are related to the reports of the areas that had the lowest or highest salinity and nitrate in the same year.

Table 6 demonstrates that the average salinity of aquifers in the province has increased from 1095 in 2010 to 1397 mg in 2019, which shows an increase in salinity in aquifers. Furthermore, the average nitrate of aquifers has increased from 3.2 in 2011 to 21.5 µs/ s in 2019, which indicates an increase in the amount of nitrate in aquifers.

**Analytical results**

According to the research findings, the number of agricultural machinery has increased from 188,969 sets to 213,872 set in 2018, which indicates an increase in the use of agricultural machinery and consequently, investment in agricultural machinery. The number of issued licenses increased from 1,786 to 2,691 items,

the amount of job creation grew from 16,446 to 2,002, and the amount of investment in agricultural processing and service industries increased from 12,567 to 30,541 billion Rials in Mazandaran province in 2018. Additionally, the capacity to absorb agricultural raw materials for this number of production sectors has increased from 870.24 thousand tons in 2013 to 1,663,131 thousand tons in 2018.

Moreover, the capacity to absorb predicted agricultural raw materials for this number of production sectors has increased from 870.24 thousand tons in 2013 to 1,663,131 thousand tons in 2018. The number of production sectors that have been put into operation has increased from 1,008 to 1,552, the amount of job creation grew from 6,377 to 12,306 and the amount of investment in agricultural processing and service industries arose from 4,087 to 8,546 billion Rials in Mazandaran province in 2018. In addition, the capacity of absorbing agricultural raw materials for this number of production sectors has increased from 441.6 thousand tons in 2013 to 6,587.8 thousand tons in 2018, which shows that the investment condition in the agricultural processing and services industries in Mazandaran province has improved.

Areas under irrigated crops has risen from 24,449 hectares in 2010 to 312,809 hectares and areas under the cultivation of rain-fed crops decreased from 189,583 hectares in 2010 to 96,268 hectares and total areas under the cultivation of irrigated and rain-fed crops reduced from 438,032 hectares to 409,078 hectares in 2018 that showed that these changes led to reducing the areas under the cultivation of rain-fed crops and increasing the areas under the cultivation of irrigated crops. The amount of seed distribution (wheat and barley) decreased from 4,867 tons in 2010 to 700 tons, distribution of fertilizers rose from 58,877 tons in 2011 to 106,517 tons, sale rate of chemical pesticides grew from 133,429 liters/kg in 2011 to 636,232 liters/kg and the total sale rate and distribution amount of fertilizers and chemical pesticides increased from 192,306 liters/kg to 742,749 liters/kg in 2018.

The amount of aquifers consumption in the province has increased from 791 million cubic meters in 2010 to 1,377 million cubic meters in 2019, indicating an increase in draining from aquifers in Mazandaran province. The average salinity of aquifers in the province has increased from 1,095 mg in 2010 to 1,397 mg in 2019, which shows an increase in salinity of aquifers. Furthermore, the average amount of nitrate in aquifers has increased from 3.2 in 2010 to 21.5 µs/ s in 2019, which demonstrates an increase in the amount of nitrate in aquifers.

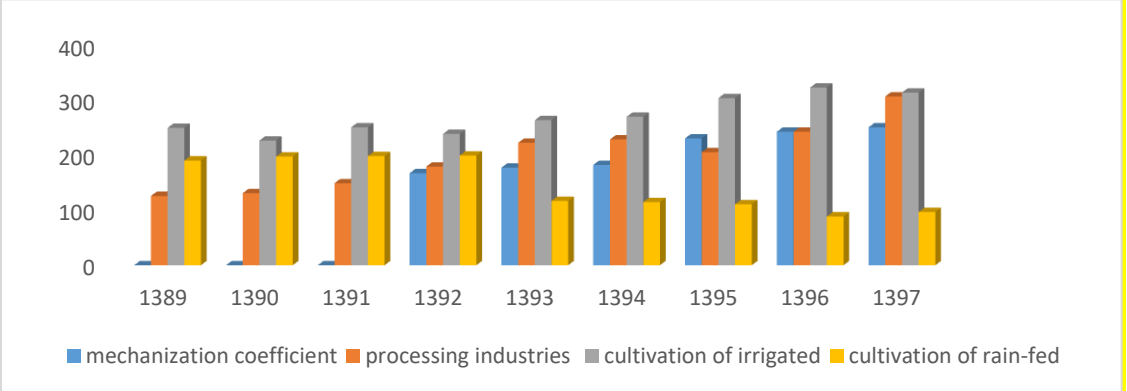


**Figure 1.** The growth of investment in agricultural machinery, arable land, and service and processing industries in Mazandaran province, Iran. (Source: Research Findings, 1399)

Figure 1 shows the growth of investment in agricultural machinery, arable land, and service and processing industries in Mazandaran province. Based on the research findings and as mentioned and shown on this chart, from 2010 to 2018 the amount of investment and the number of service and processing industries dependent on agricultural products has increased. The mechanization coefficient, as an indicator of increased investment in machinery and applied technologies in agriculture, has also increased;

but in line with the increase in irrigated crops, the areas under rain-fed crops have decreased, and indicated a change in the capital allocation from rain-fed crops to irrigated products.

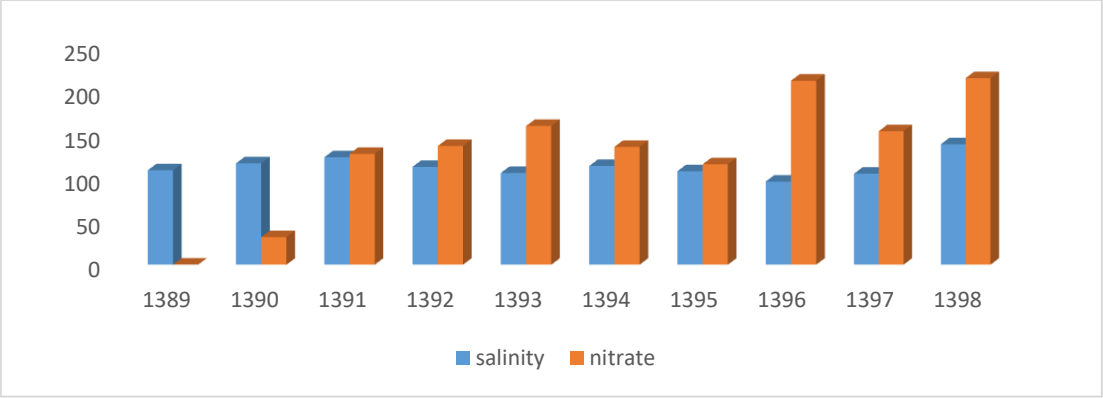


**Figure 2.** The average salinity and nitrate in aquifers of Mazandaran province, Iran. (Source: Research Findings, 2020)

Figure 2 shows the average salinity and nitrate in aquifers of Mazandaran province. According to the research findings and as mentioned and illustrated on this chart, the average salinity and nitrate in aquifers in Mazandaran province has increased from 2010 to 2019.

## Discussion and conclusion

Sustainable development is one of the main approaches of interaction between development and the environment. Agricultural activities specifically its development using technology have gradually been challenged and the instability in water resources is one of the important challenges in this regard. Agriculture is the fundamental economic element in Mazandaran that has existed for many years. Nowadays, the agriculture sector is considered significant to ensure food security, economic development, and job creation in Mazandaran province. However, regarding high degree of wasting the water in agriculture sector, its effects are assumed to be very destructive. Nevertheless, there is an emphasis on investment as one of the most important inputs to increase producing and exporting agricultural products.

Findings of our study demonstrated that the investments in the agriculture sector were either in the form of direct investment in this sector (e.g., purchasing agricultural machines, fertilizers, and seeds, farmlands, and water), or as indirect investment (such as processing and services industries, establishing and developing modern irrigation systems).

Schneiberg (Gould et al., 2016 & 2004), believes that increasing the level of capital available for investment and changing the allocation of investment altogether, caused a noteworthy growth in demand for natural resources. He considers these investments for replacing new technologies with the workforce to increase profits. He argues that these new technologies required more energy or chemical materials to replace previous materials and more labor-intensive processes. Hence, they caused degradation in deeper layers of ecology destruction more than before. Furthermore, despite previous use of the workforce, new technologies have been turned into a capital-consuming form.

The findings of this study confirmed the hypothesis that increasing and changing the investment allocated to the agricultural production, service, and process industries will increase the demand for natural resources. The reason is that as the research findings show that the capacity of agricultural raw materials by these units has increased along with the increase in investment and operation of new manufacturing units; therefore, the capacity of absorbing agricultural raw materials by these units reached 6,587.8 thousand tons in 2018 showing a significant growth.

Producing agricultural raw materials required by these manufacturing units calls for cultivating more areas and more water

resources, but since the areas of cultivation can be expanded to a certain extent, necessitates using a variety of technologies, machinery, pesticides, fertilizers, and modified seeds that increase production and consequently, profits. Moreover, as the research findings show, some parts of the increase in investment are in the form of investment in machines that are capital consuming. Types of planting, harvesting, tillage, and propulsion machinery, increased from 188,969 sets in 2010 to 213,872 sets, which show a growth in investment. Additionally, it has been in line with reducing the need for harvester and planter workers and so on.

According to the findings of the study, the area under cultivation of crops has generally decreased. Nonetheless, the area under irrigated crops has increased from 24,449 hectares in 2010 to 312,809 hectares in 2019. This increase proves the change in investment allocation on irrigated crops due to the decrease in the area under irrigated crops. Furthermore, due to the limited expansion of cultivated areas, there is a need for investment in seed modification, the use of pesticides and chemical fertilizers, aftercrop and greenhouse production, etc., and as a result, agricultural products would be increased. However, as Schneiberg argues, its price is the increase in demand for water resources and excessive extraction from water resources, the penetration of pesticides and chemical fertilizers, and consequently, the pollution of water resources. The findings also reveal that the amount of excessive consuming the aquifers reached 790.950 million cubic meters in 2010, which increased to 1377 million cubic meters in 2019. Moreover, the salinity of aquifers in the province has increased from 1095 in 2011 to 1397 mg in 2019 and the average nitrate of aquifers has increased from 3.2 μs/ s in 2010 to 21.5 μs/ s in 2019, that shows increase in the pollution of aquifers and penetration of pesticides and chemical fertilizers used in agricultural products.

According to the findings of the present study, the creation of new investments by producers in the fields of agricultural production and processing and services industries related to agriculture, investment in modification and production of high-quality seeds, and the use of various machines, may initially lead to increasing productivity or reducing the use of pesticides per square meter of farmlands and hence, seem to aid maintaining the sustainability of water resources, however, in the end, may increase the demand for natural resources. As the research findings show that the ability of agricultural units to absorb agricultural raw materials has increased, which is a repetitive cycle that leads to capital growth along with the increase in investment and operation of new production units. As Schneiberg believes, these technologies that improve resource efficiency of using the resources, superficially help reduce environmental effects but ultimately increase these effects (York et al., 2003).

Proposing the production treadmill theory, Schneiberg attempts to explain the effects of increased investment on the growth of production, which leads to the destruction of natural resources, as opposed to competing theories that assets increase in investment may lead to the growth of production and achieve certain levels of welfare. These theorists believe that further economic development can solve environmental problems because government and investors are expected to work together to protect the environment when it reaches a certain level (York et al., 2003).

Schneiberg has focused on what hinders confirmation of the hypotheses related to these theories is the tendency of capitalists and producers to maintain and increase profits, is their main concern in the production process, and this concern prevents them from ignoring a portion of their profits in favor of the environment as competing theories have suggested. The findings of this research confirm the hypothesis that the increase and change of investment allocation in agricultural production, processing and service industries are the factors for the instability of water resources and show that the Production Treadmill Theory provides a suitable sociological explanation for the causes of water resources destruction in Mazandaran province.

According to the findings of this research, given the challenges of water resources, at

the macro level and policy, redefining the priorities of water resources allocation as well as targeting the growth and economic development of agriculture is necessary. Additionally, regarding the increase in investments to expand the use of water resources, developing the investment, investigating and researching in protecting water resources, training utilizers to preserve and maintain water resources and training farmers to decrease wasting the water, reducing the use of unnecessary pesticides and fertilizers are needed.

## Acknowledgment

This article was extracted from the doctoral dissertation entitled "The Investigation of Sociological Causes of Water Resources Destruction: The Case of Mazandaran Province" which was conducted at the University of Mazandaran and received funding from "Iranian National Science Foundation" (the Vice President for Science); therefore, I hereby appreciate the support and funding

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