# The Role of Nanotechnology in Achieving Sustainable Development an Investigating Study on Industrial Companies in Egypt

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***Abstract***
*The objective of the research is to examine the impact of Nanotechnology (NT) on Sustainable Development (SD). The research population consists of all employees at industrial companies in Egypt. Due to time and cost constraints, the researcher adopted a sampling method to collect data for the study. The appropriate statistical methods such as Alpha Correlation Coefficient (ACC), Confirmatory Factor Analysis (CFA), Multiple Regression Analysis (MRA), were used to analyze the data and test the hypotheses.*
*The research has reached a number of results, the most important of which are: (1) the fields of NT application are numerous and varied in the fields of medicine, agriculture, chemistry, pharmaceutical industries, disease detection, food production, and environmental protection, (2) there are many opportunities and challenges related to NT, and these opportunities and challenges are in the technological, economic and social aspects. (3) insufficient awareness of the importance and culture of NT and its various dimensions, (4) the lack of a strategic plan for NT, in addition to the weak financial resources to put the strategic plan into practice for Industrial companies in Egypt, (5) the use of NT has brought about a new industrial revolution no less important than the first industrial wealth that occurred in the seventeenth century, (6) The United States of America is the leading country in the field of NT due to several considerations, the most important of which is that it possesses the scientists who have the ability to deal with this science, (7) SD is the choice of the people, and it is they that seek to tackle and confront challenges and problems facing the process of development and treatment, and to tackle poverty and environmental problems, (8) The essence of SD is centered around meeting the needs of current and future organizations with resources without harming the environment, and (9) SD is the source, survival and continued growth of organizations in general, and in the competitive environment in particular.*
*The study referred to a number of recommendations, the most important of which are: (1) the necessity of developing a work environment that is able to practice advanced technology and make it a philosophy of senior management in order for industrial companies to proceed in their right practices in a manner that accompanies the changes resulting from the technological revolution, on the basis of benefiting from modern technology, (2) the management of the industrial companies in Egypt must support and use advanced technology capable of keeping pace with changes in the global environment so that the skills and capabilities of workers to deal with technology in all its forms increase, (3) inviting all specialists in universities and other ministries in order to present their expertise in the field of NT, and building an integrated model for industrial companies that takes into account the infrastructure, economy and social capital. This will lead to achieving SD, (4) Allocating a sufficient budget to support, develop and attract specialists from scientists and researchers in the field of NT for the purpose of working on localizing technology and developing it in industrial companies. (5) Developing educational systems and working to achieve a qualitative transfer in the curricula and teaching methods in a manner that contributes to preparing new generations that can deal efficiently with developments in the field of technology in general, and in the field of NT in particular.*
***Keywords:*** *Nanotechnology, Sustainable Development, Industrial Companies*

## 1. Introduction

Nanotechnology (NT) is one of the advanced forms of technology, and it has a fundamental impact on many areas, the most important of which are medicine (Rebort & Freitas, 2016), agriculture (Tejpal, 2015), libraries (Simon & Mick, 2012), and learning (Ban & Kocijanic, 2011), chemistry (Steven & Krajcik, 2007), consumer products (Jason, 2008), dentistry (Maria et al., 2016) and early detection of viruses and diseases (Nikalje, 2015).

Ideas and concepts began to form for NT before it was used. Physicist Richard Feynman proposed it at a meeting of the American Physics Society at the California Institute of Technology on 1959, with a topic titled: There's Plenty of Room at the Bottom. Also, Professor Norio Taniguchi created the term NT. In 1981,

NT began with the development of the Scanning Tunneling Microscope, through which individual small atoms could be seen (Picraux, 2018).

NT is a technique that studying, understanding, and monitoring matter with dimensions ranging from 1 to 100 nanometers. NT can be used in different scientific fields, such as: physics, chemistry, biology, materials science, and engineering (Robert & Freitas, 2016).

NT relates to the basic understanding of physical, chemical, and biological properties, and the control of these properties to create functional materials and systems with unique capabilities (Maria et al., 2016).

NT has many uses and areas of application, for example in the field of medicine, where NT is used in the rapid and accurate detection of viruses, the expansion of vessels, and the improvement and strengthening of anti-bacterial activity, in addition to nano medicines that can be used to detect diseases in the early stages ( Niltalje, 2015).

NT provides many benefits that come in many areas of life. NT helps improve many technological and industrial sectors such as information technology, energy, medicine, national security, environmental science, and food safety. Also, commercial products rely on NT. For example, a transparent nano-layer on computer screens, camera, glasses, and windows can help make it water-resistant, anti-reflective, scratch-resistant, or conductive of electricity (Picraux,2018).

NT has entered into consumer products, especially in resisting stains in clothing and fabrics. Nanocrystals have been used to make invisible sunscreen. Silver-nanocrystals have been used to kill bacteria and prevent infection (Nikalja, 2015).

The technological development in the storage of electronic computer is witnessing a great development, and with the development in NT, manufacturing at the micro level will achieve a tremendous progress in the storage capacity of data. This creates an integrated library with a very simple size, where millions of trillions of pieces of data are placed. The development of electronic computer technologies may help in the production of smaller devices and genetic electronic computers (Stanshevskaya, 2012).

The development in new products that use NT is growing at a very fast pace than is the case in ongoing research in its safety field. Defenders in this technology admit that there are types of them that are very dangerous, so the NT does not differ from any other technology that excels in it. Benefits over risks (Herrington et al., 2009).

The application of NT is a comprehensive industrial revolution, as well as a scientific revolution for the twenty-first century that will lead to a comprehensive change in the world (Khalawey, 2008).

NT is reaching its full potential to contribute to building modern societies. We need a great effort from the workforce and trained in NT research. It is also necessary to develop related industries and strengthen programs to prepare and provide human resources in the field of NT (Fonash, 2001).

Sustainable Development (SD) is one of the important issues that is difficult to deal with and implement. SD is difficult to overcome obstacles to achieve it, because it consists of a set of dimensions. According to the nature and complexities of this topic, therefore its importance must be recognized to reach a comprehensive understanding and awareness of SD. Population is the mainstay driving the SD wheel (Gubo, 2017).

There are some issues that have made SD a global issue such as environmental degradation, the search for innovation, creativity and cleaner production. Studies have shown that sustainability in the organization can lead to more organizational commitment (Tooranloo, et al., 2017).

Industrial and developed countries have confirmed their need to define consumption standards within environmentally acceptable limits. Everyone seeks it in a way that ensures the equitable distribution of natural resources among the different generations to implement sustainable development, risk reduction, waste management, mitigation and environmental degradation. SD requires economic sustainability, social sustainability, and environment sustainability (Burns, 2015).

In light of the global competition among countries and the acquisition of competitive advantage, the concept of SD has become a basis for enabling the state economically, politically, socially and militarily. Countries strive to achieve SD with the aim of maintaining control over their internal resources, and preventing interference by the other dominant force. SD sector is the basis for achieving a decent life for peoples, maintaining independence and the right to make decisions (Yousef, 2011).

The beginning of SD as a concept was in Stockholm in 1972 of the human environment conference. A new concept of development was presented not in the environmental aspect, but in terms of economic and

social aspects. The necessity of SD was mentioned, which emphasizes that development is an economic and social necessity to ensure that it creates conditions for improving the welfare and standard of living of all members of society (Voigt, 2009).

The United Nations Global Commission on Environment and Development has realized that the only way to solve environmental problems is by integrating the economy and the environment. In addition, the necessity of inviting the governments and peoples of the world to take responsibility for environmental damage on the planet, and to adjust economic policies in order to achieve environmental balance (Lertzman & Vredenburg, 2005).

The concept of SD has passed through important stages that led to its expansion in the current situation, and it includes many things such as protecting the environment, replacing natural capital instead of industrial capital, achieving justice among individuals in society, and investing in human capital and society protection (Yu et al., 2000)

There are three types of sustainability: (1) economic sustainability: it is to create a productive system that meets the consumer's need without resorting to consumption of future savings, so that the economic system itself is sustainable, (2) social sustainability: it is the system that exists to organize society and reduce poverty, so that it establishes a relationship between social conditions and environmental decay, (3) environmental sustainability: natural resources are preserved while reducing the volume of waste, and the need to keep those resources in a state of renewal (Basiago, 1999).

This study is structured as follows: Section one is introductory. Section two presents the literature review. Section three presents the research model. Research questions and hypotheses are presented in section four. Section five explains the research strategy. Hypotheses testing is provided in section six. Section seven handles the empirical results. Finally, section eight presents the main recommendations of the study.

## 2. Literature Review

### 2.1. Nanotechnology

#### 2.1.1. Nanotechnology Concept

The concept of NT began in 1959. It remained a theoretical concept until 1981. Scientists have discovered what is known as the tube microscopy method, which is a microscopic examination with a special technological method that is not done through normal vision through a microscope. Using this method, scientists were able to see the very small particles (Khalawey, 2008).

NT is the infinitely small world, because the word nano is originally from Greek (Khalawey, 2008). In other words, the word NT is an expression derived from the Greek word nanos. It refers to a dwarf or finite thing in small or tiny. It is a scale equivalent to one millionth of a millimeter, and one over a billionth of a meter, which is equal to one in ten thousandth of the thickness of a human hair (Mazeed & Abas, 2011).

NT is a set of theories and applications that allow the production and processing of nano scale nano materials (Edith, 2012).

The application of NT will entail a massive and significant reduction in the cost of production, an accurate knowledge of the details of the composition of materials, as well as an accurate knowledge of the engineering of the materials to be made and the strong control of atoms (Khalawey, 2008).

In South Korea, the government of former President Kim Dae-Jung announced in July 2001 that it had allocated a budget of about $1.14 billion to spend on NT applications within ten years. In China, there are reports that the spending allocations for NT research at the end of 2005 were $2 billion. The least spending Asian countries in this area are India, which did not exceed $26 million (Benson, 2007).

US President Bill Clinton granted $ 495 million to the US initiative in NT before he left the White House. This is the largest amount allocated to this research, in terms of supporting NT and considering it an essential part of American scientific excellence globally (Khalawey, 2008).

NT is a set of tools, technologies, and applications that relate to the manufacture and installation of a particular structure using very small scales. NT is a science that specializes in researching and developing modern things and methods of size within the framework of the nano scale. NT is a scientific application that handles the production of things by aggregating them from their basic components such as atom and molecule (Mazeed & Abas, 2011).

NT is the technique whereby materials components at the atomic and molecular levels can be treated separately and regrouped to form modified materials with better properties and specifications (Fahrner, 2004).

NT is the complete and accurate control of the production of materials by controlling the interaction of the particles involved in the reaction, directing these molecules through the production of a specific substance. This type of reaction is known as molecular synthesis, placing the atoms during the reaction in their correct or appropriate place (Mazeed & Abas, 2011).

NT is the technology by which materials components at the atomic and molecular levels can be treated separately, and reassembled to form modified materials with better properties and specifications (Tanigachi, 1974).

NT is an advanced form of technology, and it has a fundamental impact on most industries and all areas of society. It is used in medicine, industry, energy and environmental protection (Khalawey, 2008).

NT is the science of coordination between biological, physical, chemical, mechanical, and electronic sciences, materials science and information technology, in order to study the structural structures of living and marine matter. Due to the information and communication revolution, new relationships have begun to emerge as a result of the tremendous development in the field of NT, biotechnology, and nano-biology (Khalawey, 2008).

The twenty-first century will be distinguished by the connection between the fields of physics, life science and computers, which means the development of science to give us an unprecedented ability to control matter, life, and intelligence. In the conference held by US government agencies on NT, it was pointed out that it is necessary to follow up the evaluation of what is being accessed first, in order to ensure the use of available financing in order to provide the technology to the consumer (Khalawey, 2008).

### 2.1.2. Nanotechnology Dimensions

The dimensions of NT are NT culture, strategic plan, technology selection and evaluation, the nature of raw materials, the nature of machines and production processes, the quality of the products, and talented management (Stobie, 2003; Kahlawy, 2008).

1. Paying attention to NT culture, the beginning of entering the NT field is preparing the appropriate climate for it to have an awareness and interest in the importance of spreading the NT culture.
2. The strategic plan, it is the basis of technology management, and that NT depends primarily on government funding, and therefore it is predominantly strategic.
3. Choosing, reviewing and evaluating technology, as there are three basic stages that the process of applying technology in the field of NT goes through, which is selection, review, and evaluation until technology is used on a sound basis.
4. The raw materials used, as the nature of NT deals with the components of the materials, so the quality of the relationship with suppliers and the ability to manage raw materials through logistical management is the key to success in managing this type of technology.
5. The nature of machines and production processes, as the machines that work in the field of NT must be flexible, since they deal with different components, which leads to ease of dealing with them.
6. The quality of the products offered, as dealing through technology requires the extraction of a distinct and different quality of products that contribute to productive, economic and social development in light of not harming the environment and public health in the country.
7. Talent management, as it attracts skilled worker in the field of NT and that has the ability to deal with the risks and control that result from the use of this type of advanced technology.

## 2.2. Sustainable Development

### 2.2.1. Sustainable Development Concept

Sustainability is one of the terms used in multiple fields. Sustainability refers to various meanings, the most important of which are (1) the long-term regular use of natural resources, (2) an advanced civilized method that must be used to achieve economic, social and environmental progress on the one hand, and to preserve the natural resources of future generations on the other hand, (3) one of the methods or means that achieve social justice for all members of society, and (4) one of the methods that can be used to fulfill the needs of present generations without harming the needs of future generations (Filho, 2009).

Sustainability is a multidimensional concept that includes the economic, social and environmental dimension. From a business perspective, sustainability is a complex concept in economic, social and environmental terms. Financial performance in sustainable organizations is linked to both social and environmental sustainability. Therefore, when assessing the success of sustainable organizations, the focus is on the extent to which sustainability is achieved, not on achieving financial results. So, the organization should focus on the social and environmental dimensions in achieving SD (Kucukoglu & Pinar, 2016).

The term SD has become one of the most important terms in the development literature in the sense that SD is the process, and sustainability is the goal on which the theory of environmental modernization focuses, which includes four basic principles: (1) focus on science and technology, (2) harnessing tools for achieving sustainable development, (3) taking into account the social responsibility of organizations, and (4) participation of all activities in achieving SD (Olsson et al., 2014).

SD is a philosophy that seeks to achieve the well-being of members of society in light of achieving economic growth, addressing social problems and reducing environmental degradation (Nguyen et al., 2018).

SD is an attempt to improve human well-being in the long term by managing the environmental system (Feil & Schreiber, 2017).

SD is the act of striking a balance between social, economic and environmental issues in order to achieve social, economic and environmental interests (Adeoye, 2017).

SD is a system that encompasses a set of dimensions, which are the social, environmental, and economic dimensions (Ehinger, 2016).

SD is the process that seeks to provide for the needs of present and future generations in terms of environmental resources, economic needs, and social aspects (Berber & Aleksic, 2016).

SD is to meet the needs and desires of members of society for long future periods without damaging or consuming available natural resources (Fulekar et al., 2014).

SD is the preservation of the stock of financial, environmental, social and human resources on which companies depend in both quantity and quality in the short and long term (Sriran et al., 2013).

SD is a set of mechanisms and means by which society is united towards achieving a sustainable future through the knowledge it provides on the one hand, and community participation on the other (Waas et al., 2012).

SD is one of the basic requirements for continuing to improve human well-being within the limits of available natural resources (Filho, 2009).

SD is what meets the needs of the present without compromising the ability of future generations to meet their own needs (Tofan, 2009).

SD is a better future for everyone now and in the future. SD consists of two parts, the first is development, which means creating better living conditions, and the second, which is sustainability and means the state that can continue to be sustained (Heideveld & Cornelissen, 2008).

SD is the ability of current generations to make optimal use of available resources without compromising the ability of future generations to access the same resources and use them to fulfill their desires and needs (Calvert & Calvert, 2007).

SD is the one that seeks to maximize the welfare of present generations without reducing the level of welfare for future generations. This requires removing the negative impacts that are responsible for the depletion of natural resources and environmental degradation. In addition to protecting the goods and services necessary for economic growth under a healthy, healthy and coherent environment (OECD, 2001).

SD is development that seeks to achieve a balance between the environmental, economic and social system, and contributes to achieving the maximum possible growth and upgrading in the previous three systems without development in any system affecting other systems (Pearce et al., 1990).

SD is the increase achieved from the gross national product of everyone, provided that this increase does not have adverse effects on nature and society such as the pollution problem and waste in the natural resources (Pearce et al., 1989).

SD is the one that seeks to meet the needs of present generations without harming the ability of future generations to meet their needs (WCED, 1987).

### 2.2.2. Sustainable Development Dimensions

The dimensions of SD are environmental sustainability, social sustainability, and economic sustainability (Nguyen et al., 2018; Tooranloo, et al., 207; Adeoye, 2017; Kucukoglu & Pinar, 2016; Rensburg, 2015; Fulekar et al., 2014; Spangenberg, 2013; Eltayeb, 2011; Romiguer, 2011; Rasmussen, 2011; Potts et al., 2010; Bounhiss, 2010; Pavlova, 2009; Winkler, 2006; Harris, 2000).

### 2.2.1. Social Sustainability

Social sustainability relates to the human aspect of sustainable development because it is linked to social problems such as poverty, disease, and inequality, and therefore the decision maker must consider the social aspects of their decisions (Hussain et al., 2018).

Social sustainability is an attempt to reduce environmental damage on the one hand, and reduce deprivation of some poor people on the other hand (Cook, 2011).

Social sustainability is the basis for SD, given that it is related to social issues related to individuals in society, as it deals with various and multiple elements, and if it is managed properly, this leads to achieving social stability and achieving social characteristics in a sustainable manner (Eltayeb, 2011).

Social sustainability can be achieved through regular community participation, while social and moral capital is of great importance in achieving social sustainability. The need for social sustainability arises in view of the necessity and importance of protecting the available resources in meeting the needs and desires of present generations without harming future generations (Rasmussen, 2011).

Social sustainability is working to meet the basic needs of members of society in general, and those with limited income in particular, which are health, housing and work, in the light of achieving social justice among members of society. In addition, meaningful community participation, whether in the distribution of opportunities and available resources, or in various decision-making (Pavlova, 2009).

Social sustainability is represented in achieving social equality in distribution, and availability of social services that include health, education, male and female equality, political accountability, and participation in decision-making (Harris, 2000).

### 2.2.2. Economic Sustainability

Economic sustainability refers to income generation and economic stability for community members. Economic sustainability is linked to consumption and production without compromising the abundance of available resources (Nguyen et al., 2018).

Economic sustainability is linked to the economic dimension of development in terms of preserving the available capital and resources, and economic sustainability is achieved when it does not affect the sustainability of natural, social and human societies (Chelan et al., 2018).

Economic sustainability is concerned with working to transform the economic situation from growth to stability. A stable economy is where natural resources are consumed at a steady and sustainable rate in light of maintaining human and environmental health (Rasmussen, 2011).

Economic sustainability falls within the framework of sustainable development, and it is not only related to how revenue and profits are generated, but rather is related to how the available resources are used efficiently and effectively, as it is not possible to create social and environmental without the economic dimension in the framework of sustainability. This is in addition to the importance and necessity of the economic system being able to meet individual and social needs in a fair and balanced way (Potts et al., 2010).

Economic sustainability is to protect and enhance the quantities of natural resources through improvement in the practice of the policy of managing the available resources efficiently and effectively (Flint, 2004).

### 2.2.3. Environmental Sustainability

Environmental sustainability is the preservation of the absorptive capacity of the ecosystem in a manner that contributes to meeting the current and future needs of community members and not to harm future generations (Bibri, 2018).

Environmental sustainability is concerned with finding solutions to environmental problems, which creates a safe environment for all members of society. Therefore, all organizations must pay attention to the

continuous improvement of the environmental aspect, and this can be implemented through green human resource management practices (Tooranloo et al., 2017).

Environmental sustainability is concerned with protecting the natural resources used to meet the special needs of members of society, and reducing environmental pollution operations. Environmental sustainability programs are linked to work on raising awareness of its importance on the one hand, and preserving the environment on the other hand (Kucukoglu & Pinar, 2016).

Environmental sustainability is making decisions and minimizing the negative impacts of human activities. This is in addition to taking measures to use non-renewable resources wisely and fairly, whether for future or future generations. In other words, environmental sustainability is to reduce the negative impacts of human activities on the environment, and to take measures that use the available resources in a fair manner to fulfill the needs of present and future generations (Yuan, 2013).

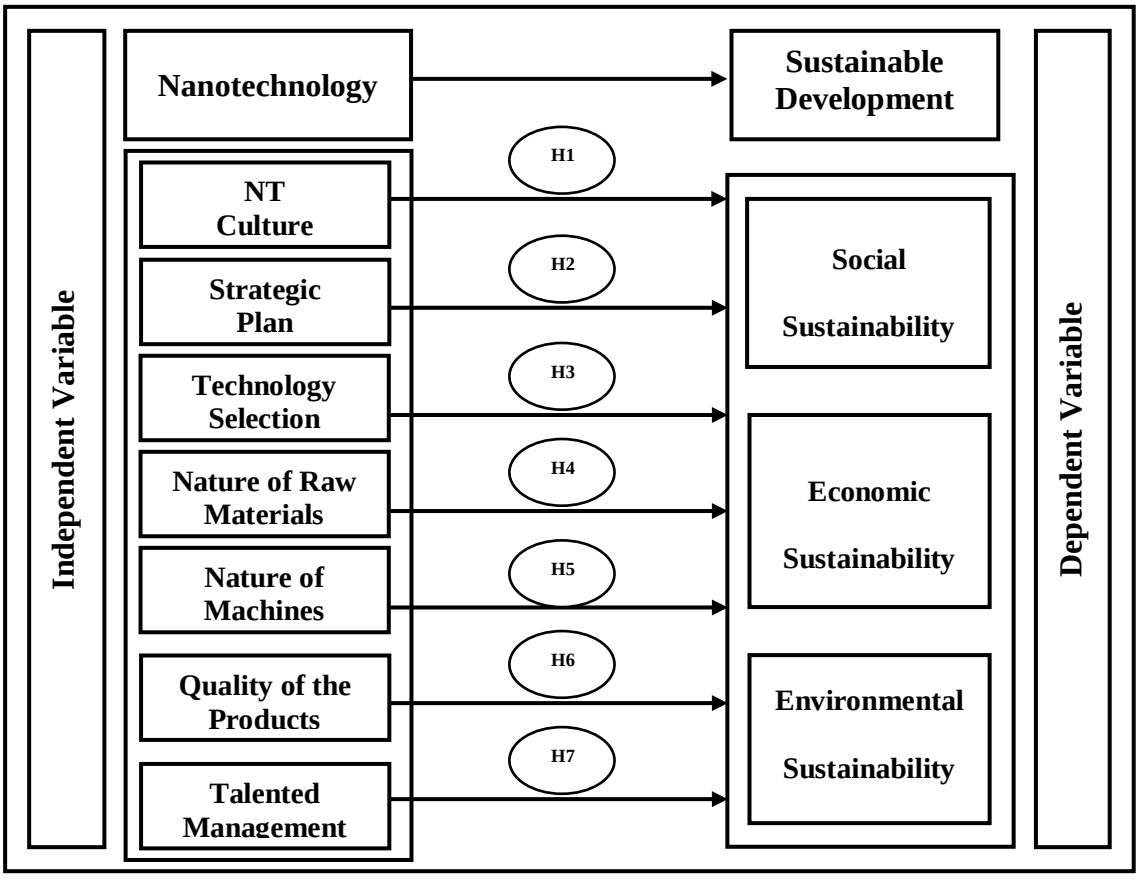
Environmental sustainability is the ability of the planet to withstand the human element by absorbing the waste and radiation that a person creates to provide them with all the natural and energy resources they need. Environmental sustainability is based on leaving the earth in good condition for future generations, and if a person maintains his activity and performance without wasting natural resources, this leads to achieving natural sustainability for present and future generations (Dadds & Veaables, 2005).

Environmental sustainability is associated with preserving natural resources from unregulated consumption, reducing the effects of pollution in all its forms, diversifying energy sources, increasing the area suitable for the livelihood of members of society, reducing the presence of the desert, and providing safe water for both consumers and the environment (O'Brien 1999).

Environmental sustainability is represented in maintaining a stable base of natural resources and avoiding excessive depletion of renewable and non-renewable resources, as well as protecting the biological type, air balance, and other natural ecosystems that are not classified as economic resources (Harris, 2000).

## 3. Research Model

**Figure (1) Proposed Comprehensive Conceptual Model**




The diagram shows that there is one independent variable of NT. There is one dependent variable of SD.

NT is measured in terms of NT culture, strategic plan, technology selection and evaluation, the nature of raw materials, the nature of machines and production processes, the quality of the products, and talented management (Stobie, 2003; Kahlawy, 2008).

SD is measured in terms of environmental sustainability, social sustainability, and economic sustainability (Nguyen et al., 2018; Tooranloo, et al., 2017; Adeoye, 2017; Kucukoglu & Pinar, 2016; Rensburg, 2015; Fulekar et al., 2014; Spangenberg, 2013; Eltayeb, 2011; Romiguer, 2011; Rasmussen, 2011; Potts et al., 2010; Bounhiss, 2010; Pavlova, 2009; Winkler, 2006; Harris, 2000).

## 4. Research Questions

The research problem has two sources. The first source is to be found in previous studies. There is a lack in the number of literature review that dealt with the analysis of the relationship between NT and SD. This called for the researcher to test this relationship in the Egyptian environment.

In light of the review of previous studies towards NT, literature has shown that NT has been used in the field of medicine for the purpose of detecting viruses and improving anti-bacterial activity, and the emergence of the so-called Nano-Factory for the manufacture of corn flour. This leads to the emergence of a new revolutionary model in the field of health care for human beings (Robert & Freitas, 2016).

Another study is concerned with the application of NT in the field of agriculture and sensors to quickly detect the causes of diseases in plants, toxins and other pollutions. In addition, NT plays a dangerous role in the field of safe pesticides (Tejfal, 2015).

Another study indicated that NT was applied in the field of libraries in terms of self-circulation service, self-return service, fine payment, storing, theft detection, collection management, inventory processing, items location, and patron privacy (Simon & Mick, 2012).

Another study is concerned with experimenting with some activities in order to introduce students to the nature of NT, in addition to designing curricula in NT for teachers in order to qualify them to work efficiently in this field. The results demonstrated the effectiveness of incorporating the subject of NT into the curricula at the secondary and intermediate levels. In addition to that there is necessity of applying NT education in the elementary stage, and adding some topics related to NT in the curricula of middle and secondary education as compulsory subjects such as engineering and technology (Ban & Kocijanic, 2011).

There is another study concerned with grouping investors in order to face the risks and challenges of NT, in addition to facing scientific uncertainty regarding the results of the application of NT (Gregory, 2008).

Another study indicated that risk management in NT is identifying many uncertainties in terms of risk, return, and future of NT application. Given that all of these things are predominantly uncertain, the principles of traditional risk management, feasibility study, cost-benefit analysis are not all appropriate in how to deal with NT (Marchant et al., 2008).

There is another study that indicated the necessity of examining the labor market in the field of NT to obtain highly trained labor in this field. This is in addition to learning about the role of universities in training current workers (Stephan et al., 2008).

Another study concluded that attention should be paid to converting theoretical contributions into practical contributions or commercial inventions that are used scientifically and commercially. This field will be fertile for multiple categories such as legal, patent holders, scientists, researchers, business managers and technology transfer specialists (Matthew, 2008).

Another study indicated the importance of having a framework for NT, the necessity and importance of government funding for this field of advanced technology, and that this be in a legal framework that regulates work in this area and intelligence (Khalawey, 2008).

Another study indicated that NT became related to consumer products, which led to the emergence of a field of NANO. This is an area of NT related matters, as trademark registration can be used as a tool for NT protection (Jason, 2008).

There is another study concerned with technology management in general, and in the field of engineering, science and management related to new technology, and how to benefit from it in achieving the strategic goals of the organization in particular. The technology management includes several dimensions,

the most important of which are the definition of technology, its selection, acquisition, absorption and investment in it (Khalawey, 2008).

Another study is concerned with the talent of management in using technology in order to achieve the low cost of money and time in achieving the goals of the organization. Large organizations are interested in choosing their leadership in terms of knowledge, their functional location, their experiences and skills, and most of all talent. Given that talent is the highest level in the classroom, and that the organization cares about talent, this means that it is concerned with strategy (Khalawey, 2008).

Another study indicated that there are many researchers in the field of chemistry who are familiar with chemical concepts due to the nature of their studies, but they lack a link with NT (Steven & Krajcik, 2007).

Another study indicated the necessity of drafting laws that transcend national borders in the field of NT, in addition to develop a series of strategic considerations that must be considered when designing these laws (Kenneth et al., 2006).

There is another study that dealt with the problems of designing and operating micro chemical plants used in production in terms of categorizing the design problems of microscopic plants into two problems, the first is related to the design of micro processing processes. The second is related to the design of microscopic plants as a whole. The features of the micro systems are explained for each sub-problem that must be solved by process system engineers, and then summarize the features of instrumentation problems and control of fine chemical plants (Hasebe, 2003).

Another study indicated that there is a problem in the process of NT evaluation in twenty Swiss organizations of different sizes from different industries, and most of these organizations are keen to provide NT in their products and processes (Bucher et al., 2003).

As for the SD, there is a study that focused on analyzing SD paths for resource-limited industries. In light of this, a number of important topics are discussed such as water, minerals, fuel, and environmental capabilities in both developed countries and insurance (Jia et al., 2016).

Another study is concerned with the role of green training in achieving SD. This is in addition to the importance of developing the green resource in achieving sustainable business, as the strategic choice of the organization on the basis of the green approach contributes significantly to achieving sustainable business (Alreshidi, 2016).

There is also another study concerned with the role of occupational safety and health in achieving SD, as innovation in the field of health and safety in the workplace plays an important role in achieving SD, in addition to influencing sustainable developments in the field of industry in general, and manufacturing industries in particular (Jilcha & Kitaw, 2016).

There is a study concerned with analyzing human resources based on innovation in order to achieve SD. This is in addition to enhancing the quality of life for all members of society in light of social sustainability, economic sustainability, and environmental sustainability (Bircan & Genclerb, 2015).

There is another study that indicated the importance of SD in educational systems. This is in addition to the importance of SD in providing students with the practices, behaviors, skills and values of SD in the field of environment, society and economics in order to achieve a bright and more sustainable future for all the members in society (Breidlid, 2012).

There is also another study concerned with developing the beliefs of teachers in order to achieve SD, and teachers have been chosen due to the vital role they play in the field of educational reform, in the sense that education for achieving SD in the contemporary period (Yang et al., 2010).

There is also another study that focused on the importance of revitalizing the process of education and training and strengthening the human being in order to achieve SD. This is in addition to the necessity of providing the basic needs for education in rural areas, on the grounds that improving the levels of the learner and acquiring skills and capabilities leads to achieving sustainable environmental, economic and social development (Ian, 2009).

There is another study concerned with teaching in order to achieve SD, in addition to that the slogan of learning for SD has been raised, and it has been pointed out the need to focus in the curricula on sustainable environmental development, and focus on the role of the teacher in a manner that increases his ability to communicate information to students on environmental issues in a way that ultimately leads to SD (Jasper, 2008).

Another study suggested a new trend in the field of education for achieving SD, and this could be done through developing educational curricula in general and secondary education curricula in particular, in terms of curricula related to education for achieving SD. This is in addition to the need to point out the importance of linking education and sustainable education policies, so changing policies and curricula leads to achieving sustainable development (Winter, 2007).

As a result of the discussions given above, the research questions of this study are as follows:

Q1: What is the relationship between NT (NT culture) and SD at industrial companies in Egypt?

Q2: What is the nature of the relationship between NT (strategic plan) and SD at industrial companies in Egypt?

Q3: What is the extent of the relationship between NT (technology selection and evaluation) and SD at industrial companies in Egypt?

Q4: What is the nature and extent of the relationship between NT (the nature of raw materials ) and SD at industrial companies in Egypt?

Q5: What is the extent of the relationship between NT (the nature of machines and production processes) and SD at industrial companies in Egypt?

Q6: What is the relationship between NT (the quality of the products) and SD at industrial companies in Egypt?

Q7: What is the nature of the relationship between NT (talented management) and SD at industrial companies in Egypt?

## 5. Research Hypotheses

In the light of a review of previous studies towards NT, literature studies has shown that NT has been applied in the field of dentistry and biomedicine. Studies have shown that nano materials can be used to renew bone, skin, and tissues in teeth. There are also many advantages to using natural or artificial organic nanostructures for dental implants and tissue regeneration (Maria et al., 2016).

Another study indicated the importance of applying NT in the field of agriculture, as it plays an important role in detecting diseases on the one hand, and the massive development of safe pesticides on the other hand. It was also pointed out that there are some concerns about the safety of applying NT to humans, as there are some potential points of exposure of the human element to nano materials present in agricultural food chains, which raises its problem in health and the environment, so an effective strategy in managing risks from technological developments (Tejpal, 2015).

Another study was concerned with the application of NT at the secondary and intermediate levels for the purpose of introducing students and teachers to the nature of NT. This is important for knowledge of developments in the field of technology, as it is important for teachers so that they can benefit from this field in order to perform their work efficiently and effectively. The results reached the importance of applying NT at the secondary and intermediate levels, in addition to the primary stage and the necessity of adding compulsory subjects such as engineering and technology in the various educational stages (Ban & Kocijanic, 2011).

Another study is related to different approaches to group all investors with the aim of working together in a new government system to meet the challenges of NT and the risk and lack of scientific certainty of the results of its application (Gregory, 2008).

Another study indicated that it is necessary to suggest a method for sharing and cooperating in how to manage risk in NT, given that traditional risk management methods will not be valid, and therefore there must be a method suitable for managing technology in the future. In this regard, we can use some similar cases that have proven successful in the field of technology (Marchant et al., 2008).

There is also another study that indicated the determination of the demand for highly trained workers in the field of NT. The study concluded that the demand for this type of employment is still small. So, universities must play their role in the field of training and qualification of workers in the field of NT (Stephan et al., 2008).

There is another study concerned with the talent component in management to achieve the success of the organization, and successful management depends on the culture that is placed in the organization, ease of application, integration among its members, sharing data, ease of use of available capabilities and resources, and ease of using information, which ultimately leads to achieve the organization objectives

efficiently and effectively (Khalaweg, 2008).

Another study indicated that NT became fast and related to consumer products, which led to the emergence of trademarks and patents, or what is known as NANO, and that relates to the aspects surrounding NT, and registration of the trademark, which made fraudsters in the field of NANO on the shelf (Jason, 2008).

Another study is concerned with how to manage technology in multiple fields in order to benefit from it in achieving the strategic goals of the organization. The dimensions of technology management are the existence of a strategic plan for the organization in the field of technology, finance, and the efficiency of its management, assessing its risks, and using auditors and accountants to assess the efficiency of technology management in the organization ( Khalaweg, 2008).

Another study indicated the need to provide a framework for NT and how to build it, with the need to focus on the importance of government funding for this type of technology in the presence of a legal framework governing this area (Khalaweg, 2008).

Another study concluded that the theoretical contribution should be transformed into commercial biological inventions that will be used in all fields, whether at the level of researchers, business managers, and specialists in technology transfer (Matthew, 2008).

Another study is interested in knowing the extent of students in the concepts and technology of nano science in the field of chemistry, and it became clear that students are more understanding of chemical concepts, they lack the link to nano science and NT techniques (Steven & Krajcik, 2007).

Another study indicated the need to take into account the dangers of NT, determine the extent of legal permissibility, and the need to emphasize the importance and flexibility of laws related to overcoming legal limits in the field of NT. This is in addition to the need to consider that NT is beneficial despite full knowledge of it, and for this it is necessary to study some legal models that have been designed in some technologically similar situations (Kenneth et al., 2006).

Another study referred to the report of the future of NT project implemented in 2004. The study and analysis addressed the methodological issues related to the classification of the scope and its impact on the results, and the use of data, getting to know the future and making some important recommendations (Andersen, 2005).

Another study indicated that a general framework for NT evaluation was reached through a scientific approach based on the use of artificial intelligence technology, decision-making technology, and technology building in industrial organizations (Bucher et al, 2003).

As for the SD, there is a study concerned with analyzing the relationship between SD and innovation-based human resources. The study concluded that there is a moral relationship between human resources and SD, based on the premise that human resource development contributes significantly to achieving SD (Bircan & Genclerb, 2015).

Another study is concerned with analyzing the relationship between product design and reducing consumption of available resources, the study indicated a significant relationship between designing products related to the environment and reducing consumption of available resources. In addition, there are multiple pathways to SD, whether linked to water resources, minerals or other available resources (Jia et al., 2016).

Another study confirmed the analysis of the relationship between green training and SD. The study concluded that developing the skills of workers contributes to achieving SD, that is, the green approach contributes to achieving sustainable business (Alreshidi, 2016).

Another study indicated the relationship between innovation in workplace safety and health and SD. The study concluded that safety in the workplace helps individuals to innovate, develop and modernize at work, which leads to lower costs, less accidents in the workplace, and thus achieving SD in general, and environmental sustainability in particular (Jilcha & Kitaw).

There is a study concerned with analyzing the relationship between education systems and SD, and it has found a moral relationship between educational systems and sustainable development in the sense that educational systems work to increase the skills, behaviors and practices that lead to achieving SD (Breidlid, 2012).

Another study is concerned with analyzing the relationship between the views of those responsible for education at the secondary level and SD. The study concluded that there is a fundamental relationship

between educational reform and SD. The study also indicated the importance of the role of teachers at this stage in achieving educational reform, which in turn leads to achieving SD (Yang et al., 2010).

Another study emphasized the relationship between the basic needs of education and SD. The study indicated that there is a direct relationship between the basic needs of the educational process and achieving SD, and that the educational needs contribute to developing the skills and behaviors of the learner, which in turn leads to achieving economic, environmental and social development, and thus achieving SD (Ian, 2009).

Another study indicated the relationship between educational curricula at different stages and SD. The study indicated that interest in educational curricula contributes to achieving SD for teaching personnel, which in turn reflects on students in terms of familiarity with various environmental issues and thus improving the process of SD (Jasper, 2008).

Another study is concerned with analyzing the relationship between curricula at the secondary level and SD. The study found that secondary education curricula at the present time do not achieve SD, and therefore educational curricula at the secondary stage must be changed and developed in a manner that leads to achieving SD, based on the premise that there is a fundamental relationship between educational programs and SD (Winter, 2007).

The following hypotheses were developed to decide if there is a significant correlation between NT and SD.

H1: There is no statistically significant relationship between NT (NT culture) and SD at industrial companies in Egypt.

H2: NT (strategic plan) has no significant effect on SD at the industrial companies in Egypt.

H3: There is no relationship between NT (technology selection and evaluation) and SD at industrial companies in Egypt.

H4: NT (the nature of raw materials) has no significant impact on SD at industrial companies in Egypt.

H5: There is no relationship between NT (the nature of machines and production processes) and SD at industrial companies in Egypt.

H6: There is no statistically significant relationship between NT (the quality of the products) and SD at industrial companies in Egypt.

H7: NT (talented management) has no significant effect on SD at industrial companies in Egypt.

## 6. Research Population and Sample

The total population of the industrial companies in Sadat city in Egypt is 11550 employees. The sample size was calculated using the formula (Daniel, 1999) as follows:

$$n = \frac{N \times (Z)^2 \times P(1-P)}{d^2 (N-1) + (Z)^2 \times P(1-P)}$$

The number of samples obtained by 377 employees at the industrial companies in Sadat city in Egypt is presented in Table (1).

**Table (1) Distribution of the Sample Size**

| Industrial Companies | Employees | Percentage | Sample Size |
|---|---|---|---|
| 1. Iron and Steel Sector | 8100 | 40% | 377X 40% = 150 |
| 2. Construction Sector | 5926 | 29% | 377X 29% = 110 |
| 3. Food Industries Sector | 2087 | 10% | 377X 10% = 38 |
| 4. Textile Sector | 2520 | 13% | 377X 13% = 49 |
| 5. Chemical Industries Sector | 1567 | 8% | 377X 8% = 30 |
| **Total** | **20200** | **100%** | **377X 100% = 377** |

***Source: Personnel Department at Industrial Companies, Sadat City, Egypt, 2020***

**Table (2) Characteristics of the Sample**

| Demographic Variables | | Frequency | Percentage |
|---|---|---|---|
| 1. Gender | Male | 230 | 77% |
| | Female | 70 | 23% |
| | **Total** | **300** | **100%** |
| 2. Marital Status | Single | 90 | 30% |
| | Married | 210 | 70% |
| | **Total** | **300** | **100%** |
| 3. Age | From 30 to 45 | 180 | 60% |
| | Above 45 | 120 | 40% |
| | **Total** | **300** | **100%** |
| 4. Educational Level | University | 260 | 87% |
| | Post Graduate | 40 | 13% |
| | **Total** | **300** | **100%** |
| 5. Period of Experience | From 5 to 10 | 220 | 73% |
| | More than 10 | 80 | 27% |
| | **Total** | **300** | **100%** |

## 7. Procedure

The objective of this study was to identify the role of NT in affecting SD. A survey research method was used to collect data. The questionnaire included three questions, relating to NT, SD, and biographical information of employees at industrial companies in Egypt. About 377 survey questionnaires were distributed. Multiple follow-ups yielded 300 statistically usable questionnaires. Survey responses were 79%.

## 8. Research Variables and Methods of Measuring

The 28-item scale NT section is based on Stobie, 2003; Kahlawy, 2008. There were four items measuring NT culture, four items measuring strategic plan, four items measuring technology selection and evaluation, four items measuring the nature of raw materials, four items measuring the nature of machines and production processes, four items measuring the product quality, and four items measuring talented management

The 15-item scale SD section is based on Nguyen et al., 2018; Tooranloo, et al., 2017; Adeoye, 2017; Kucukoglu & Pinar, 2016; Rensburg, 2015; Fulekar et al., 2014; Spangenberg, 2013; Eltayeb, 2011; Romiguer, 2011; Rasmussen, 2011; Potts et al., 2010; Bounhiss, 2010; Pavlova, 2009; Winkler, 2006; Harris, 2000. There were five items measuring environmental sustainability, five items measuring social sustainability and five items measuring economic sustainability.

Responses to all items scales were anchored on a five (5) point Likert scale for each statement which ranges from (5) “full agreement,” to (1) “full disagreement”.

## 9. Data Analysis and Hypotheses Testing

### 9.1. Coding of Variables

**Table (3) Description and Measuring of the Research Variables**

| Main Variables | | Sub-Variables | Number of Statement | Methods of Measuring Variables |
|---|---|---|---|---|
| Independent Variable | Nanotechnology | NT Culture | 4 | Stobie, 2003; Kahlawy, 2008 |
| | | Strategic Plan | 4 | |
| | | Technology selection and Evaluation | 4 | |
| | | Nature of Raw Materials | 4 | |
| | | Nature of Machines and Production | 4 | |
| | | The Quality of the Products | 4 | |
| | | Talented Management | 4 | |
| **Total OV** | | | **28** | |
| Dependent Variable | Sustainable Development | Environmental Sustainability | 5 | Nguyen et al., 2018; Tooranloo, et al., 2017; Adeoye, 2017; Rensburg, 2015; Spangenberg, 2013; Eltayeb, 2011; Romiguer, 2011 |
| | | Social Sustainability | 5 | |
| | | Economic Sustainability | 5 | |
| **Total SD** | | | **28** | |

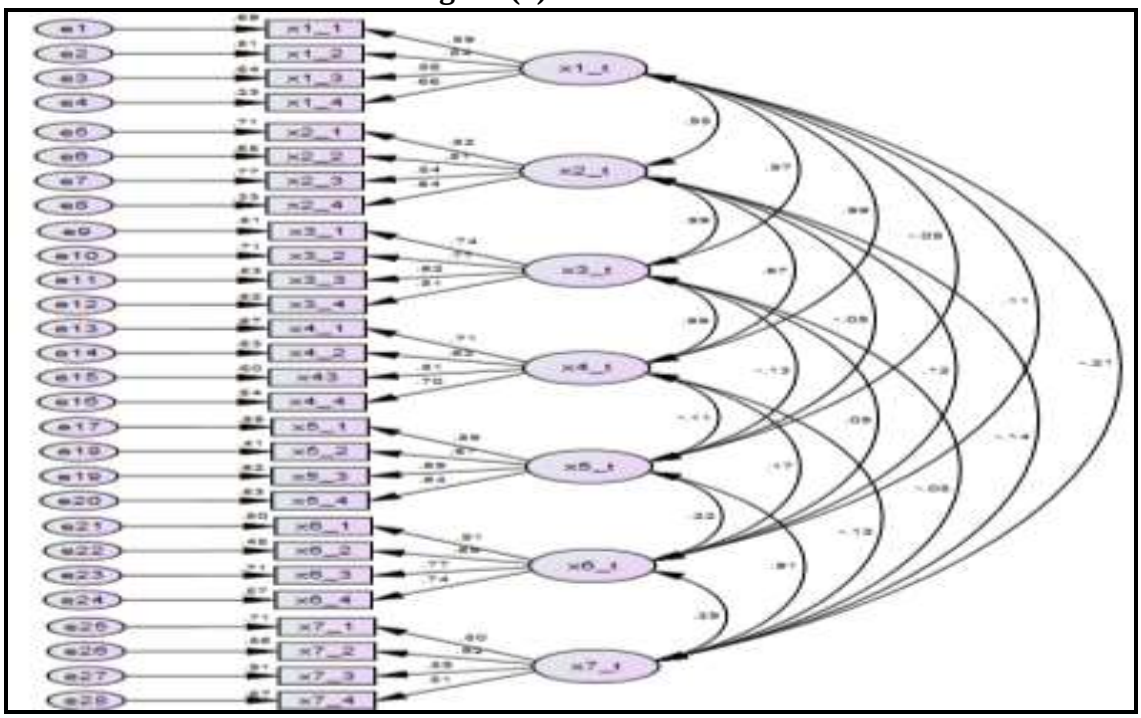
According to Table (3) the research consists of two main variables. The first is NT (independent variable). The second is SD (dependent variable). Each variable consists of sub-variables.

### 9.2. Construct Validity

#### 9.2.1. Nanotechnology

The researcher used Confirmatory Factor Analysis (CFA) for NT. This variable consists of seven dimensions. They are NT culture, strategic plan, technology selection and evaluation, the nature of raw materials, the nature of machines and production processes, the quality of the products, and talented management. The total number of NT is 28 statement. This can be illustrated by the following figure:

**Figure (2) CFA For NT**



**Source: AMOS, V.23**

From the previous figure, it is clear that all the statement of NT are greater than 0.50, which corresponds to GFI. This is a good indicator of all other statistical analysis. The quality indicators for NT can be illustrated in the following table:

**Table (4) Quality Indicators for NT Using AMOS Analysis**

| Test the Quality of the Model<br>Acceptance Condition (Daire et al., 2008) | Test Value |
|---|---|
| $X^2$ / Degree of freedom >5 | 624.328 |
| P. value > 0.5 | 0.000 |
| Goodness of fit Index (GFI) > 0.90 | 0.839 |
| Tuker-Lewis Index (TLI) > 0.95 | 0.917 |
| Comparative Fit Index (CFI) > 0.90 | 0.928 |
| Normed Fit Index (NFI) > 0.90 | 0.881 |
| Incremental Fit Index (IFI) > 0.95 | 0.928 |
| Relative Fit Index (RFI) > 0.90 | 0.862 |
| Root Mean Square Residual (RMR) < 0.5 | 0.399 |
| Root Mean Square Error of Approximation (RMSEA) < 0.5 | 0.071 |

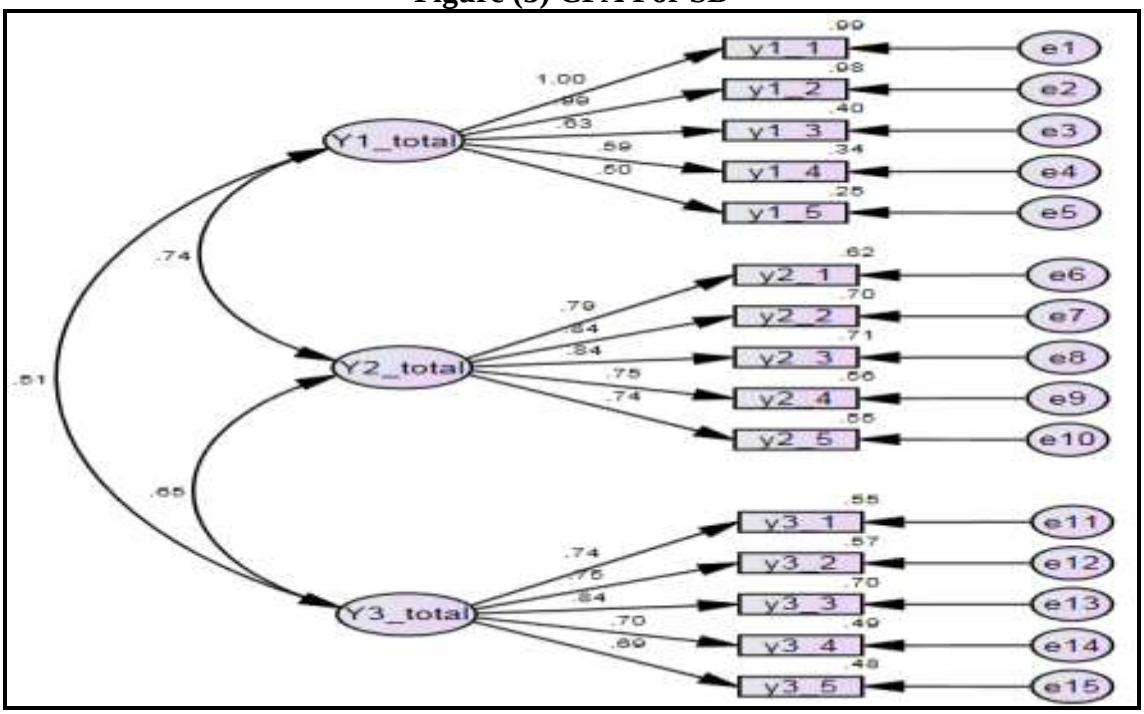
**Source: AMOS, V.23, 2015**

In light of the above-mentioned indicators, it is clear that the previous indicators are good for making all other statistical analysis.

#### 9.2.2. Sustainable Development

The researcher used CFA for SD which consists of three dimensions. They are environmental sustainability, social sustainability, and economic sustainability. The total number of SD is 15 statement. This can be illustrated in Figure (2).

**Figure (3) CFA For SD**




**Source: AMOS, V.23, 2015**

According to Figure (2), it is clear that all the statement of SD are greater than 0.50. This is a good indicator of all other statistical analysis. The quality indicators for SD can be illustrated in the following table:

**Table (5) Quality Indicators for SD Using AMOS Analysis**

| Test the Quality of the Model Acceptance Condition (Daire et al., 2008) | Test Value |
|---|---|
| $X^2$ / Degree of freedom < 5 | 457.386 |
| P. value > 0.5 | 0.000 |
| Goodness of fit Index (GFI) > 0.90 | 0.821 |
| Tuker-Lewis Index (TLI) > 0.95 | 0.876 |
| Comparative Fit Index (CFI) > 0.95 | 0.897 |
| Normed Fit Index (NFI) > 0.90 | 0.877 |
| Incremental Fit Index (IFI) > 0.95 | 0.898 |
| Relative Fit Index (RFI) > 0.90 | 0.852 |
| Root Mean Square Residual (RMR) < 0.5 | 0.095 |
| Root Mean Square Error of Approximation (RMSEA) < 0.5 | 0.119 |

**Source: AMOS, V.23, 2015**

In light of the above-mentioned indicators, it is clear that the previous indicators are good for making all other statistical analysis.

### 9.3. Descriptive Analysis

**Table (6) shows the mean and standard deviations of NT and SD**

| Variables | The Dimension | Mean | Standard Deviation |
|---|---|---|---|
| Nanotechnology | NT Culture | 2.95 | 0.773 |
| | Strategic Plan | 2.98 | 0.685 |
| | Technology selection | 3.08 | 0.652 |
| | Nature of Raw Materials | 3.44 | 0.615 |
| | Nature of Machines | 3.18 | 0.626 |

| | | | |
|---|---|---|---|
| | The Quality of the Products | 2.82 | 0.736 |
| | Talented Management | 3.06 | 0.665 |
| | **Total Measurement** | **2.64** | **0.468** |
| Sustainable Development | Environmental Sustainability | 2.69 | 0.820 |
| | Social Sustainability | 2.53 | 0.877 |
| | Economic Sustainability | 2.81 | 0.869 |
| | **Total Measurement** | **2.68** | 0.738 |

According to Table (6), most of the respondents identified the NT culture (M=2.95, SD=0.773), strategic plan (M=2.98, SD=0.685), technology selection and evaluation (M=3.08, SD=0.652), the nature of raw materials (M=3.44, SD=0.615), the nature of machines and production processes (M=3.18, SD=0.626), the quality of the products (M=2.82, SD=0.736), talented management (M=3.06, SD=0.665), and total NT (M=2.64, SD=0.468).

Regarding to SD, most of the respondents identified the environmental sustainability (M=2.69, SD=0.820), social sustainability (M=2.53, SD=0.877), economic sustainability (M=2.81, SD=0.869), and total SD (M=2.68, SD=0.738).

### 9.4. Evaluating Reliability

**Table (7) Reliability of NT and SD**

| Variables | | Number of Statement | ACC |
|---|---|---|---|
| Independent Variable | Nanotechnology | 28 | 0.870 |
| Dependent Variable | Sustainable Development | 15 | 0.929 |

**Source: The researcher based on the outputs of SPSS, V.23, 2015**

Table (7) presents the reliability of NT. The 28 items of NT are reliable because the ACC is 0.870. Thus, the internal consistency of NT can be acceptable.

The 15 items of SD are reliable because the ACC is 0.929. Thus, the internal consistency of SD can be acceptable.

### 9.5. The Means, St. Deviations and Correlation among Variables

**Table (8) Means, Standard Deviations and Intercorrelations among Variables**

| Variables | Mean | Std. Deviation | NT | SD |
|---|---|---|---|---|
| Nanotechnology | 2.64 | 0.468 | 1 | |
| Sustainable Development | 2.68 | 0.738 | 0.557** | 1 |

**Source: The researcher based on the outputs of SPSS, V.23, 2015**

Table (8) shows correlation coefficients between NT and SD. NT is (Mean=2.64; SD=0.468), while BD is (Mean=2.68; SD= 0.738). Also, the correlation between NT and SD is (R=0.557; P <0.01).

### 9.6. The Correlation between NT and SD

**Table (9) Correlation Matrix between NT and SD**

| Research Variables | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| NT Culture | 1 | | | | | | | |
| Strategic Plan | 0.770** | 1 | | | | | | |
| Technology selection | 0.362** | 0.333** | 1 | | | | | |
| Raw Materials | 0.557** | 0.471** | 0.549** | 1 | | | | |
| Nature of Machines | 0.749** | 0.687** | 0.285** | 0.470** | 1 | | | |
| Product Quality | 0.845** | 0.719** | 0.392** | 0.596** | 0.655** | 1 | | |
| Talented Management | 0.544** | 0.548** | 0.432** | 0.480** | 0.462** | 0.554** | 1 | |
| Sustainable Development | 0.460** | 0.413** | 0.530** | 0.528** | 0.255** | 0.489** | 0.474** | 1 |

**Note:** ** Correlation is significant at 0.01 level.

Based on Table (9), correlation between NT (NT Culture) and SD is 0.460 whereas NT (strategic plan) and SD shows correlation value of 0.413. Also, NT (technology selection) and SD is 0.530 whereas NT (raw materials) and SD shows correlation value of 0.528. The correlation between NT (nature of machine) and SD is 0.255 whereas NT (product quality) and SD shows correlation value of 0.489. Also, NT (talented management) and SD is 0.474.

### 9.6.1. Nanotechnology (NT Culture) and SD

**Table (10) MRA Results for NT (NT Culture) and SD**

| Nanotechnology (NT Culture) | Beta | R | $R^2$ |
|---|---|---|---|
| 1. The company is keen to follow scientific articles on nanotechnology. | 0.438** | 0.673 | 0.452 |
| 2. The company is keen to attend the conferences related to nanotechnology. | 0.320** | 0.641 | 0.410 |
| 3. The company holds seminars and workshops on nanotechnology. | 0.022 | 0.058 | 0.003 |
| 4. The company is keen to spread nanotechnology culture. | 0.035 | 0.047 | 0.002 |
| ▪ MCC<br>▪ DC<br>▪ Calculated F<br>▪ Degree of Freedom<br>▪ Indexed F<br>▪ Level of Significance | 0.707<br>0.500<br>73.767<br>4, 295<br>3.31<br>0.000 | | |
| ** P < .01 | | | |

As Table (10) proves, the MRA resulted in the R of 0.707 demonstrating that the 4 independent variables of NT (NT Culture) construe SD significantly. Furthermore, the value of $R^2$, 4 independent variables of NT (NT Culture) can explain 0.50% of the total factors in SD level. Hence, 50% are explained by the other factors. Therefore, there is enough empirical evidence to reject the null hypothesis that it said there is no relationship between NT (NT Culture) and SD.

### 9.6.2. Nanotechnology (Strategic Plan) and SD

**Table (11) MRA Results for NT (Strategic Plan) and SD**

| Nanotechnology (Strategic Plan) | Beta | R | $R^2$ |
|---|---|---|---|
| 1. There is a strategic plan for the company on nanotechnology. | 0.306** | 0.527 | 0.277 |
| 2. There is integration between the various departments that work in the field of NT. | 0.527** | 0.659 | 0.434 |
| 3. There are sufficient financial resources to cover the strategic plan in the field of nanotechnology. | 0.028 | 0.095 | 0.009 |
| 4. The goals of each company's management are in line with the strategic goals of nanotechnology. | 0.067 | 0.100 | 0.010 |
| ▪ MCC<br>▪ DC<br>▪ Calculated F<br>▪ Degree of Freedom<br>▪ Indexed F<br>▪ Level of Significance | 0.716<br>0.512<br>77.521<br>4, 295<br>3.31<br>0.000 | | |
| ** P < .01 | | | |

**Source: The researcher based on the outputs of SPSS, V.23, 2015**

As Table (11) proves, the MRA resulted in the R of 0. 0.716. This means that SD has been significantly explained by 4 variables of NT (Strategic Plan). As a result of the value of $R^2$, the four independent variables of NT (Strategic Plan) justified 51% of the total factors in SD. Hence, there is enough empirical evidence to reject the null hypothesis that it said there is no relationship between NT (Strategic Plan) and SD.

### 9.6.3. Nanotechnology (Technology Selection) and SD

**Table (12) MRA Results for NT (Technology Selection) and SD**

| Nanotechnology (Technology Selection) | Beta | R | $R^2$ |
|---|---|---|---|
| 1. There are specific criteria in the company on which to choose the new technology. | 0.310** | 0.511 | 0.261 |
| 2. The company uses reviewers to assess how technology is managed, especially NT. | 0.437** | 0.579 | 0.335 |
| 3. The company assesses the risks of modern technology, including nanotechnology. | 0.031 | 0.001 | 0.001 |
| 4. The company is keen to follow the latest developments in nanotechnology. | 0.138 | 0.163 | 0.026 |

| | |
|---|---|
| ▪ MCC | 0.658 |
| ▪ DC | 0.434 |
| ▪ Calculated F | 56.458 |
| ▪ Degree of Freedom | 4, 295 |
| ▪ Indexed F | 3.31 |
| ▪ Level of Significance | 0.000 |
| ** P < .01 | |

As Table (12) proves, the MRA resulted in the R of 0.658 demonstrating that the 4 independent variables of NT (Technology Selection) construe SD significantly. Furthermore, the value of $R^2$, 4 independent variables of NT (Technology Selection) can explain 43% of the total factors in SD. Hence, 57% are explained by the other factors. So, there is enough empirical evidence to reject the null hypothesis that it said there is no relationship between NT (Technology Selection) and SD.

### 9.6.4. Nanotechnology (Raw Material) and SD

**Table (13) MRA Results for NT (Raw Material) and SD**

| Nanotechnology (Raw Material) | Beta | R | $R^2$ |
|---|---|---|---|
| 1. The company has logistical management systems for various materials in the field of NT. | 0.355** | 0.606 | 0.367 |
| 2. The company has patents in the field of raw materials, especially nanotechnology. | 0.410** | 0.627 | 0.393 |
| 3. The company is following up on the international experiences of raw materials in the field of NT. | 0.013 | 0.005 | 0.002 |
| 4. The company is keen to recycle the waste products of its products in the field of nanotechnology. | 0.034 | 0.081 | 0.006 |
| ▪ MCC | 0.689 | | |
| ▪ DC | 0.474 | | |
| ▪ Calculated F | 66.555 | | |
| ▪ Degree of Freedom | 4, 295 | | |
| ▪ Indexed F | 3.31 | | |
| ▪ Level of Significance | 0.000 | | |
| ** P < .01 | | | |

As Table (13) proves, the MRA resulted in the R of 0. 0.689. This means that SD has been explained by the 4 independent variables of NT (Raw Material). As a result of the value of $R^2$, the four independent variables of NT (Raw Material) justified only 47% of the total factors in SD. So, there is enough empirical evidence to reject the null hypothesis that it said there is no relationship between NT (Raw Material) and SD.

### 9.6.5. Nanotechnology (Natural of Machine) and SD

**Table (14) MRA Results for NT (Natural of Machine) and SD**

| Nanotechnology (Natural of Machine) | Beta | R | $R^2$ |
|---|---|---|---|
| 1. The company's production processes are easy to adapt to suit any changes in raw materials. | 0.612* | 0.614 | 0.376 |
| 2. The available machines in the company are flexible to accommodate changes in raw materials. | 0.061 | 0.047 | 0.002 |
| 3. Flexibility of different tools in the company to suit changes in raw materials. | 0.045 | 0.013 | 0.001 |
| 4. There is flexibility in machinery, tools and production processes in the field of NT. | 0.032 | 0.067 | 0.004 |
| ▪ MCC | 0.616 | | |
| ▪ DC | 0.380 | | |
| ▪ Calculated F | 45.180 | | |
| ▪ Degree of Freedom | 4, 295 | | |
| ▪ Indexed F | 3.31 | | |
| ▪ Level of Significance | 0.000 | | |
| ** P < .01 | | | |

As Table (14) proves, the MRA resulted in the R of 0.616 demonstrating that the 4 independent variables of NT (Natural of Machine) construe SD significantly. As a result of $R^2$, the 4 variables of NT (Natural of Machine) explain 0.38% of the total factors in SD. Hence, 62% are explained by the other factors. Therefore, there is enough empirical evidence to reject the null hypothesis that it said there is no relationship between NT (Natural of Machine) and SD.

### 9.6.6. Nanotechnology (Quality of Product) and SD

**Table (15) MRA Results for NT (Quality of Product) and SD**

| Nanotechnology (Quality of Product) | Beta | R | $R^2$ |
|---|---|---|---|
| 1. The company's products are leading in the local and international market. | 0.437** | 0.673 | 0.452 |
| 2. The company's products are trusted by the end consumer. | 0.324** | 0.641 | 0.410 |
| 3. The company takes into account in its products not to harm the environment and public health. | 0.035 | 0.049 | 0.002 |
| 4. The company's products are reviewed to know their effects on the environment and public health. | 0.012 | 0.049 | 0.002 |
| ▪ MCC<br>▪ DC<br>▪ Calculated F<br>▪ Degree of Freedom<br>▪ Indexed F<br>▪ Level of Significance | 0.707<br>0.500<br>73.844<br>4, 295<br>3.31<br>0.000 | | |
| ** P < .01 | | | |

As Table (15) proves, the MRA resulted in the R of 0.707 demonstrating that the 4 independent variables of NT (Quality of Product) construe SD significantly. Furthermore, the value of $R^2$, 4 independent variables of NT (Quality of Product) can explain 0.50% of the total factors in SD. Hence, 50% are explained by the other factors. Therefore, there is enough empirical evidence to reject the null hypothesis that it said there is no relationship between NT (Quality of Product) and SD.

### 9.6.7. Nanotechnology (Talented Management) and SD

**Table (16) MRA Results for NT (Talented Management) and SD**

| Nanotechnology (Talented Management) | Beta | R | $R^2$ |
|---|---|---|---|
| 1. The company has a clear strategy for recruiting talented individuals in management. | 0.062 | 0.058 | 0.003 |
| 2. The people working in the company are flexible in dealing with the changes in the raw materials. | 0.013 | 0.056 | 0.003 |
| 3. Workers' adventure is available to learn about the new nanotechnology. | 0.519** | 0.642 | 0.412 |
| 4. Training missions abroad on the latest industrial industry technology in the world. | 0.259** | 0.511 | 0.261 |
| ▪ MCC<br>▪ DC<br>▪ Calculated F<br>▪ Degree of Freedom<br>▪ Indexed F<br>▪ Level of Significance | 0.686<br>0.470<br>65.412<br>4, 295<br>3.31<br>0.000 | | |
| ** P < .01 | | | |

As Table (16) proves, the MRA resulted in the R of 0. 0.686. This means that SD has been significantly explained by the 4 independent variables of NT (Talented Management). As a result of the value of $R^2$, the four independent variables of NT (Talented Management) justified only 47% of the total factors in SD. Hence, there is enough empirical evidence to reject the null hypothesis that it said there is no relationship between NT (Talented Management) and SD.

## 10. Research Results

### 10.1. Research Results Related to NT

1. The fields of NT application are numerous and varied in the fields of medicine, agriculture, chemistry, pharmaceutical industries, disease detection, food production, and environmental protection.
2. There are many opportunities and challenges related to NT, and these opportunities and challenges are in the technological, economic and social aspects. Therefore, we must work to take advantage of opportunities and take advantage of them, and reduce the risks that result from the application of NT at Industrial companies in Egypt.
3. In light of (Stobie, 2003) model, a number of results related to technology management were achieved (Khalawey, 2008):

- Insufficient awareness of the importance and culture of NT and its various dimensions, although it is one of the vital elements in companies that work in the field of NT, including the Industrial companies in Egypt.
- The lack of a strategic plan for NT, in addition to the weak financial resources to put the strategic plan into practice for Industrial companies in Egypt.
- Poor standards upon which to choose, review and evaluate the new technology used, especially in the field of NT, in addition to not following the latest developments in NT, and assessing the opportunities and risks that result from its application in Industrial companies in Egypt.
- There is no effective system sufficiently for the logistics management of the raw materials that are used in the field of NT, in addition to insufficient attention to follow-up global experiences of raw materials related to the field of NT and their appropriate use which leads to maximizing the benefits from them, and reducing the risks that arise from their use in Industrial companies in Egypt.
- The nature of the production processes and the machines used are not commensurate with keeping pace with the changes related to the raw materials that are used in the field of NT, bearing in mind that the machines used are considered one of the most essential requirements for the success and effectiveness of the application of NT in the Industrial companies in Egypt.
- Some of the products provided by Egyptian industrial companies have an impact on the environment, which requires legislative rules regulating work in such products.
- The management and employment used in the field of NT are not sufficiently skilled to deal with the risks of NT and control it in Egyptian industrial companies. This requires missions to be trained abroad on the latest technology in the industrial companies in the world.

4. The most prominent Arab weakness in the technology field and its reflection on NT is the best way to prepare a scenario for reforming nano scale knowledge, and this can be done through (Mazeed & Abas, 2011):
   - The scientific progress is only the result of continuous research in the areas of scientific research that is based on drawing knowledge, developing institutions and developing products through spending on areas of scientific research.
   - Weak private financing of technology in general, and NT in particular, on the grounds that this is a long-term investment, in addition to the limited government allocations for spending on the scientific research and technology sector.
   - The lack of clarity of technological policies, or in other words, the absence of a strategic vision related to technology transfer and exploitation, in addition to the lack of coordination with other policies.
   - The increase in the sales and nano products, especially consumer products in the Arab markets, which leads to the depletion of Arab money and its waste on the consumer side, which results in the loss of the ability to establish legal capital and falling into the net of failure to keep pace with the NT.
   - The growing gap between the developed and Arab countries in the field of using technology in general, and in the field of NT in particular, despite the fact that technology is one of the main pillars in achieving economic development based on knowledge in general, and nano knowledge in particular.
5. One of the studies carried out in the Arab environment has reached a set of general conclusions that explain the Arab weakness in the technological field, the most important of which are the following (Mazeed & Abas, 2011):
   - The use of NT has brought about a new industrial revolution no less important than the first industrial wealth that occurred in the seventeenth century. The uses of NT in medicine, agriculture, libraries and other and varied.
   - The United States of America is the leading country in the field of NT due to several considerations, the most important of which is that it possesses the scientists who have the ability to deal with this science. In addition to that it is the largest country in terms of allocating financial resources for the development and use of NT in all areas in which it can be used.

- One of the most important challenges facing Arab countries is the volume of spending on NT research, as there is a large gap between the developed countries and the Arab countries in terms of the size of the agreed upon research on NT development.

### 10.2. Research Results Related to SD

1. SD is the choice of the people, and it is they that seek to tackle and confront challenges and problems facing the process of development and treatment, and to tackle poverty and environmental problems.
2. The essence of SD is centered around meeting the needs of current and future organizations with resources without harming the environment.
3. SD is the source, survival and continued growth of organizations in general, and in the competitive environment in particular.
4. SD plays an important role in preserving and protecting resources, given that most resources suffer from negligence and unlimited spending, which leads to their enforcement if the SD principle is not applied.

## 11. Recommendations

### 11.1. Recommendations Related to NT

1. The necessity of developing a work environment that is able to practice advanced technology and make it a philosophy of senior management in order for industrial companies to proceed in their right practices in a manner that accompanies the changes resulting from the technological revolution, on the basis of benefiting from modern technology. In addition to the ability of available human resources to realize the importance of modern technology in achieving SD.
2. The management of the industrial companies in Egypt must support and use advanced technology capable of keeping pace with changes in the global environment so that the skills and capabilities of workers to deal with technology in all its forms increase. This will lead to reducing the gap in the use of technology in terms of increasing productivity and reducing costs, on the other hand.
3. Inviting all specialists in universities and other ministries in order to present their expertise in the field of NT, and building an integrated model for industrial companies that takes into account the infrastructure, economy and social capital. This will lead to achieving SD.
4. Allocating a sufficient budget to support, develop and attract specialists from scientists and researchers in the field of NT for the purpose of working on localizing technology and developing it in industrial companies, in addition to the necessity of establishing a local scientific base that specifies the types of technology that can be transferred from developed countries to the industrial companies in Egypt.
5. Developing educational systems and working to achieve a qualitative transfer in the curricula and teaching methods in a manner that contributes to preparing new generations that can deal efficiently with developments in the field of technology in general, and in the field of NT in particular. This will lead to achieving economic sustainability, social sustainability, and sustainability environmental.
6. There are several requirements that must be considered when applying NT in the Industrial companies in Egypt (Khalawey, 2008):
   - The need to pay attention to the culture of NT by following scientific articles in the field of NT, and attending conferences and workshops related to NT in the Egyptian industrial companies.
   - Focusing on the importance of having a strategic plan in the Industrial companies in Egypt about NT, in addition to its importance to provide sufficient financial resources to cover the strategic plan.
   - The importance of good selection, review and evaluation of the new technology that is used in industrial companies in general, and in the field of NT in particular. This is in addition to the necessity of these companies being keen to follow the latest technology in the field of NT and trying to increase productivity and reduce costs in the industrial companies in Egypt.
   - Focusing on the existence of a logistic management system for various materials in the field of NT, and the need to follow up global experiences of raw materials in the field of NT. This is in addition to the need to recycle the waste products of Egyptian industrial companies.
   - The need to pay attention to providing machines and equipment with multiple characteristics that can deal with the changes that occur in the raw materials that are used in Egyptian industrial companies.
   - Focusing on the necessity of a unique quality of products to the local and global market, provided that these products can obtain the ultimate consumer confidence on the one hand, and not harm the environment and public health on the other hand. In addition, Egyptian industrial companies need to

review and evaluate their products on an ongoing basis to know their effects on human health and environmental health from time to time.

- Focusing on the importance of having a strategic plan related to the importance of having talented individuals in the field of management, in addition to the presence of skilled and distinguished labor in the field of NT to deal with the changes that occur in the raw materials that are used in the Egyptian industrial companies. This is in addition to the need to pay attention to sending workers to missions and attending conferences and workshops to train in the latest industrial companies technology in the world, which leads to achieving the goals of Egyptian industrial companies on the one hand, and increasing productivity and reducing costs in the field of medicines on the other hand.

7. The necessity of keeping pace with technological developments in general, and NT in particular, through academic decisions in the various educational stages, workshops, seminars, and conferences in a manner that leads to increasing awareness of the importance of nanotechnology in all areas of life.
8. The need to enrich scientific research in the field of NT and work to develop and spread the culture of NT by sending researchers and scholars to developed countries in the field of NT. This is in addition to the training courses that contribute to increasing familiarity with and knowledge of NT in terms of its importance, applications and risks, which ultimately leads to keeping pace with the developed countries in the field of NT.
9. The necessity for the Ministry of Higher Education, in cooperation with all universities, to reconsider the preparation of decisions and programs to enhance NT culture and to include them in curricula in order to keep pace with global developments in this field, as the application of NT includes many fields such as chemistry, biology, geology, and physics, which leads to make the current learning system in line with and compatible with developments in the field of NT.
10. Developing the laboratories of the faculties of science in the field of physics, chemistry, biology and geology, to keep the developments of courses in the field of NT, in addition to the advanced educational methods associated with this field. This requires a comprehensive strategy between the Ministry of Higher Education, international universities, and research centers in various developed countries that are interested in the field of NT to benefit from different experiences and experiences, and exchange ideas, experiences and programs in the field of NT.
11. Technology transfer and development are subject to ideological options that are far from the economic conditions for their implementation, and this requires: (Mazeed & Abas, 2011):
    - The necessity to compel the government to involve scientists in the field of technology in particular in decision-making in the national planning process. This is in addition to the periodic and systematic evaluation of the status of scientific systems and technology to advance the level of research structure in the scientific and technological fields.
    - Establishing world-class scientific and technological bodies and committees working to encourage scientific achievements on the one hand, and the introduction and application of technological policies on the other hand.
    - Encouraging technological interaction, spreading scientific awareness related to nanotechnology and simplifying it for members of society, and showing its role in achieving growth and progress for societies.
    - Benefiting from Arab experiences abroad by mobilizing the largest possible number of human scientific competencies in the field of technology in general, and NT in particular, and working to transfer technology in a manner that achieves benefit from the experiences of developed countries.
    - Using information technology in a way that helps decision-makers in setting the policy that achieves economic development based on technology in general, and nano knowledge in particular.
12. The necessity of accessing strategic industrial technology related to NT, the main axes of which are as follows (Mazeed & Abas, 2011):
    - Identifying successful experiences in the field of NT in the world to define the mechanisms through which the technological base in the Arab countries can be developed, with a view to reducing the size of the technology gap between the developed and Arab countries.
    - Establishing specialized centers in the field of technology in general, and NT in particular in the Arab countries, with a view to absorbing NT in the light of industrial development programs in the Arab countries.

- The necessity of the interests of the various sectors to extract part of the financial resources to finance and develop their research centers in the field of technology in general, and NT in particular, in order to reduce the gap between the developed countries and the Arab countries on the one hand, and keep pace with technological developments in the field of NT on the one hand other.

**11.2. Recommendations Related to SD**

1. The necessity of encouraging workers to reduce waste, pay attention to the environment and improve their behavior in a manner that leads to preserving the environment and creating a safe and healthy environment for all members of society.
2. The necessity of paying attention to achieving social sustainability through programs, courses and seminars that explain the importance of the social dimension in achieving SD, in addition to the need to encourage teamwork among workers in order to achieve cohesion and interdependence among them. Also, the necessity and importance of linking the performance of employees to the extent of taking into account environmental and social sustainability in the organization.
3. The necessity of enriching the curricula in the different educational stages with concepts and dimensions of SD, and its importance using a simple and interesting methodology in dealing with the various concepts of SD.
4. The necessity of holding educational sessions and seminars for students, teachers and parents in all educational stages to clarify SD and its role in the process of socialization, as it is one of the dimensions of SD, in addition to economic sustainability and environmental sustainability.
5. Preparing a level cultural program for all employees in companies on the concept and dimensions of SD, whether social, economic or environmental, provided that this program includes a set of lectures, seminars and workshops that focus on the importance of spreading cultural awareness related to SD in society.
6. Increasing the interest of corporate management in the environmental dimension of SD, by identifying the scale of the pollution process that companies cause as a result of exercising their activity, and working to provide means and tools through which to reduce environmental pollution operations, in the sense that environmental sustainability is one of the dimensions of SD in the society.
7. The interest of corporate management in the social dimension of SD, through holding educational seminars to explain the importance of socialization and its role in achieving SD, in the sense that social sustainability is one of the general dimensions of SD. This is in addition to the need to increase the awareness of managers of the importance of the social dimension in achieving SD.
8. Increasing the interest of corporate management in the economic dimension of SD, by working to use the resources available to them efficiently and effectively, and working to increase the number of products that are presented to the final consumer in a way that leads to the fulfillment of his desires and needs on the one hand, and to preserve human and environmental health from another side.
9. Spreading the culture of sustainability in the Egyptian environment in general, by adding it as one of the curricula in the early stages of the educational process, in addition to the university stage, in the sense that the university is the lighthouse of society and that radical development and change starts from the university.
10. Organizing seminars, courses and workshops for students in general, and at the university level in particular, with a view to activating the role of educational guidance towards preserving the current environmental resources and working on their sustainability in a manner that meets their desires and needs, and preserving them for future generations.
11. The interest of the state in general in drawing a road map to achieve SD, and monitoring adequate transformation in the state budget to achieve social, economic, and environmental sustainability in Egyptian society. This must be pointed out to the role of Egyptian universities in carrying out this role in a manner that leads to organizing the utilization of all available resources of all kinds efficiently and effectively.
12. The need for corporate management to pay attention to the process of SD by preserving the natural resources on the ground on the one hand, and taking into account other groups that benefit from these resources on the other hand.

13. The need to pay attention to adding the SD course to the educational curricula in the various educational stages in a manner that leads to the development of behaviors, skills and capabilities of members of society towards the dimensions of SD, whether environmental sustainability, social sustainability, and economic sustainability.
14. Increasing the interest of industrial companies management in the concept and dimensions of SD in a manner that leads to strengthening and improving the companies' ability to survive and grow under the changing environmental conditions. This can be done through seminars, lectures, workshops and discussion groups on what is SD, and how to achieve economic sustainability, social sustainability, and environmental sustainability.
15. Increasing the interest of the management of industrial companies in obtaining ISO certificates related to the environment in a manner that leads to the use of all appropriate means to preserve the environment and reduce pollution resulting from its products.
16. Increasing the interest of the management of industrial companies in achieving economic growth. This can be done through using the available resources efficiently and effectively in a manner that leads to an increase in the number and quantity of products that are produced in order to achieve the different needs and desires of customers without harming human and environmental health. This is in addition to the need to pay attention to waste disposal in a safe way that increases environmental preservation.

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