Metallic preparations being highly efficacious in small doses and having long shelf life, was very popular among Ayurvedic physicians. Modern research on *Tamra Bhasma* have confirmed its efficacy for anti-ulcerogenic, anti-oxidant, anti-hyperlipidemic activities. Toxicity studies of *Tamra Bhasma* have also proved to be safe at the therapeutic drug dose level. Each and every ingredient in the formulation has its own specific role in the body. Exploring the role of Tamra Bhasma in particular formulation in a specific disease conditions can provide guidelines for renewed research in Ayurveda. [13]

A research work carried out in 2017 by R.K. Singh and coworkers[21], reported the preparation of nano-crystalline *Tamra Bhasma* by incineration of pulverised copper wire in an electrical muffle furnace and studied on the physical properties of Ayurvedic nano-crystalline *Tamra Bhasma* with X-ray diffraction analysis, scanning electron microscopy, UV-IR, photoluminescence and magnetometry studies. The XRD results showed that *Tamra Bhasma* has nanocrystalline nature with size less than 100 nm. The SEM micrograph also revealedthat they formed micrometer samples due to agloromation of nanocrystallites. FTIR results indicated that different crystalline oxides and salts of Cu were present in the prepared bhasma. VSM measurement revealed super-paramagnetic nature of the *bhasma* that supports its medicinal value. The antimicrobial study showed effectiveness on both gram positive and gram negative bacteria and was useful in controlling bacterial infections.

In another work, S. Ophale and his team 2022 [22], prepared *Tamra Bhasma* and studied the pre-clinical efficacy of the the drugs on the liver function tests of Wister albino rats. They prepared the *bhasma* by two methods, viz- indirect heat by using sunlight method called *Aputi Tamra Bhasma* and by direct heating method called *Puti Tamra Bhasma*.These drugs were used in elevated Bilirubin and elevated SGOT(serum glutamic-oxaloacetic transaminase) levels in rats. As per results, *Puti Tamra Bhasma* is more effective for elevated bilirubin and *Aputi Tamra Bhasma* for elevated SGOT. Both the drugs were found to be safer for liver functions. No physiological or adverse behavioural change was seen in the rats. Histopathological reports of the kidney for both the drugs also showed normal echo texture.

An analysis of recent literature made by M. J. Wozniak-Budych [23] explored several aspects of the prospects and challengesassociated with copper-based nanomaterials. Biocompatibility of such materials remains a constraint for their conversion from the laboratory to the clinic. Innovative solutions are required to ensure the smoothblending into the human body. Precise design and careful engineering is required to achieve the controlled release of therapeutic agents from copper nanoparticles. In a recent review by I. A. Ivanova and coworkers [24], analysed the application of copper ions and nanoparticles as broad-spectrum antimicrobials. Copper nanoparticles were presented as an alternative to rising antibiotic resistance with basic mechanisms for antimicrobial resistance.

Conclusion :

Billions of people around the globe lack access to safe drinking water and many children die of basic hygiene and water related diseases such as cholera and diarrhoea every year.[8] The public water distribution systems in most developing countries are poorly maintained. Moreover, unsafe storage and handling practices often results in recontamination of drinking water. It is therefore important to develop effective strategies that are acceptable and affordable to the general people and can be implemented at a domestic level. The merits of copper surfaces for their use in improving public hygiene in healthcare facilities and for the purification of drinking water have been highlighted in several studies. As such, copper holds potential to provide a viable and cheaper alternative to provide microbial-safe drinking water to the rural masses in developing countries.

Copper has been utilised for healing and good health for a very long time dating back to the ancient times of the Egyptians and Ayurveda. Its usage by ancient societies was not just based on customs but also on their knowledge of it's therapeutic powers. Copper pots have been used since ages in Indian households and is also socially very acceptable to the people. Copper pots are simply a passive storage of water and does not need power, fuel, filters or sunlight to operate or maintaining the benefits that can be achieved by using copper pots for water sanitisation outweighs its costs.[2] It is important to note that more research is needed to fully understand the extent of copper's potential health benefits. The risk of toxicity from copper is also minimised when used appropriately and under the guidance of a healthcare professional.

Contemporary medical research has opened up new avenues for potential uses of copper. Copper is a beneficial addition to one's health prescription due to its possible health advantages. Copper's value in traditional medicine is evident from its continued use in health and wellness. But, it is also important to consult with a healthcare professional before using any form of alternative medicine. In todays era of modern medicine, it seems difficult to accept the fact that ancient Indian knowledge and medicine system understood the significance of certain metals in the body and turned these otherwise poisonous metals into human assimilable forms. In the last decades, serious doubts rose on safety and efficacy of these herbo-metallo-mineral formulations. The efficacy of these drugs change with the minor changes in the methods of preparation, ingredients etc. The number of expert practitioners have dwindled and those who are prescribing these formulations don't have the sufficient knowledge regarding the method of preparation, dose, appropriate adjuvant, specific and other indications of the formulation etc. As a result, this field has suffered major setbacks. To overcome this degrading situation, systemic and conceptual research in the field of synthesis and uses of these formulations is highly essential. [13]

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Vedic Multipliers in Digital Circuits : A Short Review

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Abstract

The utilization of Vedic multipliers in digital circuits is growing in popularity due to their efficiency. This article provides a review of the Vedic Multipliers based on the *Urdhva Tiryakbhyam (UT) Sutra* from Vedic mathematics. Additionally, the article provides an overview of the diverse application areas where Vedic multipliers are used. By exploring the potential aspects of using Vedic multipliers leading to a technological shift in digital circuits, this review article offers valuable insights into the possibilities of future high speed digital circuit applications.

Keywords: *Digital Signal Processing, Multipliers, Urdhva Tiryakbhyam, Vedic Mathematics, Vedic Multipliers.*

Introduction

Binary addition and binary multiplication are crucial operations for high performance digital computing systems [1]. The multiplier units are the fundamental and most frequently used units of the digital signal processing systems. High operating speed, low power consumption, and design regularity in less area are some of the basic requirements for the VLSI implementation of these devices [2, 3]. The Vedic mathematics-based multiplier designs have shown excellent speed, small size, and power-efficient operations because of their simple and regular architecture [4]. Vedic multiplication minimizes signal propagation time and increases circuit efficiency by concurrently generating partial products and their sums.

The *Urdhva Tiryakbhyam (UT) Sutra* is the most preferred multiplication technique in Vedic mathematics among all the Sutras. This is explained by the *UT sutra's* universal applicability and use of both vertical and transverse multiplication. This article discusses the basics of the *Urdhva Tiryakbhyam (UT) Sutra* and the design of Vedic multipliers based on it. Additionally, this article also discusses the application of the UT based Vedic multipliers in various domains such as arithmetic computing circuits and digital signal processing circuits.

Basics of Urdhva Tiryakbhyam Sutra

Vedic mathematics is an ancient Indian mathematical system that employs sixteen principles known as *'Sutra's* [4]. These principles have effective applications in various mathematical specialties as well as diverse technological domains. The Table-1 presents the categorization of Vedic *sutras* relevant to different areas of mathematics [4]. A significant number of published works appears to employ the *Urdhva Tiryakbhyam (UT) Sutra* among the several *Sutras* in Vedic mathematics. Since the UT sutra can be applied in every situation and utilizes both vertical and transverse multiplication, UT Sutra is the most recommended method for multiplication in Vedic mathematics. The words *Urdhva* meaning vertically and *Tiryakbhyam* meaning crosswise, the term *Urdhva Tiryakbhyam* means Vertically and crosswise.

Table-1: Categorization of Application of Vedic Mathematic Sutras

Sl. no.	Name of Sutras	Meaning of the name	Application
1	*Urdhva Tiryakbhyam*	Vertically and crosswise	Multiplication and Division
2	*Yaavadunam*	Whatever the extent to fits deficiency	Multiplication and Division
3	*Nikhilam Navatashcaramam Dashatah*	All from 9 and the last from 10	Multiplication and Division
4	*Ekadhikina Purvena*	By one more than the previous one	Multiplication and Division
5	*Ekanyunena Purvena*	By one less than the previous one	Multiplication and Division
6	*Paraavartya Yojayet*	Transpose and adjust	Multiplication and Division
7	Puranapuranabhyam	By the completion or non-completion	Addition
8	*Vyashtisamanstih*	Part and Whole	Fatorization
9	*Shesanyankena Charamena*	The remainders by the last digit	Fatorization
10	*Gunitasamuchyah*	The product of the sum is equal to the sum of the product	Fatorization

11	Gunakasamuchyah	The factors of the sum is equal to the sum of the factors	Fatorization
12	Chalana-Kalanabyham	Differences and Similarities	Fatorization/algebra related
13	Sopaantyadvayamantyam	The ultimate and twice the penultimate	Algebra related
14	Shunyam Saamyasamuccaye	When the sum is the same that sum is zero	Algebra related
15	Sankalana-vyavakalanabhyam	By addition and by subtraction	Algebra related
16	Anurupye Shunyamanyat	If one is in ratio, the other is zero	Algebra related

The basic steps of the multiplication for two digit numbers are illustrated in the following example [4]. Let us perform multiplication of the two digit numbers 43 and 75. The multiplication process of the two numbers using the UT method is illustrated in the Figure-1. The multiplication can be described by the following three steps [4]-

- Step 1(Vertical multiplication): Multiply the LSBs 3 and 5 (outcome=15), place the LSB of outcome 5 as result and MSB 1 as carry.

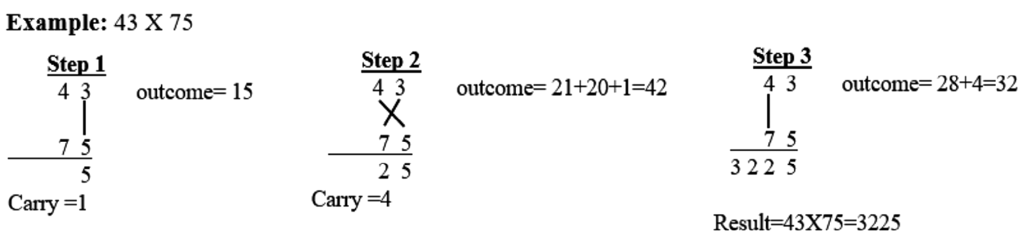

Fig-1: Urdhva Tiryakbhyam multiplication of 43 and 75.

- Step 2 (Crosswise multiplication): Multiply LSB of one number with MSB of the other, add the two products terms (21 and 20) as well as the carry from step 1. LSB of the outcome (42) is the middle term of final result whereas the MSB of outcome will be the carry for step 3.
- Step 3 (Vertical multiplication): Multiply the MSBs of the two terms and add the product (28) with the carry generated from step 2. Place the outcome (32) as result.

The UT method can be applied to larger numbers following a similar procedure. The Figure-2 illustrates the multiplication of the four digit numbers 4356 and 7219 by the UT method, yielding the result 31445964 [4].

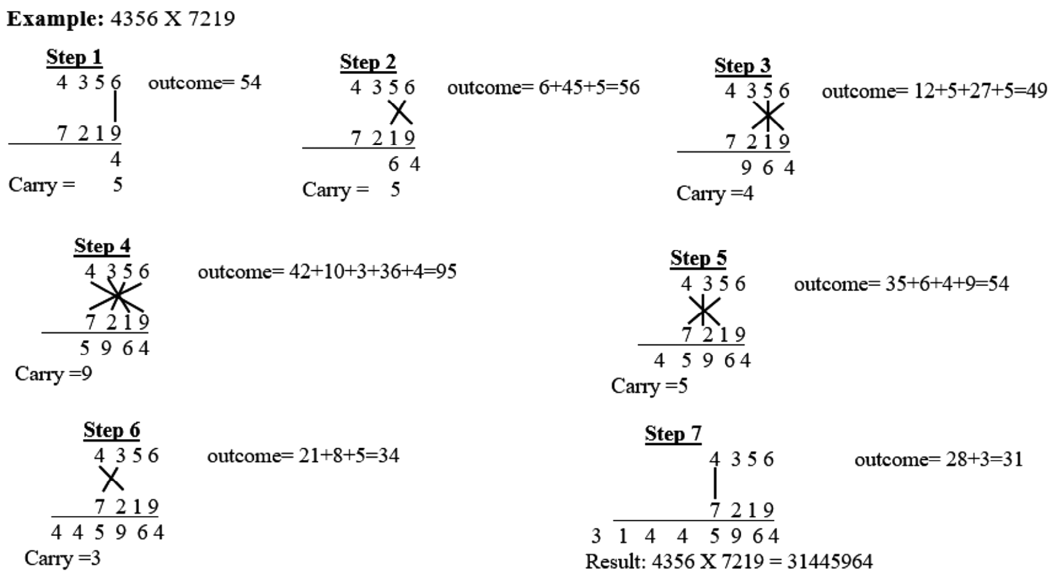

Fig-2: Urdhva Tiryakbhyam multiplication of 4356 and 7219.

Vedic Multipliers Based on Urdhva Tiryakbhyam Sutra

The implementation of the Vedic multiplier is based on the basic UT multiplication rules discussed above. The Figure-3 shows the logic circuit of a basic 2-bit Vedic multiplier used for multiplication of two binary numbers having LSB L_1 and L_2 and MSB M_1 and M_2 respectively [5]. The output of the multiplication is the number Q having the bits Q_0 (LSB), Q_1, Q_2 and Q_3 (MSB). Thus, a 4-bit binary product can be obtained from the multiplication of two 2-bit binary numbers.

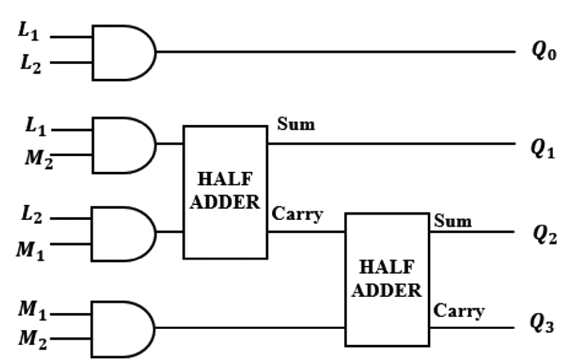

Fig.-3: Logic circuit of a basic 2-bit Vedic multiplier with two binary inputs having LSB L_1 and L_2 and MSB M_1 and M_2.

The design an UT based n-bit Vedic multiplier can be achieved by employing four $\frac{n}{2}$-bit multipliers arranged in an optimized manner, along with a number of adders upto n-bits [5]. The output of such a multiplication yields a 2n-bit binary number. For example, the design of 4-bit multiplier is an arrangement of 2-bit multipliers and 4-bit binary adders along with OR gate and half adders, giving rise to an 8-bit output.

The operating speed of the n-bit Vedic Multiplier is not significantly impacted despite the use of multiple logic components due to the concurrent operation of those components. Furthermore, in comparison to other existing multiplier circuits, such a Vedic multiplier produces fewer partial products and hence requires fewer additions, resulting in a higher operating speed and greater efficiency than other conventional multipliers.

A comprehensive literature review indicates that the UT-based Vedic Multipliers are 0.74 times, 0.5 times and 0.62 times more compact and 1.03 times, 1.19 times and 1.14 times faster compared to previously reported array amplifiers, booth amplifiers and Wallace amplifiers respectively [6-9]. Furthermore, UT-based Vedic multipliers are found to exhibit 0.54, 0.8, and 0.49 times lower power consumption as well as 0.61, 0.49, and 0.45 times lower propagation delay in comparison to array amplifiers, booth amplifiers, and Wallace amplifiers, respectively [6-9].

The overall efficiency of a Vedic multiplier is dependent on a few key performance factors namely delay, physical dimensions, power consumption and quantum cost. In view of these parameters, Vedic Multipliers are typically implemented using three main technological approaches- CMOS based software implementations [10-12], QCA based software implementations [13-15], and HDL languages based hardware implementations [16-18]. A comprehensive review of the literature on Vedic multipliers reveals a paradigm shift in technological methods from traditional CMOS technology to new and innovative QCA technology. Due to its benefits such as smaller device size, reduced power consumption, and higher operating speed, QCA technology has emerged as a potential alternative to the CMOS technology as the key technology to implement Vedic multipliers.

Apart from the UT sutra, Vedic Multipliers are also designed using other Vedic Sutra's such as *Yaavadunam Sutra* (meaning- Whatever the extent to fits deficiency), *Ekanyunena Purvena sutra* (meaning- By one less than the previous one), *Ekadhikena Purvena sutra* (meaning- By one more than the previous one), *Nikhilam Navatashcaramam Dashatah sutra* (meaning- All from 9 and the last from 10), etc. whereas, the *Paraavartya Yojayet sutra* (meaning- transpose and adjust) has been employed for the design of divider circuits. However, aside from UT sutra, every other sutra is a particular multiplication technique, and are only applicable when the numbers meet specific requirements. The *Nikhilam Sutra*, for instance, requires that at least one operand be close to the power of 10, *Ekanyunena Purvena* is only useful when the multiplier contains just nines as digits, etc. Due to their universal applicability, the UT sutra is the most popular multiplication technique employed in the implementation of Vedic multipliers for use in diverse technological fields. Nevertheless, Vedic multipliers based on other Vedic multiplication sutras are also utilized in certain regions that satisfy their specifications and are found to be just as efficient as UT-based Vedic multipliers.

Application of Vedic Multipliers

Vedic multipliers have the innate capacity to minimize propagation delay and area, which makes them ideal for circuits involving multiplication operations in many different fields. Vedic Multipliers play a vital role in the design of high-speed arithmetic processor circuits. Vedic Multipliers are used as the basic multiplication blocks of some basic arithmetic processor components such as ALUs [19,20], MACs [21,22], ASICs [23,24] etc. Due to their highly efficient operation, many reported works use Vedic multipliers as the basic multiplication unit of such devices.

Additionally, Vedic Multipliers are widely used in many different fields such as Digital Signal Processing (DSP) [25,26], Biomedical Signal Processing [24,27,28], Digital Image Processing [29,30], Cryptography [31,32] etc. as well as for high performance computing, neural networks and communication systems. Radar signal processing, image and video compression, speech recognition, and audio and video processing are a few notable DSP applications of Vedic Multipliers. Vedic multipliers in biomedical signal processing are used to improve the speed and precision in the analysis of ECG, EEG, and medical imaging data. Vedic Multipliers are effectively employed in Digital Image Processing to improve the compression ratio as well as image quality of the image processing algorithms such as DWT, JPEG etc. Vedic multipliers are also employed to accelerate numerous high performance computing operations (viz., weather forecasting, various scientific simulations, etc). The application of Vedic multipliers to communication systems is useful in a number of areas, including error correction codes, channel encoding/decoding, digital modulations as well as many other tasks employed in wireless communication. Vedic Multipliers are used in cryptography and security systems for efficient implementation of encryption/decryption algorithms, digital signal schemes, hash functions etc.

Conclusion

This article presents an overview of the basic design of Vedic multipliers based on *Urdhva Tiryakbhyam (UT) Sutra* from Vedic Mathematics. It is evident that the Vedic multipliers provide excellent speed, small size, and power-efficient operations making it a potential candidate in improving the performance in a wide range of applications across several fields. The article also demonstrates the usefulness and versatility of Vedic multipliers in a variety of domains, underscoring their effectiveness and possible influence on improving computational performance and efficiency in a range of applications. Overall, the article offers an in-depth analysis of the current status of the study regarding Vedic multipliers and opening the door for additional research and development in this domain.

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A Review of Ancient India's Traditional Water Harvesting Systems

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Abstract :

India is a land of traditional scientific knowledge**.** In ancient times traditional techniques of water harvesting and conservation were used to meet the needs the community. These systems were not only environment friendly and sustainable but were cheap, reliable and efficient that catered to the climate and topology of a particular region. Archeological marvels like Surangama, Eri, Madaka in the south; Phad, Virdas, Nala bandha, Tank, Step well, Johad in the west; Naula, Gul, Kul and Zing in the north; Kund, Ahar Pyne, Bamboo drip irrigation, Apatani, Dongs, Garh and Zabo in the east are proof of rich heritage of India's water harvesting systems. Case studies show that these traditional water harvesting systems combined with modern technology can rejuvenate India's depleted water resources.

Keywords : *Traditional, Harvesting, Rainwater, Community, Irrigation*

Introduction :

In ancient India water bodies were revered as Gods. Holy rivers as the Saraswati, Ganges, Yamuna, Krishna, Kaveri, Narmada and Brahmaputra were mentioned in Rigveda. The Vedas mentioned that water and the Universe are of the same age. Along with being divine and worshipped, through Puranas, Vedic, Jain, Buddhist texts, Ramayana, Mahabharata, Ramayana it could be understood that ancient India understood the importance of water harvesting and collection through canals, tanks, wells and embankments [1]. The geographical diversity of India ensured varied and unique structures for water harvesting and conservation. Many existing archeological sites, dilapidated ruins are proof of such systems. However, with time the use of traditional techniques of water harvesting has declined. The inception of British rule of Indian subcontinent in 1850s expedited the decline of the traditional knowledge and practice of water harvesting methods. The British policies of centralized revenue collection system played a decisive part in the demise of the traditional water harvesting systems [1]. With the economic exploitation of the village communities, the vital link between nature and humans was snapped [2, 3]. Additionally, in recent times too, the neglect of policy makers towards existing traditional structures, lack of community participation led to the decline of traditional techniques of water harvesting.

On the basis of the UN-Water report 2024, it is said that around 720 million people i.e. 10% of the global population approximately suffered with critical levels of water availability and quality in 2021 [4]. The 2017 report of NITI Aayog states that India is one of the most water deficient regions in the world having only 4% of overall water resources available in the world [5]. Millions lack access to safe drinking water. Indian agriculture being still dependent on rainfall, a bad monsoon drastically affects the national economy. Rising temperatures with climate change, increasing consumption, rapid urbanization, industrialization, pollution and excessive ground water extraction is further deteriorating the quality and quantity of fresh water. Immediate and collective action is necessary to stop this impending doom. The Indian Government has thus started promoting water conservation among local communities, seeking sustainable solutions to water conservation and developing necessary infrastructures in order to mitigate this problem. One of the best possible ways is to redevelop and reincorporate traditional water harvesting systems of ancient India [6]. These systems are simple, environment friendly, efficient and unique to every region's geography and culture.

Traditional Water Harvesting Systems :

Ancient India showcased a deep knowledge of climate, topology, engineering and technology through their water harvesting structures [6, 7, 8, 9]. The ancient Indian text Ramayana mentioned two lakes: Panchapsarotataka and Pamasaras [9]. Proof of dams built with stones dating back to the 3rd millennium B.C. were found in Baluchistan and Kutch. The Indus-Saraswati civilization of 3000 to 1500 B.C showed proofs of existing reservoirs to store rainwater. Proof of the earliest tanks were found in the excavations of Harappa and Mohenjodaro civilizations [9]. Chandragupta Maurya's dynasty in 321-291 B.C. showed evidence of dams, lakes and irrigation systems. The Chalukya dynasty's rule in the 12 century is considered the golden age for tanks. Several structures like lakes, tanks and canals were built during this period [1, 9].

The design, structure and engineering of the water harvesting systems depended on the terrain and climate of a specific region as well as on whether they were used for drinking water or for irrigation purposes [1]. Based on this we mention below the various ancient Indian water harvesting systems.

- **Surangam**, **Karambu :** These two systems were widely used in Kerala. Water is diverted away from a well with the help of a tunnel or surangam, then collected and stored at the mouth of the surangam with the help of a reservoir. Karambus are temporary dams stretching across the mouth of channels. These karambus boost the water level within the canals as well as divert that water into nearby fields also [6, 7, 8, 9, 10, 11].
- **Eri** : Some 1500 years ago i.e. during 6th to 10th century, Eris were developed in Oorani, Tamil Nadu. It is constructed with a large number of tanks that restores the ground water table as well as provide for drinking water and irrigation. Eris formed a very rich water harvesting system of Tamilnadu. Community participation was ensured for the maintenance of the Eris [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Madakas, Neeruganti :** Used in Karnataka, India these are naturally occurring depressions. Rain water is diverted using gravity into these depressions. The water from these guts is then distributed for various purposes [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Cheruvu :** Local to Andhra Pradesh, a tank or a small pond is called a cheruvu. It is used to store and conserve rain water runoff [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Bhandara Phad Irrigation, Ramtek** : Bhandaras originated in the Ramtek town of Maharastra. Bhandaras are check dams constructed over river or streams. These check dams increase the level of the water in the river. This water is then directed using an extensive network of tanks and polis for irrigation purposes [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Katas, Mundas, Bandhas :** Katas are triangular or rectangular check dams built to block off a region on a large field and collect water. This water is then used for irrigation purposes. These structures are mainly found in Madhya Pradesh and Orissa [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Virdas :** These are small, shallow pools constructed at the foothills of hills or mountains mostly prevalent in Kutch area of Gujarat. These structures capture and store runoff from monsoon rains which are then used in the dry months. The size and depth of these structures depends upon on the landscape they are built on [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Naada/Bandha :** These are check dams built across a stream with stones and found mainly in the Mewar, Thar Desert. This check dams capture rain water runoff in the monsoons and the resulting silt deposits on around these check dams makes the land fertile [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Johads** : Johads are mainly found in Rajasthan. They are made of stone and mud and act as obstacles that helps arrest rain water going down the slopes. This allows rain water to perlocate the ground and recharge the ground water table. Johads are used for irrigation purposes [6, 7, 8, 9, 12, 13, 14, 15, 16].

- **Talabs** : They are naturally occuring depressions/pond/lakes or can be man-made. Narrow streams are used to collect rain water from various directions. Talabs can store large quantities of water for various purposes like drinking, in household works, in temples and for tourism. The oldest talab in Rajasthan is said to be the Ranisar talab built in 1490 AD [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Tankas/Tanks** : Prevalent in Bikaner, Rajasthan, India these structures are mainly underground holes made in the ground inside the main house to collect rain water. These structures were polished with lime and pasted with tiles to keep the water cool and uncontaminated which can be later used for drinking and irrigation purposes. The oldest tank known is Fatehsagar tank built in 1780 [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Stepwells or Baoli** : Baolis are the wells with descending step. These structures are mostly found in Gujarat and Rajasthan. The baolis were used to store water during drought as well as acted as retreats during hot summers. These baolis also served as a place for societal meetings and religious functions [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Jhalara :** Jhalaras are one of the most prominent techniques of rain water harvesting systems in ancient India. Jhalaras consist of a large shallow basin that collects rainwater from rooftops of nearby buildings and other similar sources. Jhalaras have the advantage of better storage capacity, lower maintenance, efficient filtration, lower cost, greater flexibility and reduced urban flooding compared to the other traditional water harvesting systems. The Mahamandir Jhalara of Jodhpur dates back to 1660 AD and is said to be one of the oldest Jhalara [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Naula, Gul, Dhara, Simar, Khel** : Found in Uttarakhand and Himalayan ranges, a Naula is a type of small hut made of stones built to cover a spring. Gul is a system of small channels that supplies water to the fields. Dhara is a naturally occurring spring source [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Kul, Khatri :** Used in Himachal Pradesh, a Kul is almost identical to a Gul. A Gul is connected to a channel that diverts water from a source to another direction or to a reservoir. Khatri is a tank built with stones that harvests rain water and prevents percolation of water to the ground [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Zing** : These are small tanks specific to Jammu, Kashmir and Ladakh region and were to made to collect melted water from glaciers [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Kunds** : These are saucer shaped areas lined with lime, usually made for harvesting rain water in Utter Pradesh, India. While lime prevents water contamination, water inlets were fitted with wire mesh to prevent unwanted objects falling into the well pit. These structures were mostly used for drinking

water purposes during dry seasons. According to some archeological evidence, the first kund at Vadi Ka Melan, dated 1607 AD, was built by Raja Sur Singh [6, 7, 8, 9, 12, 13, 14, 15, 16].

- **Ahar Pyne :** Ahars and pynes were used to store water during the rainy season in Bihar, India. Ahars are basically rectangular basins sided with embankments on three sides and attached to a small pyne on the fourth side. Pynes are the man-made channels developed to connect water from the rivers to the nearby fields for irrigation purposes [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Bamboo Drip irrigation :** This ingenious system was developed by the Khasi and Jaintia tribes of Meghalaya some 200 hundred years back especially for black pepper cultivation. Pipes made of bamboos are used to channel the water from springs in the hill tops to low lying areas through gravity. Again, at the field there are layers of channels of bamboos of different forms used for distribution of water. At the last stage of the system, the number of channel sections and diversion units are reduced [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Apatani :** This system is named after the Apatani tribes of Arunachal Pradesh who used this system to harvest both ground and surface water for irrigation and fish farming purposes. Dams supported by bamboo frames are used to terrace a field into plots. Water inlets and outlets are built on these plots [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Dongs, Garh, Dara :** The Bodo tribes of Assam used to harvest rain-water using Dongs, a centuries old technique similar to a pond for irrigation purposes. The water into the Dongs is diverted from a river through a diversion channel. These Dongs are individually owned and community participation is not necessary for its maintenance. The Garh is in the form of a big nala and is used to divert water from the rivers to the fields. Dara is a small embankment made in a paddy field by dividing it into small square pieces to store rain water [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Jampois** : Jampois or Dungs are mostly found in Jalpaiguri, West Bengal, India. These are small irrigation canals connecting rivers and paddy fields [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Zabo :** Zabo is a multipurpose water conservation system developed in Nagaland, India and is used for agriculture, foresting, fishing and animal care. This system is also known as Ruza system. In hilly terrains, run-off rain-water is collected in a pond-like structure. The water from the ponds is then channeled into the paddy fields on the foot hills [6, 7, 8, 9, 12, 13, 14, 15, 16].
- **Jackwell :** This system was developed by the Shompen tribe of Great Nicolar Island. Logs of hard bullet wood were used to make bunds in the low-lying areas. Further, bamboos were split longitudinally, put under trees at gentle slopes to collect rain water from leaves and leading this water to a shallow pit called

Jackwells at the lower end. The Jackwells were then interconnected to form a bigger structure of dimensions approximately 6m in diameter and 7m in depth forming an efficient water management system [6, 7, 8, 9, 12, 13, 14, 15, 16].

Government Initiatives :

The National Action Plan on Climate Change (NAPCC) was released by the Government of India on 30th June 2008 [16]. The National Water Mission (NWM) is one among the eight National Missions identified by the government to address the challenges posed by climate change [17]. The primary aim of the NWM is 'Conservation of water, minimizing wastage, and ensuring its more equitable distribution both across and within States through integrated water resources development and management' [17]. The Jal Jeevan Mission (JJM) was launched in 2019 which focuses on achieving universal and equitable access to safe and affordable drinking water for all by 2030 [18]. The Ministry of Jal Shakti was created in May 2019 mainly for conservation of water and revival of traditional water bodies. It also aimed at promoting efficient use of water in agriculture, industry, and domestic sectors by involving local communities and creating awareness about water scarcity and how it can be managed [18]. Another initiative taken by the Ministry of Jal Shakti is the Atal Bhujal Yojana. It aims at promoting sustainable groundwater management [18]. Some other important initiatives taken are the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), 2015, Accelerated Irrigation Benefit Programme (AIBP), National Aquifer Mapping and Management Programme (NAQUIM) and Bureau of Water Use Efficiency (BWUE) [19, 20, 21, 22].

Success Stories :

Alwar, once a region historically rich in water with community traditions of rain water harvesting using structures called Johads, started drying up by 1980s. Reasons for this are mainly attributed to deforestation leading to erosion of soil, water percolation and a drained groundwater table. The land being unfit for agriculture or rearing livestock, forced migration of its people to cities. Tarun Bharat Sangh (TBS), a Non-Government-Organisation (NGO) from Rajasthan, started work on this area in around 1985 [23]. The studied the actual needs of the local communities, its ecology and revived the old system of water conservation called Johads. When the first Johad retained and filled up a few village wells, the second Johad was built in 1986. Soon a system of Johads was built filling up every other well in the village. Soon the land turned rich and fertile. By 1988, this community initiative reached seven other neighboring villages. Dr Rajendra Singh, the founder of TBS was since then acclaimed as the "Waterman of India" [23].

Jakhni in Uttar Pradesh's Banda district is another example of traditional wisdom and community participation. Due to the vision of social activist Uma Shankar Pandey, rainwater was trapped in the fields using raised embankments called Medhs [24]. These Medhs were then surrounded with trees to avoid erosion. Soon, the barren land became a thriving agricultural hub. The Jakhni model was replicated in around 1050 other villages across the country by the Indian Government. For his contribution to water conservation, Pandey was awarded the Padma Shri in 2023 by India [24]. More such success stories are available at https://jalshakti-dowr.gov.in/government-initiatives [**25**]**.**

Discussions :

Murthy *et al.* in their paper in ISVS e-journal, 2022, 9 (2), discusses how for an agrarian society like India alternative sources of water is a must. Due to population and pollution, freshwater is scarcely available in India [13]. Due to over use of modern techniques like borewells and tubewells, the ground water tables are depleted. The traditional systems of water systems are not only more efficient and dependable, they can be made from locally available resources, have low environmental impact and can last for decades [13]. Moreover. these traditional systems of water harvesting also have socio-economic and cultural significance. This was shown by Nandini et al. in her study of revival of traditional water harvesting systems in the drought prone regions of Tamil Nadu [26].

Conclusions :

The "*United Nations World Water Development Report 2024: Water for Prosperity and Peace*" highlighted how water scarcity can adversely affect lives and livelihoods. It further explores, how water can bring unity, peace, sustainability, climate action and regional integration [27]. So, time has come for the policy makers to take water conservation seriously before it's too late. Though the harmful effects of rapid urbanization cannot be completely undone, the knowledge of traditional water harvesting systems along with modern techniques & advancements can lead to a better and sustainable future. The traditional techniques of water harvesting are ecologically safe, dependable and economical. Awareness programs about these systems and community participation combined with modern technology, can be answer to India's perennial water issues.

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Religious Foundations and Evolution of Higher Education in India: From Ancient to British India

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Abstract

The evolution of the Indian higher education system reflects a rich historical trajectory shaped by diverse influences across ancient, medieval, colonial, and post-colonial periods. Initially, the system was deeply rooted in religious traditions, with the Brahminical and Buddhist educational frameworks prevailing during the Vedic period. While the Brahminical education was largely governed by religious values, the Buddhist approach was more secular, allowing broader access to education. The medieval period saw the emergence of Madrasahs under Islamic rule, with significant impacts on the existing Brahminical and Buddhist institutions. However, the most transformative phase occurred during British colonial rule, where the introduction of English education and the establishment of universities such as those in Calcutta, Bombay, and Madras profoundly reshaped the Indian higher education landscape. Despite these developments, the period also witnessed resistance from Indian elites who sought to use higher education as a means to support the growing nationalist movement. This complex history highlights the role of higher education in social change, intellectual progress, and the broader development of India. The study highlights the dual impact of these changes on India's educational landscape, emphasizing how higher education has been a crucial agent of social change and national development throughout history.

Keywords : *Higher Education, Brahminical Education, Buddhist Education, Indian Universities, Educational Evolution.*

Introduction

The English education system has taken a prime position in the Indian higher learning institution in today's time. But the higher education system of India has evolved through different periods, like the ancient, medieval, colonial and post-colonial. The institutions of higher learning are considered the most important agency of social change, social transformation, and entire development of the country. In fact, this journey of higher education started with an ancient system of education in the Vedic period in which two types of educational system were present there, viz., the Brahminical and the Buddhist systems of education. The Brahminical system of education was regulated by religious values, while the Buddhist form of education was secular in nature. But the major change in Indian higher education took place through the initiatives of British rulers that made an impact both in positive and negative ways.

Religious Influence

During ancient times in India, the educational system for higher learning was predominantly influenced by religion. The prevalent religions during that period were Hinduism and Buddhism. The educational system, which was founded on religious principles, played a crucial role in the generation, evolution, and dissemination of knowledge and ideas to the wider society. The two primary systems of religious-based education during that era were the Brahminical or Vedic system and the Buddhist system (Ghosh).

Brahminical Education

Brahminical education developed in India in the Vedic Period (Jha, 1991). During this period, efforts were made to preserve the oral transmission of religious texts in the Rigveda. The domestic schools of that time, which were run by teachers called 'Rishis,' were the educational institutions based on the Rigveda, where they instructed their students in the literature they possessed. Women enjoyed an equal status during this period and were admitted to educational facilities. The learning was conducted in Sanskrit and included the study of Smritis and Shastras. In the later Vedic age, from 1000 BC to 600 BC, there were three types of educational institutions in existence (Jha, 1991). The first type of educational institution admitted pupils at a young age. The second type, called "parishads" or debating circles, organized various discussions to introduce students to different aspects of knowledge. The third type consisted of conferences convened by kings and emperors, where representatives from various schools presented their teachings. The pursuit of higher knowledge occurred in 'Brahma Sanghas,' while the highest form of knowledge was acquired in the parishads.

During the later stage of the Vedic age, the Varna system became dominant, and it was monopolized by the Brahmins. While women were influential in their sphere of education at that time, they were relegated to the background (Jha, 1991). During this period, higher education was primarily for the service of the priesthood or ritualistic religion. These developments occurred before the Upanishads, when teachers were typically Brahmins from the priestly class (Ghosh, 2001).The elaboration of educational rituals was only done in the post-Vedic early classical age from 600 to 300 BC. Although members of the three upper castes were theoretically allowed to have an education during this period but the Brahmins were the dominant class that monopolized the education system.

Buddhist Education

In contrast to the Brahminical education system, the Buddhist education system was not only religious but also secular, and it introduced the monastic education system. The most significant aspect of Buddhist education was that it was open to all persons, regardless of their caste, except for slaves, army deserters, and those who were disabled or sick (Jha, 1991, p. p. 3). It grows out of the teachings of the Buddha as classified as Vinaya (monolithic discipline), Sutta (group discourse) and Abhidhamma (works of doctrine) (Ghosh, 2001, p. p. 54). Under the Buddhist education system, the monasteries were similar to modern-day universities.

The Buddhist seats of learning taught various subjects, such as the four Vedas and Vedangas, astrology, astronomy, yoga, Nyaya, music, medicine, the art of war, magic, poetry, and several other subjects related to art and craft. Taxila was the most famous Buddhist higher education institution of that time, renowned for its schools of medicine, law, and military science. By the mid-6th century, it had acquired a reputation as a great center of learning, attracting scholars from distant parts of India (Dongerkery, 1997). Students were not restricted by caste when choosing their discipline of study. Brahmins could choose to study archery, and Kshatriyas were free to study the Vedas or Upanishads as well.

During the 7th century B.C., Banaras was renowned as a hub of knowledge and education. In the era of Ashoka, the Sarnath monastery located in the vicinity of Banaras gained recognition as a prominent center of learning, attracting a significant number of Buddhist monks (Choudhary, 2008, pp. pp. 50 -72). Among the significant educational institutions of ancient India were Nalanda, Vallabhi, and Vikramshila. In addition to Taxila, Nalanda emerged as a vital center of Buddhist education for advanced studies. Located in Bihar, it drew students from not only India but also other nations, including Nepal, Korea, China, and Tibet. Nalanda was renowned for its curriculum in Buddhist and Brahminical texts, as well as its practical and secular subjects. It was worth mentioning that the University was run democratically (Jha, 1991). Nalanda was renowned for teaching Mahayana Buddhism, while Vallabhi in Gujarat specialized in Hinayana Buddhism. Another prominent institution for advanced Buddhist studies was Vikramshila, located in the present-day Bhagalpur district of Bihar.

Rigveda was the basis of education in ancient India which was composed by the priests orally among the Aryans between 1500 and 1000 B.C (Choudhary, 2008, p. p.

54). During that time, the Brahmins were appointed as advisors to Kings and Emperors, and they held significant influence over religious scriptures. The Brahmins created a set of religious texts, known as Brahmanas, to assert their dominance. Aranyakarand Upanishads were added to the Brahmanas and by 600 B.C., they together with the Vedas and their six Vedangas were studied in the Vedic schools by the Brahmins, the Kshatriyas and Vaishyas (Ghosh, 2001, p. p. 175). In contrast, the Shudras, who were regarded as the lowest caste, were forbidden from studying the Vedas and were limited to learning vocational skills such as animal husbandry, spinning, weaving, and other artisanal trades. The Buddhist education system, on the other hand, provided opportunities for individuals from all castes, as it offered a straightforward path to salvation. As a result, the Buddhist Viharas did not possess the inherent vitality of the Vedic schools (Ghosh, 2001, p. p. 158). Thus, it is evident that ancient Indian higher education had a rich tradition.

Higher Education in Mediaeval India

The medieval era in India played a crucial role in the advancement of higher education, as it reflected the social, economic, and religious aspects of medieval Indian society. The state, along with other agencies such as Sufism and Bhakti ideology, was instrumental in facilitating integration and co-existence in a protracted process (Choudhary, 2008, p. p. 55).

Although several early educational centers persisted during this era, Madrasahs emerged as the new focal point of higher learning in medieval India. Brahminical education was restricted to Hindu kingdoms and primarily focused on the priestly castes. Conversely, Buddhist educational institutions suffered severe damage during this period, particularly institutions like Taxila and Nalanda (Alam, 1991, p. p. 17). The first Islamic invasion in India, led by Mahmud, resulted in the destruction of educational institutions in several significant cities in Northern India, including Hindu temples and Buddhist Viharas. The libraries of Nalanda and Vikramshila suffered severe damage as well (Choudhary, 2008, p. p. 56). However, many Hindu educational institutions in Banaras, Nadia, and Mithila continued to exist and emerged as important centers for intellectual development (Ghosh, 2001, p. p. 112). In Banaras, students were required to study only in Sanskrit, but specialization in the language was restricted to Brahmins. During the Mughal reign, Mithila gained prominence for its studies in Logic, much like Nadia. However, an important aspect of education in Nadia was that Sanskrit was freely accessible to people of all castes.

During the medieval period, which was largely dominated by the Mughals, there were three primary institutions of learning: Muktabs, Madrasahs, and Khangahs. Muktabs provided basic education, while Madrasahs imparted higher education. Khangahs, on the other hand, were responsible for providing religious or theological education (Ghosh, 2001, p. p. 20). Women education was also given equal importance in the Mughal period. Gulbadan Begum, the sister of Humayun wrote Humayun Nama is an example of women education during this period (Dongerkery, 1997, p. p. 13). Therefore, it is evident that the developments in higher education during the medieval period aimed to establish a balance between various social groups and the aspirations of the people of that time.

Unveiling the Educational Landscape of British India

It is evident that the current higher education system in India has been influenced by the British pattern of education to a great deal. During their rule, the British East India Company had the need to maintain offices in India but found it expensive to bring British clerks from London. To address this issue, the Company aimed to provide western education to the Indian population. As their activities grew, they established schools and colleges, and with the increasing number of British personnel in India, it became necessary to establish educational institutions for their children (Panikkar, 2001, p. p. 3614). The needs of the colonial masters during the colonial era of India determined the development of education in the country. The entire Europe as well as England has witnessed industrial consolidation towards the end of 18th century and in the beginning of 19th century (Hobsbawm, 1999). Expansion of English language and their culture became the need of the colonial rulers in their colonies.

In order to develop studies on Arabic and Persian languages the first Governor-General of India, Warren Hastings established the Calcutta Madrasa in 1781. In 1791, Jonathan Duccan from Banaras established the Banaras Sanskrit College to spread the learning of Sanskrit language (Robinson(ed), 1989). These institutions were established basically with the idea of training the Indian people who will act as the assistants to the British Judges to interpret the Hindu and Muslim laws. A section of upper-class Indians was also satisfied with the establishment of these institutions as these were preparing them for the government jobs. From its initial years to up till 1812, the basic educational activities on the part of East India Company were the establishment of these two educational institutions in Calcutta and Banaras and the approval of grants-in-aid to some private schools of that time. In 1813, the Charter of East India Company was renewed. The most serious concern of the Indians towards this Charter was regarding the medium of instruction. In 1823, a committee was formed to resolve all the issues related to this charter. With ten members, the Central Committee of Public Instruction was formed. The chairman of this committee was Lord Macaulay who was the Law Member of the council. As the Chairman, Macaulay on February, 2, 1835 wrote a Minute on the issues concerned. This Minute of Lord Macaulay was like the foundation stone English education in India (Sarkar, 1970, pp. pp. 338 - 348).

On March, 7, 1835, Lord William Bentinck, the then Governor-General of India, after a month of Macaulay's note on Indian education gave the ruling that the objective of British Government is to promote the literature and science of Europe in its colonies. He also ruled that all the funds in this direction would be provided by the British

Government. The political benefit of the British government was one of the basic reasons for this development as there was a growing opinion and recognition of this fact. Another reason was the needs of the colonial rulers for their administrative purposes. When the Charter Act of 1833 was passed, the British East India Company was in a serious financial crisis and needed to cut down its expenses. Lowering the number of employees from Europe and employing natives from the colonies in lower wages was a good option for the company at that time. After this Act, the doors for Indians in the lower order civil services were opened-up. Therefore, the policy of 1835 was ruled by Lord Bentick (Sarkar, 1970) .The expansion of the British market was another cause for spreading English education in India.

The official and court language of British India was replaced from Persian to English in 1837. In 1844, it was announced that the Indians with English education will be given preference in the civil services under company's rule (Chandra, 1965, pp. pp. 417 - 431). In accordance with the growing popularity of English education, in 1854, Sir Charles Wood forwarded a Despatch which in the later period came to be known as "Woods Despatch". In his dispatch Charles Wood recommended the setting of the University of Bombay, the University of Madras and the University of Calcutta, which in 1857 were established (Kumar K., 1998, pp. pp. 447–454). The three universities formed after Woods Despatch was structured on the model of London University. They were purely examining bodies and drew their candidates for different examinations from affiliated colleges and schools (Mukerji R., 1974). In accordance with the establishment of the universities of Bombay, Madras, and Calcutta, the University of Punjab was founded in 1882, and the University of Allahabad followed in 1887, both based on the same model as the earlier universities. By 1901-02, there was a very rapid expansion of college education. As against 68 colleges in 1881-82, there were 176 affiliated colleges in 1901-92, 138 in British India, 32 in Indian states and 9 in Ceylon (Mukerji R., 1974, p. p. 169).

At the beginning of the 20th century, there was a decline in the grants received by universities and colleges. This decline was due to the growing belief among British officials that there was a connection between the popularity of Indian nationalistic sentiments and English education. This perception led to a reduction in funding for educational institutions, which was seen as a means of curbing the growth of nationalist movements in India. In 1901 another landmark in the direction of Indian education came in the form of Indian University Commission under Lord Curzon, the then Governor-General of India. The commission was formed with the basic responsibility of finding out the conditions and to inquire the prospects of university education under British India. The Indian Universities Act of 1904 was the result of the Indian University Commission of 1901. It urged for changes in the composition of the structure of administrative bodies in universities. But the Act rejected the idea of setting up of new universities at Aligarh, Banaras, Decca, Patna, Rangoon, and Nagpur, though there was a heavy vocal demand for them. It also could not conceive of universities other than the affiliation type (Mukerji S., 1976, p. p. 170).

The Indian Universities Act of 1904 marked a watershed moment in Indian university education, granting universities the authority to offer teaching and research programmes (The Indian Universities Act, 1904, 1904). The Government of India Resolution of 1913 formalized this by emphasizing the need for local, residential, and teaching universities in each province of British India. In addition, the resolution called for the establishment of residential and teaching universities in Decca, Aligarh, Banaras, Patna, and Nagpur. The establishment of these universities, as well as the provision of teaching and research facilities, was viewed by the government as a means of promoting intellectual progress and fostering corporate sentiment among Indians. In pursuance of this policy as advocated above and meet with new developments, the following new universities sprang up: Banaras and Mysore in 1916, Patna in 1917, Hyderabad in 1918, and the S.N.D.T. women's university in 1916 (Mukerji S. , 1976, p. p. 172).

There was the establishment of few universities that adopted Urdu as the language of instruction. In order to meet the demands and aspirations of the Muslim community, in 1875 under the leadership of Sir Syed Ahmed, the M.A.O. College, Aligarh was formed and was later developed into a Muslim University (Azhar, 2017, pp. pp. 107 - 109).

The Government of India Act, 1919 established a new political structure in Indian administration called the "Diarchy." At the provincial level, the Act divided government activities into reserved and transferred departments. For the first time, the Department of Education was handed over to Indians themselves under this system. As a result of this encouragement, more universities were founded after 1919, and India had 19 universities before its independence. As the number of universities grew, so did the need for an organization to coordinate their efforts. The government of India convened a Conference of Indian Universities in 1924 to establish an Inter-University Board, which would serve as the inter-university organization and information bureau for these universities (Kumar P. , 2008).

During the British period, there was a lack of consensus on India's education policies, and the clash of interest between the Indian elites and British rulers was evident. The British rulers aimed to control the students' activities to prevent them from engaging in active politics, while the Indian elites saw higher education of Indians as a tool to strengthen the ongoing National Independence Movement and develop human resources for India's development.

Conclusion

The higher education system in India has been significantly shaped by the British colonial influence. During their rule, the British East India Company sought to educate the Indian population in Western ways to meet administrative needs and reduce the cost of employing British personnel. This led to the establishment of schools, colleges, and eventually universities modelled after London University. The expansion of English-language education was intended to serve colonial interests, preparing a workforce of clerks and administrators. However, as nationalist sentiments grew, the British government reduced funding for education, fearing its role in fostering independence movements. The establishment of universities like Banaras, Aligarh, and others aimed to promote intellectual progress, yet the underlying motives remained tied to colonial control. Ultimately, the British education policy in India was marked by a tension between the colonial rulers' desire to maintain power and the Indian elites' efforts to use education as a tool for national development and independence.

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Assamese Traditional Practice of Cloth Making : A Study on 17th -19th Century Assam

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Abstract :

Spinning, weaving and sericulture are important parts of the cultural heritage of Assam. The traditional cloth making industry holds a unique position in the economy of Assam. In medieval Assam, the handloom industry grew rapidly due to the efforts, cooperation and support of the Ahom Kings. Assamese women belonging to every class, caste or faith were engaged in spinning, weaving and dyeing. The presence of handlooms was as common to every Assamese family as the kitchen. The weavers of medieval Assam produced enough clothes both for their household consumption as well as for supply to the nobility and royal house. Assamese handloom products were famous for its unique charm and aesthetic appeals. Though with the advent of the colonial rule in Assam in the first half of the 19th century, the importance of traditional handloom industry declined, still spinning and weaving were considered as necessary accomplishments for every Assamese woman. In Assam, during the period of this study, women mostly used throw-shuttle loom in plain areas and in hill areas loin-loom was used for weaving. The present paper makes an attempt to study the traditional practice of cloth making in 17th-19th century Assam.

Key words : *Assam, weaving, spinning, silk, dyeing*

Introduction :

During the pre-colonial times Assamese society was self-sufficient in the matter of cloth; as Assamese women produced enough clothes to full fill the clothing requirements for their families. In Assam, clothes were manufactured by the means of hand weaving. Assamese women produced thread from cotton as well as they used to produce silk thread from the cocoons of the silk worms. It was an exceptional feature of Assamese society that there was no any particular caste reserved for weaving(Bhuyan, 66). From a very young age Assamese girls acquired knowledge of weaving cloths and the techniques of handloom weaving are handed down from one generation to another. Francies Hamilton noted that, in the early nineteenth century Assam, every woman of all castes, from the queen downwards, weave four kinds of silk that they produced in the country, and with these clothes three-fourths of the Assamese people were clothed. (Hamilton, 61)

Objectives of the study :

This paper aims to study the traditional cloth making process prevalent in the 17th -19th century Assam. It discusses the traditional spinning, weaving and dyeing practices of Assam. The present work also tries to assess the equipment used in the traditional handloom weaving process.

Methodology :

This study is historical and descriptive in analysis and data have been collected from both primary and secondary sources. The former includes the *buranji*s, some British official records, survey of archival sources as well as various contemporary literary works published in periodicals, newspapers etc. Secondary source data consist of relevant literature on the topic.

Discussion :

Silk rearing process :

Assam is known for its rich silk culture. Three kinds of silks were produced in Assam during the period of our study. These were- *Muga* silk, *Eri* silk and *Pat* or mulberry silk. *Kautilya's* reference to *kshauma, dukula* and *patrorna* cloths obtained from *Suvarnakunda* (in kamarupa) may be the *eri, muga, pat* silk of Assam (Choudhuri, 330). Muga silk worm were reared on trees in open air and much care was needed for attending them. Muga silk worm passes through four phases, egg, larvae, cocoon or pupa and moth. The *muga* moths come out of the cocoons after 18 days during summer and 30 days during winter. After coming out of the cocoons the moths became ready to coupling with the moths of opposite sex. The paired couple was tied together in wisps made out of thatching grass. Subsequently the female moths start laying eggs. The young larvae within a p*eri*od of eight to twelve days come out of the eggs. Then the caterpillars are tied in the *som* (Machilus bombycina) or *sualu* (Litsaea polyantha) trees. The worms eat the tender leaves of the *som* or *sualu* trees for a period of 22 to 50 days. Then they become mature to weave cocoons. The rearers put the worms in *salonies*, a triangular bamboo made rearing appliance. Then again put them in another tree full of leaves. When the larvae become mature, they stop eating leaves. The mature worms were put on *jalis* made of partially dried tree leaves for two weeks to spin cocoons. The cocoons are harvested from the *jalis* after a period of seven days during summer and 12 days during winter. Then the cocoons selected for reeling are dried up under sunlight or smoked to kill the pupa inside and the cocoons selected as seed for the next breed are preserved in bamboo baskets so that the pupi remained unharmed. The cocoons have to be boiled in an alkaline solution (*kharani*) for about fifteen to thirty minutes to remove the natural gum contained in the silk. Traditionally a kind of tool called *bhangori* is used for reeling.

The *eri* worms are reared entirely within doors. The female *eri* moths are tied to long reed or canes. In each reed or cane twenty to twenty-five moths are kept. The reeds are hung up inside the house. The eggs laid by the moths during the first three days are tied in a piece of cloth. When a few of the worms are hatched, the cloths are put on small bamboo platters. The worms are fed tender leaves. After that, the worms are removed to feed on bunches of leaves. When the worms stop eating leaves, they are kept in baskets filled with dry leaves to form cocoons. Keeping some cocoons for next breed, others are exposed to the sun for two to three days. After it the cocoons are boiled in a potash solution over slow fire. Removing them from water the silk is draws out. The thread is then exposed to the sun (Robinson 227,228). The appliances used for spinning *eri* are the drop spindle or *takuri* and *jatar* (spinning wheel).

Cultivation of pat silk was confined to a particular community called the *Katoni* or *Jugi* in medieval Assam. *Pat polu* or Mulberry silk worms are reared indoors. The Mulberry silk worms are of two types- *Bar polu* and *Soru polu*. R Das Gupta cited the following description from B. C. Allen's writing, published in the Assam District Gazetteers, Darang (Ch. V, p 153) about the production process of mulberry silk worm, "The eggs of the Bar Polu take ten months to hatch …The life of the worms lasts forty days, and the cocoons take six days to spin. The cocoons are of bright yellow colour, but the silk when boiled in potash water, becomes perfectly white. From twelve to fifteen thousand cocoons are required to yield one pound of thread...The thread obtained from the *Soru Polu* is not so valuable as that of the bombyx textor, but as the worms yields four broods in the year it finds greater favour with the cultivators" (Das Gupta 195).

Cotton thread :

Cotton was produced chiefly by the hill tribes. They used to sell it to the people of the plains in the *hat*s (markets). Basically, the kachari, Garo and Mishing communities produced fine cotton clothes (Das Gupta 196). The cotton produced in the Muttack country was nearly twice valued than that of the Garo Hills (Robinson 240). A type of a good quality cotton known as *Bariya kopah* (cotton) was produced in Assam. Another kind of cotton produced in Assam was *Sepeti kopah* . But with the easy access of cheap mill made imported cotton thread, Assamese people gradually left cotton cultivation. During the 19th century, the affluent section of the Assamese society began to prefer imported cotton clothes. Though spinning lost its utility from the time when mill made yarns became easily obtainable, weaving was continued by Assamese women till today (Goswami 169,170).

In preparing threads from the fibers of different trees, hill tribes of Assam were very expert. Even from the Chorat plant, which is a devil nettle, the Abors used to spin threads and made clothes (Rajguru 301). In the medieval period, there was a custom among the Assamese warriors to go to the battlefield wearing a particular kind of evil-averting dress called *Kavach Kapor* or talisman cloth. Dr. John Peter Wade noted the following description about the production of the *Kavach Kapor* , "At midnight the cotton is cleared from the seeds, formed into rollers, spun into thread, manufactured into clothes worn by the warrior. The work must be completed before daybreak. It is written in the Shastrus that it is fortunate to wear this cloth in battle" (Wade 34).

Weaving process and the tools used :

The weaving process constitutes interlacement of two sets of threads viz., warp and weft and the equipment which assists this interlacement is called the loom. Looms, that used by Assamese weavers during the period of our study can be classified under two groups- *Mati sâl* or throw shuttle loom and *kokâlot bondha sâl* or loin loom.

Mati sâl or throw shuttle loom :

This type of looms was used in the plain areas of Assam. In these looms four bamboo posts of about six feet high were dibbed into the ground with provision for holding two bars called *Jakhala mari*. At these *Jakhala maris* the loom was let hang with the help of a bamboo pole called *Chalimari*. In this kind of looms shuttles were thrown across the thread by hand. The equipment used in the throw shuttle loom were-

- *Tolothâ* : *Tolothâ* is a wooden cylindrical roller of about 883 in length and 63 in diameter. Two *tolothâ*s are used in a loom, one for holding the yarn and other for holding the cloth.
- *Darpati* : *Darpati* is a wooden flat bar of about 703 in length and 23 in width.
- *Mâko* : *Mâko* is the wooden shuttle with two pointed ends. It is used to pass weft thread through wrap thread.
- *Mahurâ* (pin) : It is narrow bamboo tube of about 2 ½ 3 in length. It has a hole from one end to another. It used to wind weft thread to weave cloth and an iron or bamboo stick called *gereli mâri* or *gereli kâthi* is used to place the *mahurâ* in the mako. Another tiny bamboo stick called *gereli khuti* is used to keep *gereli kâthi* in proper position.
- *Rânch* (Reed) : *Rânch* is a bamboo comb fixed with a reed cap made of bamboo and wood.
- *Baw* (Heddle) : The warp shed is formed with the heddle and a bamboo rod or stick called *baw sali* or *naki sâli* is used to keep heddle. A bamboo tube called *baw cungâ* is used to make heddle or *Baw* before weaving.

- *Dângmâri* : *Dângmâri* or *Tâldhorâ* is a bamboo stick of about 883 in length and it is used to make the harness of the loom attached to the lower portion of the heddle shaft. Two *dangmari*s are attached crosswise on the cord of the *garaka*.
- *Garaka* (*treadle*) : It is a pedal placed bottom of the loom. Heddle shafts are connected in it by means of cords.
- *Garakâ khuti* : It is the post placed at the end of the *Garakâ* .
- *Cirimâri* : This is a wooden or bamboo rod of about 57 ½ 3 length and 1 ½ 3 width, which is used to divide wrap threads ahead of the heddle shafts.
- *Phulor kâthi* : Flat bamboo sticks used to weave motifs in the clothes.
- *Sali*: It is a long and thick bamboo stick used in the time of weaving motifs on the textile.
- *Putol* : *Putol* is a bamboo or wooden rod with two small nails at the end of both sides to keep the cloth end properly
- *Posts* : Four big and two small bamboo posts are used to fix the loom on the ground.
- *Nâchani* : It is a small piece of bamboo or wood, flat in shape and having a central hole to contain a thin rod. The two ends of the *Nachani* are attached to a strong *sali* which holds the heddles in upward direction.

Besides these, *Kan dia mari* (bamboo or iron rod used to revolve the beams), *Jatar* (spinning wheel), *Letai, Ugha, Chereki* (wooden rollers of different sizes) were required to complete a *mâti sâl.* Almost all the parts of this type of loom were made by Assamese people in the period of our study with their own labour.

Kokalot bandha sâl or loin loom :

Loin loom is a kind of primitive loom used by the people of the hilly areas of Assam. These looms are also called Back strap loom because this type of looms is attached to the body of the weaver with a back strap. These looms are portable. They don't have any permanent fixture or heavy frames. Loin loom consisted of :

- *Front bar* : It is a circular wooden bar put in between two loops.
- *Breast bar* : It is a circular wooden bar. The wrap thread is fixed between the front bar and the breast bar.
- *Sword* : A sword is a flat piece of wood; it's one end is pointed and the other is blunt. It is rests in front wrap.
- *Healt bar* : It is a circular bamboo bar.
- Another circular bamboo bar is placed after the healt bar.
- *Lease rod :* It is fixed after the circular wooden bar mentioned above.
- *Back strap* : It is made either of cloth or leather. The two loops at the end of the back strap are attached to the notches of the front warp bar.
- *Shuttle* : It is a bamboo piece ship containing yarn.

During the time of weaving the healt bar is lifted with the weaver's left hand and the circular bamboo bar is pressed down simultaneously by the right hand. The sword is then placed in the shed keeping vertically and the weft is passed from the right to left through the shuttle. The weft is then beaten up by the sword. The sword is then taken out and the centre thread is produced through which the shuttle is passed by the left hand from the left side and picked up by the right hand in the right side. The sword is used again to beat the weft. The process is repeated (Bahadur 29,30).

Traditional dyeing technics :

Before the yarns produced by modern textile factories became easily accessible, Assamese weavers used to dye threads by indigenous dyeing process. In Assam, instead of dyeing cloth, people used to dye threads. Banabhatta mentioned in Harshacharita that Bhaskaravarmana, the king of Kamarupa gifted many coloured clothes along with other articles to Harshavardhana (Baruah 16). This reference indicates that, since ancient times, people of Assam knew the art of dyeing. A great variety of dye stuffs were used for dyeing threads. Sometimes different items were used in different areas of Assam for producing the same colour. Barks, leaves, fruits and roots of different trees like *Achchugach, Majathi, Palash, Chandan, kujithekera, Borthekera, Tepartenga,* Turmeric, *Bhamrati, Jarath, Urahi, Leteku, Jammu, Bharathi, Silikha, Amlakhi, Madhuriam,* lemon, *kendu* fruites, pomegranate as well as lac, indigo, vermilion was used as dyeing material in Assam. *Leeteku* was used to produce red, *Bharathi* for yellowish colour, bark of *Jamu* for black colour, *Palash* mixed with the roots of *Achchugach* produced maroon colour, *Majathi* or *Manjit* or Indian madder was used to produce reddish yellow colour and by mixing it with Lac, *Barthekera, Leteku* scarlet red colour can be produced. Red was also produced from red *Chandan*. From *Urahi* green colour was produced, *Sewali* was used for producing yellow colour, the *Nil* or indigo produces blue colour but by mixing it with other elements one can prepare black, purple or green colour. Lac was used to dye both silk and cotton fabrics. Pradip Chaliha in '*Purani Asomar karikari Silpa*' mentioned about forty-eight plants which could be used as dyeing agents. Some of these species were used as mordents so that the colour remains permanent. For example, *Bhumrati* leaves was used as mordents with every colour except blue. Assamese people regarded the craft of dyeing as an ordinary household activity and therefore they did not realize its commercial value. With the easy availability of imported dyed thread, Assamese people abandoned the practice of dyeing. Rajen Saikia remarked, "By the end of the 19th century, the number of people engaged in domestic preparation of dyes and dyeing was few and far between. Within the next twenty years it became a thing of the past" (Saikia 53).

Ornamentation in fabrics

Along with dyeing, embroidery too was a highly skilled work during the period of our study in Assam (Baruah 438). Assamese people used a king of gold and silver thread called *guna* in embroidery works. *Guna* was locally produced by a class of workmen called *Gunakatia*. In addition to *guna*, different coloured threads were also used in embroidery work.

Assamese textile motifs were inspired by rich biodiversity. Natural objects like flowers, birds, animals and geometric patterns find expression in the Assamese textile. Besides, some religious motifs were also used by Assamese weavers.

Assamese traditional cloth producing technics were basically weaving oriented. Assamese weavers basically embroidered clothes in loom; hand embroidery was not a very popular practice during the time of our study. It is believed that sewn up cloth became popular in Assam approximately from the fourteenth century, because there is no any evidence of sewn costume in Assam before it come into frequent contact with the Muslims (Sarma 252).

Though in Assam printed cloth making was not common, yet *Bandhani* or tie-dye cloth was produced in Assam in small scale. Pratap Chandra Goswami mentioned in his autobiography that, in Lower Assam Bandhani clothes were integral part of bridal dress. These clothes were made by colouring different parts of the clothes while these were folded and tied up.

Conclusion :

Handloom weaving has a great significance in the socio-economic life of Assam since early times. Assamese society was self-sufficient in cloth production during pre-colonial times. Clothes were basically manufactured by the means of hand weaving. By rearing silk worms and producing silk thread from the cocoons of these worms, clothes were woven. Cotton clothes were also produced in Assam. Weaving technology remained almost same during the period of this study as the earlier times of the medieval period.

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Transformation of Indian Farming System : A Comparison of Traditional Farming and Modern Farming in Agriculture

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Abstract

The backbone of India's economy is agriculture. The agriculture sector is also not free from the influence of the rapid growth of technology. This paper explores the changing nature of farming practices from traditional to modern farming in India. It provides an idea about how traditional methods that relied upon indigenous knowledge, organic inputs and natural processes have been supplemented by modern technology such as AI, mechanization and other digital tools. Through the comparison, the author highlights the benefits and challenges of modern agriculture including increased production rates, environmental concerns and growing need of technical expertise among farmers.

Keywords : agriculture, farming, traditional, modern, artificial intelligence.

Introduction

The role of agriculture in India's economy is pivotal with over 58% of the rural population relying on it as their primary source of livelihood (Gulati & Juneja, 2022). Contributing to approximately one-fourth of the Gross Domestic Product (GDP), agriculture remains a key sector today. The Green Revolution of the 1960s driven by high-yield varieties (HYVs), irrigation expansion and chemical fertilizers marked a major shift in Indian farming practices transforming the country from one grappling with food shortages to becoming self-sufficient in food production. Today, with a market size of $400 billion, India stands as the world's largest producer of pulses, milk, and spices. It is also the second largest producer of tea, fruits, sugar, cotton, vegetables, rice and wheat (How Has Green Revolution Changed Agriculture In India - Agruculture Lore, n.d.).

In the present context India is a global player of agriculture production having a share of 2.2% in world agricultural trade (Agriculture Export Policy in India, n.d.). Though the majority of population depends on agriculture, the share of agriculture has been falling while the other two sector industry‘s and service sector‘s share is rising constantly. Around 54.5% population lives on only 18.8 percent of total income of the economy. Throughout history, there has been a profound relationship between Mother Earth and agriculture in India. For centuries, the agricultural sector has relied heavily on nature's rhythms and resources. However, with the rapid growth in population, the demand for increased food production has intensified. In response to this challenge, traditional farming methods are gradually giving way to new technologies that aim to make agriculture more efficient, productive and sustainable, balancing the needs of both people and the environment.

With population growth, environmental concerns and technological advancements, Indian agriculture continues to evolve, integrating modern scientific innovations with traditional practices. This transformation aligns with modernization theory which suggests that societies progress from traditional agrarian systems to industrialized economies through the adoption of new technologies (Rostow,1990). Traditionally Indian agriculture was subsistence based, labor-intensive and dependent on organic fertilizers and indigenous seeds. With the advent of mechanization high-yielding varieties, chemical inputs and data driven farming techniques, agriculture has become more commercialized. The increasing use of artificial intelligence (AI), exemplifies this shift. According to this theory, economic development necessitates agricultural modernization as outdated farming methods hinder progress. Furthermore, the Diffusion of Innovation Theory (Rogers, 1995) provides insights into how agricultural modernization spreads across different segments of the farming community. The adoption of hybrid seeds, sensor-based irrigation, and AI driven decision-making tools initially occurs among large commercial farmers and research institutions before diffusion to smaller farmers. Various factors such as government policies, financial support, accessibility of technology and farmers risk perception determine the rate at which these innovations spread. For eg. India's adoption of AI driven agricultural system has been uneven due to infrastructural challenges, digital literacy gaps and financial constraints among small farmers. In addition, the Sustainable livelihood framework (DFID,1999) provides a useful perspective on how Indian farmers navigate between traditional and modern farming to ensure economic stability and environmental sustainability. Traditional farming methods have been characterized by organic fertilizers indigenous seeds and biodiversity conservation while modern agricultural methods introduce genetically modified crops, sensor-based irrigation and automated machinery to optimize productivity. Understanding these transitions helps assess the broader implications of agricultural modernization on farmers.

Objectives

The objectives of the paper are :

- To make a comparison between the traditional agriculture methods with modern methods
- To understand the implementation of AI in Agriculture
- To understand the change in production after using modern technologies

Methodology

A strong methodology is crucial for ensuring the credibility of research findings. This article employs a comparative and qualitative research approach to analyze the transition from traditional to modern farming in India. The study follows a descriptive comparative research design. Data are collected from various secondary sources like books, peer-reviewed journals, government reports and reliable online databases. Empirical study is done by analyzing government agricultural policies.

Traditional Farming Practices In India

Traditional farming practices in India have been the cornerstone of the country's agricultural heritage for centuries. They are characterized by a symbiotic relationship with nature, where farming techniques are adapted to the soil, climate, and bio-diversity. Traditional farming emphasizes sustainability, self-reliance and minimal environment impact. This approach not only ensures long-term health of the land, but also preserves the rich biodiversity that is essential for the resilience of ecosystems.

Agro-forestry :

Agro-forestry is an age-old practice of agriculture system in India, which involves the practices of tree plantations alongside crops. It has the potential of mitigating the effects of climate change, food security and crop productivity(Hamadani et al.). This practice enhances the soil quality, biodiversity and climate resilience increasing the farmer's income. A system of agro-forestry, known as silvopastoral sytem, is beneficial for livestock, in which leguminous fodder gasses are grown with trees (Reis et al.)((Isaac et al.), (Hamadani et al.).

Intercropping :

Intercropping is essentially a system of small and dry land farmers as it is a risk minimizing agriculture cropping system. Intercropping or mixed cropping involves cultivating two or more crop species simultaneously to optimize productivity (Brooker et al.). It enhances the productivity in any weather and climate condition and also it can reduce risk and uncertainty arising in the production of crops. The multi-cropping or inter-cropping provides about 15-20% of food supply for global population.

Crop rotation-based agriculture :

Crop rotation means the cultivation of two or more crops in a cyclic manner using same resources. It improves soil nutrient level, prevent soil degradation and act as a solution for scarcity of resources. It is a traditional practice, which is effective in the control of weeds, pests and disease (Patel et al.)

Livestock integrated agriculture practice :

Animal husbandry in agriculture is one of the oldest mainstays of cultivation in a tropical and developing country (Patel et al.). Current scenario indicates that a quarter of the global terrestrial land with the integration of animal husbandry produces almost one-tenth of the world‘s meat supply. It has historically played a vital role in Indian agriculture. Farmers integrate livestock for milk, meat, labor, and organic fertilizers, contributing to food security and sustainable farming (Patel et al.).

Shifting cultivation :

Shifting cultivation or jhum kheti also refers to as slash burn cultivation, which is a practice of growing crops on a land covered with ashes produced from burning trees. When the soil becomes exhausted the land left uncultivated and farmers shift their cultivation to another land and start with the same process. This method has been a way of life for many indigenous communities, particularly in North-East India. While effective for short term productivity, this method raises concerns regarding deforestation and soil erosion.

Modernization Agricultural Practices in India :

In the past, the agriculture activities were limited to food and crop production but in modern time it has includes processing, marketing distribution of crops and livestock products. In India agriculture activities generates employment, national income, provides raw material for other industries. Changing dimension of world economy and growing population now demand for more productive technology on this sector. Though the green revolution was the one step ahead of that traditional agriculture, it can‘t say that it was a viable solution for India as food in-adequacy has been a broad problem. It is believed that global population would hit by 10 billion by 2050 and to meet the population growth demands, global food production must increase 70% by 2050. In such situation modern farming is an emerging approach to agriculture which helps to increase productivity and reduce the number of natural resources required for agricultural production. Modernization of agriculture involves technological advancement, data-driven solutions and AI-based automation to increase efficiency and yield. Some modern farming systems use in agriculture sector in India are as follows :

Hydroponics and Aquaponics

These techniques are gaining popularity in urban and pre-urban areas, allowing for the cultivation of vegetables and herbs with minimal land use and water. Aquaponics is a closed loop system that relies majorly on the symbolic relationship between aquaculture and agriculture for fertilization. This farming method combines conventional aquaculture with hydroponics. Hydroponics method doesn't require any type of soil. It is a method of growing plants without soil, using a nutrient-rich water solution to deliver essential minerals and nutrients directly to the plant's roots. The process involves growing healthy plants without the using of solid medium using mineral rich water for nutrients.

Organic farming **:**

Organic farming is an agricultural method that developed in response to rapidly evolving farming practices early in the 20th century. Compost manure, green manure, bone meal uses as an organic fertilizer. In this method biological management of pests, mixed production and the promotion of insect predators are encouraged. According to the Union Ministry and Farmer's Welfare, 2.78 million hectares of agricultural land had been cultivated organically. Madhya Pradesh tops the list with an area under organic farming of 0.76 million hectares, which is over 27% of the total organic farming area. Madhya Pradesh is followed by Rajasthan and Maharashtra on total area covered by organic farming.

Precision farming :

Precision farming or satellite farming involves satellite mapping, IoT devices and AI-driven data analytics to optimize crop management, irrigation and resource efficiency. It focuses on the observation calculation and response of crop intra-field and inter-field variability. The advent of GPS and GNSS has enabled the practice of precision agriculture. Data analytical tools help in making informed decision about crop management, predicting yields and managing risks like pests and disease. Precision farming can lead to higher productivity, resource efficiency and help farmers better cope with climate variability.

Genetic manipulation of crop plants :

Modern agriculture has taken advantage of the advancement in a large number of molecular breeding and a bio technological tool, crop productivity has been increased in recent past. Genetically modified crops are developed in in-vitro conditions by altering the genetic makeup of a host organism (Kale et al.). At commercial level the best-known common example of genetically modified crop (GM) crop in India is Bacillus Thuringiensis [kale et al.,2020]. The GM crop has been developed for bioremediation of tainted soil.

Introducing AI in farming as a modernization of agriculture sector

In modern times, farmers are becoming increasingly aware of the benefits of using artificial intelligence in agriculture to enhance productivity and profitability. Automation and AI-driven technologies are key solutions in addressing pressing social challenges such as ann aging farming population and declining workforce availability. However achieving the accuracy and complexity required for operations that were traditionally carried out by farmers to maintain high-quality produce remains a significant challenge

(Zha). Recently some state has introduced AI driven agricultural process. With *Sensor Device,* that check weather and soil health uses AI figures out when to water the crops which led to a near 25% boost in productivity on crops. Informed decision making is only one part of the solution to improve productivity, inefficiencies in the existing in conventional methods of agriculture. To provide actionable insights AI used as Sensors, Drones and satellite imagery to collect data on soil conditions, weather and pest infestations. AI tools using in agriculture can be used as a management of supply chain and planning for better yielding of crop. Introducing robotics in agriculture also increase in higher yielding. Automatic tractor, machine, drones perform tasks such as planting, weeding and harvesting with high efficiency. Artificial intelligence is the concept that can transform present day agriculture to more productive input model. Some uses of AI in agriculture process such as follows;

- **Crop health monitoring system :** AI facilitates identification of pests, disease and weeds problems and automated the management of these problems. AI also predict for future situation and enabled issues advisories for sowing, pests' control and commodity pricing. Remote sensing techniques, hyperspectral imaging and AI build crop health monitoring system use as tools for monitoring crop.
- **Smart irrigation system :** Smart irrigation system includes providing the actual quantity of water for right crop at the right time. In conventional method most of farmers are depends on rainwater but lake of proper irrigation the yielding was low comparative to the modern agriculture system. Using sensor based automated irrigation system issued associated with the low irrigation efficiency of Indian agriculture which is around 38% (Sinha et al.) can be resolved to greater extent.
- **Agricultural risk management :** There are a very high level of risk and uncertainty arising during the cultivation of crop. Uncertain drought, rain and other disease can affect the production of crop. In such situation AI based technologies support farmers in the management of risk and uncertainty by facilitates preparedness to the farmer.
- **Natural Language Processing for agricultural advisory :** India is a multi-lingual society and majority of farmers are illiterate. A lot of content failed to reach the desired people because of language problem and lake of human resource to convert it to the end user‘s language. This gap can effectively fill through natural language processing tools of AI.
- **Agriculture growth driven by IoT :** AI and information technology or sensor can be used to create intelligent system that can be embedded in machines to make it worth higher accuracy. IoT is an advancement built on several existing technology such as wireless sensor networks and cloud computing. IoT can be