

SSPC **MONOGRAPH** SERIES No. 1



NANO TECH: AN EMERGING FIELD IN INDIAN ARMY'S STRATEGIC DEFENCE

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List of Abbreviations

AAA- Anti-Aircraft Artillery
AR- Assault Rifles
ARA- Arms Research Association
BT- Biotechnology
BSF- Border Security Force
CAIR- Centre for Artificial Intelligence and Robotics
CSIR- The Council of Scientific and Industrial Research
CWC- Chemical Weapons Convention
DAE- Department of Atomic Energy
DBT- Department of Biotechnology
DIT- Department of Information Technology
DEW- Directed Energy Weapons
DPC- Defence Production Cell
DRDO- Defence Research and Technology Organization
ELINT- Electronic Intelligence
FATF- Financial Action Task Force
GOI- Government of India
GCHQ- Government Communications Headquarters
GPS- Global Positioning System
HUMINT- Human Intelligence
IB- International Border
IB- Intelligence Bureau
IDSA- Institute for Defence Studies and Analyses
ISIS- Islamic State in Syria and Iraq
IM- Indian Mujahidin
ISRO- Indian Space and Research Organization
IIT- Indian Institute of Technology
ICT- Information and Communication Technology
IOT- Internet of Things

IBG- Integrated Battle Groups

ITBP- Indo- Tibetan Border Police

JUD- Jamat ud Dawa

J&K- Jammu and Kashmir

LET- Lashkar e Taiba

LWE- Left Wing Extremism

LOC- Line of Control

LAC- Line of Actual Control

MOD- Ministry of Defence

NT- Nanotechnology

NSTI- Nanoscience and Technology Initiative

NSAG- Nano Science advisor Group

NATAG- The Nano Applications and Technical Advisory Group

NBC- Nuclear, Biological and Chemical Weapons

OFB- Ordnance Factories Board

OPCW- Organization for Prohibition of Chemical Weapons

R&AW- Research and Analysis Wing

SIGINT- Signal Intelligence

SFF- Special Frontier Force

UAV- Unmanned Aerial Vehicle

UGV- Unmanned Ground Vehicle

WMD- Weapons of Mass Destruction

Chapter 1

Introduction

By 2030 India will be among the top three countries in Science and Technology and will be among the most attractive destinations for the best talent in the world. The wheels we set in motion today will achieve this goal.

- Narendra Modi, The Prime Minister of India

The story of technology is at par with the time human civilization evolved and has been of great importance to fulfil man's grandiose design of power domination. From the days of its evolution, man has had the desire to evolve his knowledge of technology and apply it in diverse areas with the aim of meeting his demands. In the arena of International Relations, technology plays a very important role, as the world leaders are always in a quest of power domination. Technology serves as a driver for many to exhibit their show of dominance to the entire world. With technology as a priority, diplomacy evolved in dealing with each other for mutual benefits and shared interests.

Diplomacy is an act of engaging with other nation-states in order to achieve mutual benefits for national interests and security. The era of the 21st century and beyond is, and will be totally dependent on technological advancements in order to fulfil human's grandiose proposals of power domination. Thus, it's very essential to understand and work in coordination with the diplomats around the globe with the nuances of technology in their day to day activities.

Every diplomat wants to have a higher degree of precision in order to achieve the national goals and objectives abroad. In the same context, engineers and scientists also

want to have a higher degree of precision when it comes to deliverability of technology for national security. The transition from macro to micro has given birth to the idea of miniaturization. The technological advancements have given an edge to Nanotechnology with a focus on the goal of miniaturization.

Science and Technology (Balakrishnan, 2017) have always been important for mankind in order to show power dominance. Some real time examples are the technological advancements achieved during World War- II and the era of the Cold War when many European nations remained economically weak in order to fulfil the desires of winning the war with the act of showing deterrence to the enemy by indulging in the arms race. Since then, technology and sharing of defensive technologies have been made an important factor in carrying out the acts of modern diplomacy amongst nation-states.

Though diplomacy is a strategic act of maintaining relations with other countries, the other concept that comes into the domain is International Security. Only diplomacy won't work to gain advantage over other nation-states in order for oneself to be secure. The nexus of diplomacy, technology and militaries should work together for international security and to address the threats facing a nation being internal or external. In the 21st century it's totally unpredictable for the militaries of the world to understand the nuances of evolving concept of hybrid warfare (Deshpande, 2018), that is completely new to the conventional acts of warfare where there were set battlefields.

In terms of military strength, India is at number 4 in the world's powerful militaries but does India have the ability and capacity to handle the new forms of warfare which is not only nuclear but also dominated by chemical and biological warfare? The foreign policy objectives of India should match with its national security goals in order to withstand the nuances of hybrid warfare. The most critical point to understand is that technologies have not always been inducted into the systems just because they are intentionally good and have certain merits or demerits, instead their induction in defence have some non-technological (Lele, Strategic Technologies for Militaries, 2009) biases that are directly linked to the business interests of the international assets and that's how international security is being traded.

To safeguard the nation from external threats, which are always unknown in the present scenario of evolving warfare, the military have to be on head-on-eye with the technological advancements in order to tackle all the perceived and unrecognizable threats emanating from the hybrid warfare. Nuclear warfare, at times, is a mere act of deterrence for nations towards each other with a common threat of no first use policy. But, the evolving use of chemical agents with biological enzymes in order to increase the number of targets is a serious issue of concern.

The Indian defence policy makers should take this into consideration while framing the defence budget and also the technologies to be introduced into the infantry domain of Indian Army for the safety of our soldiers in a direct combat area. The technology that should act as a blockade for these chemical agents and biological enzymes has to be lighter, faster and act as a stealth agent for the soldiers. Nanotechnology is a small but powerful technology to provide camouflage to the army in tackling biological enzymes and chemical agents, thus tackling the nuances of hybrid warfare at large.

The origin of Nanotechnology goes back to 1974 when a professor introduced the term molecular machining (Kharat, 2006) and also in recent time in 1986 when it was felt that this technology is a general purpose technology. In Chapter 3, later in the monograph, we will be discussing in detail what nanotechnology is and how it emerged from a general purpose technology to the technology most suited for military purpose. Nanotechnology basically deals with atoms at a molecular level that is at the Nanoscale (approximately 1-100 nm).

The technology is also cost effective when it comes to its usage in the defence industry. The potential of Nanotechnology was realized first in India in the year 2001 when the government launched a Nano Science and Technology Initiative (NSTI) as a mission mode program with an annual budget of 65 million INR under the Department of Science and Technology, Government of India. Particularly focusing on defence, India's Defence Research and Development Organization (DRDO) along with the Ordnance Factories Board (OFB) is currently working in the areas of sensors, high energy applications, stealth and camouflage, Nano electronics and characterization.

Based on the existing level of technology, many argue that many applications of Nanotechnology might need two to three decades to mature.

Among all the Indian Defence Forces, Indian Army accounts for the maximum share of the defence annual budget (Behera, 2019) -- that is 56% of the total expenditure -- and the defence budget allocated is around INR 3, 01,866 crore that includes everything from pay and allowances to the weaponry and modernization of the armed forces (Behera, 2019), which will be further discussed more clearly in Chapter 3.

Biological warfare is a new type of emerging warfare where with the use of biological toxins or infectious agents like bacteria, virus can kill humans at mass level without actually taking into consideration the actual source of attack. Bacillus Anthracis is one of the most deadly biological weapons. But, many scientists and engineers feel that Nanotechnology is the fast emerging frontier as a biodefense. Currently, DRDO is working on developing biosensors for providing camouflage to the infantry soldiers in order to detect the nerve gas agents in the atmosphere. This will be further discussed in detail with chemical agents and their usage as a war agent in Chapter 4.

This monograph's main purpose is to address the issues related to the technological developments in weaponry for militaries, especially in tackling the modern warfare agents like chemical and biological warfare and how especially the Nanotechnology can help as a great stealth for tackling chemical agents and biological enzymes as weapons of silent mass killings. The main argument will be related to the case study of Indian Army's use of Nanotechnology as a camouflage weapon for its own strategic defence. Also, the contrary argument presented will be of Nanotechnology itself being a weapon of mass killings, will it be able to provide a strategic defence to Indian Army and what role does non-state actors have to play will be discussed in Chapter 3.

There are no concluding remarks in the monograph because Nanotechnology is a subject that needs further analysis and research to be developed as a concept of strategic defence to the Indian Army in evolving with the modern warfare agents. Like any other military technology, India should also think upon the countermeasures to address the threats from Nano weaponry, also further research should be carried

out to understand the threats versus countermeasures as the technology is still at its premature stage of development. Chapter 5 will discuss more about the further research to be carried out with the aim of understanding the nuances of Nanotech as a strategic defence for Indian Army.

Chapter 2

Research Methods

2.1 Review of Literature

Science has been associated with the business of fighting ever since the primitive man picked up a club instead of using his bare hands to fight, with little improvisation of spears and bows to their weaponry (Asthana, 2016). Initially the weaponry was made up of wood but then with the evolution of mankind, metals came into existence for weapon development in terms of sword etc. In 212 B.C. the most famous invention that can be recalled in the rescue of soldiers was the Archimedes defensive engines and burning glasses for the defence of Syracuse against the Roman's attack. Throughout history, gradual developments in the field of arms and armament continued and are still in the process of a quantum jump to increase the ability to fight and inflict damage to the enemy with maximum impact.

In the 21st century, the notion of simple fighting has changed to conflicts and more into the concept of wars. With war comes the concept of securing each other at personal, national or international level. In the competition for dominance and control, societies and nations have forged ahead from the basic mastery of technological advancements to the business of killing, and sometimes far beyond expectations (Balakrishnan, 2017). With the evolution of technology, there exists evolution of human mind in terms of dominating capabilities with much higher degree of precision used weaponry against the enemy. Nanotechnology, the technology of small with huge possibilities, came into existence to be used as a weapon that could be light and faster.

Nanotechnology is a generic term given to the production of small nanoparticles that are about one-thousandth of the size of human hair. The word Nano is a Greek word which means dwarf. It basically manipulates the matter at an atomic level and is considered as the fastest technology, thus a highly potential one for the defence

applications (Kharat, 2006). The implementation of nanotechnology can bring a drastic reduction in the price of weaponry production and also the energy used and consumed with an ability to cure many diseases caused due to biological attack by the use of enzymes like anthrax, and other enzymes responsible for Ebola virus spread in order to be used as a defensive weapon against such enzymes.

With the advancement of technology in arms and armaments, there is a need to check their capabilities and thus states have a tendency to show deterrence towards each other by performing military exercises, thus the whole concept of warfare (Altmann, 2004) gets evolved with new advancements coming in.

Nanotechnology is also seen as to have an impact on the science of robotics. The concept of evolutionary robotics is a new method for the automatic creation of autonomous nanobots. Inspired by the Darwinian principle of selective reproduction of the fittest, a robot is viewed as an autonomous artificial organism that develops skills according to the environment and without any hindrance by humans (Nolfi, 2004). In defence, particularly in Indian Army infantry brigade, nanobots could play a significant role when it comes to hitting the enemy with major impact without having any casualty on the human side. Also nanobots can be implied with Nano sensors that can be used in jungle warfare in order to give a surprise element to the enemy and also it can act as a defensive mode for Indian Army infantry soldiers (Asthana, 2016).

Many researchers working in the arena of military technology worldwide, especially focussing on the strategic role of nanotechnology, argue that it has the potential to influence the modern forms of warfare in multiple ways. They argue that lighter, stronger, heat resistant nanomaterials can be used at producing all kinds of armaments ranging from smart uniforms for infantry to strengthening armour and stealth for better defence to the infantry soldiers (Altmann, 2004). Other applications like Nano sized communication devices and Nano sensors for early detection of biological and chemical agents too are used in order to strengthen battlefield surveillance with the objective to monitor equipment health.

One scholar (Balakrishnan, 2017) argues that in the modern warfare it has been essentially important to be able to detect very small devices at sub-microscopic level.

The massive arrays of Nano sensors could be able to determine the outcome of any conflict or war like scenario and could predict the early signs of any mass killings through biological or chemical agents and could act as a defensive shield against them. As compared to nuclear weapons, termed as the weapons of mass destruction (WMD), Nano weapons are easy to build and handle, and thus offer lighter and faster stability for combat operations.

Nanotechnology alone cannot solve the issue of combat preparedness against biological and chemical agents; there needs to be redefined strategy with the nexus of information technology and biotechnology to address the issues related to military utility of any manner (Lele, Strategic Technologies for Militaries, 2009). There seems to be a lot of potential in the use of nanotechnology for military, but there also exists certain risks when it comes to combining this technology with civilian uses argues a researcher from United States of America in his report titled, *Military Uses of Nanotechnology and Converging Technologies: Trends and Future Impacts* (Neve, 2012).

With the involvement of Information Technology, Evolutionary Robotics and Biotechnology with the mere concepts of physics and chemistry, nanotechnology has seen a new form of growth when it comes to improving battlefield surveillance systems with light and faster communication networks, thus improving the stealth of the infantry and signal regiments in the Network Centric warfare. The use of nanotechnology with self-assembled Nano networks will improve the situational awareness capabilities of the military (Deshpande, 2018).

In India, the research on Nanotechnology was started in 2001 with a mission mode program launched by the Department of Science and Technology (DST), Government of India named as *Nanoscience and Technology Initiative (NSTI)*. The NSTI was then followed by the Nano Mission in the year 2007 for a five year plan with the annual budget allocation of about INR 10 billion. This Nano Mission was an umbrella program steered by Nano Mission council and was further guided by two advisory groups, The Nano Science advisor Group (NSAG) and The Nano Applications and Technical Advisory Group (NATAG) (Tomar, 2015). Along with DST, other departments that have been involved in research on Nanotechnology are DRDO, The Council of Scientific and Industrial Research (CSIR), Department of Atomic Energy

(DAE), Department of Biotechnology (DBT), Department of Information Technology, Indian Council of Medical Research (ICMR) etc. with a special focus of R&D to build a strong ecosystem having four important pillars (Tomar, 2015):

- Policy makers
- Knowledge generation bodies
- Knowledge transfer bodies
- Knowledge application bodies

The leading economies of the world are spending a significant budget on the military aspects of Nanotechnology. However, along with its advantages of being lighter, fastest and heat resistant, there is also the other side of the Nanotechnology which has some serious implications on human health and environment. Nanomaterials are chemically reactive and thus can easily move into and through the biological systems, thus posing serious health risks. Some nanoparticles can penetrate into the human liver and can pass through the nervous system to the human brain, thus making it dysfunctional within microseconds. Also, Nano-powders pose a great threat to the environment and human health by having an increased risk of dust explosion and ease of ignition (Balakrishnan, 2017).

Even though with an increased risk, Nanotechnology can also be used as a weapon in biodefense to detect the presence of nerve agents in the environment in order to detect possible chemical attacks. A Nano sensor with high sensitivity and stability responds to a non-toxic gas called dimethyl methyl phosphonate (DMMP), when a microelectromechanical system reacts with the tin oxide in the sensor element within the range of very high temperatures in the presence of two electric rods. This is the generalised technique how a typical Nano sensor responds to the detection of nerve agents (Space Daily, 2005).

2.2 Research Questions and Methodology

The method of research is both mixed i.e. qualitative and quantitative analysis. The data is collected on the basis of existing research done till now on the topic keeping in view the timeline of two decades. The research questions thus framed are categorized

in order to provide qualitative study analysis and some eminent research journals and books are referred for studying the political and economic scenarios in which the Indian Army needs to adjust with the changing trends in technology. The research has been done mostly on the basis of data available from secondary sources, but in order to study the need for modernization of Indian Army primary data was collected from the MOD sources. The main objective is to see how the nuances of nanotechnology can help Indian Army in providing strategic defence from the acts of hybrid warfare.

The research questions in the monograph are:

- What potential properties does Nanotechnology possess in order to handle the nuances of hybrid warfare?
- Is Nanotechnology alone sufficient in providing strategic defence to the Indian Army and how?
- What are the risks associated with the use of Nanotechnology as a military utility?

Apart from this, the purpose of this monograph is to find out whether military technologists around the globe have a universal say on the military utility of nanotechnology. Even though many discussions have already been done on this subject, it has now become essential to find out its significance with real time scenario.

The literature referred for this monograph is completely from the secondary sources such as issue briefs, commentaries, secondary reports, journal articles etc. There also exist some limitations and challenges to research on this subject. Being a topic about the military utility of nanotechnology, it is very difficult to authenticate the data available and then rely on it for further research.

But the challenge is to consolidate the research which is available on the subject in isolated form. The nexus of nanotechnology, biotech and AI can help better in providing strategic defence to the soldiers of Indian Army. The role of Indian Army is very important because it alone accounts for 56% of annual defence budget out of the total revenue expenditure.

Also, research has been carried out on how various types of nerve, blood agents can lead to quick death of a thousand lives and why nanotechnology can act as a frontier force multiplier for these agents to get blocked, thus providing lifesaving mechanisms to the soldiers and to see how relevant is the hybrid warfare in the coming future.

The research methodology is more qualitative in nature than quantitative and thus the topic requires more of a practical based approach of study. But the policy makers and technologists have to realize the feasibility of the monograph with regard to the economic viability. Thus, this monograph is completely focused on finding the answers to the above questions with the main argument being the case study of Indian Army in using nanotechnology as a camouflage weapon for its strategic defence.

Chapter 3

Nanotech- the technology of Defence

And it turns out that all of the information that man has carefully accumulated in all the books in the world can be written in this form in a cube of material one two- hundredth of an inch wide-which is the barest piece of dust that can be made out by the human eye. So there is plenty of room at the bottom.

- Richard P Feynman, 1959

3.1 Why Nanotechnology is important in Indian Army's Strategic Defence?

Indian Army is always committed to internal and external defence and security of the nation across the entire spectrum of evolving warfare. Also, in the times of natural calamities, Indian Army always acts as a forefront frontier force in order to provide aid and succour to the affected population (S.Manjula, 2018). The issues in front of the Indian Army in order to defend the nation are much diversified ranging from Jammu and Kashmir (J&K) to the North-east, from ceasefire violations to infiltrations across the International Border (IB) and the Line of Control (LOC). The total length of the IB with Pakistan is about 3400 kilometres and most of the responsibility to protect this border falls on the Border Security Force (BSF). The security situation of J&K is very critical from the point of transforming the domain from conflict stabilisation to conflict resolution. Actual ground level threats also come from counter terrorist operations inside the country with an effort to control terrorists' initiated incidents in J&K. Also, there are the perceived threats emanating from radicalized groups such as Islamic State in Syria and Iraq (ISIS), Indian Mujahidin (IM), Jamat ud Dawa (JuD), Lashkar e

Taiba (LeT) and also the threats from the Left- Wing Extremism (LWE) in the states of Jharkhand and Chhattisgarh.

The North-east shares a 1650 kilometre long border with Myanmar, which is under the control of Indian Army and Assam Rifles. The problem in the North-east is not only limited to Myanmar, but also in the states of Assam, Nagaland and Arunachal Pradesh in the context of Chinese influence. The length of Indo-China border is around 3800 kilometres, including the disputed Line of Actual Control (LAC) region, and the area is safeguarded by the Indo-Tibetan Border Police (ITBP) and the special frontier force (SFF). Also, in the states of Manipur and Meghalaya with the presence of insurgents groups, the fight for Indian Army's strategic defence becomes even more significant. This tends to be the generalized threat scenario for India from a security point of view. The wars of this century have become hybrid and are actually fought at three distinct levels: tactical level, operational level and strategic level. All three levels differ from each other in terms of time involved, persons involved and its objective.

Thus, the role of Indian Army becomes very critical when it comes to securing the nation along varied threats from internal and external attackers. The role of technology becomes even more critical to provide defence to the soldiers in their line of duty in order to have a higher rate of efficiency and effectiveness in carrying out direct combat operations with minimal or no casualties. With the use of technology come the state of the art weapons used by the Indian Army ranging from anti- aircraft artillery (AAA) to armoured vehicles to the modern snipers and assault rifles (AR). With weaponry also comes the intelligence unit because in every war the most critical deciding factor is information. The intelligence gathering mechanism forms the basis of winning or losing any war. The intelligence mechanism should also be updated with technological advancements which comprises of Human Intelligence (HUMINT), Electronic Intelligence (ELINT) and Signal Intelligence (SIGINT). With the changing character of warfare (hybrid), technology has to be at par with the nuances that the soldiers have to deal with.

Nanotechnology provides answer to modern day warfare as this is a faster yet lighter technology and can provide stealth to the army in support of their defence towards

any kind of hybrid warfare agents. Nanotechnology is defined as the technology of small but with huge possibilities, it can manipulate atoms or molecules below 100 nanometres in size. Understanding nanotechnology in itself is very complex but it displays very novel properties when it comes to reliability, power to stealth ratio and the way in which the components are arranged or shaped. The military utility of nanotechnology consists of weapon making, designing, intelligence gathering mechanisms comprising of Nano sensors, nanotubes for transfer of secretive information which comes under electronic and signal surveillance systems of Indian Army. With microelectronics the success rate of information gathering has become very significant in increasing the effectiveness of having strategic advantage over the enemy. Nanotechnology (NT) often acts as an enabler that enhances the applications in exhilarating ways for the army if used in a defensive state. Thus, the technology is expected to become fundamental in the domain of defence industry.

The use of nanotechnology can help Indian Army in numerous ways ranging from sensing of weapons of mass destruction (WMD), provision of combatant defensive kits which includes smart armour and stealthily active camouflage and medicinal sensors in order to protect them from chemical and biological agents in order to serve as the self- healing material. There are also some nerve agents (also known as the nerve gases) which are a combination of some organic chemicals that act as a disruptive mechanism in delivering messages to the human brain through the medium of nerves, thus affecting the central nervous system. The disruption of such kind is caused by the use of nerve agents such as sarin and VX that blocks the acetylcholinesterase, an enzyme which catalyses the neurotransmitters in the human body. These nerve agents have the capacity to immobilize the army within seconds. Thus, these types of agents form the basis of hybrid warfare, which is the warfare of the future and is even more dangerous and catastrophic. Even a minimal exposure to these poisonous nerve agents can cause quick and sudden death. The other chemical warfare agents include:

- Choking agents
- Blood agents
- Vesicants
- Incapacitants

Choking agents are also termed as the pulmonary agents like mustard gas, and are composed of a certain group of special organic compounds that disrupts the normal breathing and thus chokes the respiratory system and can cause quick death; on the same line the blood agents such as cyanide and arsenic are also the type of toxic chemical compounds that are potentially lethal poisonous compounds. Given the changing character of warfare, the probable use of such warfare agents is high in the near future. In the past also, the use of such kinds of lethal weapons has been proved significant. Some examples are listed below:

1. Iraq's use of mustard gas as a choking agent against the Iranian ethnic group Kurds in 1988 is the only large scale use of any chemical weapon.
2. The Tokyo Subway Sarin attack in 1995
3. Sarin gas used in the Syrian Civil War in 2013
4. The use of nerve agent VX for the assassination of Kim Jong Nam, the brother of North Korea's Chairman Kim Jong Un in the year 2017
5. Use of nerve agent for the poisoning of the Russian intelligence officer Sergei Skirpal and his daughter in 2018

These examples explain the severity of modern day warfare where there will be no set battlefields. Thus it becomes very critical for Indian Army and other defence forces to adopt new methods for strategic defence. Technology can be the only solution to cut the nuances of technology. Thus, it has been found that Nanotechnology can act as a defense mechanism against the sensing of these lethal warfare agents and also in order to prevent them from spreading and controlling the diffusion of harmful gases in sensitive environment.

Many researchers have found that effective Nano sensors can easily sense these types of agents and can destroy them before they actually spread or diffuse in the environment. There exist potential nanoparticles that act as an antidote against these agents by purifying a protein from the bacteria that can degrade the nerve agents into non-toxic compounds and when this foreign protein is coated with a gel then it was observed that it helped the object to protect itself from these agents for over a week, and the tests were positive. In order to save the soldiers from perceived threats of chemical and biological agents, it is essential for the Indian Army to incorporate nanotechnology in their state of the art weaponry as a strategic defence mechanism in order to fight the nuances of the hybrid warfare. Nanotechnology can act as a frontier in biodefense for Indian Army with the Ordnance Factories Board (OFB), the Defence production cell (DPC), DRDO taking immediate and effective steps in order to be technologically at par with the changing character of warfare. Also, the use of nanotechnology is now significant in the production of biological mass spectrometers that are used to detect biological warfare agents (Lele, Strategic Technologies for Militaries, 2009). At present, nanotechnology possesses some unique chemical, physical and mechanical properties that are potentially useful for diverse uses in military applications. These novel properties actually have the potential to improve the existing weapons and military hardware systems such as improving the strength to width ratio in order to have more stealth applications.

3.2 Biomedical Applications of Nanotechnology for Indian Army

The military applicability of nanotechnology has been seen clearly in section 3.1. With nanotechnology being significant in delivering the state of the art weapon systems in fighting the modern forms of warfare, another technology that is known to be the sister of nanotechnology is biotechnology and both these technologies are the future of Indian defence in order to provide strategic advantage to the Indian Army. Throughout history we have seen that the military activities and life sciences are intertwined (Lele, 2009). Over the years it has been observed that the science of biology has helped in saving lives of many soldiers whether be it in reducing the number of casualties in direct combat operations or the use of biotech in saving soldiers from the effect of lethal poisonous agents. With biotechnology comes the science of protein engineering which in unison have been found significant in Nano sensors applicability of sensing and destroying the effects of biological warfare agents.

The use of bioweapons has been very significant in the human history since World War II era. The weaponization of diseases actually began in the early 1970's. The first gene was cloned in the year 1973 and that impacted the whole business across the globe in the weaponry mechanisms with more importance being given to research in genetic engineering. The militaries started gaining intelligence on the readily available mechanisms related to genetic engineering that could change the whole arena of warfare. The intelligence agencies across the world started harnessing data on genetic engineering and also developed strategies in order to defend the army and forces from the perceived threat of the new form of bioweapon.

The Indian Army has a fundamental and significant role to defend and secure the country from these new threats of hybrid warfare. Thus, the government has to allocate a reasonable budget for research in Nano biotech to be granted to the Indian Army and the Defence Production Cell (DPC) in order to provide the army with the best state of the art weapon systems for tackling the weaponization of diseases by the other state or non- state actors for its own strategic defence.

Thus, the connection of nanotechnology with biotechnology can help save lives of thousands of soldiers, who can be the direct targets of the weaponization of diseases. Nano bio sensors can easily be incorporated in the human body in order to monitor and disintegrate the effects of the bad tissues or cells that can affect the central nervous system of a person thus resulting in quick death. In this changing state of character of warfare, infected blood or cells can be easily transfused into the human mainstream thus affecting the whole ratio of oxygenated to deoxygenated blood, and can cause blood cancers and thus these infected cells can easily affect the population at a large scale. Nanotech with its application of miniaturization can be well used in medicine for easy diagnosis of disease and can be well treated on time in order to reduce its effect (Choe, 2010).

Hence, in-depth research has to be carried out to see how the manipulation of tissues at a nanoscale has to be carried out for better system delivery mechanisms to be in place for early detection of blood agents in the human body. An integrated chip based mechanism has to be worked in place for better tracking and monitoring of soldiers in Indian Army being exposed to the nuances of the toxic blood agents that have the potential to kill armies of army. Nanotechnology is the only technology that has the novel properties to manipulate the physical and chemical properties of cells and tissues at a nanoscale in the human body and thus can save the lives of many soldiers from this menace of bioweapon, the future of warfare. The military utility of Nano - biotechnology has seen a significant research in the areas like (Lele 2009),

- Therapeutics: drug delivery mechanisms, genomics
- Electronics and Computing: protein based devices, biomedicine hybrid chips
- Materials: tissue and protein engineering, hybrid materials
- Logistics: miniaturization of biological devices

3.3 The convergence of Artificial Intelligence and Nanotech for the better preparedness of Indian Army

Artificial Intelligence (AI) is the future of technology in terms of military utility and the effectiveness with which this technology delivers. Since AI imitates normal human intelligence, it has the power to revolutionize the way human beings think, live and even eat. It basically deals with the simulation of the intelligent behaviour of the computers. A lot of studies are being undertaken at present on AI. But the efforts need to be very serious when it comes to research on artificial intelligence because this has the ability to empower our national security and thus can enhance the economic prosperity of the country.

Indian Army has been using AI in various areas of its operation such as Unmanned Aerial Vehicle (UAV), Unmanned Ground Vehicle (UGV's), for its intelligence gathering mechanisms, in microelectronics and sensor technology etc. But the critical point is the convergence of this technology with the theory of miniaturization. The convergence of Nanotechnology and Artificial Intelligence is yet to be achieved by the military technologists in India. DRDO has a well-established lab on artificial intelligence named as Centre for Artificial Intelligence and Robotics (CAIR) which focuses on the following areas (Balakrishnan, 2017):

- AI, robotics and advanced systems
- Command, control, communication and surveillance systems
- Communication secrecy
- Communication and networking strategy building

The Indian Army has to get prepared for any adversary, and with the hybrid warfare being the futuristic warfare, AI plays a very fundamental role for the defence policy makers to decide on the procurement of weapons from other states and also to learn strategic defence policy for design and producing weapons at home. For example - the chips and micro sensors for LCA (Light Combat Aircraft) Tejas have been successfully developed by CAIR. The Indian Army has always been talking about network centric warfare (NCW) and keeping that in mind the Army is actually planning to introduce a fleet of Integrated Battle Groups (IBG) with directed energy weapons (DEW's) for the act of showing deterrence (Morgan, 2017) to the other states with an ironical objective of "No War, No Peace."

The introduction of AI with nanotechnology in Indian Army will increase the operational capabilities of the force with much focus being given to the modern warfare. The Department of Defence Production (DDP) India should focus on the military utility of the convergence of AI with nanotechnology and how the production capacity can be increased for nanobots; Nano drones like the replica of a housefly which are AI enabled and can have their strategic advantage to provide defence to the army in the network centric warfare. Also, in order to block the effects of chemical and biological agents, AI can be converged with Nano -biotechnology for better delivery of biodefense mechanisms to the Indian Army in the form of Nano chips to be incorporated into the human body which is AI enabled, and thus can measure the mental ability of the soldier with the other body changes, controlling the amount of neurotransmitters and other enzymes being released at the time of sabotage for national security.

Another concept that finds relevance with AI is the Internet of Things. The Internet of Things (IOT) is a concept of smart integration of various devices or equipment to enhance the data gathering and sharing capabilities, thus making it much more user friendly. RFID (Radio Frequency Identification) is a smart way of integrating, identifying and accumulating the data in building the interface for IOT by using radio waves. It is generally used for tracing and tracking inanimate and animate objects. In the present system of network sharing, RFID technology is turning out to be a promising one, an efficient locator to face the heterogeneity and the scalability of the communication framework. This is also useful when RFID enabled tags and chips can be incorporated at a Nano scale into the mainstream tracking of soldiers as an intelligence gathering and sharing mechanism in order to act as a blockade for internal spies.

Some areas where AI with nanotechnology can help in providing strategic defence to Indian Army are:

- Systems for the diagnosis of sophisticated weaponry
- Image interpretation for better target identification
- Nano missile applications and for deciding its trajectory, range and capacity

3.4 Annual Budget allocation to Indian Army and other applications where Nanotech has military utility

With the annual budget comes the defence budget each year that explains the need to spend revenue on the country's national security objectives and also the weapons and armaments to be produced and procured within and outside the state. The average amount allocated to the Ministry of Defence every year is 3 lakh crores to 4.5 lakh crores INR. The total defence budget is divided into three main categories (Behera, 2019):

- India's main defence budget amounting to INR 2.7 lakh crores
- Ministry of Defence (miscellaneous) for INR 16,000 crores
- Defence Pensions accounting for INR 1.3 lakh crores

Of the total annual budget, the Indian Army gets 56% followed by Navy, Air Force and then DRDO and Ordnance Factories. The interim budget of 2019-20 saw an increment of total 7.7% particularly in the defence sector (Behera, 2019). This is aimed at modernization of the defence forces, particularly Indian Army as it holds the maximum percentage of share in the annual budget of the Government of India. In terms of manpower deployment and revenue expenditure, if there has been over 85% of the total revenue expenditure in maintaining the total manpower of the entire defence forces in India, then Indian Army gets 69% of the share out of this. Thus, it explains the critical role that Indian Army plays in securing the country from perceived threats across the International Borders and its demand for modernization to face the nuances of hybrid warfare, which is mostly network-centric. Recently, the MOD has published a report (Meena, 2019) on Artificial Intelligence as an important aspect of force multiplier and has ordered all the line organizations along with the DRDO to establish high level task force on Strategic Implementation of Artificial Intelligence for National Security and defence, and has established a high level Defence Council on Artificial Intelligence (DAIC) with Honourable Raksha Mantri as the Chairman. The annual budget allocated to DAIC is 100 crores for initial research and development to be carried out in the AI sector with focus on AI enabled weapon systems and infrastructure for the Indian Defence forces (Meena, 2019).

The Indian Army is an intensive combat ready fighting force but when it comes to the modernization of army with respect to the budget allocation it always faces the shortage of funds. Public Private Partnership (PPP) model can help modernize Indian Army to enhance the operational capabilities of the force in terms of artillery, weaponry and electronic surveillance systems. The academic institutions, DRDO, Defence Production Cell and Ordnance Factories Board among others should collaborate on research activities to evolve technology that is lighter, much effective and faster and that which can stand at par with the modern day threats of hybrid warfare.

The defence technologists, policy makers and the government should think on the application of Nanotech to provide strategic defence to the Indian Army and other areas where Nanotech can deliver like:

- Directed energy weaponry like lasers
- Nano suits with AI enabled Nano sensors for the soldiers
- Nanotubes for effective delivering of secret data for communication
- Nano missile which is lighter and will have better efficiency with maximum impact
- Nano drones in the shape of small flies that can enhance the operational capabilities of any mission
- Nano medicinal chips that can integrate with the human central nervous system in order to block threats from various blood agents

However, India should not look in isolation to develop this technology, rather it should consider a smart nexus of nanotechnology with Information Technology, Biotechnology etc. in order to carry out further research in the field for the enhancement of the objectives of national security, and should also try to understand the risks that this technology brings along with it.

India and the Hybrid Warfare

The twentieth century can be considered the bloodiest century in recent history due to two world wars, which led the way to the cold war era. The 21st century is built on this historical baggage. With technology coming into the domain of warfare, the entire concept is getting hybrid. There is no place for conventional wars now, where there were set battlefields, and now the character of warfare is completely dynamic. Along with nuclear weapons, there also exists the deadliest weapon in the form of chemical and biological agents that has the ability to kill many people within minutes. These are now termed as WMDs (weapons of mass destruction). Various deadly, lethal poisonous agents like cyanide, anthrax, sarin gas have been used in the past and thus are the new forms of warfare agents that have the capability of killing without actually getting involved in direct combat.

National security is the foremost priority for any state in the domain of International Relations, but in reality it has become one of the most traded concepts across the globe with selling or buying of weaponry as an act of deterrence. The changing character of warfare has affected the relations among states due to the nexus of state and non-state actors in trading this business of war.

In Kautilya's arthashastra there exist four modern types of warfare (Asthana, 2016):

- MantraYudha or the War by Counsel: the exercise of diplomacy to win wars
- Prakasa Yudha or Open warfare: the conventional warfare in order to show your might to your enemy in open battlefields
- Kutay Yudha or Concealed warfare: irregular methods and ambush in the enemy camps
- Guda Yudha or Tusnim Yudha: this type of warfare is waged without actually fighting the battle, it's a silent means of warfare where the enemy is killed with major impact covertly

Today in the 21st century the combination of *Kutay Yudha and Guda Yudha*, will find direct relevance in explaining the methods of hybrid warfare that are silent, covert and irregular. The use of chemical and biological warfare agents today has links with Arthashastra. Only the nomenclature has changed, but the taxonomy and the character remains the same.

Various military strategists and philosophers like Sun Tzu think and argue that wars are not just fights based only on the strength of a military but also supreme excellence to provide resistance to the enemy strategies' (Deshpande, 2018). Thus, hybrid warfare is a relative term for India. As highlighted in previous chapters, Indian Army has a very strategic role to play in defending the nation from asymmetric threats arising from the use of lethal gases or agents. Hybrid warfare has certain elements ranging from using diplomacy to rage short wars everyday with ceasefire violations along the IB by deep state like Pakistan, from cyber deterrence to the act of using blood agents against the armies, from the use of AI enabled drones to the use of Nanoparticles.

The hybrid warfare is also known as the fourth generation warfare which is fought on different fronts, it's more centralized, fluid and dynamic. It's a combination of different tactical moves by the enemy in order to hinder the growth of the nation and can easily target the enemy growth installations without actually waging a real war like scenario, and it's even more impactful.

The most common types of hybrid warfare are the nexus of nuclear, biological and chemical warfare (NBC). Chemical warfare is defined as the use of chemical agents like nerve agents for the act of killing people at a very large scale. This type of warfare is used to cause intentional deaths and has maximum impact. The Chemical Weapons Convention treaty of 1997, which has 193 state parties as signatories, prohibits any development, production and use of chemical weapons as a warfare agent. However, as nation states compete for power dominance and the role of non- state actors and terrorists enters the domain of international security, it has become very difficult to guarantee whether states will respect international laws and treaties. India in particular has to get prepared in order to defend itself from hybrid wars (most likely coming from Pakistan and China), so as to protect its national interests and sovereignty. Thus, the perceived threat of biological and chemical weapons is still a

point of worry for India because when it comes to national security you cannot trust non- state actors and their actions; the only thing that can be done is to enhance our operational capabilities to make it at par with the threats to be faced in the real time war scenario.

In the network centric warfare, which is in itself a hybrid, any number of people, state, data etc. can be destroyed. Social media plays a very critical role in creating rumours and thus amplifying any small scale differences into large scale disputes through propaganda. The changing character of warfare is slightly unpredictable because it's a mixed kind of warfare where there are chemical and biological threats and also the cyber threats exists with the possibility of causing disruptions to the social, political and economic security of any state.

India's strategy has always been defensive capability rather than offensive, thus the disruptions can always be tackled by the nuance of technology that are fast enough to handle them and that is why nanotechnology can act as an emerging field in Indian Army's strategic defence. Indian defence experts and also General Bipin Rawat (Rawat, 2018), the Chief of Army Staff (COAS), believes that the one who starts the use of hybrid warfare is the only sufferer left, while talking in the context of the deep state like Pakistan using hybrid warfare in Jammu and Kashmir.

"Before we launch the hybrid warfare in the offensive-defensive domain, we should be prepared to see what will happen to those people once the objective is achieved. What you do with those people?"

- General Bipin Rawat, (COAS)

Chapter 5

Conclusions

For states, preparing for war is now a dynamic progression. In the 21st century, it's more evident for every state to be at par in terms of its weaponry and military might in order to show deterrence towards each other. For centuries, technology has been playing a critical role in the overall culture of war- fighting. Some practitioners and researchers believe that producing Nanotechnology is feasible and cheap as compared to the development of macro structures. In the initial stages of development cost may be a concern, but it's novel properties provide lighter, faster and reliable applications for life' saving mechanisms.

This monograph is aimed at testing the theoretical knowledge about nanotechnology and to see how this technology can provide huge possibilities to Indian Army in its strategic defence viewing from the changing character of warfare. Some researchers argue that nanotechnology possess very high potential in terms of data sharing and gathering mechanisms to deliver credible intelligence to the army. Information is defined as an important tool or the deciding factor in winning or losing any war. As the 21st century is totally dominated by the network centric warfare, therefore the need is to incorporate nanotubes, microelectronics with Nano sensors into the weapon systems of Indian Army and other defence forces.

There also exist some risks of using nanotechnology: nanotechnology in itself possess some grave risks when used as a weapon for mass killings. Nanoparticles possess novel properties but it also causes damage to human lungs and can penetrate into the human liver thus affecting the whole nervous system and other organs of the human body. With this also comes the risk of social behaviour of using this technology as a weapon against each other which forms the silent basis of warfare for mass killings of armies and thus having strategic advantage over your enemies.

This chapter is divided into two parts; the first part will focus on research findings and will relate how the research question stated in Chapter 2 holds good for Indian Army; the second part will focus on the recommendations and the final argument stating what kind of future research should be carried out. Being one of the largest importers of arms and ammunition, it has become essential for India's defence policy makers and technologists to understand the nuances that this nanotechnology possesses. It is better not to follow ambitious goals regarding this technology, but India should rather work initially on economic viability and the risks for humans and the environment (Altmann, 2004).

5.1 Research Findings

There are two arguments on whether nanotechnology will be able to provide strategic defence to Indian Army or not. The first being that nanotechnology holds very noble physical, chemical and mechanical properties that find its military utility with the nexus of other modern technologies to handle modern warfare; and the second is that nanotechnology in itself possess grave risks to humans and the environment. During the time of preparing this monograph, it was found that other major developing states like USA, Russia, China and Israel are doing very well in military technology and mostly they have AI enabled autonomous assault rifles with much more enhanced operational capabilities. The US has a well-established centre on nanotechnology where a decent amount of research has been done and more studies are underway to relate nanotechnology with biomedicine in order to save lives from the deadly lethal weapons.

Most researchers till now have been focusing on the general military utility of Nanotechnology and how this technology is getting matured with the other technological advancements. Mostly it's having civilian use, but its military utility can't be ignored. Lighter the technique faster will be the machinery. The only argument that was missed generally was the use of this technology by Indian Army in their strategic defence and how the new modern forms of warfare can be tackled like biological and chemical agent centric warfare. Also, the critical point to worry is that very minimal research has been done in order to focus on the self-implications of Nanotechnology as a weapon of mass destruction. The Indian policy makers have to look into the initial investments made into this technology and its tactical advantage in the Nano battlefields. There exists a hypothetical scenario named, "Grey Goo" which involves molecular nanotechnology and therefore can automatically produce self-replicating bots that has the potential to consume all the biomass on Earth and is like the end of the world scenario.

Thus, the main argument that comes out of this is that there exists no consensus among various scholars about the use of nanotechnology and whether it's a boon or a bane for the society and environment.

5.2 Future Research Recommendations

There will be several technical and environmental challenges across the globe for the scientists to carry out further research on the use of nanotechnology with life sciences for its military utility. The unfortunate part is that military research is purely secretive in India and thus private technologists find it a serious challenge to share and exchange their work with defence technologists. In the long run, it's recommended to share the experiences of research between public and private sector in order to save humanity from any adversary. Nanotechnology is a very promising field and thus this monograph offers some important recommendations for future research to be carried out by the policy makers in India, particularly for Indian Army and other defence forces in the country.

- **Recommendation 1:** There is a need to understand what this technology has to offer for military technocrats and a multidisciplinary approach should be followed in order to understand its engagement with the military.
- **Recommendation 2:** In the context of sensor technology for better intelligence gathering mechanisms to tackle hybrid war agents like biological or chemical, biotechnology should be incorporated with nanotechnology because it is very difficult to understand the risks each one of them possess individually.
- **Recommendation 3:** A study of a consolidated mechanism has to take place in the future for a country like India where academic research quality is good but is usually performed in isolation; there exists a dire need to combine IT, AI and nanotechnology for study of military utility.
- **Recommendation 4:** The Indian Army should test on a pilot project what potential nanotechnology holds for their soldiers and weapon systems before directly getting involved in any nuances of war trading with other states.

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Technology has come to play a very important role in the conduct of International Relations today. Technology has in fact been a dominant factor in determining power of any country. With technology as a priority, diplomacy has evolved in dealings amongst states for mutual benefits and shared interests.

Diplomacy is an act of engaging with other nation-states in order to achieve mutual benefits for national interests and security. This monograph titled, “**NanoTech- an emerging field in Indian Army’s Strategic Defence**” focuses on the past research and developments done in the field of Nanotechnology and how this can help Indian Army in handling the nuances of the hybrid warfare which is mostly network centric warfare with chemical and biological warfare agents being the next future of warfare. The paper touches upon the annual budget allocated to Indian Army and discusses how and why Indian Army is accountable for providing defence and security to the nation.

Nanotechnology alone cannot handle this menace of hybrid warfare, but there should be a nexus of nanotechnology with Information Technology (IT), Artificial Intelligence (AI) and Biotechnology (BT). Thus, this monograph lays stress on importance of nanotechnology and where it can find its military utility with special emphasis on the risks associated with the technology. The main argument will be related to the case study of Indian Army’s use of Nanotechnology as a camouflage weapon for its own strategic defence.

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