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Thesis Report

On

Adoption of Nanotechnology in case of Ethiopian Textile Industry

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DECLARATION

I hereby declare that the work which is being presented in this thesis entitle "Adoption of Nanotechnology in case of Ethiopian Textile Industry" is original work of my own, has not been presented for a degree of any other university and all the resources of materials used for the thesis have been properly acknowledged.

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This is to certify that the above declaration made by the candidate is correct to the best of my knowledge.

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Acronyms

- ✓ AHP Analytical Hierarchy Process
- ✓ BAT Best Available Techniques
- ✓ BETIN Bio and Emerging technology Institute
- ✓ CNT Carbon Nanotubes
- ✓ CR Consistency Ratio
- ✓ DURINT Defense University Research Initiative on Nanotechnology
- ✓ DOD Department of Defense
- ✓ DNA the design and manufacture of artificial nucleic acid structures for technological uses.
- ✓ EBTI Ethiopian Biotechnology Institute
- ✓ FDA Food and Drug Administration
- ✓ FDI Foreign direct investment
- ✓ GDP growth development program
- ✓ GPS Global Positioning System
- ✓ GTP Growth and Transformation Plan
- ✓ HCM home-country measures
- ✓ IPR pure' Intellectual Property Rights
- ✓ LDC least developing countries
- ✓ R&D research and development
- ✓ SIT Smart/interactive textiles
- ✓ MIT Massachusetts Institute of Technology
- ✓ MCDM multi-criteria decision making
- ✓ NASA The National Aeronautics and Space Administration
- ✓ NIH The National Institutes of Health
- ✓ NT Nano technology
- ✓ NNI National Nanotechnology Initiative
- ✓ NBIC Nano science, biology, information, and cognitive sciences
- ✓ TiO2 Titanium dioxide
- ✓ UV ultra-violate
- ✓ ZnO zinc oxide

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Abstract

Nanotechnology provides plenty of efficient tools and techniques to produce desirable fabric attributes, mainly by engineering modifications of the fabric surface. Due to the advancement of Nanotechnology in the manufacturing of fiber or yarns including the development of fabric finishes, the applications and scopes are widespread in the area of textiles for the last few decades. According to this research study the existence and the application of Nano technologies with in Ethiopian textile industries are very minimal or we can say it does not exist. So we listed enablers which will introduce Nanotechnology and used a multi criteria decision making method MCDM to rank which is more effective to implement Nanotechnology among the listed enablers and according to the research result the government is highly capable to introduce and implement Nanotechnology within the Ethiopian textile industries. Government can mobilize market, technical, financial institution and socio economic activities to introduce Nano technology within textile manufacturing industries. The introduction and implementation of Nano technology by the government with in textile manufacturing industries could be easier than the other alternatives. The implementation of Nano technology within textile manufacturing industries enhances the quality of the textile and the development of manufacturing industries.

Chapter 1

Introduction

1.1 Background

Ethiopia has emerged as one of the fastest-growing economies in Africa in the early twenty-first century. Despite this rapid growth, structural transformation of the economy remains the country's central challenge. The Ethiopian government has followed development and practiced an active industrial policy since the early 2000s. However, a review of industrial policies in various priority sectors shows that the outcome has been uneven across sectors, indicating the importance of the strong interaction between industrial structure, linkage dynamics, and politics/political economy for the evolution and effectiveness of industries. (Oqubay, 2018)

Ethiopia's manufacturing sector is among the key productive sectors of the economy identified under GTP (2010-2015) which can spur economic growth and development because of its immense potential for wealth creation, employment generation and poverty alleviation.

The manufacturing sector makes an important contribution to the Ethiopian economy and employs about 173 thousand people in 2012/2013. The sector comprises about 2,610 manufacturing establishments and divided into eight broad subsectors namely food and beverage products, textile and apparel products, leather and leather products, wood and pulp products, chemical and chemical products, rubber and plastic products, other non-metallic minerals products and metal and engineering products industries. The top two manufacturing subsector; food and beverage and metal and engineering industries account for 51% of the sector's GDP and the food and beverage sector alone holds 38% of the employment in the sector. The sector contribution to the GDP in 2012/2013 is 4.8%. The performance of the sector has been affected by low productivity of workers and use of outdated technologies which is attributed to the poor state of physical infrastructure, limited access to finance, limited research and development, poor institutional framework, and inadequate managerial technical skill (DRT), 2014)

Ethiopia's Growth and Transformation Plan (GTP) reports some of these challenges by attempting to improve employment opportunities for a growing population and varying its trade. This strategy has shifted the country's focus from agricultural sector growth to the manufacturing industry.

Although Ethiopia's garments industry has been identified as a key growth industry since 1995, its performance was uninspiring until the implementation of the GTP in 2015. Under the terms of this development policy, industrial zones have been constructed or are being constructed across areas surrounding the capital city of Addis Ababa and the government has significantly improved foreign investment incentives in the sector. Today, Ethiopia's garments and textile industry ranks amongst countries like China and Bangladesh in terms of industry output. (AmericanBarAssociation, 2017)

As the manufacturing industry is contributing to the development of the Ethiopian economy by establishing different industrial sectors it would help to introduce and implement new technologies to further strengthen the growth of the Ethiopian and also increase the competiveness, standard and quality of the Ethiopian Textile Industrial sectors. One of the ways to achieve is to implement new technologies like the Nanotechnology which is a new technology worldwide and has different application areas within the industrial sector. Mainly in agro-process, manufacturing, medicine, textile and leather.

1.2. Statement of the problem

Manufacturing in Ethiopia was, before 1957, dominated by cottage and handicraft industries which met most of the population's needs for manufactured goods such as clothes, ceramics, machine tools, and leather goods. Various factors – including the lack of basic infrastructure, the birth of private and public investment, and the lack of any steady public policy aimed at promoting industrial development. (K.Mekonen, 2013)

Although Ethiopia is a recommended market for investment in textiles, there are still a lot of challenges that the country and investors are facing. Even though the industries are using machines which are designed and installed to meet the current standards but still face problems in improving the performance of textile engineering. Some of the improvements Nanotechnology will be improving low tensile strength, low surface structure, water and soil absorbency, low durability, easy creasing, easy soiling and flammability.

Implementation of technologies which are not integrated with Nanotechnology, Lack of Academicals knowledge on the benefits of Nanotechnology regarding Textile Industrial development, Lack of strategy for expanding the application of Nanotechnology and most of all

the financial and infrastructural limitation are the major problems Ethiopian textile industry is facing.

This research paper will solve stated problems by assessing Ethiopia stands in the world of Nanotechnology and determine the importance of Nanotechnology for Ethiopian Textile industry development. Determine the current practice of Nanotechnology application in Ethiopian Textile Industry in order to know who are responsible for adopting nanotechnology by recognizing stakeholders and technology enablers and mainly develop a strategy for expanding the application of Nanotechnology to contribute towards accelerated development of Textile industries in Ethiopia.

1.3. Objectives

1.3.1 General objectives

The main objective of this research is to study the current practice of Nanotechnology application on Ethiopian Textile Industries and to device wide raged applicability of Nanotechnology to bring accelerated Textile Industries development in Ethiopia.

1.3.2 Specific objectives

The specific objectives are:-

1. Assess the current practice of nanotechnology in the Ethiopian textile Industries
2. Review competitive advantages of nanotechnology implementation in the textile industries
3. Device strategy to enhance the application of nanotechnology in to contribute towards accelerated development of the textile industries in Ethiopia

1.4.Research questions

At the end of this research the following questions are answered

1. What is the importance of Nanotechnology for Ethiopian textile industrial development?

2. What is the current practice in terms of Nanotechnology application in the Ethiopian textile industrial development?
3. What is the strategy in expanding the application of nanotechnology in contributing towards accelerated development of textile industries in Ethiopia?

1.5. Significance of the study

The main purposes of research are to inform action and gather evidence for nanotechnology to bring an enormously promising and bright future for the Ethiopian textile industries. The unique and new properties of Nanomaterial's have attracted not only scientists and researchers but also businesses, due to their huge economical potential. Although Nanotechnology is still in its infancy, it is already proving to be a useful tool in improving the performance of textiles and generating worldwide interest.

1.6. Scope of the Study

The scope of this research is to show the contribution of Nanotechnology for accelerated Textile Industrial development in Ethiopia.

The scope of the study specifically covers the following:

1. Reviewing existing literatures and secondary data on status of Ethiopian Textile industries.
2. Compiling the data collected from the selected manufacturing sectors and triangulates the findings with data from secondary sources and key informant interviews.
3. Analysis of Nano Technology utilization
4. Determine advantages of Nanotechnology implementation on Textile Industries
5. Develop possible strategy to implement application of Nanotechnology for Ethiopian Textile Industries.

1.7.Ethics

Respondents and participants of this research study have been involved with their full consent and readiness. Primarily they were told about the purpose and objectives of the study. With the intention of privacy and confidentiality of the respondents the study does not spell out the name and the actual position of the Respondents and participants

1.8. Organization of the study

The first chapter of the study consists of background of the study, the second chapter consists of Literature Review and policies, the third chapter consists Research Design and Methodology the forth chapter also consists of primary data presentation and analysis, the fifth chapter deals with result and discussion of the research study , whereas the sixth chapter consists conclusion and recommendation. Reference and Annexes are also available.

Chapter 2

Literature Review

2.1 What is Nano Technology?

The word "Nano" comes from the Greek for "dwarf". One Nanometer is about 60,000 times smaller than a human hair in diameter or the size of a virus, a usual sheet of paper is about 100,000 nm thick, a red blood cell is about 2,000 to 5,000 nm in size, and the diameter of DNA is in the range of 2.5 nm. Therefore, Nanotechnology deals with matter that ranges from one-half the diameter of DNA up to 1/20 the size of a red blood cell. (Sekhn, 2010)

While many definitions for Nanotechnology exist, the National Nanotechnology Initiative calls it "Nanotechnology" only, if it involves all of the following:

1. Research and technology development at the atomic, molecular or macromolecular levels, in the length scale of nearly 1-100 Nanometer range
2. Creating and using structures, devices and systems that have novel properties and functions because of their small and/or intermediate size
3. Ability to control or manipulate on the atomic scale. (Lech Ozimek1, 2010)

2.2. Nanotechnology Applications

Nanotechnology is helping to extensively improve, even revolutionize, many technology and industry sectors: information technology, homeland security, medicine, Textile Industries transportation, energy, food safety, and environmental science, among many others. (National nanotechnologyinitative)

Agro-Processing Industries

Accordingly, recent studies are looking for naturally occurring food preservatives to lengthen the shelf life of food products without any complications, establishing important field of study for researchers and producers Edible coatings and films have attracted further attention because of their ability to carry food additives, including antimicrobials, antioxidants, colors, and flavors, as well as to keep high doses of such agents on the food surface. (Asghar Azizian1, 2019)

Textile and garment

Nanotechnology brings an enormously promising and bright future for textile industries. The unique and new properties of Nanomaterial's have attracted not only scientists and researchers but also businesses, due to their vast economical potential. Although Nanotechnology is still in its beginning, it is already proving to be a useful tool in improving the performance of textiles and generating worldwide interest. These multi-use benefits may include one or more of the following: tissue engineering scaffolds, improved surface cleaning, Wet ability, strike-through, comfort, stain resistance, soil removal, mal odor control, modification of surface friction, reduced damage to abrasion, and color enhancement properties relative to surfaces unmodified with such Nanoparticle systems. (Rezwan Mahmud, 2017)

Leather and leather products industries

Ecologic and health effects of applying materials with advanced functions for leather surface finishing are priorities for the European leather industry and donate to the increase of added value and durability of leather and fur articles. The innovative properties of silver-titanium dioxide Nanomaterials on leather surface are due to their antimicrobial, self-cleaning and flame retardant characteristics. Furthermore, it leads to a reduction of chemicals with high pollutant potential. (Gaidau, 2017)

Pharmaceutical Industries

Pharmaceutical Nanotechnology applies the methods and principles of Nano science and Nano medicine to pharmacy to develop new drug delivery systems which can improve the drawbacks of conventional drug delivery systems. (Muntha, 2016)

Metal Engineering industries

Nanotechnology is expected to be a main driver of technology and business in this century and holds numerous potential applications in steel industry as well. The use of Nanotechnology in steel leads to improvement in the properties of steels such improvements include fatigue strength due to cyclic loading. Use of nanoparticles improves the delayed fracture, increase in weld toughness, improvement of corrosion resistant and conventional stainless-steel at a lower cost, reduces surface roughness, improvement of strength but also the plasticity and cold strength of the steel

may be increased on the basis of local synergetic transitions and thermo mechanical treatment. (Harish Singh, 2015)

2.3 Nanotechnology Initiatives and strategies in the Developing World

Nanotechnology and the Developing World

Applications of Nanotechnology in developing countries are Energy storage, production, and conversion Agricultural productivity enhancement, Water treatment and remediation, Disease diagnosis and screening, Drug delivery Systems, Food processing and Storage, Air pollution and remediation, Construction, Health monitoring Vector and pest detection and control. (PETER A. SINGER, 2019)

Initiatives and strategies for development of Nanotechnology in nations

A lesson for Africa and other least developed countries. The evolution of Nanotechnology is at its early stage globally. It is a chance for developing countries to become part of the industrial shaping and through such participation strengthen their technological capability, capabilities, and sustainability. Some developing countries which have the knowledge and which are investing heavily in it are India, Brazil, China, Thailand and South and South Africa are among others. Some of the challenges of Nanotechnology development in third world nations as reported by Babajide are (Ikechukwu C Ezema, 2014)

- Lack of proper legislation/regulatory framework and the relevant political drive
- Lower government spending on research and development (R&D)
- Lack of infrastructure and human capacity
- Lack of proper education relating to curriculum development matters
- Lack of private enterprise participation in research and development
- Lack of proper collaboration and network programs among agencies
- Research institutes and industries that will translate basic research into applied research and end products
- Poor industrialization status of the third world countries
- Inadequate foreign linkage particularly with donor agencies in Nanotechnology
- Fear of health, environmental, and safety risks associated with Nanotechnology

2.4 Investment on Nanotechnology

Nano scale development and its application in multidisciplinary area: An African perspective:

South Africa	Is one of the first African countries that have introduced Nanotechnology well. The government entirely funded most of the stakeholders, research institutions and academic institutions for more research for its benefits and risk associated with the usage; furthermore, Department of Science and Technology (DST) had placed a 10 year plan for Nanotechnology that had given birth to other bodies. South African approach to Nanotechnology shows how the country‘s policy is influenced, by national interests (for example risk assessment, occupational health and strategic social focus) (Musse et al., 2013).
Nigeria	Poverty is a major problem in many developing countries in the world, including Nigeria with reportedly over 70% of the population deriving their livelihood from agriculture. Hunger and malnutrition are aggravated by rapid population growth, influences the food insecurity- adequate quantity and quality of food (Fasoyiro and taiwo, 2012). Despite socio- economic challenges Nigeria has implemented a project on environmental remediation carried out as a joint collaboration of the African University of Science and Technology and the Sheda Science and Technology Complex since 2006 (Masoka et al., 2012; Musse et al., 2013
Egypt	Nanotechnology Research Centre was funded by the Information Technology Industry Development Agency and the Science and Technological Development Fund in partnership with IBM, and was launched in 2009. This project is probing the possibility of developing devices for enhancing health provision, and water purification, mostly targeting the rural areas. While the UN Department of Economic and Social Affairs (DESA), for example, is engaged in providing support to the construction of high tech R&D and industrial parks in Ghana and Senegal, while Egypt and Kenya already have techno parks and Ethiopia is currently developing a similar project (Masoka et al., 2012; Musee et al., 2012).
Morocco	Projects on the implementation of an international laboratory for molecular chemistry, creation of a Euro-Mediterranean competence pool in micro technology and Nanotechnology, purification and preservation of Moroccan water

	resources, and urban waste treatment have already been started (Khachani, 2005; Bouoiyour, 2006). In the year 2006, National Initiative for Nan sciences and Nanotechnologies was launched; an industrial high tech park was built in Rabat (Technopolis) (Masoka et al., 2012).
Algeria	Although, the field of Nanotechnology is nascent in Algeria, incorporated Nano micro-electronics in the Microelectronics Division of the Advanced Technologies Development Centre, and a National Centre for Research on Nanomaterials and Nanotechnology was established at the University M´Hamed Bougara of Bourmerdes in 2011 (Musse et al., 2013). (Anza-vhudziki Mboyi, 2017)

Economic Impacts of Nanotechnology Industry Case Study on Egypt

Egypt has been interested in a number of research projects based on Nanotechnology by establishing a number of specialized laboratories in the field of Nanotechnology, as follows

Table 1 Government financial resources for Nanotechnology in Egypt during 2009 to 2015 (Hebatallah Adam, 2019)

Government financial resources for Nanotechnology in Egypt during 2009 to 2015	
Constructions	**Investment cost (in Egyptian Pounds)**
Nano Center at Mansoura University	5 million
Nanotechnology Laboratory at the Agricultural Research Center in Cairo	20 Million
The center of Nanotechnology Research at Cairo University in cooperation with the Ministry of Communications and the University of the Nile	150 Million
The Nano lab in Zewail City is funded by National Bank of Egypt	100 million
Total	**275 million**

Nanotechnology infrastructure Needs: - Nanotechnology infrastructure considers where we have been, where we are going and where we will need to be. The six areas of opportunity relevant to infrastructure are Nano-manufacturing, Nanomaterial's Metrology, Physical infrastructure, Infrastructure Access = Value, Approaches to complexity and Qualified Talent pipeline. (julia M.Phillips, 2013)

A QUICK LOOK AT NANOTECH ADOPTION IN BRAZIL, CHINA, INDIA AND RUSSIA

As of 2011, China, India, and Russia all had "full-fledged Nanotechnology policies involving dozens of institutions, hundreds of research and education centers and large amounts of R&D spending. (Anne L. Clunan, 2014)

Brazil	has also made a concerted investment in Nanotechnology. BRAZIL established its national Nanotechnology initiative in 2004-2005. Declared Nanotechnology to be one of eleven areas for strategic government investment. The Ministry of Science, Technology and Culture invested an average of $5 million a year from 2004-2008 and contributes more than 50% of the continent's Nanotechnology research output. As of 2012, there were 17 Nanotech networks established in Brazil, and eight national labs, over 2,500 researchers and 3,000 graduate students were focused on Nanotech.
China	has designated Nanotech R&D as one of twelve "mega-projects" under its Medium and Long Term Development Plan 2006-2020. China has stepped up publishing and patenting in Nanotechnology in order, by some accounts, to increase their ranking in global Nanotechnology indices. The head of the Chinese Academies of Science is a Nanotechnology scientist, and China has "come up very quickly academically, its labs are very good," according to a senior U.S. official.
India	established a Nano Science and Technology Initiative in 2001, but with modest support and aims. In 2005, an Indian Defense Research and Development Organization (DRDO) official stated that India was set to become a "leader in Nanotechnology within the next five to ten years. In 2007, India launched a new Mission on Nano Science and Technology (Nano Mission) under the Department for Science and Technology, with a budget of approximately $145 million over

	five years. 2012: “Nanotechnology should lead to higher protection, more lethality, longer endurance and better self-supporting capacities of future combat soldiers.
Russia	RUSSIA, is one of the last entrants in the Nanotech in 2007, with the establishment of a $9 billion state-funded Nanotechnology initiative, and the detonation of a thermo baric “father of all bombs” that the Russian government claimed was the first Nano-weapon. The Russian Nanotech program has been pushed at the highest levels, beginning with President Vladimir Putin. By 2011, new Nanotechnology products were to have been developed that could be industrially produced within two to three years, and an efficient system for their commercialization established. The ultimate goals were to have laid the foundations for a large-scale increase in the production volumes of new types of Nano-industry products by 2015, and to have established Russian companies in the global high technology market

2.5 Global Nanotechnology market value 2010-2020

Nanotechnology, the manipulation of matter on a Nanoscale, has many exciting applications, and research and development continues to produce more practical applications. In 2017, Nanotechnology had a market value amounting to nearly 49 billion U.S. dollars worldwide, and is projected to increase to nearly 76 billion U.S. dollars by 2020. (M. Garside, 2020)

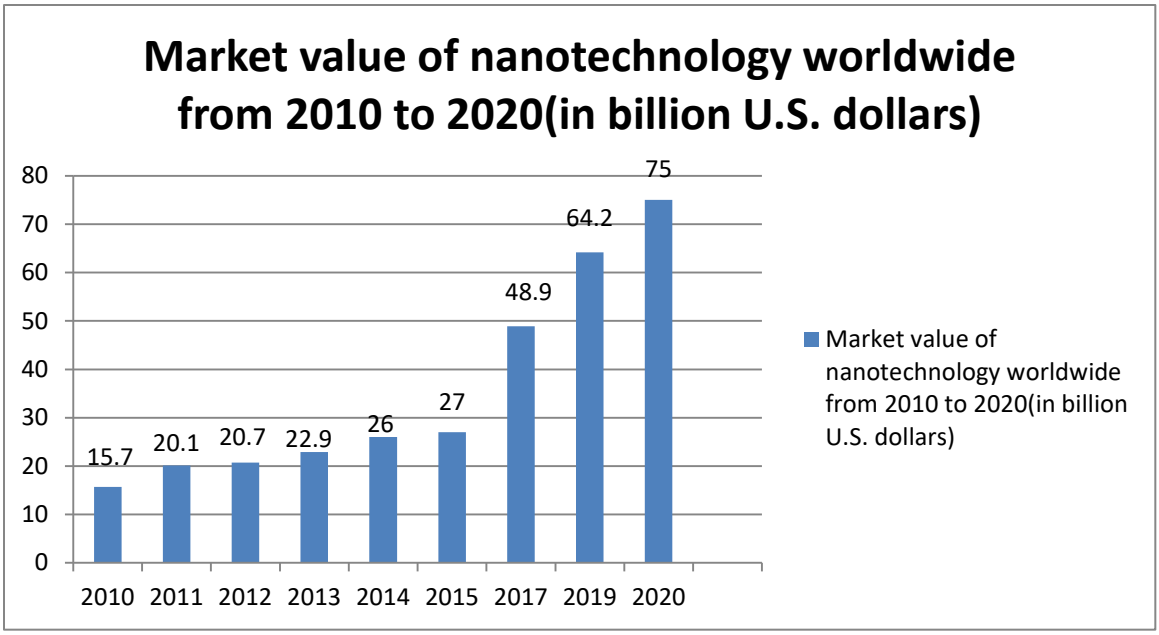


Figure 1Market value of Nanotechnology worldwide from 2010 to 2020(in billion U.S. dollars)

Assessing the Nanotechnology on the grounds of costs, benefits, and risks

Market needs of Nanomaterials the growing acceptance of Nanotechnology by the society is creating the demand for Nano-inspired goods. This is also highlighting the necessity of understanding the potential effects these products would be having on environment, eco-balance, animals, and human beings. In the year 2019, the global market of Nanomaterials was estimated to be 8.5 billion US dollars and is anticipated to grow with an annual rate of 13.1% from the year 2020 to the year 2027. This rise in market share of Nanotechnology is attributed to the rapid acceptance and adoption of Nanostructures in aerospace applications, medical and health sectors, food and packaging industry, agriculture and farming, sports, cosmetics, constructions, paints and coatings, electronics, environmental remediation power and energy sectors, etc. The key factor for this growing market of Nanomaterials is the characteristic physical, chemical, and biological properties of metal Nanoparticles. (Jain G. P., 2020)

2.6 Rules and regulations of Nanotechnology

Nanotechnology within the Legal and Regulatory Framework: An Introductory Overview

Nanomaterial's being Nano scale chemical has more or less similar features of chemicals with some unusual results. Similar to the notion that not all chemicals are harmful, Nanomaterial's are of no exception, although there are some Nanomaterial's which are used in a ubiquitous scale in consumer products that are highly predicted to be injurious. For such Nanomaterial's, law should immediately intervene. However, since it has turned to be an interdisciplinary study, more issues than the chemicals are involved here. The global community is still unsure on whether the conventional legal provisions relating to chemicals and chemical management will be sufficient and applicable in the case of Nanoparticle, or whether new law should be enacted. (MD ERSHADUL KARIM, 2014).

2.7 The role of Nanotechnology in modern textiles

NT provides plenty of efficient tools and techniques to produce desirable fabric attributes, mainly by engineering modifications of the fabric surface. Examples of NT on modern textiles are water repellent textiles, Wettability, Antibacterial property, UV protection and Nanosols (Srinivas, 2016)

Reviews on Nanotechnology & Its Application in Coating Industry

Nano-coatings are materials that are produced by shrinking the material at the molecular level to form a denser product. The appearance and usefulness of Nanoparticles brings many advantages and opportunities to paint and coating industry. Coating industry is among the first to tap the potential of Nanotechnology. Addition of Nanoparticles to coatings can upgrade many properties of coating system and can produce multipurpose coatings with a little cost difference. (Dnyaneshwar Chaudhari, 2018)

Nanotechnology: indicators for development

From a policy perspective, Nanotechnology is positioned as essential for future economic and societal development; an innovative enabling technology with applications throughout the whole of product space. Stimulation policies and programs around the world focus on further development of the science and engineering aspects as well as subsequent valorization and utilization. Increasingly large sums of public and private money are being invested to drive the

technology forward. Indicators like the number of Nano-related scientific publications and patents and the usage of Nano-terminology in scientific publications all show a large, almost exponential increase. As yet, their economic impact is unclear, but economic assessment methods and data gathering are under development. (Westra, 2014)

2.8 Advantages and disadvantages of Nanotechnology

Advantages of Nanotechnology

- Nanotechnology has the capability to revolutionize many electronic products, their procedures and their applications. The areas that benefit from this technology include Nano transistors, Nano diodes, OLED, plasma display, quantum computers and many more.
- Some Nanoparticles serve as an effective way to remove contaminants from the environment. Scientists had a huge success in using Nanoparticles to remove polychlorinated biphenyls or PCB, DDT and various dioxins from industrial sites, arsenic salts and so on.
- The energy sector can also be benefited by Nanotechnology. The development of a more effective source of energy- producing, absorbing and storing into smaller and more efficient devices is made possible with Nanotechnology. Items like batteries, fuel cells and solar cells can be built in a smaller yet more effective size with this technology.
- Scientists are working to create Nano sensors that will be able to detect and monitor pollutants with high sensitivity. These sensors will be capable enough to detect even the smallest number of contaminants and the presence of dangerous bacteria. Industrial areas will be provided with sensors that can alert the surrounding community in case of a leak into the ground water.
- Nanotechnology is considered a boon in the medical world, since smart drugs can be produced using this technology. It will help people cure faster and without any side effects. It is also used in areas like tissue regeneration, bone repair and even cures for ailments like cancer. (Positive, 2017)

Potential Disadvantages of Nanotechnology

- Is very expensive and developing it can cost a lot of money. Moreover it is also difficult to set up and manufacture the technology. Even the labor costs are high and this is why the resultant items or products are quite expensive.

- Nanotechnology has put a lot of people out of jobs in the past few decades expected to increase in the coming time.
- Development of Nanotechnology can bring about a certain kind of a crash in the markets which is due to the lowering of value of diamonds and oil due to the development of alternate source of energy. Since these sources of energy are more efficient and won't require fossil fuels, it can put many markets to their brink. This also means that since people are now capable of developing products at a molecular level, diamonds may lose their value because they can now be mass produced.
- Due to the development of Nano technology, atomic weapons can now be made more accessible and can also be made more destructive and powerful. This is yet another major disadvantage of Nanotechnology.
- Another issue with Nanotechnology is that since the particles of Nanotechnology are very minute, problems can crop up from the inhalation of these particles.
- Working with Nanotechnology can prove to be very risky too. The investment needed to start up a project involving this science can be huge without any guarantee of success and this can lead to huge losses. At the same time, the technology poses risks to health as well.
- It is true that Nanotechnology has raised our standard of living but it has also led to an increase in the levels of pollution. The pollution caused due to Nanotechnology is known as Nano pollution and this can be very dangerous for living organisms.
- Another major disadvantage of Nanotechnology is the possible mass poisoning of material which is processed at a Nano scale. This can leave a negative impact on the health and industry and can happen if the coatings on the products produced by this technology include some of the poisonous micro particles which can penetrate into our brains. (Nanotechnology, 2018)

2.9 Technology Enablers

Once we have identified the advantages and disadvantages of Nanotechnology and where Nanotechnology stands in Ethiopia we need to determine which enablers are best suited to adopt Nanotechnology to Ethiopia.

Three intertwined enablers' people, governance, and partnerships are essential for lasting digital change. (By Luis Benavides, April 21, 2017)

Technology Enablers include governments, regulatory bodies and other organizations that facilitate technology adoption through standards, guidelines, policies, funding, and investment.

List of Technology Enablers

- Individuals,
- Academe,
- Private Sector,
- Government,
- Professional Societies and
- Other Organizations. (Sims, 2002)

2.9.1 Transfer of Technology

It is a process for applying known technologies to new and novel applications. The term is widely recognized, but the process is not well understood. Technology transfer has significant value for developing industries including the field of assistive technology. However, this value cannot be realized until the process is fully understood and properly implemented. (Joseph P. Lane, 2017)

Transfer of technology is viewed as an important channel of technological learning and innovation capability-building in Ethiopia. However, the relationship between the transfer of technology and local technological learning and upgrading is not automatic. How the transfer takes place, the policies and incentive schemes used to prompt the transfer and, more importantly, what happens to the technology once it has been transferred are key determinants of the ability of Ethiopia to upgrade its technological capability and acquire the capacity to assimilate and generate new technologies It identifies channels of technology transfer to Ethiopia and the implications for technological learning and innovation.

Types of Home-Country Measures

The most common HCMs related to technology transfer include project financing (including through FDI and venture capital), training, matching services, partnerships and alliances and support for equipment purchase or licensing. The measures are intended to help identify possible

sources of technology, acquire the required technology, adapt it to local needs and develop the local technological base.

A. Financing of technology transfer
B. Technology transfer through FDI Foreign direct investment
C. Matchmaking and provision of information on technologies
D. Promoting public-private partnerships
E. Access to venture capital and technology transfer
F. International alliances and transfer of technology
G. Measures to improve host-country absorptive and technological capacity. (UNCTAD, 2004/5)

2.9.2 Understanding a Business Ecosystem

What Is a Business Ecosystem?

A business ecosystem is the network of organizations including suppliers, distributors, customers, and competitors, government agencies, and so on involved in the delivery of a specific product or service through both competition and cooperation. The idea is that each entity in the ecosystem affects and is affected by the others, creating a constantly evolving relationship in which each entity must be flexible and adaptable in order to survive as in a biological ecosystem.

Moore defined the business ecosystem as follows:

"An economic community supported by a foundation of interacting organizations and individuals the organisms of the business world. The economic community produces goods and services of value to customers, who are themselves members of the ecosystem".

The member organisms also include suppliers, lead producers, competitors, and other stakeholders. (HAYES, 2021)

Dimensions of Business Ecosystems

Your dynamic business ecosystems may sometimes create partners from competitors, at least for a little while. When BMW and Toyota need to develop key technologies, such as batteries, they may join together and then later go on to compete in the marketplace.

Ecosystems enable organizations to respond and exist in an increasingly digital world, assuming that CIOs and senior IT leaders consider the eight dimensions when making strategic decisions about how to participate and when to change tactics.

- Dimension 1: Ecosystem Strategy
- Dimension 2: Degree of Openness
- Dimension 3: Engagement of Diverse Participants With increased connectivity.
- Dimension 4: Types of "Relationships" interconnection will create an ecosystem challenge.
- Dimension 5: Form of Value Exchange
- Dimension 6: Diversity of "Industries"
- Dimension 7: Complexity of Multiple Ecosystems
- Dimension 8: Technologies Discussions about ecosystems can be overwhelming. (Betsy Burton, 2017)

2.10 Multi-criteria decision making models

Decision making is the process of arriving at a determination based on consideration of alternatives. It involves making decision based on more than one criterion, usually conflicting criteria.

- Linear Goal Programming (LGP),
- Multi-Attribute Utility Theory (MAUT),
- Technique for Order Performance By Similarity to Ideal Solution (TOPSIS),
- Merit Point System (MPS) and
- Analytic Hierarchy Process (AHP).

AHP According to Satty (1980) a pair wise comparison matrix is created to determine the degree of significance of the criteria and sub-criteria by AHP. Decision-maker performs a value-and definition-based scoring in a way to determine the relative significances of the elements at a level and creates a pair wise comparisons matrix. As a result of the Eigen value-eigenvector calculation this matrix, criterion weights with a total value of 1 (normalized weight coefficients) are retrieved. By a statistical test known as Consistency Ratio, the consistency of the decisions made in the pair wise comparisons in AHP technique is calculated. (Satty, 1980)

Chapter 3

Research Design and Methodology

The research design, data sources, data collection instrument and procedure, and methods of data analysis will be presented in this chapter.

3.1.Research Design

Research design is the step by step method for answering the research objectives and research questions. It specifies the methods and procedures for collecting and analyzing the required information. The method of research design is based on the objective of the research; the objective of this research is to analyze and determine the status of Nanotechnology in Ethiopia and develop a strategy to adopt this technology to Ethiopia textile industry.

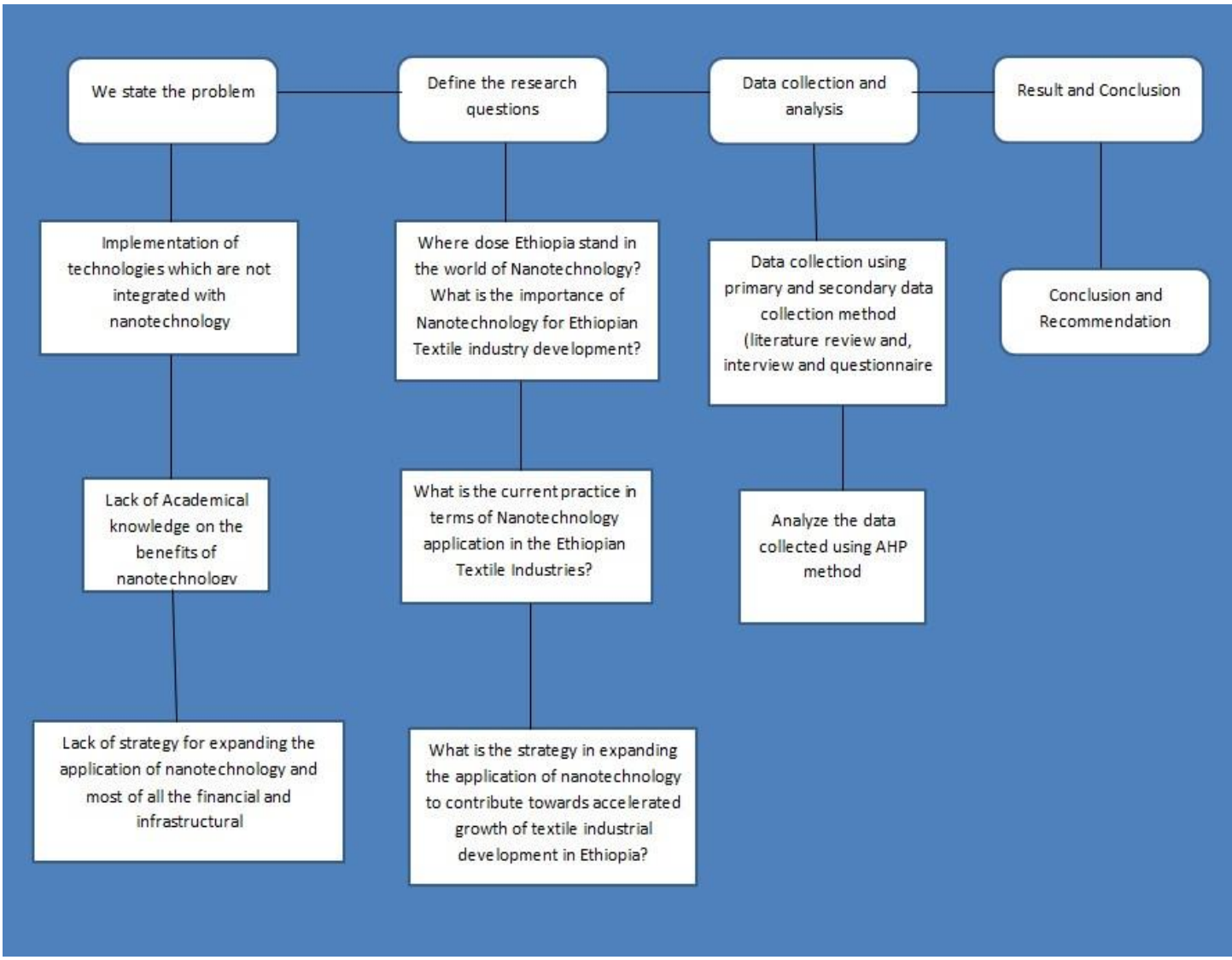


Figure 2 Research design

3.2.Research methodology

The researcher will use both qualitative and quantitative research approach which involves the use of primary and secondary data in order to answer the research questions and achieve its research objective.

The research methodology will focus on the research target areas, which are:-

- What is the importance of Nanotechnology for Ethiopian Textile industry development?

- What is the current practice in terms of Nanotechnology application in the Ethiopian Textile Industries?
- What is the strategy in expanding the application of Nanotechnology to contribute towards accelerated Textile Industrial Development in Ethiopia?

3.3Sampling

3.3.1How to determine population and survey sample size?

A survey can only be truly valuable when it's reliable and representative for your business. However, determining the ideal survey sample size and population can prove tricky. In other words, who will you be surveying and how many people?

"What is the population that I would like to survey?" Or, who do you need to survey to gain valuable insights in the success?

3.3.2 What is the survey sample size?

A sample is a selection of respondents chosen in such a way that they represent the total population as good as possible. However, instantly a new question comes to the forefront: "How many people should my sample consist of?" Using a correct survey sample size is crucial for your research. After all, a sample that is too big will lead to the waste of precious resources such as time and money, while a sample that is too small will not allow you to gain reliable insights.

So, how large should your sample be? Should you survey 1%, 5%, 10%, etc well, this depends largely on how accurate you want your survey data to be. In other words, how closely you want your results to match those of the entire population. There are two measures that affect the accurateness of the data.

First of all there is the margin of error (or confidence intervals). In short, this is the positive and negative deviation you allow on your survey results for the sample. Or, in other words the deviation between the opinions of your respondents and the opinion of the entire population. An example will shed some light on this statistical explanation. Suppose you set your margin of error on 5%. If – let's hope so! – 90% of your survey respondents, a 5% margin of error mean that you can be 'sure' that between 85% (90%-5) and 95% (90%+5) of the entire population.

How many respondents does your survey require?

Once you have decided how accurate you want your sample data to be, you can start calculating how many respondents (people who have completely filled in the survey or completes as we call them at Check Market) you actually need.

Below you find an indicative table on how to calculate your number of completes. As a consequence, the appropriate number of completes will be found on the last row of the table below. Depending on the confidence level and the margin of error, the number of completes will vary. (Medallia, 2013)

Table 2 Population size confidence level

	Confidence level=95%			Confidence level=99%		
	Margin of error			Margin of error		
Population size	5%	2.5%	1%	5%	2.5%	1%
100	80	94	99	87	96	99
500	217	377	475	285	421	485
1,000	278	606	906	399	727	943
10,000	370	1,332	4,899	622	2,098	6,239
100000	383	1,513	8,762	659	2,585	14,227
500,000	384	1532	9,423	663	2,640	16,055
1,000,000	384	1534	9,512	663	2,647	16,317

3.4 Data collection techniques and tools

3.4.1primary data sources

This study depends on both primary and secondary data sources. The primary data will be collected by the researcher by preparing relevant questionnaire, appropriate questions for interview and detailed observation within the scope of the specific objective for the selected companies which in turn will help in acquiring new and detailed information for the study.

3.4.2The secondary data

The secondary data for this research are going to be data, collected and written by other Researchers and institutes on the industrial sector and documentations from private and government institutes and from Ethiopian Textile Institute.

3.4.3 Methods of Data Analysis

Data presentation and analysis is one of the core points of this study and will be handled as follows. Qualitative analysis will be applied to elaborate the data, which will be collected through interviews and document reviews. Hence, both quantitative and qualitative approaches will be employed in the research. Data collected through the above-mentioned tools will be organized and analyzed by AHP methods.

3.4.4 AHP method

In the 1970s, Analytical Hierarchy Process (AHP) has been introduced accidentally by Satty as a tool to allocate resources and planning needs for the military. However, due to its ability to identify the weight age of variables efficiently in research, it has become popular in many sectors. Basically, AHP is a tool in decision making that arranges the variables into a hierarchical form in order to rank the importance of each variable. Leading to the weight age calculation of the variables indirectly researchers in all over the world also have discovered that AHP can be modified and used not only for military but in any sectors as well. The modification of AHP has been widely used in other sectors such as automotive, medical, education, business, and administration. And also in the property market field. (Saaty, 2001)

Basically, AHP uses mathematical approach based on metrics algebra. It has been used as a tool to identify the importance of criteria in decision making or problem solving to achieve a goal. AHP bringing the qualitative and quantitative approach in research and combines it into the context as a sole empirical question. AHP applies the qualitative approach to restructure problems into hierarchy which is more systematic. On the other hand, based on a quantitative approach, it uses more of the comparison method of pair-wise to obtain responses and reliability that are more consistent through questionnaire forms.

Steps in forming the frame work for AHP

Step 1: Hierarchy Construction, construction of the hierarchical structure is a foundation stone of AHP. It is considered as an important step of AHP, and there is no specialized approach for making a hierarchy. Construction of hierarchy is a top-down process and comprises of several levels. Elements of hierarchical levels are managed in such a way that they are on the same scale and magnitude. However, a typical AHP model comprises of four levels. It starts from Level 1 as objectives or goal, its associated main criteria as Level 2, sub criteria as Level 3, and Level 4 of the hierarchy contains the choices of alternatives. Overall, the criteria, sub criteria, and alternatives options are clustered for achieving the top-notch goal or objective.

Step 2: Pair wise Comparison. After the hierarchy construction, the next step is to establish the relative importance of the main criteria and sub criteria by comparing them in the form of pairs. It is an important step and considered as a spine of AHP. During this process, the items in each set of the hierarchy are compared with their corresponding group members. For this, a nine-point scale, as shown in Table below, it is used to measure the relative importance of the items.

Table 3 Intensity of Importance

Intensity of Importance	Definition
1	Equal importance
2	Weak or slight
3	Moderate importance
4	Moderate plus
5	Strong Importance
6	Strong plus
7	Very strong
8	Very very strong
9	Extreme importance

Step 3: Deriving Relative Weights. Is step requires the estimation of relative weights for each of the criteria and sub criteria of decision hierarchy. Researchers have developed many approaches to estimate the relative weights from the comparison matrix. However, eigenvector and logarithmic methods are commonly used for deriving relative weights. Satty (1991), as a pioneer of AHP, has

proposed the eigenvector method, which is derived from the matrix theory. In this method, the corresponding weights of decision elements are determined by comparing the normalized Eigen value to the principal Eigen value.

Step 4: Checking the Consistency Ratio. Measure of "Consistency Ratio" (CR) is an important aspect of optimal decision-making in pair wise comparison is mainly associated with the permissible value of consistency ratio.) is step acts as a gateway to observe the consistency and inconsistency of the decision matrix.

Step 5: Synthesizing Results. Final step starts from the summation of relative values for each set of alternatives on all hierarchy levels. These values are combined together to establish the overall score or criteria weight of each alternative. As an outcome, the normalized local priority vectors are obtained due to this additional function. Now, the final priorities are synthesized by aggregating the product of local priority vector and the relative weights of the respective alternative. Process of aggregation starts from the bottom level of the hierarchy and proceeds upwards to the highest level goal. It is pertinent to note that summation of all weights of alternatives and their corresponding importance are equal to 1.00.) the following equation shows a simplified arithmetical formulation for aggregation of criteria weights at different levels hierarchy (Muhammad Waris, 2019)

$$.\sum[(\textbf{weight of alternatives w.r.t criteri}) \times (\textbf{importance of criteri})]$$

Equation 1 Arithmetical formulation for aggregation of criteria weights

As defined above I have outlined 5 criteria's for this research.

CRITERIA

In this research study we consider the following factors which are listed as criteria's because Once a project idea has passed the identification "test" it must be advanced to the point at which a firm decision can be made whether or not to proceed with it.

This requires a progressive refinement of the design of the project in all its criteria dimensions namely market, technical, economical, financial, social and institutional.

Figure 3 AHP model Criteria's

Alternatives (Enablers of Nanotechnology)

Who should play a major role in adoption of Nanotechnology?

Everybody because nanotechnology has a wide influence in various areas in the scientific community. Nanotechnology as an interdisciplinary fields it needs financial support and involvement from various organizations of government as well as the private sector. It should be known it can be carried out independently by federal governments, state/regional governments, agencies, and private companies with the proper policy/legal frame work in place; but the best results are usually achieved by networking and collaboration strategies.

3.4.5 List of Technology Enablers

List of Technology Enablers I have listed six enablers and below I have classified them in to four alternatives which play a major role in implementing Nanotechnology These are listed as follows

- Alternative 1 Government
- Alternative 2 Academe and professional societies,
- Alternative 3 Individual and private sectors and
- Alternative 4 Non-Governmental Organization.

What does a hierarchy structure look like?

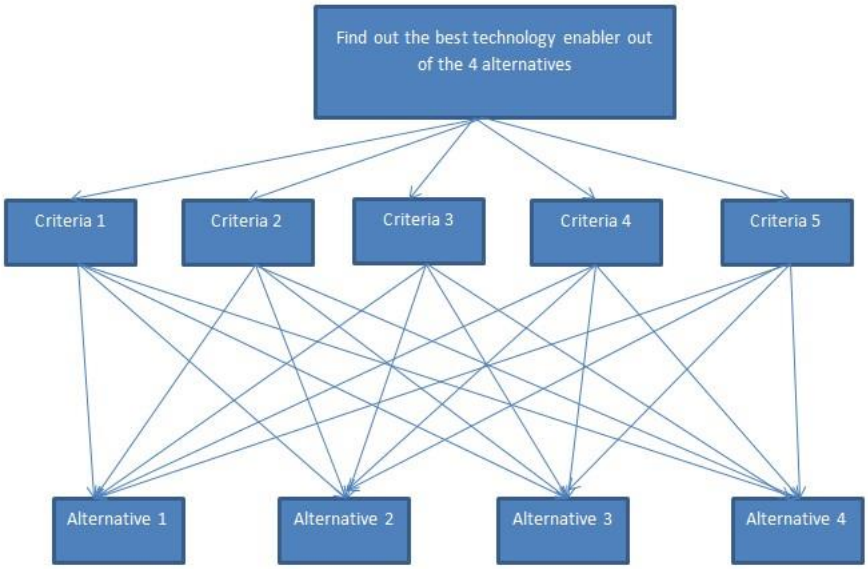


Figure 4 Structure of Hierarchy

How do we set priorities?

We set priorities by method of Intensity of importance method which uses a scale of 1-9 which have different definitions

Table 4 Setting Intensity of importance

Intensity of importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the element
3	Moderate importance of one over the other	Experience and judgment slightly favor one element over another
5	Essential or Strong importance	Experience and judgment strongly fever one element over another
7	Very strong importance	An element is strongly favored and its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation

2,4,6,8	Intermediate value between the two adjacent judgments	Compromise is needed between two judgments

3.4.6 Risk mitigation

A risk assessment matrix (sometimes called a risk control matrix) is a tool used during the risk assessment stage of project planning. It identifies and captures the likelihood of project risks and evaluates the potential damage or interruption caused by those risks.

The risk assessment matrix offers a visual representation of the risk analysis and categorizes risks based on their level of probability and severity or impact. This tool is a simple, effective way to get a holistic view of the project risks for all team members and key stakeholders. (Boogaard, 2022)

How does a Risk Matrix Works

In simple terms, risk assessment is defined as the probability of an event multiplied by its impact. Levels of probability and impact can be divided into verbal and numerical scales like so: (anu.edu.au, 2022)

Table 5 likelihood relation with consequence

Likelihood		Impact/Consequence				
		5	4	3	2	1
		Catastrophic	Major	Moderate	Minor	Insignificant
5	Almost Certain	Extreme(25)	Extreme caution(20)	High(15)	High(10)	Moderate(5)
4	Likely	Extreme caution(20)	High(16)	High(12)	Moderate(8)	Moderate(4)
3	Possible	High(15)	High(12)	Moderate(9)	Moderate(6)	Low(3)
2	Unlikely	High(10)	Moderate(8)	Moderate(6)	Low(4)	Low(2)
1	Rare	Moderate(5)	Moderate(4)	Low(3)	Low(2)	Low(1)

Table 6 Risk evaluation ratings

Risk evaluation ratings	
Rating	**Description and color coding**
From 21-25	*Unacceptable*
From 16-20	*Extreme Caution*
From 11-15	*Cautionary*
From 6 - 10	*Acceptable*
From 1 - 5	*Acceptable*

Chapter 4

Result and discussion

4.1 Ethiopia:What It Takes to Penetrate the Nanotechnology World?

4.1.1 Industrial Policy in Ethiopia

The ongoing second Growth and Transformation Plan (GTP II) of Ethiopia, and its industrial development strategy are all centered agricultural-based, manufacturing sector-driven and export-led development. The GTP pursued the growth through the export-driven industrialization strategy focusing on:- labor and capital Intensive manufacturing industries, export-oriented and import substituting industries, Contribute to rapid technology & know-how transfer, have broad linkages with the rest of the economy, and use Agricultural Products as Inputs (Agro-processing).

The key strategic directions are small and medium scale industrial development; and large scale industries with special emphasis all geared to poverty alienation & development. The manufacturing industries that have given due attentions are:-

- Agro-Processing industries
- Textile and garment
- Leather and leather products industries
- Pharmaceutical industries
- Metal and engineering industries

(EhiopianIndustrialParkDevelopmentCorporation, 2015)

As Ethiopia continued aspiring to upscale its emerging materials science, investing on Nanotechnology has become an order of the day for a rapid advancement of its agriculture, energy, biotechnology and manufacturing industry, scholars say. Therefore this study tries to give answer for these research questions,

Where does Ethiopia stand in the world of Nanotechnology? What is the importance of Nanotechnology for Ethiopian Textile industry development?

This research question are answered by secondary data sources collected from researchers, literature reviews, interviews, and reports and taking experiences of other countries .On this section deep literature review is reviewed on the base of Nanotechnology for industrial development and I have listed enablers which are used to adopt the Nanotechnology into Ethiopian Textile Industrial development.

What is the current practice in terms of Nanotechnology application in the Ethiopian Textile Industries?

This research question deals with primary data sources collected by the researcher. The data is collected by method of interviewing and observation within selected companies, which in turn will help in acquiring detailed information about the study.

What is the strategy in expanding the application of Nanotechnology to contribute towards accelerated the Textile Industrial development in Ethiopia.

These research questions are dealt by primary data source collected by the researcher preparing relevant questionnaire and will be analyzed by multi criteria method AHP model.

4.2 Towards an African Nanotechnology future Trends, impacts and opportunities

The state of Nanotechnology in selected African countries Ethiopia is investing in Nanotechnology to ensure the rapid advancement of its agricultural and energy sectors, and its biotechnology and manufacturing industries. However, the country's Nanotechnology program has so far failed to take off because of a lack of effective legislation and policies, and inadequate infrastructure development. Postgraduate courses on Nanotechnology have only recently been offered to those wishing to study the subject in Ethiopia. (Demissie, 2021)

In an interview conducted in Ethiopia textile institute

In an interview conducted in Ethiopia textile institute within 4 departments of the institute namely the sewing, weaving, finishing and environmental department there are no Textile industries in the country that use Nanotechnology. However, in some textile institute departments there is a startup research in their laboratory to produce Nanotechnology products.

Abi Taddesse Associate Professor of Chemistry at Haramaya University, says currently the Nation's Nanotechnology program is at a dormant stage for the fact that it is a new field, due to lack of proper legislation of laws or policies concerning this particular field including lack of infrastructure, poor industrialization status, unavailability of postgraduate curricula related to materials science and Nanotechnology until recent years and that it is still difficult to trace Nano science programs in higher educational institutions throughout the country.

Kebede Gamo Emerging Technology Center Nanotechnology Director(Previous) at the Ethiopian Biotechnology Institute (EBTI) for his part says although Nanotech is new globally and most countries in the world have had growing public and private investments and had positive impact on their economy and ensure their global competency and sustainability. But in cases of Ethiopia Kebede notes that Nanotech activities has been undertaken as basic research in various universities in less organized manner and are been left to remain on shelves. Because of lack of awareness it kept the development of this field slow and it has brought certain effects on the Nation's export commodities, particularly on agricultural products. "Aflatoxin problems for instance could be solved through Nanotechnology. (Tbebu, 2018)

Dr Alemayhu current Nanotechnology department director at Bio and Emerging technology Institute (BETIN) has noted Nanotech in Ethiopia is at early stage and most of the studies are made within the institute and with collaboration with Higher educational and research institutes namely ;

- Addis Abeba university AAU,
- Addis Abeba Science and Technology university AASTU,
- Adama Science and Technology university ASTU,
- Gonder university GU,
- Hawasa university HU,
- Jimma university JU,
- Haromaya university HU and
- Kotebe Metropolitan university KMU

Dr Alemayhu also noted that they are only doing research works within institute or with collaboration parties and that they are directly copying the technology without meeting the whole needed infrastructure.

Dr Alemayhu also noted that there hasn't been current situational analysis been done on Nanotechnology in case of Ethiopia which makes it even more difficult to know if there are any products on the market.

4.3 StakeHolders

An all-inclusive definition would outline a stakeholder as a group (or a coalition, collective, market, neighborhood, network, publics or society), individual (or actor, agent, constituent, member, participant, partner, party or vector) or entity (institution, corporate or organization) that may be a human (person or citizen) or non-human (the environment, natural entity or God) even anyone or anything. Stakeholders may be allies, beneficiaries, benefit providers, benefit receivers, value chain participants, claimants, risk bearers or risk providers. A stakeholder is recognized if it is strategic or significant, identifiable, concrete, political or visible. Stakeholders may be past (nonliving), present or future (potential, an unborn fetus or future generations). (Miles, 2017)

Stake holders from BETin Quality Manual chapter 4 Context of organization
(BIOANDEMERGINGTECHNOLOGY, 2022)

Table 7 List of Stake holders

Stake holders
Investor and private sectors(importers)
Society and citizen
Chemical and construction inputs industry development institute
Food drinks and Pharmaceutical Industrial Institute
Ministry of Health and others affiliated institutes
Ministry of finance
Ministry of education
Civil service commission
Ministry of trade and industry

Mass medias
Ethiopian leather industry development institute, Ethiopian Textile industry development institute and Ethiopian Metal industry development institute
Federal and regional TVET agency(Kotebe Metropolitan university)
Institutions that work towards quality and standards
Academic centers (Universities AAU, AASTU, ASTU, GU, HAWSAU,JU,HRUMAYA and colleges
NGO

Table 8 Roles of the stake holders

Roles of the stake holders	
Investor and private sectors(importers)	Joint venture, procurement service to increase productivity, give support to increase competency
Society and citizen	Develop community awareness on new products to avoid misunderstanding
Chemical and construction inputs industry development institute	Collaboration on research on new research materials and replace imported chemicals
Food drinks and Pharmaceutical Industrial Institute	Collaboration on research and training on Food drinks and Pharmaceutical packaging and preservative
Ministry of Health and others affiliated institutes	Collaboration on research , training and consulting service
Ministry of finance	Successful budget usage, working by respecting finance rules and regulations
Ministry of education	Collaboration with related parties, develop curriculum with related fields, provide research , developments , consulting and training
Civil service commission	Recruiting employee according to civil service commission

Ministry of trade and industry	Create local and international competency for products and improved quality products
Mass medias	Develop work integration, provide up to date information
Ethiopian leather industry development institute, Ethiopian Textile industry development institute and Ethiopian Metal industry development institute	Collaboration on research training related to leather, Textile and Metal products and research on environmental sustainability
Federal and regional TVET agency(Kotebe Metropolitan university)	Training for industry extension workers, curriculum development, tangible technology change and consultation, training and result follow up
Institutions that work towards quality and standards	Committed to implementation of quality management, incorporation with other quality standards, cooperation works and providing recent information
Academic centers (Universities AAU, AASTU, ASTU, GU, HAWSAU,JU,HRUMAYA and colleges	Collaboration on research and development, conducting of different types of lab works and create awareness on newly technological advancements
NGO	Provide financial aid and provide grants for different researches

4.3 Technology Enablers

Are Individuals, Academe, Private sector, Government, professional societies, and other organizations should play in converging technology.

Table 9 Relationship between Enablers and Stake holder

Enablers	Stake holders
Individuals and privates sectors	Investor and private sectors(importers)
	Society and citizen

	Chemical and construction inputs industry development institute
	Food drinks and Pharmaceutical Industrial Institute
Government and Policy makers	Ministry of Health and others affiliated institutes
	Ministry of finance
	Ministry of education
	Civil service commission
	Ministry of trade and industry
	Mass medias
	Ethiopian leather industry development institute, Ethiopian Textile industry development institute and Ethiopian Metal industry development institute
Academe and Professional societies	Federal and regional TVET agency(Kotebe Metropolitan university)
	Institutions that work towards quality and standards
	Academic centers (Universities AAU, AASTU, ASTU, GU, HAWSAU,JU,HRUMAYA and colleges
NGO	NGO

4.4 Business Ecosystem

What should our Business Ecosystem look like?

A business ecosystem is the network of organizations including suppliers, distributors, customers, and competitors, government agencies, and so on involved in the delivery of a specific product or service through both competition and cooperation. The idea is that each entity in the ecosystem affects and is affected by the others, creating a constantly evolving relationship in which each entity must be flexible and adaptable in order to survive as in a biological ecosystem.

Our business ecosystem helps us to observe what kind of relationship there is when adopting Nanotechnology. Our business ecosystem should:-

- Nanotechnology in the middle of the Enablers

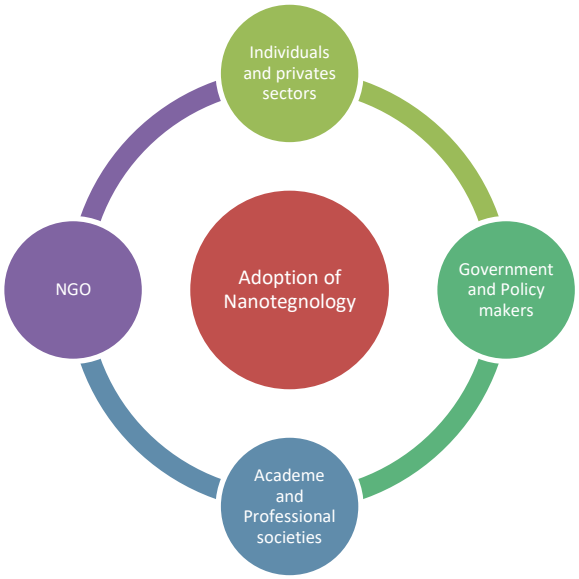


Figure 5• Nanotechnology in the middle of the Enablers

- Each enablers should connect with Nanotechnology individually

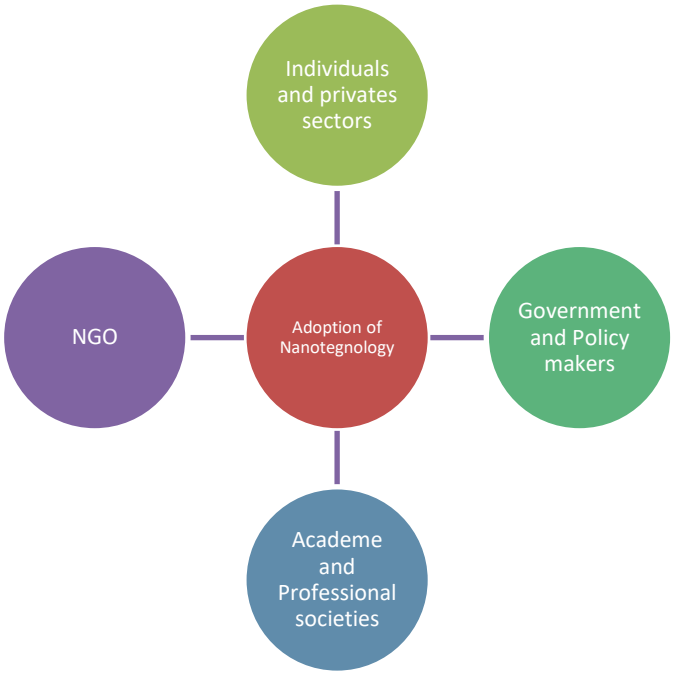


Figure 6 Relation of Each enablers with Nanotechnology

- Each enablers should connect with Nanotechnology with collaboration

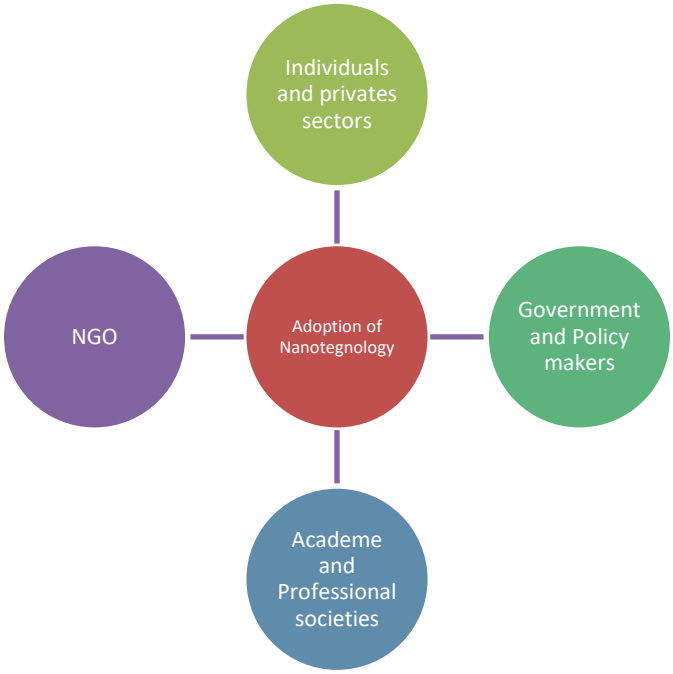


Figure 7 Each enabler's relation with Nanotechnology and each other

4.5 Nanotechnology products in Ethiopia private sector

Regarding the private sector there are some who use Nanotechnology products. Namely;

- Yes water uses Nano reverse osmosis machine for water purification purpose

Figure 8 Product of Yes Water Company

- A company named Nano Tech East Africa imports energizer product used for engine recovery and better fuel consumption

Figure 9 Imported product of Nanotech East Africa Company

- Green Tech Ethiopia has imported Nanotechnology device for vehicles to increase their overall performance and at the time reduce their fuel consumption and reduce their carbon emissions.

Figure 10 Imported green tech Africa nanotech device for cars for less fuel consumption

4.6 AHP model

A pair wise comparison matrix is created to determine the degree of significance of the criteria by AHP. As a Decision-maker performed a value-and definition-based scoring in a way to determine the relative significances of the elements at a level and creates a pair wise comparisons matrix. As a result of the Eigen value-Eigen vector calculation this matrix, criterion weights with a total value of 1 (normalized weight coefficients) are retrieved. By a statistical test known as Consistency Ratio, the consistency of the decisions made in the pair wise comparisons in AHP technique is calculated.

We prepared a questionnaire based on the AHP method. It involves 4 alternatives and 5 criterions. We have distributed the questionnaire for - peoples which are directly related to the subject matter or who have adequate knowledge of the subject matter. Candidates have filled the questionnaire and we have analyzed the data based on their response. Candidates are selected from universities, research centers, budget offices, Nanotechnology importers and foreigners who work on Nanotechnologies.

The data provided by the candidates is analyzed by Microsoft Excel and will be shown below in the Annexed part. Our goal is to show which alternative among the 4 alternatives ranks the highest.

Alternative in Ahp model are (Technology Enablers)

- Alternative 1 Government
- Alternative 2 Academe and professional societies,
- Alternative 3 Individual and private sectors and
- Alternative 4 Non-Governmental Organizations

Best alternative will be chosen by AHP method. We relate our goal to each criterion and each criterion to each alternative and as well each criterion to their respective sub-criteria's.

What do the alternatives represent?

- Alternative 1 Government A national research and development priority area should be established that focuses on converging technologies that enhance human performance. Organizations should provide leadership to coordinate the work of other institutions and must accelerate convergence by supporting new multidisciplinary scientific efforts while sustaining the traditional disciplines that are essential for success. Special effort will be required to identify future technological developments; explore their implications for human performance; study unexpected consequences of NBIC developments; and consider ethical, legal, and policy issues. Governments must provide support for education and training of future NBIC workers and to prepare society for the major systemic changes envisioned for a generation from now. Policymakers must envision development scenarios to creatively stimulate the convergence. Ethical, legal, moral, economic, environmental, workforce development and other societal implications must be addressed from the beginning, involving leading NBIC scientists and engineers, social scientists and a broad coalition of professional and civic organizations. Research on societal implications must be funded, and the risk of potential undesirable secondary effect must be monitored by a government organization in order to anticipate and take corrective actions. Tools should be developed to anticipate scenarios for future technology development and applications.
- Alternative 2 Academe and Professional Societies Educational institutions at all levels should undertake major curricular and organizational reforms to restructure the teaching of science and engineering so that previously separate disciplines can converge around common principles to train the technical labor force for the future. The basic concepts of Nano science, biology, information, and cognitive sciences should be introduced at the beginning of undergraduate education; technical and humanistic degrees should have common courses and activities related to NBIC and the human dimensions of science and technology. Investigations of converging technologies should focus on the holistic aspects and synergism. The hierarchical architecture in which various components are integrated and used is expected to be a major challenge. The scientific community should create new means of interdisciplinary training and communication, reduce the barriers that inhibit individuals from working across disciplines, aggressively highlight opportunities for convergence in their conferences, develop links to a variety of other technical organizations, and address ethical issues related to technological developments. Through

mechanisms like conferences and publications, professional societies can see the NBIC ideas in learning organizations, society at large, and funding agencies.

- Alternative 3 Individual and private sectors Scientists and engineers at every career level should gain skills in at least one NBIC area and in neighboring disciplines, collaborate with colleagues in other fields, and take risks in launching innovative projects that could advance technology convergence for enhancing human performance. Manufacturing, biotechnology, and information service corporations will need to develop partnerships of unparalleled scope to exploit the tremendous opportunities from technological convergence, engaging in joint ventures with each other, establishing research linkages with universities, and investing in production facilities based on entirely new principles and materials, devices, and systems.
- Alternative 4 Non-Governmental Organizations that represent potential user groups should contribute to the design and testing of convergent technologies and recommend NBIC priorities, in order to maximize the benefits for their diverse constituencies. Private research foundations should invest in NBIC research in those areas that are consistent with their particular missions. The public media should increase high-quality coverage of science and technology, on the basis of the new convergent paradigm, to inform citizens so they can participate wisely in debates about ethical issues such as unexpected effects on social equality, policies concerning diversity, and the implications of transforming human nature.

4.6.1 Hierarchy Construction

Step 1: Hierarchy Construction, in hierarchical structure is the base of AHP. Construction of hierarchy is a top-down procedure and consists of several levels. Elements in hierarchical levels are managed in a way that they are on the same scale and magnitude. However, in this typical AHP model it comprises of four levels. It starts from Level 1 as objectives or goal, its associates 5 main criteria as Level 2, multiple sub criteria for each criterion as Level 3, and Level 4 of the hierarchy contains the choices of alternatives. Overall, the criteria, sub criteria, and alternatives options are organized to achieve goal or objective.

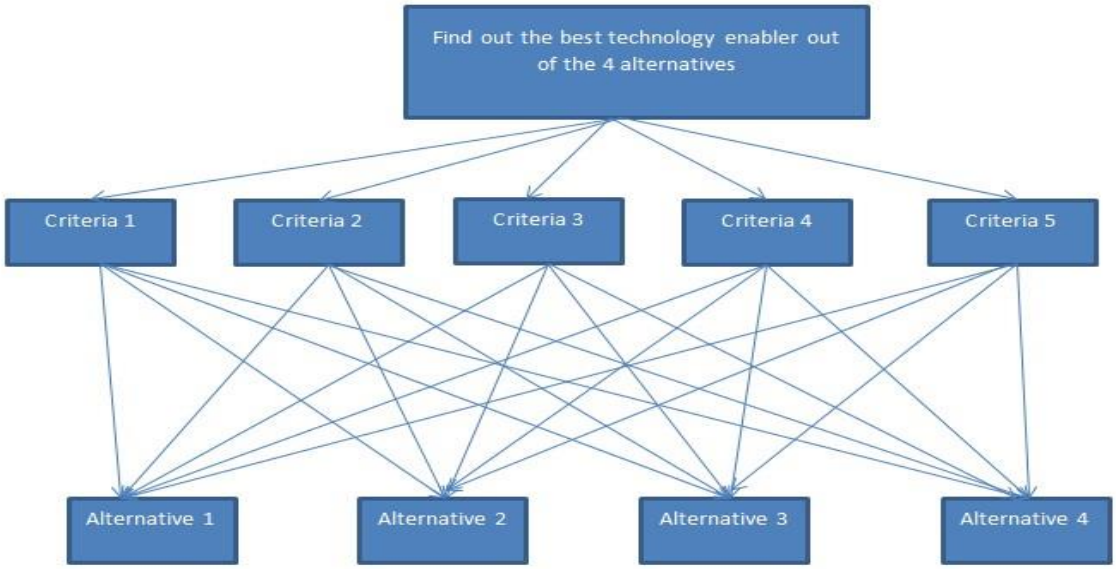


Figure 11 Relation between goal, criterion and Alternative

4.6.2 Pair wise matrix

Step 2 after the hierarchy construction, we determine the relative importance matrix also known as pair wise matrix. During this process, the items in each set of the hierarchy are compared with their corresponding group members. The calculation is shown in the annexed part

4.6.3 Lamda max, consistency index and consistency ratio

step 3 Checking the Consistency Ratio (CR) is an important aspect of optimal decision-making in pair wise comparison is mainly associated with the permissible value of consistency ratio. It is a step act as a gateway to observe the consistency and inconsistency of the decision matrix. In order to determine the consistency calculation of pair wise matrix. We need to find the weighted sum. After that we will be able to calculate the lamda max, consistency ratio and consistency index as well.

Table 10 Result of lamda max, consistency ratio and consistency

Candidates	Lamda max	consistency index	consistency ratio
1	9.22822288	1.057056	1.067733
2	11.90	1.73	1.74

3	5.7102607	0.177565	0.179359
4	6.81227	0.453068	0.457644
5	6.102686	0.27575	0.278535
6	5.701626	0.175406	0.177178
7	5.027862	0.006966	0.007036
8	5.135311	0.033828	0.034169
9	5.79	0.20	0.20
10	6.25652	0.31413	0.317303
11	5.71366	0.178415	0.180217
12	5.411631	0.080419	0.081231
13	5.345751	0.086438	0.087311
14	8.354058	0.838514	0.846984
15	5.53	0.13	0.13
16	5.924641	1.23116	1.243596
17	5.878916	0.219729	0.221949
18	5.554493	0.138623	0.027725
19	5.847837	0.211959	0.2141
20	6.533615	0.383404	0.387276
21	6.360894	0.340224	0.34366
22	6.446194	0.361549	0.365201
23	6.45	0.36	0.37
24	6.068078	0.267019	0.269717
25	5.743665	0.185916	0.187794
26	6.01574	0.253935	0.2565
27	6.39	0.35	0.35
28	7.006489	0.501622	0.506689
29	5.70	0.18	0.18
30	6.982573	0.495643	0.50065
31	6.94	0.49	0.49
32	5.919915	0.229979	0.232302

33	5.79	3.14	3.18
34	5.467916	0.116979	0.118161
35	5.78	0.20	0.20
36	6.193683	0.298421	0.301435
37	6.23	0.31	0.31
38	5.624328	0.156082	0.157659
39	5.70	0.18	0.18
40	5.52625	0.131563	0.132892
41	6.06	0.26	0.27
42	5.365371	0.091343	0.092265
43	6.23	0.31	0.31
44	5.61365	0.153413	0.154962
45	6.05	0.26	0.27
46	5.431966	0.107992	0.109082
47	5.78	0.20	0.20
48	5.641666	0.160416	0.162037
49	5.84	0.21	0.21
50	6.379001	0.34475	0.348233
51	5.39	0.10	0.10

4.6.4 Total Rank of the alternatives with respect to each respondent

Step 4 final step starts from the summation of relative values for each alternative on all hierarchy levels. The values are combined together to establish the overall criteria weight for each alternative. As a result the normalized local priority vectors are obtained due to this additional function. Now, the final priorities are synthesized by aggregating the product of local priority vector and the relative weights of the respective alternative. Process of aggregation starts from the bottom level of the hierarchy and continues upwards to the highest level goal. It is significant to show the summation of all weights of alternatives and their corresponding importance is equal to 1. The following equation shows a simplified arithmetical formulation for aggregation of criteria weights at different levels hierarchy.

$$\sum[(\textbf{weight of alternatives w.r.t criteri}) \times (\textbf{importance of criteri})]$$

Equation 2 simplified arithmetical formulation

Table 11 Total rank of 51 respondents

Respondent	Alternative 1	Alternative 2	Alternative 3	Alternative 4
1	0.36	0.53	0.07	0.04
2	0.38	0.45	0.08	0.04
3	0.52	0.29	0.12	0.06
4	0.528	0.292	0.136	0.052
5	0.629856	0.199353	0.106479	0.070108
6	0.53	026	0.14	0.07
7	0.24	0.37	0.20	0.19
8	0.42	0.36	0.16	0.06
9	0.41	0.35	0.15	0.08
10	0.52	0.29	0.13	0.07
11	0.53	0.26	0.14	0.07
12	0.46	0.27	0.17	0.09
13	0.45	0.28	0.18	0.09
14	0.54	0.22	0.17	0.07
15	0.49	0.28	0.16	0.07
16	0.55	0.23	0.16	0.06
17	0.47	0.29	0.17	0.07
18	0.48	0.30	0.15	0.06
19	0.55	0.26	0.12	0.07
20	0.53	0.30	0.12	0.05
21	0.50	0.30	0.14	0.94
22	0.49	0.27	0.15	0.09
23	0.50	0.31	0.14	0.05
24	0.50	0.24	0.20	0.06
25	0.48	0.23	0.16	0.13
26	0.51	0.26	0.15	0.08
27	0.48	0.23	0.13	0.06
28	0.59	0.25	0.11	0.06
29	0.57	0.25	0.12	0.06
30	0.60	0.23	0.10	0.06
31	0.43	0.35	0.14	0.08
32	0.56	0.20	0.12	0.06
33	0.31	0.23	0.25	0.21
34	0.54	0.26	0.15	0.06
35	0.33	0.29	0.23	0.16
36	0.56	0.26	0.12	0.06
37	0.54	0.25	0.14	0.07
38	0.49	0.30	0.15	0.06
39	0.53	0.28	0.11	0.07
40	0.53	0.29	0.12	0.05
41	0.54	0.26	0.15	0.05

42	0.45	0.31	0.16	0.07
43	0.06	0.08	0.42	0.45
44	0.52	0.26	0.17	0.05
45	0.52	0.26	0.17	0.05
46	0.56	0.28	0.10	0.06
47	0.55	0.28	0.12	0.06
48	0.54	0.26	0.15	0.05
49	0.54	0.26	0.16	0.04
50	0.46	0.28	0.19	0.07
51	0.47	0.29	0.15	0.08

The above tables describe the total rank of the each 51 respondents on which is the best technology enablers of the four alternatives.

Out of the four Alternatives that we have put under consideration used on the AHP method are listed below and their ranks are listed in the table below as well

Alternative in Ahp model are (Technology Enablers)

- Alternative 1 Government
- Alternative 2 Academe and professional societies,
- Alternative 3 Individual and private sectors and
- Alternative 4 Non-Governmental Organizations

Table 12 Total Rank of Alternatives

Selected Alternative	Total rank
Alternative 1	1
Alternative 2	2
Alternative 4	3
Alternative 3	4

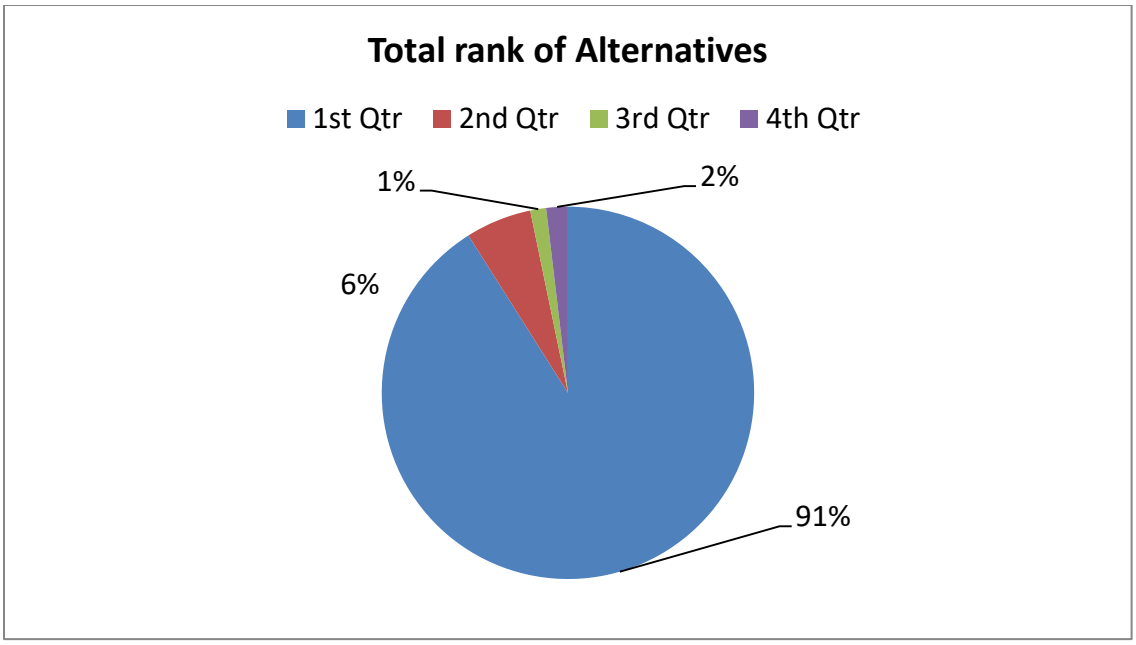


Figure 12 Total ranks of Alternatives presented by percentage

- 1st quarter stands for Alternative 1 Government
- 2nd quarter stands for Alternative 2 Academe and professional societies,
- 3rd quarter stands for Alternative 3 Individual and private sectors and
- 4th quarter stands for Alternative 4 Non-Governmental Organizations

4.6.5 Risk mitigation

A risk assessment matrix (sometimes called a risk control matrix) is a tool used during the risk assessment stage of project planning. It identifies and captures the likelihood of project risks and evaluates the potential damage or interruption caused by those risks.

In this study the risk assessment matrix offers a visual representation of the risk analysis and categorizes risks based on their level of probability and severity or impact. It provided us with simple, effective way of the holistic view of the project risks for all stakeholders as shown below

Table 13 Risk mitigation evaluation

Risk		Likeliho	Impacts of		Risk Level		

Nanotechnology Policy	**Public awareness**	**Political Instability**	**Financial**		
Lack of polic frame-work	Misinformatio on Nanotechnolog y industry	change o governments	Financial limitation as a risk is the possibility of insufficient money on research projects. It is a threat to the research institutes that can result i the loss of valuable research projects from		**Description**
3	**5**	3	5		
5	5	4	5		
3&5	**5&5**	**3&4**	**5&5**	**L x C**	**Risk Score**
15	**25**	**12**	**25**		
Use internationally available guidelines,	Public consultation education, using media t	development o binding policies an procedure on dealin with Nanotechnolog	Use of public-privat partnership financ model		**Mitigation**
Use internationally available	Public consultation education,	Government	Finance and corporat directorate, DG, DDC Information and Publi		**Owner**

Health an safety	**legal**	**Confidentiality**	**Nano Wast (environmental**	**Human Resource Developmen**
Public an Environment Exposure t toxic Nanoparticle	Legal risks a risks happe twhen th research metho predisposed for violation of th law(the countries'	• During ethical research involving huma subjects needs confidentiality and th identity of participants should not b exposed. Subjects have the rights to b protected against injury or illegal invasion of their privacy and to preservation of the personal dignity. The investigators, there f pay greater attention and care in obtaining	Public an Environment Exposure to toxi Nanoparticle an the probability an consequence of a unwanted inciden in the environme	Lack of skills and experience
2	2	2	2	3
4	3	2	3	4
2&4	**2&3**	**2&2**	**2&3**	**3&4**
8	**6**	**4**	**6**	**12**
are a risk occurred to researcher, la technicians an	Report the cas to the la department misconduct	Report the to the research ethics committe soon after information loss is occur to g an advice on how best to manage, minimiz and mitigate any negative effects as a resu	Design Safet Procedures Standards, Wast Management	Develop National HRD plan an train professional abroad
Laboratory technician Researchers	Researchers Misconduct investigation	Researchers Biosafety tea Research ethics committee	Laboratory technician Researchers	Develop National HRD plan an train professional abroad

Incompatible product	**Personal disruption**	**Infrastructure limitations**
Release of technology which is n feasible, release of new variety whic may lead to loss of locally availabl variety and may cause other adver effects which leads to social an economic impacts and ext payments by subjects for procedur not otherwise required, loss of wage	occurrence of researcher an participants personal destructions th behave abnormally whe performing jo	Infrastructure limitations as risk is a potenti loss occurred i the institute du to failure c basic service facilities an
2	2	4
5	3	4
2&5	**2&3**	**4&4**
10	**6**	**16**
Stop releasing the product to th community, and immediate sho and\or long term actions should tak to fix the problem.	Reducing workplace stres consulting wit workers to creat	• strengthe cooperation an collaboration with othe
Researchers Biosafety tea EBTi	Finance an corporate directorate, DC	Finance an corporate directorate, DC

Chapter 5

Conclusion and Recommendation

5.1 Conclusion

Due to the advancement of Nanotechnology in the manufacturing of fiber or yarns including the development of fabric finishes, the applications and scopes are widespread in the area of textiles for the last few decades. According to this research study the existence and the application of Nano technologies with in Ethiopian textile industries are very minimal or we can say it does not exist.

This research paper focused on problems like where Ethiopia stands in the world of Nanotechnology, determine the importance of Nanotechnology for Ethiopian Textile industry development, determine the current practice of Nanotechnology application in Ethiopian Textile Industry in order to know who are responsible for adopting nanotechnology by recognizing stakeholders and technology enablers and mainly develop a strategy for expanding the application of Nanotechnology to contribute towards accelerated development of Textile industries in Ethiopia.

So we listed enablers which will introduce Nanotechnology to Ethiopia and implement this well advanced technology but our goal is to show which of the four enablers is best suited to implement it. We listed all technology enablers for our comparison and used one of multi criteria decision making method MCDM namely Analytic Hierarchy Process (AHP) to rank which is more effective to implement Nanotechnology.

According to the analysis done by AHP model the goal was to choose the best alternative out of the four and Alternative 1 which is Government ranked 1st.

Government can mobilize market, technical, financial institution and socio economic activities to introduce Nano technology within textile manufacturing industries. The introduction and implementation of Nano technology by the government with in textile manufacturing industries could be easier than the other alternatives.

Government is a national research and development center with priority areas established that focuses on converging technologies that enhance human performance. Organizations should provide leadership to coordinate the work of other institutions and must accelerate convergence by supporting new multidisciplinary scientific efforts while sustaining the traditional disciplines that are essential for success. Special effort will be required to identify future technological developments; explore their implications for human performance; study unexpected consequences of NBIC developments; and consider ethical, legal, and policy issues. Governments must provide support for education and training of future NBIC workers and to prepare society for the major systemic changes envisioned for a generation from now. Policymakers must envision development scenarios to creatively stimulate the convergence. Ethical, legal, moral, economic, environmental, workforce development and other societal implications must be addressed from the beginning, involving leading NBIC scientists and engineers, social scientists and a broad coalition of professional and civic organizations. Research on societal implications must be funded, and the risk of potential undesirable secondary effect must be monitored by a government organization in order to anticipate and take corrective actions. Tools should be developed to anticipate scenarios for future technology development and applications.

5.2. Recommendation

As future recommendation I would advise future interested researchers to focus on

- The business ecosystem is the network of organizations including suppliers, distributors, customers, and competitors, government agencies, and so on involved in the delivery of a Nanotechnology specific product or service through both competition and cooperation. The idea that each entity in the ecosystem affects and is affected by the others, creating a constantly evolving relationship in which each entity must be flexible and adaptable in order to survive as in a biological ecosystem.

- Discuss the effects of Nanotechnology on social factors since Nanotechnology is being predicted as the next technological revolution. Thus, the products manufactured from it will be affecting both our lifestyle and our economy. It has been predicted that a huge workforce will be required to develop this and people from all areas of science and engineering will be required in its development.

- Discuss the application of Nanotechnology with regard to Ethiopian textile industries as it is being predicted as the next technological advancement and focus on
    - Rules and regulations to follow while using nanotechnology
    - Socioeconomic factors
    - Review application areas used in the textile industries

Reference

(n.d.).

(EIAR), E. I. (2017). Cotton Research Strategy 2016-2030. *Cotton Research Strategy 2016-2030*. Addis Ababa, Ethiopia, Ethiopia: Ethiopian Institute of Agricultural Research (EIAR.

https://www.investopedia.com/terms/b/business-ecosystem.asp#:~:text=Moore%20defined%20the%20business%20ecosystem,themselves%20members%20of%20the%20ecosystem. (2022, September 1). Retrieved 2022, from Investopedia.

A.P.S. Sawhney, B. C. (2014). Modern Applications of Nanotechnology in Textiles. *Research gate*, 11.

Abate, B. (2018). Nanotechnology Applications in Textiles. *ResearchGate*, 38.

aitex. (2020). *aitex textile research institute.* Retrieved 4 11, 2020, from aitex textile research institute: https://www.aitex.es/smart-textiles-ict-solutions/?lang=en

Akpan, P. U. (2015). Nanotechnology Status in Africa (1995-2011): A Scientometric Assessment. *Researchgate*, 10.

Alebel Bayrau, F. B. (2014). *An Institutional Assessment of the Cotton and Sugarcane Commodities in Ethiopia: The Climate Change PerspectiveThe Climate Change Perspective.* Addis Ababa: Ethiopian Development Research Institute(EDRI).

AmericanBarAssociationRuleofLawInitiative. (2017). Ethiopian Textile Industry. *Rle of LawIntititive*, 13.

Anne L. Clunan, K. R.-H. (2014). *Nanotechnology in a Globalized World:Strategic Assessments of an Emerging Technology.* Monterey: Project on Advanced Systems and Concepts for Countering WMD (PASCC).

anu.edu.au. (2022, 9 20). *ANU_Risk_Assessment_Matrix.* Retrieved 9 20, 2022, from anu.edu.au: https://services.anu.edu.au/files/document-collection/ANU_Risk_Assessment_Matrix.pdf

Anza-vhudziki Mboyi, I. K. (2017). Nanoscale development and its application in multidisciplinary area: An African perspective. *Research gate*, 17.

Asghar Azizian1, S. K. (2019). Inhibitory Effect of Nano-gel/Emulsion of Chitosan Coating Incorporated with Ziziphora Clinopodioides Essential Oil and Nisin on Escherichia Coli O157:H7 Inoculated in Beef at Cold Storage Condition. *journa of nutrition fasting and health*.

Awny, M. M. (2005). Technology transfer and implementation processes in developing countries. *Reserachgate*, 8.

BETin. (2022). *Quality Objectives of Nanotechnology Directorate.* Addis Abeba: BETin.

Betsy Burton, e. a. (2017, July 12). *8 Dimensions of Business Ecosystems*. Retrieved august 27, 2022, from www.gartner.com: https://www.gartner.com/smarterwithgartner/8-dimensions-of-business-ecosystems

BIOANDEMERGINGTECHNOLOGY. (2022). *Context of organization.* Addis Abeba: BIO AND EMERGING TECHNOLOGY.

Boogaard, K. (2022, May 13). *https://www.wrike.com*. Retrieved 09 19, 2022, from https://www.wrike.com: https://www.wrike.com/blog/what-is-risk-matrix/#What-is-a-risk-assessment-matrix-in-project-management

By Luis Benavides, R. K.-P. (April 21, 2017). Mastering the enablers of a sustained digital journey. *McKinsey&Company*, 15.

Chen Jun, a. G. (2010). Perspective on Devolpment of Nanotechnology In Textiles. *Advanced Materials Research Vols 113-116*, 5.

Chow, C. (2008). NANOTECHNOLOGY IN TEXTILE INDUSTRY AND ADVANTAGES. *MicroNano2008*, 3.

Chowdhury, N. (2014). Regulatory Supervision of Emerging Technologies: A Case for Nanotechnology in India. *Research gate*, 5.

daily, S. (2019). Nanotechnology's Miniature Answers To Developing World's Biggest Problems. *Science daily*, 5.

Dan Dumitru Ionescu, Elisabeta Jaba. (2013). The Investments in Education and. *Journal of Knowledge Management, Economics and Information Technology*, 19.

Demissie, M. (2021). Towards an African nanotechnology future Trends,impacts and opportunities. *Researchgate*, 79.

DEVELOPMENT, U. N. (2020). *Science, Technology and Innovation Policy Review of Ethiopia.* United Nations publication.

Dissanayake, M. L. (2018). Nanotechnology for developing countries. *Ceylon Journal of Science*, 2.

Dnyaneshwar Chaudhari, P. T. (2018). Review on Nanotechnology & Its Application in Coating Industry. *Research gate*, 13.

Dr. A. Damodaran, P. I. (2014). *Committee on Development and Intellectual Property (CDIP).* Geneva,: wipo.

DRT), D. D. (2014). *A Survey of Ethiopian Manufacturing sector.* DAB Development research and training PLC(DAB DRT).

EhiopianIndustrialParkDevelopmentCorporation. (2015). *Ehiopian Industrial Park Development Corporation.* Retrieved 2 9, 2020, from Ehiopian Industrial Park Development Corporation: http://www.ipdc.gov.et/index.php/en/investment-opportunitiesmm/priority-sectors

Engineering, T. R. (2004). *Nanoscience and nanotechnologies:opportunities and uncertainties.* UK: Latimer Trend Ltd, Plymouth.

Ezema, I. C. (2014). Initiatives and strategies for development of nanotechnology in nations: a lesson for Africa . *researchgate*, 9.

FAS, A. (2019). *Ethiopia Cotton Production Annual.* Addis Ababa: USDA Foreign Agricultural Service.

Fiber2Fashion. (2014, march). *Fiber2Fashion.com*. Retrieved 4 11, 2020, from white Biotechnology in textile processing: https://www.fibre2fashion.com/industry-article/7286/white-biotechnology-in-textile-processing

Gaidau, D. C. (2017, 12 31). *www.nanosafeleather.eu/.* Retrieved 2 11, 2020, from www.nanosafeleather.eu/: www.sinn.eu: www.siinn.eu/en/joint-calls/2013-second-siinn-call/call-2-funded-projects/nano-safe-leather/,170.html

Gudeta, B., & Egziabher, A. G. (2019). Cotton production potential areas, production trends, research status, gaps and future directions of cotton improvement in Ethiopia. *Greener Journal of Agricultural Sciences*, 8.

Gupta, D. (2001). Biotechhnology applications in textile industry. *Indian Journal of Fibre and Textile Research* , 8.

Gutierrez, E. (2004). *epic.org*. Retrieved 9 23, 2020, from https://www.epic.org/: https://www.epic.org/privacy/nano/

Hall, B. H. (2014). The Financing of Research and Development. *Research gate*, 26.

Haque, M. (2019). Nano Fabrics in the 21st century: a review. *Asian Journal of Nanoscience and Materials*, 18.

Harish Singh, K. S. (2015). application of nanotechnology in steel industry. *Research gate*.

HAYES, A. (2021, January 20). *Investopedia*. Retrieved August 12, 2022, from Investopedia: https://www.investopedia.com/terms/b/business-ecosystem.asp#:~:text=Moore%20defined%20the%20business%20ecosystem,themselves%20members%20of%20the%20ecosystem.

Hebatallah Adam, A. Y. (2019). Economic Impacts of Nanotechnology Industry: Case Study on. *Elsevier*, 17.

Iftikhar, M. A. (2017). A Study on Fuzzy AHP method and its applications in a "tie-breaking procedure". *Global Journal of Pure and Applied Mathematics*, 12.

Ikechukwu C Ezema, P. O. (2014). Initiatives and strategies for development of nanotechnology in nations: a lesson for Africa and other least developed countries. *springer open journal*, 8.

Jain, G. P. (2020). Assessing the nanotechnology on the grounds of costs, benefits, and risks. *springer*, 10.

Jain, G. P. (2020). Assessing the nanotechnology on the grounds of costs, benefits, and risks. *springer*, 10.

Janusz Zięba, M. F. (2006). Textronics – Electrical and Electronic Textiles. Sensors for Breathing Frequency Measurement. *Department for Automation of Textile Processes, Faculty of Textile Engineering and Marketing Technical University of Łódź*, 6.

Joanna Szmyt, P. D. (n.d.). *Textronics Evolution of intelligent textiles.* Reserch and innovation centre PRO-AKADEMIA.

Joseph P. Lane, M. (2017). Understanding Technology Transfer. *Research gate*, 16.

julia M.Phillips, P. (2013). Nanotechnology Infrastructure. *NNI Strategi Plannng Stakeholder workshop*, 14.

K.Mekonen, Y. (2013). *Ethiopia: The land, Its People, History and Culture.* Dar es Salaam, Tanzania: New Africa Press.

knowledge, T. D. (2019). *https://www.textiletoday.com.bd/top-ten-latest-technology-introduced-in-textile-3/.* Retrieved march 16, 2020, from https://www.textiletoday.com.bd/top-ten-latest-technology-introduced-in-textile-3/: https://www.textiletoday.com.bd/top-ten-latest-technology-introduced-in-textile-3/

Langnhove, L. V. (2007). *Smart Textiles for Medicine and Healthcare: Materials, Systems and Applications.* Cmbridge, England: WOODHEAD PUBLISHING LIMITED .

Lauterwasser, D. C. (n.d.). *Opportunities and risks of Nanotechnologies.* OECD.

Lech Ozimek1, E. P. (2010). NANOTECHNOLOGIES IN FOOD AND MEAT. *Acta Scientiarum Polonorum, Technologia Alimentaria*.

Lei Qian, J. P. (2004). Application of Nanotechnology for high performance textiles. *JOURNAL OF TEXTILE AND APPAREL, TECHNOLOGY AND MANAGEMENT*, 7.

M. Garside. (2020). *Global nanotechnology market value 2010-2020.* Nanotechnology global market value.

Maclurcan, D. (2015). Nanotechnology and Developing Countries – Part 1: What Possibilities? *Research gate*, 11.

Makoni, M. (2010). Southafrica uses nanotech against TB. *SciDevNet*, 9.

MD ERSHADUL KARIM, P. A.-S. (2014). NANOTECHNOLOGY WITHIN THE LEGAL AND REGULATORY FRAMEWORK: AN INTRODUCTORY OVERVIEW. *Malayan Law Journal Articles*, 12.

Medallia. (2013, february 11). *https://www.checkmarket.com/blog/how-to-estimate-your-population-and-survey-sample-size/.* Retrieved 04 2022, 2022, from https://www.checkmarket.com/blog/how-to-estimate-your-population-and-survey-sample-size/: https://www.checkmarket.com/blog/how-to-estimate-your-population-and-survey-sample-size/

Miles, D. S. (2017). STAKEHOLDER THEORY CLASSIFICATION, DEFINITIONS AND ESSENTIAL CONTESTABILITY. In S. Miles, *Stakeholder Management* (pp. 21-47). Australia: Emeraldinsight.

Mochammad Sobandi Dwi Putra, S. A. (2018). Fuzzy Analytical Hierarchy Process Method to Determine the quality of Gemstones. *Hindawi*, 7.

Muhammad Waris, S. P. (2019). An Application of Analytic Hierarchy Process (AHP) for Sustainable Procurement of Construction Equipment: Multicriteria-Based Decision Framework for Malaysia. *Hindawi*, 21.

Muntha, P. (2016). Pharmaceutical Nanotechnology - Applications of Nanotechnology in Pharmaceutics. *Research and Reviews: Journal of Pharmaceutics and Nanotechnology*, 7.

Muthu Thiruvengadam · Govindasamy Rajakumar. Ill-Min Chung. (2018). Nanotechnology: current uses and future applications in the food industry. *springer*, 13.

Nanotechnology, T. P. (2018). *The New Ecologist*. Retrieved august 27, 2022, from The New Ecologist 2018: http://www.thenewecologist.com/2016/11/disadvantages-nanotechnology/

National nanotechnologyinitative. (n.d.). *https://www.nano.gov.* Retrieved from https://www.nano.gov: https://www.nano.gov/you/nanotechnology-benefits

Omer Mahmoud, O. k.-H. (2012). Technology Transfer in Developing Countries. *Research gate*, 6.

Oqubay, A. (2018). *Industrial Policy and Late Industrialisation in Ethiopia.* African development bank group .

P. a. (2017, september 14). *Positive and negative effects*. Retrieved august 27, 2022, from Positive and negative effects: https://www.positivenegativeeffects.com/nanotechnology

PETER A. SINGER, A. S. (2019). Harnessing Nanotechnology to improve Global Equity. *singer*, 13.

Prof. Babajide Alo, P. (n.d.). *https://www.who.int/ifcs/documents/forums/forum6/ppt_nano_alo.pdf*. Retrieved 9 23, 2020, from https://www.who.int/ifcs/documents/forums/forum6/ppt_nano_alo.pdf: https://www.who.int/ifcs/documents/forums/forum6/ppt_nano_alo.pdf

R. Kalpana Sastry, H. R. (2011). Nanotechnology for enhancing food security in India. *Reserch gate*, 12.

Radwan, N. (2014). What is the difference between AHP, Fuzzy AHP, Fuzzy Logic and Fuzzy Delphi method?. Retrieved from: https://www.researchgate.net/post/What_is_the_difference_between_AHP_Fuzzy_AHP_Fuzzy_Logic_and_Fuzzy_Delphi_method. *researchgate*.

Rani, A. M. (2008). A sustainable development tool for textile sector. *The Indian Textile Journal* .

Rediguieri, C. F. (2009). Study on the development of nanotechnology in advanced countries and in Brazil. *Brazilian Journal of Pharmaceutical Sciences*, 12.

Rezwan Mahmud, F. N. (2017). Application of Nanotechnology in the field of Textile. *iosrjournals*, 6.

ROSS, S. (2019, july 22). *Investopedia*. Retrieved 12 31, 2020, from Investopedia: https://www.investopedia.com/ask/answers/043015/what-are-benefits-research-and-development-company.asp

Roy, M. M. (2017). Feasibility Studies and Important Aspect of Project Management. *International Journal of Advanced Engineering and Management*, 4.

Saaty, T. (2001). *Decision Making with Dependence and Feed Back.* University of Pittsburg, Pittsburg: RWS publications.

Salerno-Kochan, R. (2014). The foresight technologies for textile industry. *Reserch gate*, 11.

Satty, T. (1980). *The Analytic Hierarchy Process.* new york: Mcgraw Hill.

sawahel, w. (2013). Nanotech filter may protect farmed fish from fungus. *Sci DevNet*, 4.

Sekhn, B. S. (2010). Nanotechnology, Science and Applications 2010:3 1–15. *Dove press journal*.

Sims, M. C. (2002). *CONVERGING TECHNOLOGIES FOR IMPROVING HUMAN PERFORMANCE.* Arlington, Virginia: World Technology Evaluation Center (WTEC), Inc.

Singh, M. (2020, march). *https://www.fibre2fashion.com/.* Retrieved 4 11, 2020, from fibre2fashion: https://www.fibre2fashion.com/industry-article/4653/biotechnology-a-boon-to-textile-industry

Srinivas, K. (2016). The role of nanotechnology in modern textiles. *Journal of Chemical and Pharmaceutical Research*, 8.

Srinivasan K, R. K. (2018). Nanotechnology Trends in Fashion and Textile Engineering. *Curr Trends Fashion Technol Textile Engineering* , 4.

Subrata Chandra Das, D. P. (2014). APPLICATION OF NANOTECHNOLOGY IN TEXTILES: A REVIEW. *Research gate*, 7.

T. STEGMAIER. (2012). Recent advances in textile manufacturing technology. *Woodhead Publishing Limited*, 18.

Tatalovic, M. (2019). Nanotechnology: a blessing or a curse for developing nations? . *SciDevNet*, 8.

Tbebu, H. (2018, May 26). *https://allafrica.com/stories/201806010374.html.* Retrieved from https://allafrica.com/stories/201806010374.html.

Trust Saidi, T. S. (2017). Nanotechnology in South Africa – Challenges in evaluating the impact on development. *Researchgate*, 2.

UNCTAD. (2004/5). *Facilitating Transfer of Technology to Developing Countries: A Survey of Home-Country Measures.* New York and Geneva,: UNITED NATIONS PUBLICATION .

UNCTAD/ITE/IPC/. (2004/5). *Facilitating Transfer of Technology to Developing Countries: A Survey of Home-Country Measures.* New York and Geneva,: UNITED NATIONS PUBLICATION.

Walczak, S. (2013). NEW DIRECTIONS OF INTEGRATION OF DIFFERENT DISCIPLINES OF SCIENCE AS ILLUSTRATED BY THE EXAMPLE OF TEXTRONICS. *Research and Innovation Centre Pro-Akademia*, 7.

Westra, J. (2014). *Assessing health and enviromental risks of nanoparticles.* Bilthoven, The Netherlands: National Institute for Public Health and the Environment.

Y. W. H. Wong, C. W. (2006). SELECTED APPLICATIONS OF NANOTECHNOLOGY IN TEXTILE. *AUTEX Research Journal, Vol. 6*, 8.

ZARAH, L. (2020, DEC 30). *owlcation*. Retrieved 12 31, 2020, from owlcation: https://owlcation.com/academia/Why-Research-is-Important-Within-and-Beyond-the-Academe

Zeki İpek, Ali Derya Atik, Şeref Tan and Figen Erkoç. (2020). Awareness, exposure, and knowledge levels of science. *Issues in Educational Research*, 22.

Annexes I

Questionnaire for Assessment of Nanotechnology in Ethiopian Value Chain of Textile Industry

To solve Multi Criteria Decision Making (MCDM) by Analytic Hierarchy Process (AHP)

Age

Place of work

Position

Educational back ground

Below I have listed criteria and alternatives. The hierarchy has been structured and Intensity of importance has been defined. After setting priorities we proceed to synthesis and we check for the consistency.

This research uses AHP model to solve the following questionnaire

What is AHP model?

AHP model uses mathematical approach based on metrics algebra. It has been used as a tool to identify the importance of criteria in decision making or problem solving to achieve a goal. AHP bringing the qualitative and quantitative approach in research and combines it into the context as a sole empirical question. AHP applies the qualitative approach to restructure problems into hierarchy which is more systematic. On the other hand, based on a quantitative approach, it uses more of the comparison method of pair-wise to obtain responses and reliability that are more consistent through questionnaire forms.

Selected candidates will help us by establishing the priorities by

1. Fill the AHP table below as seen in the example. please access this link to know how to fill the AHP model table (https://youtu.be/J4T70o8gjlk)

Below are Criteria, Sub criteria and Alternative

CRITERIA AND SUBCRITERIA

Criteria's are

- Market
- Financial
- Socio - economic
- Technical
- Institutional

Alternative in Ahp model are

- Alternative 1 Government
- Alternative 2 Academe and professional societies,
- Alternative 3 Individual and private sectors and
- Alternative 4 Non-Governmental Organizations

2 Fill the AHP table below using the intensity of importance by using the example below

Intensity of importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the element
3	Moderate importance of one over the other	Experience and judgment slightly favor one element over another
5	Essential or Strong importance	Experience and judgment strongly fever one element over another
7	Very strong importance	An element is strongly favored and its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of

		affirmation
2,4,6,8	Intermediate value between the two adjacent judgments	Compromise is needed between two judgments

i. priorities of the four criteria in terms of overall goals

Criteria	Market	Technical	Financial	Institutional	Socio-economic
Market					
Technical					
Financial					
Institutional					
Socio-economic					

ii. Priorities of the four alternatives in terms of the Market criteria

Market	Al 1	Al 2	Al 3	Al 4
Al 1				
Al 2				
Al 3				
Al 4				

iii. Priorities of the four alternatives in terms of the Technical criteria

Technical	Al 1	Al 2	Al 3	Al 4

Al 1				
Al 2				
Al 3				
Al 4				

iv. Priorities of the four alternatives in terms of the Financial criteria

Financial	Al 1	Al 2	Al 3	Al 4
Al 1				
Al 2				
Al 3				
Al 4				

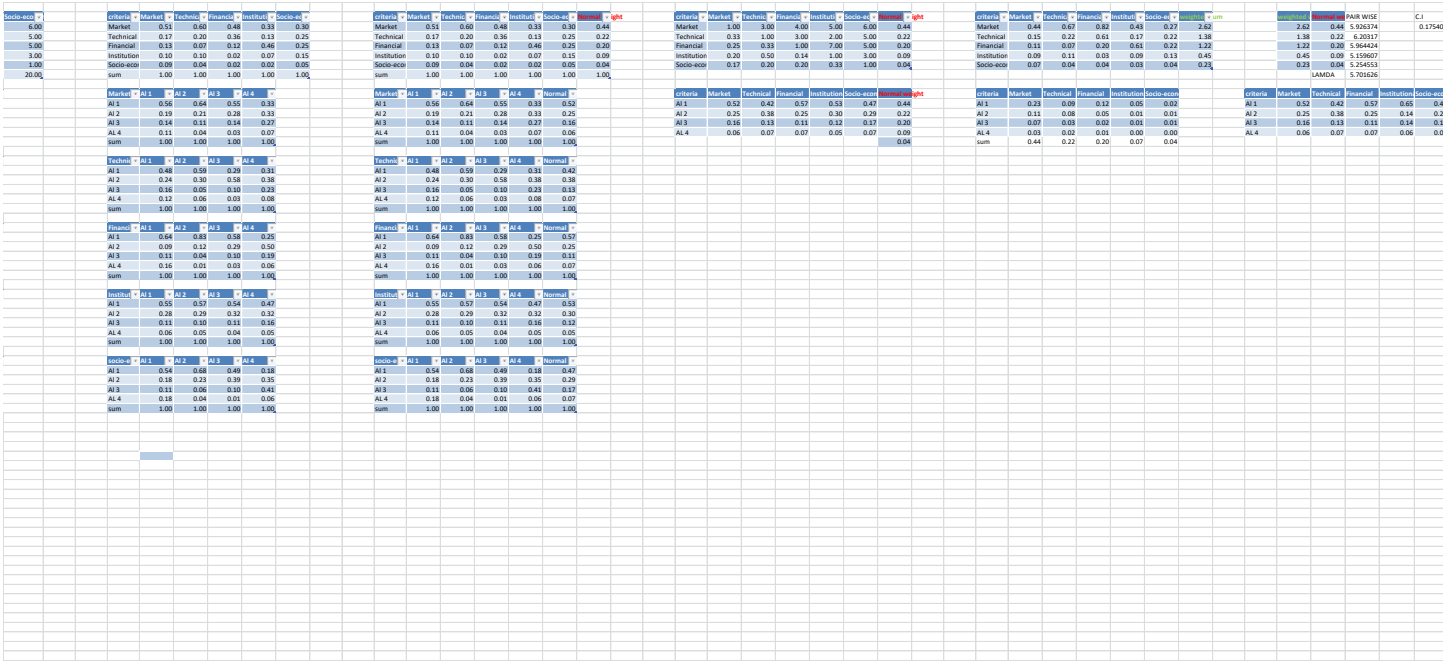
v. Priorities of the four alternatives in terms of the Institutional criteria.

Institutional	Al 1	Al 2	Al 3	Al 4
Al 1				
Al 2				
Al 3				
Al 4				

vi. Priorities of the four alternatives in terms of the Socio-economic criteria

Socio-economic	Al 1	Al 2	Al 3	Al 4
Al 1				
Al 2				
Al 3				
Al 4				

Annexes II



Annex III

Risk	Description	Likelihood	Impacts of Consequence	Risk Score L x C	
Financial	Financial limitation as a risk is the possibility of insufficient money on research projects. It is a threat to the research institutes that can result in the loss of valuable research projects from being accomplished and or being funded.				
Political Instability	change of governments				