## CHAPTER 15

# GREEN NANOTECHNOLOGY: THE NOVEL AND EMERGING STRATEGY FOR SUSTAINABLE DEVELOPMENT

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## ABSTRACTS

A ground-breaking discovery of the 20th century is the ecologically sound Nanotechnology (NT). It can benefit many industries like for medical purposes – drugs (especially for cancer), surgeries, agriculture, cosmetics industry, fabrics, in many devices – computers, mobiles, waste material management, water treatment, and others. Green NT is a combined effort with green chemistry with engineering in modified ways and is investigating without distressing human health and the environment. Presently, the chapter emphasizes synthesizing green nanoparticles (NPs) and their prospective approaches at a multitude of organizations. The valuable part of this green revolution is the copious availability of its source, which can mitigate the effects of global warming and lessen both food security and productivity. Different plants, algae such as *Mikania* sp., diatoms, *Salvinia molesta*, etc., are used to extract the NPs and are used for variegated environmental practices both in and undeviating way or ambiguously. Moreover, those green NPs can also alter the metabolisms within plant bodies themselves, including oxidative stress, apoptosis-related changes, etc. Comprehensive investigations are going on globally for the nanomedicines, and usage of green NPs in drug delivery systems (DDS), and this field should acquire attention for the sake of more advanced civilization.

Sustainable Nanomaterials for Biosystems Engineering: Trends in Renewable Energy, Environment, and Agriculture. Junaid Ahmad Malik, Megh R. Goyal, Mohamed Jaffer M. Sadiq (Eds.)

## 15.1 INTRODUCTION

"Nano" is a Greek term that denotes a little dwarf or minute material with a magnitude of $10^{-9}$ m [104]. When dealing with the term "nano," two other phrases come up frequently: "nanoscience" and "nanotechnology," while NT is a subfield of nanoscience that specializes in developing devices, components, and systems with the smallest unit size possible (1 nm) [95, 138, 153]. NT has been used since the time of Democritus in the 5th century B.C. [101]. People believed that matter could be split down into numerous indestructible essential components, eventually referred to as atoms [152]. In the late 1800s, Dmitri Mendeleev and Lothar Meyer constructed periodic tables separately [35], widely regarded as the first method for arranging elements according to their atomic masses [27]. The 20th century was significant in terms of science since it saw the development of nuclear and particle physics and the discovery of subatomic particles [76]. NT was used by ancient people from the 4th century AD, according to historical records.

The Lycurgus Cup, a roman cage cup made of dichroic glass, is a classic example of NT in practice [62]. When the source of light and the observer are on the same side, it emits a green color and a bright red color when the viewer and the light source are on opposite sides. [67, 156]. This unusual effect was caused by two distinct silver (Ag) and gold nanoparticles (Au NPs). The green reflection comes from the Ag particles, whereas the red comes from the gold (Au). It is said to be the only surviving antique glassware with remarkable optical features [77]. According to medieval European artisans, adding gold chloride ($AuCl_3$) to molten glass gave it a reddish tinge [133], while silver nitrate ($AgNO_3$) gave it a yellowish tint [60]. During the 16th to 18th centuries, this method reached its pinnacle, resulting in creating some of the most magnificent stained glass in the world [22, 97]. However, the craftsmen were unaware of the scientific explanation for these beautiful hues at the time. Scientists later revealed that Au and silver nanoparticles (Ag NPs) in stained glassware operated as quantum dots (QDs), reflecting red and yellow light and enhancing the brilliance of the stained glass [24]. During the Renaissance period, around the 15th and 16th centuries, Italians employed nanoparticles (NPs) to make pottery. The Au and ruby red lusters could be explained by the existence of NPs of Ag, copper (Cu), mercury (Hg), and bismuth (Bi) in various proportions in the pottery [118].

Nanotechnology was also widely used in the Islamic world. The Islamic culture was also enamored by luster and strove to imitate pottery and art. The record states that the earliest luster beautifications were applied to glazed pottery in the Caliph's palace in Samara around 836–883 AD. A

variety of metals was discovered during a chemical investigation of Islamic lustered potteries, out of which Cu and Ag NPs, in general, contributed to the coloration [142]. The ottomans manufactured "Damascus" saber blades made of cementite nanowires and carbon nanotubes (CNTs) that provided increased stability, toughness, and a sharp cutting edge until the 18th century [145]. Michael Faraday made one of the earliest attempts to investigate the properties of NPs [128] systematically. He investigated the characteristics and behavior of colloidal suspensions of 'ruby' Au in great detail, demonstrating that Au NP is responsible for various colors in solution [33]. The NT R&D Act of 2003 established the idea of NNI.

This chapter is an overview of the use of green NPs in various fields. Efforts have been made to have an in-depth overview of the utilization pattern and its potential benefits.

## 15.2 HISTORY OF NANOTECHNOLOGY

Richard Feynman, an American physicist and Nobel Laureate came up with "nanotechnology" in 1959. He gave a talk titled "There's Plenty of Room at the Bottom" at the American Physical Society's annual meeting at the California Institute of Technology. The underlined necessity of influencing and controlling things on a tiny scale in that lecture. He envisioned building a machine that could eventually build smaller machines down to the molecular level [39]. His predictions proved true, earning him the title of "Father of Modern NT" [59]. After 15 years, in a study published in 1974, Norio Taniguchi, a Japanese physicist, was the first to use and define NT [46]. After this, there was no looking back, and NT began to increase, and its potentials were applied to several disciplines for human benefits. NPs' harmful effects on living systems were caused by their small size, vast surface area, and propensity to create reactive oxygen species (ROS) [164]. NPs cause inflammatory reactions [38] and induce fibrosis in the living system [82]. They also trigger oxidative stress and alter electrochemical function [140]. Moreover, NPs suspended in the air due to contamination also adversely affect health [49, 141]. Thus, to minimize the harmful effects of NPs synthesized through conventional methods, scientists resorted to alternative and eco-friendly ways to synthesize NPs. The creation of green technology is a significant accomplishment in the realm of NT. Green NT is a green technology that incorporates green chemistry and green engineering principles, with the term "green" referring to nanomaterials (NMs) derived from plants. The key benefits of green NT are enhanced energy efficiency,

less waste and greenhouse gas (GHG) emissions, and lower demand for non-renewable raw resources. Green NT provides a fantastic opportunity to prevent negative consequences before they arise [173]. These can be traced the history of green NT back to the National Nanotechnology Initiative (NNI) initiated by the United States of America under the leadership of Bill Clinton [55]. The NT R&D Act of 2003 established the idea of NNI [135]. The NNI had four goals, namely:

- Developing and expanding modern age NT R&D;
- Promoting the transformation of innovative technology into economic and public goods;
- Developing and maintaining educational materials and strengthening the framework and equipment needed to progress NT;
- Boosting the growth of NT in a responsible manner [71].

The fourth goal is 'sustained' via green NT by reducing or eliminating harmful substances generated during the synthesis of NMs [71]. Presently green NPs are synthesized using both plants and microbes. A first-time observation by Beveridge and Murray in the 1980s related to the use of $AuCl_3$ solution to suspend unfixed *Bacillus subtilis* cell wall. It can observe that Au NP was deposited extracellularly on the wall surface [42]. *Pseudomonas stutzeri* AG259, for the first time, was found to produce Ag NPs due to its reductive potential [129]. Another investigation states that *Pseudomonas aeruginosa* can generate a range of NPs intracellularly [159]. One of the first reports of fungus synthesizing Au NP was through *Verticillium* sp. [48]. Synthesis of palladium NPs was observed in *Chlorella Vulgaris* for the first time [11]. Gardea-research Torresdey's group initially reported Ag and Au NPs at the University of Texas at El Paso in the early 2000s by using *the Medicago sativa* plant. It offered up new and exciting possibilities for NP fabrication. In the developing field of nanobiotechnology, their work revealed a link between materials science and biotechnology [125]. In a more recent study, the potential of *Salvia Spinosa* to produce Ag NPs was reported [123]. Presently there has been an increase in awareness of green NPs, and their uses are increasing in several industries.

## 15.3 GREEN MANUFACTURING PROCESSES FOR BIO-NANOPARTICULATE MATTERS

The compelling reason behind the production of green nanomolecules is that these are both energy-saving and economical techniques considering

the crucial circumstances of sustainable development. This technology also reduces the production of pernicious waste materials, which will safeguard our atmosphere rather than ecosystems. The green NPs are extracted from natural sources like plant extracts, algae, bacteria, fungi, yeast, and viruses. Here, we are discussing mainly how plant materials are used to manufacture green NPs. Plants are a rich source of phytochemicals, biopolymers, proteins, nano-cellulose, reducing agents, and metals along with their compounds which can draw out from disparate anatomical fragments like a few somatic and reproductive areas from the plant body and even by utilizing the whole individual.

The entire plant body of aquatic weed *Salvinia molesta* is used to retract the Au NP. After accumulating a specific amount of this particular freshwater hydrophyte, the undamaged, developed, and healthy aerial and submerged portions of the plant were taken, cleaned properly in normal water, and sterilized using saline water. The samples are dried at 105°C before taking their weight. About 1 gm of plant material is taken with 100 ml distilled water to boil for 5 minutes [2]. The filtration is done with Whatman no. 42 filter paper and is kept for refrigeration at 4°C [43–45]. The competence of the solution is retained for up to 3 days, and it can analyze through Reconnoitery experiments. The analytical reagent grade Chloroauric acid ($HAuCl_4$) is used to prepare a $10^{-3}$ M aqueous Au solution. The brown bottles are appropriate to store the produced Au NPs by wrapping them in. It needs to be veneered with dark paper. Characterizing of those Au NPs is done through various processes like UV-Visible Spectroscopy, studies of Fourier Transform Infrared Spectroscopy (FTIR), Energy Dispersive X-Ray (EDAX), Selected Area Electron Diffraction (SAED), and Scanning electron microscopy (SEM) or Transmission electron microscopy (TEM) [1]. *Pistia stratiotes* also aim for Au NPs extraction in the same way as it has been done from *Salvinia molesta* [9].

Ag-NPs can be synthesized from *Eichhornia crassipes* (presently the most troublesome aquatic weed). Those particles are both the reductant and coating agent within an aqueous medium. Differences in their efficiency are also observed according to the NP's variation in its optical and morphological properties [102]. The ultraviolet radiation promotes the percentage of chemical reactions combining the Ag molecules and the leaf essence of *E. crassipess*. At the same time, the Plasmon vibrations excite the solution showing color variation in various shades of yellow during a concise time duration of 5 minutes only. The NPs are validated by using UV-visible spectroscopy, TEM, X-ray diffraction (XRD) spectrometry, and Energy Dispersive X-ray (EDX) [64]. AuNPs also be drawn out from this invasive species.

The seeds of *Salvia Spinosa* were taken and sprouted in *in-vitro* conditions to get Ag-NPs [123], Pelargonium *graveolens, Salvia officinalis, Lippia citriodora, and others* can also be used for AuNPs squeezing [36], *Eucalyptus macrocarpa. Psidium guajava, Terminalia catappa,* and others [173]. Some plants like cashew nut, neem [17, 19, 40, 87], *Aloe vera* [173], etc., also provide bimetallic NPs (Au-Ag).

Unconventional approaches like water and supercritical carbon dioxide are explored as the substituted reaction media of organic solvents [162, 163]. "Hydrothermal approach" is the most approved technique among [91]. The warmed and excited green chemical kinetics are also investigated for elevating nano-molecules and plating critical articles [3]. Moreover, the absorbed sunshine [175], microwave power is also utilized to manufacture NPs [111]. There are some biosynthesis techniques are mentioned below.

### 15.3.1 MICRO-EMULSION TECHNIQUE

It is a resourceful procedure as it helps to manage particle's different characteristics like its expanse, shape, architecture, and consistency [58, 122] by providing variation in its occurrence like water-in-oil (W/O), bicontinuous structure, sponge phase, and through various dispersed phase emulsions [94]. Two main models are focused on their working principle: i) LaMer diagram and ii) the thermodynamic stabilization of the particles [81]. It can also induce various types of NPs like metals, metal oxides (MO), iron oxide ($Fe_2O_3$.FeO), colloidal silver chloride (AgCl), nanocrystalline titanium dioxide ($TiO_2$), aluminum oxide ($Al_2O_3$), and many others by using this method [12, 14, 21, 57, 83, 183].

### 15.3.2 ADDITIVE MANUFACTURING METHOD

These 3D printing techniques are more advantageous in terms of time efficiency, requirements, money-saving, and acquiescence, using for fabrication and biomedical industry at a greater magnitude during recent times [172]. A practical model can even mitigate the expenditure, pollution, and energy by 170–593 billion US dollars, 130.5–525.5 metric tons, and 2.54–9.30 joule respectively, within 2025 [47]. Discrete practices are involved within this technique as per requisite or for which purpose it is used. The advanced 3D nano-plasmonic architectures' peer-group printing deploys the spatial nanometer resolution through electron-stimulated

responses within the direct-write fabrication of 3D metallic nano-designs while the tissue engineering is applying 2-photon-based nanofabrication process with self-restrained electrospinning [79].

### 15.3.3 NANOSUSPENSION METHOD

Many botanical medicines show its limitation regarding molecular mobility, assimilation rate, water solubility, and lesser *in vivo* capacity. Nanosuspension is an excellent applied method to solve this problematic issue of herbal drug production and delivery system [66]. The sonification is done to solvate the prepared plant solution like seeds of *Coriandrum sativum* (2.5 g) with the acetone and ethanol mixture (15 ml) at 3:1 proportion only for 60 seconds, followed by administering that mixture to different polyvinyl alcohol solutions. The produced NPs are finally kept cool to −18°C, and the lyophilizer is operated to make the desired one into dry dust [100].

In addition to that, other ways such as Rotary-evaporated film ultrasonication method, Ionic Gelation method, Emulsion Solvent Evaporation, Dialysis method, Rapid prototyping, Sol-Gel technology, etc., and sometimes an integrated approach are also used to generate the green NPs. We need to concentrate on supplemental turning out of these particles during a short time and with profitable strategies.

## 15.4 USE OF NANOPARTICLES IN VARIOUS DOMAINS

### 15.4.1 AGRICULTURE

Currently, agriculture is dealing with some significant challenges, standing out to be an intervening factor for this sector. Drastic climate changes decrease soil fertility, macro and micronutrient deficiency, and excessive usage of fertilizers and pesticides.

In this scenario, Green NT has an immense role in uplifting the present agricultural systems [4]. NPs have varied applications in the field of agriculture, namely pesticides delivery [113], delivery of nutrients [72], biofertilizer formulation [146], supplying genetic materials for crop improvement [177], and plant disease management [178]. The declining awareness of the farmers and overuse of chemicals is taking hard on Agriculture Industry. The commonly used NPs used here include Ag, nano-aluminosilicates [34], Titanium oxide [92], and CNM [108].

The use of nanopesticides has inconspicuously increased crop productivity [130]. A stable nano-pesticides-Biofenthrin using polymer stabilizers like polyvinyl pyrrolidone, polyvinyl alcohol, and polyacrylic acid, has been successfully formulated [88]. Nanosilica is obtained from various shell walls of diatoms [99] which can be potentially treated as pesticide [37].

NPs for disease management with specific antimicrobial properties prevent microbial infestations. To name a few, cobalt and nickel ferrites [148], Cu NPs exhibit strong anti-fungal properties [63]. Chitosan NPs, Zinc oxide (ZnO), and silica are quite effective against the viral diseases-Mosaic virus for Tobacco, Potato, and Alfalfa [165]. NT is also coming up with a good enhancement in the field of Agriculture with nano-fertilizers. Nano-fertilizers are made from different plant parts encapsulated with NM [158]. Different forms of nano-fertilizers are available in the form of Nitrogen(N), Phosphorus(P), Calcium(Ca), Magnesium(Mg), and Potassium(K), Manganese(Mn), etc. [19]. Bio fertilizers-based nano-fertilizers are equally effective for crop development programs as they positively interact with microbes and organic compounds, making the latter bioavailable to plants [143]. In one such study, the effects of PGPR containing nano-biofertilizers towards fatal fungal and bacterial pathogens within the rhizosphere of the leguminous crops [61].

Nanobiotechnology has also revolutionized the field of seed technology. Seed quality is a significantly measurable attribute of Agriculture, and it comprises the entire genetic complement of the crop. Studies from recent literature have shown that NPs have increased germination, vigor, and quality of seeds like groundnut, onion, lettuce, spinach, tomato, etc. For faster germination, CNTs penetrate more deep seed layers and support water up taken by them [151].

Nano-biosensors are another domain of NT that has revolutionized farming systems to a great extent. NPs like Au, Ag, Si, Pt are commonly used as biosensors [29, 30]. Fluorescent Silica NPs associated with antibodies can identify the presence of plant pathogens like *Xanthomonas axonopodis pv. Vesicatoria* [139]. Au NPs can be used to detect hidden infection of brown rot of potato [131]. Besides the application of nano-biosensors, nanobiotechnology has a conspicuous role in the field of Agriculture. Nanobiotechnology is amalgamating molecular and cell biology leading to the development of outstanding crop varieties [74]. To revolutionize sustainable Agriculture NT, we need to prioritize the aspect of controlled green synthesis of NPs, the interaction of NPs with the plant system, and its adverse side effects on different environmental conditions [32]. Focusing on the right policies for developing a sustainable Agri-nanotechnology is of utmost priority, which includes the formulation of specific guidelines by the Food Safety and

Standards Authority, collaborative research for developing a better research system, proper evaluation for biosafety of NPs, and most importantly, educating farmers about this novel strategy.

### 15.4.2 FABRICS

The textile industry has a high dependency resource rate globally as it exploits considerable amounts of energy, water, and various hazardous chemicals. The current situation has induced some issues regarding the sustainability of textiles due to major answerability on the environment. So, researchers have come up with the best possible alternative for the long-term sustenance of the textile industry. Currently, green chemistry has emerged as an effective tool for keeping this industry sustainable. Green chemistry has exceptionally contributed to the development of alternative biodegradable chemicals which can be used as washing and wetting agents. Out of several NP synthesis techniques, the green synthesis technique stands out to be most effective in controlling particle size and morphology.

In comparison to other conventional techniques, this technique is relatively amicable. Papaya peel-derived Ag NPs pose a practical example in developing fabrics due to their potential antibacterial activity [30]. The remarkable deceleration in reaction time with fruit peel extract led to significant results that have enabled NP biosynthesis to give a tough competition with any other strategies for forming NPs that are more reproducible [149]. According to a recent study, biosynthesized Ag NPs from *Acalypha indica* leaf extract were coated over cotton fabric [51]. Besides, the Ag NPs coated cotton fabric flaunted significant antimicrobial activities [52]. Amongst the different metal oxide NPs used in textile finishing, silver oxide ($Ag_2O$) has speculated more sustenance, especially for outstanding antimicrobial properties. Papaya peel-derived Ag NPs, have been amalgamated into fabric processing, and the manufacturers are providing textiles free from ruination by microbes [5]. These once again proves an extraordinary green revolution in NT for a better textile industry tomorrow.

### 15.4.3 COSMETICS

Cosmeceuticals are now the fastest-growing ancillary of the personal care industry with promising economic growth-besides, immense benefits of NPs. The two most crucial tools – liposomes [127] and niosomes [25]

play the roles of delivery vehicles in the cosmetic industry. Structures like solid lipid NPs and nanostructured lipid carriers have proven superior to liposomes [150]. Moreover, nanostructured lipid carriers are prospective as next-generation cosmetic delivery agents that can enhance skin hydration, bioavailability, and biostability of the agent and occlusion in a more controlled manner [109, 120]. Nanocrystals and nanoemulsions are also pioneers in the cosmetic industry [176]. Dendrimers which are nanosized and radially symmetric molecules with a homogeneous structure continues to be one of the vital necessities of cosmeceuticals. Several patents have been filed for the same [1, 18]. ZnO NPs – a major constituent of all sunscreens block ultraviolet rays minimizing the white coating on the skin [157]. Ivy plants generate most of the NPs used in sunscreens. Based on current research surveys, ivy NPs are more effective than oxide NPs in preventing ultraviolet rays [179]. All skin creams utilize proteins from stem cells to inculcate anti-aging properties [157]. These proteins are coated with liposome NPs which merge with the skin membrane, thereby allowing delivery of the proteins. Skincare lotions are just an amalgamation of nutrients condensed in NPs in liquid suspension, leading to nanoemulsion formation. The smaller size of NPs allows the better penetration into the skin [73] when compared to particles in conventional emulsions, thereby enriching the skin layer with maximum nutrients.

### 15.4.4 WATER POLLUTION MANAGEMENT

In the present scenario, water quality and water availability have been found as one of the main obstacles that the human race is confronting. Water contamination is caused by various factors, including discarding of garbage, oil spillages, see page of different fertilizers, weedicides, insecticides, manufacturing spin-offs, fossil fuels extraction, and burning [80]. In this circumstance, NT presents an eclectic array of abilities and technologies to enhance the attribute of prevailing environs [136]. NT possesses three critical uses in the spheres of natural environs [182], such as (Figure 15.1):

- Remediation and decontamination of polluted substances;
- Perceiving and recognition of contamination; and
- Preclusion of contaminations.

NMs possess more excellent responsiveness, capability, and a perceptiveness for heavy metals and other impurities. The reason for utilizing NMs is the elevated receptiveness, heftier exterior interaction, and enhanced clearance

ability. Several NMs have been used to treat water pollutants [183], such as CNTs, biopolymers, zerovalent iron (ZVI), self-assembled monolayers, etc.

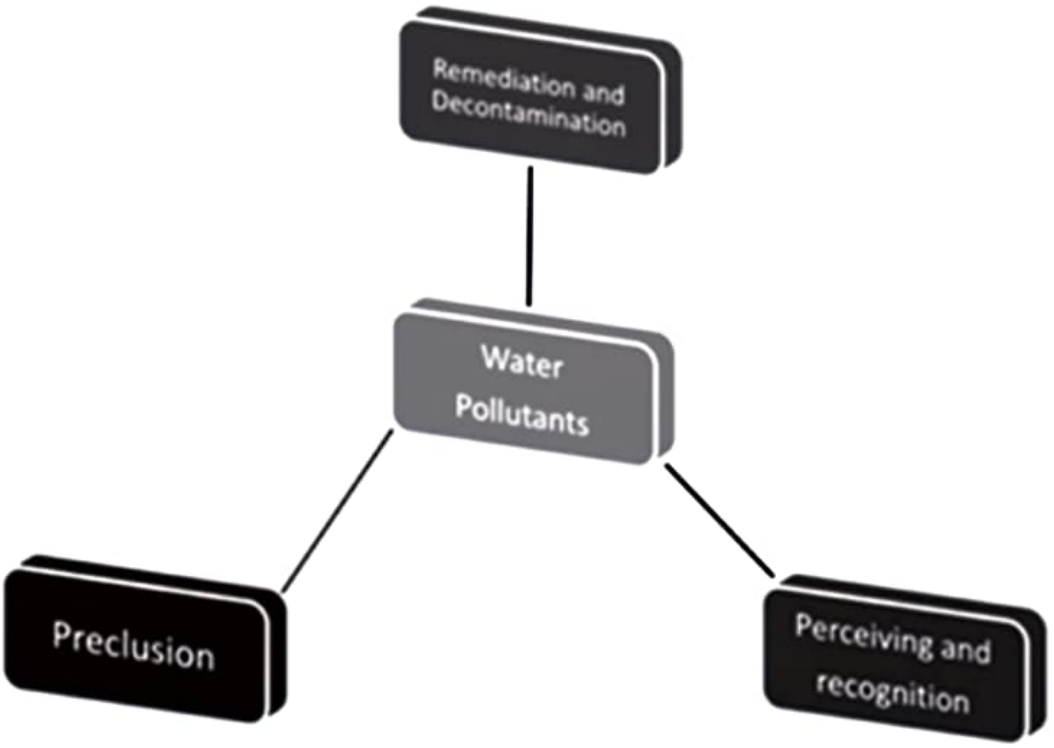


**FIGURE 15.1** Key uses of NT in water pollution control.

The pumping and treating approach were applied to mitigate water pollutants till 1998. An alternative approach to mitigate water is through applying a permeable reactive barrier (PRB). It cleanses sub-surface groundwater. In addition to that, it mitigates devoid of the necessity to bring in the water towards the surface. PRBs are utilized to cleanse contaminants, for instance, chlorinated hydrocarbons (HCs), aromatic $N_2$ compounds, Polychlorinated biphenyls (PCBs), insecticides, and chromates [183]. The use of PCBs is costly. But it observed that some ZVI, i.e., zerovalent metals such as Fe, purported to be a filtering substance of PBR, can manage or ease hazardous toxins present in the water in massive amounts [70]. The tiny unit size establishes nano-Fe, which is proficient in multipurpose usage intended for remedial reasons. Usage of nano-iron along with the PRBs has been shown efficient. Other metals like Zn might replace Nano-iron, and Sn can lessen impurities like Fe. Even two metal alloys, i.e., Fe and FeNi–Cu are engaged to vitiate $C_2HCl_3$ (Trichloroethene) [115].

Ferritin, a Fe-containing protein that is present in plants and animals. It can convert Fe atoms into ferrihydrite NPs. In visible daylight or solar radiation, ferritins can reduce toxic metals and chlorocarbons [124]. There are countless other examples of NT applications in water treatment in addition to the methods illustrated before., such as Self-Assembled Monolayers on Mesoporous Silica, dendrimers (SAMMS), Single Nanoparticle Enzymes (SEN), etc. [183].

In Recent Times, Green, and biologically synthesized NPs have been reconnoitered for sewage remediations, treatment works, etc., accompanied by other water decontamination tools to diminish or eradicate the hazardous tainted components present in water reserves [155]. However, the magnitude of regulations, steadiness, accretion, and alleviation are yet regarded as constant encounters for commercial usages of biogenic NPs in alleviating overflows of water contaminants. There are three nanocomponents such as (1) nano-adsorbents, (2) nano-catalysts, and (3) nano-films which are playing essential roles in exclusions of heavy metals [170] along with the dilapidation of organic, inorganic, radioactive, and therapeutic contaminants, nitrogen compounds), nitrate ($NO_3^-$), Phosphate ($PO_4$), and other hazardous dyes [10, 11, 85, 181].

### 15.4.5 WASTE MATERIAL MANAGEMENT

Wastewater is the spinoff of various water utilities such as domestic utilizes, such as bathing, cleaning utensils, washing clothes, and cleaning out the toilet. In addition, water coming out from the industries is also regarded as wastewater treatment. Although developed drainage systems were well before the 18th century, wastewater disposal is a relatively new activity. Wastewater or sewage treatment is the procedure and skill applied to eliminate many of the impurities to make sure sturdy environs that help suitable civic wellbeing [8]. Controlling wastewater involves managing wastewater to keep the environs safe for the public's monetary, societal, political comprehensiveness, and healthiness [96].

Nowadays, NT is considered a critical practice to treat wastewater to detect and exclude several contaminants [12]. The usage of NT in managing wastewater is achieving impetus worldwide due to the exclusive characteristics of NMs and higher congeniality amongst the accessible typical treatment processes for treating wastewaters [107]. Different nanotechnological approaches like photo-catalysis, nano-filtration, adsorption, and oxidation of electro-chemicals encompass different various technical domains (Figure 15.2).

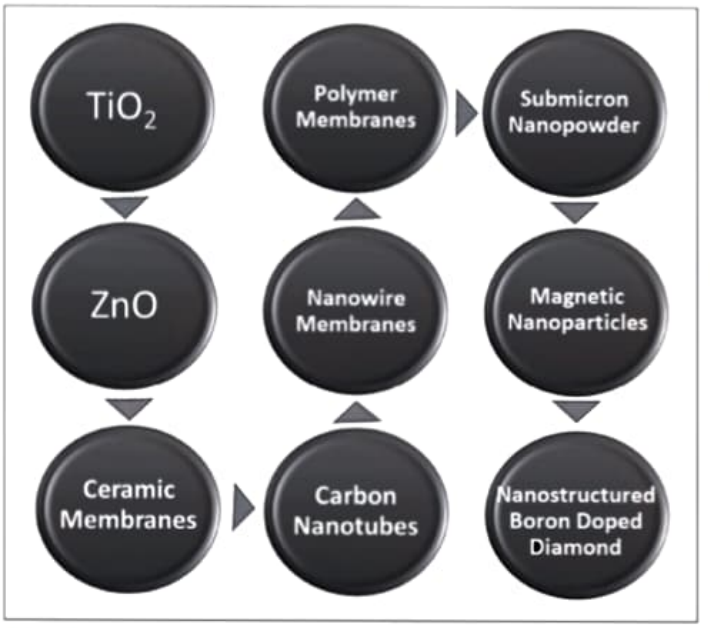


**FIGURE 15.2** Different components of green nanoparticles used in waste material management.

NPs are utilized as adsorbents, nanosized zerovalent ions, or nano-filtration membranes, causing the amputation of pollutants from wastewater [114]. While NPs used as catalysts for oxidation of photo-chemical results in the obliteration of impurities present. Nanoscale materials are utilized to treat wastewater. Nanoscale materials consist of four classes [168]: dendrimers, metal-containing NPs, zeolites, and carbonaceous NMs.

Nanotechnology also uses dendrite polymer materials in wastewater treatment and purification. Dendrite polymers comprise random hyperbranched polymers, dendrigraft polymers, dendrons as well as dendrimers [41]. Dendrimers vary in shapes and size ranges 2–20 nm [171]. It has been observed that dendrons with a multi-functional mainstay form a dendrimer structure. Dendron-enhanced ultrafiltration techniques having poly-amido-amine Dendrimers combining with Ethylene Diamine (present as core molecules) and amine ($NH_2$) group's (at the terminal end) can produce $Cu^{++}$, which reduces toxic components of wastewater [31, 32]. Ag-NPs show elevated antimicrobial activity [168].

NPs of oxides of metals, namely $TiO_2$, ZnO, and cerium dioxide ($CeO_2$), which possess greater reactivity and photolytic properties than others, can cause the purification of wastewater [75]. Magnesium and Magnesium oxide (MgO) NPs are inhibitory to Gram-positive and Gram-negative bacteria [161]. $Pd/Fe_3O_4$ nano-catalysts have also been observed to treat wastewater

processes [56]. Zeolites are utilized to remove heavy metals present in wastewater like – $Cr^{3+}$, $Ni^{2+}$, $Zn^{2+}$, $Cu^{2+}$, and $Cd^{2+}$ from the wastewaters [7]. Carbon NPs, nanotubes, nano-diamonds, and nanowires are act as sorbents and possess higher capability and specificity, intended for organic solutes present in the wastewater. They are steady, having inadequate receptiveness used as potent antioxidants [171].

### 15.4.6 MEDICAL TRENDS

It is essential to be explored more to protect human life from undesirable health-related disorders. Green NT ensures greater feasibilities in the medical field, significantly influencing the drug delivery system (DDS) and surgery-associated affairs. Including all the green NPs, the Ag and Au NPs are explored chiefly yet. Despite an emerging area, the boon of NT assists our medical system in several realistic ways. Massive investigations are going on for variegated algal, plants, and bacterial species. We can extract copious NPs showing antimicrobial properties and can be used for other medical purposes. It should be anticipated that different sources for varying NPs gaining and those NPs are essential to fight against diseases. So, biodiversity-rich countries like India, Brazil, Mexico, and others should invest more to invent convenient NPs which will be availed for the betterment of human civilization. The nano-material and nano-devices are currently employed at a noteworthy scale in nano-medicinal trends, which are presently [86] by dividing into distinct groups from first to fourth generation nanosystems. The last generation's achievements have paved the path of human organs renewal [93]. Even though the procedure is overpriced and tedious, the newly invented nano-drug molecules help to increase the shelf life, permeability, and mitigate the virulence [26]. Ag-NPs and Au NPs are also used in gene delivery systems [91]. The versatility, like recognition, distribution of well-planned remedy, etc., is the principal focus of these types of nano-drug delivery systems [84, 132, 134, 180]. The impenetrable anti-cancerous drug Sorafenib can be used via nano-carriers [166].

The newly advanced cartilage adjustment nano-materials like stainless steel, bioactive bone cement, titanium alloy, calcium phosphate apatite, etc., are more biocompatible, contributing to better chances for limb implantations [86], and those can even be handled particulars from outside via the internet or exterior operators [116].

The assemblage of more particles diagnoses the tumor site, while magnetically operating diatom frustules also facilitate the transportation of

tiny anti-cancerous particles. Frustule modifications with different natural and inert bio granules ameliorate its service by making it an advanced nano-structured appliance. Nano-carriers such as obtained from diatoms help to reach most of the target site within the affected area of the human body, automatically reducing the chemical dosages [166]. It (Au nanoshells) can destroy tumors gradually through chemotherapy. The PH-specific NPs are more effective for that kind of treatment. Platinum NPs are also taken to cure cancer in various parts of the human body [121]. Au NPs and Ag NPs from pollen solution of *Phoenix dactylifera* create good impacts for MCF-7 type of cancer in the mammary gland treatment by destructing units related with the apoptosis and triggering the disease all over the body [15] while *Nostoc* and *Anabaena* sp. Colonies' extracted Ag NPs are used as anti-cancerous agent [20]. The human infected cells of Leukemia (lymphoblastic Leukemia mainly) can be obstructed by applying those Ag NPs [137]. *Desertifilum* sp. also permits Ag NPs to inhibit a higher level of different colon, liver, and breast cancer cell lines propagation at competent concentrations [54]. Un-uniformed shaped ZnO nanoparticles (ZnO NPs) from *Ziziphus nummularia* leaves (distilled portion) reduces the possibility of cervical cancer at the rate of more than 50% [117] and the combination of 80 $\mu g\ ml^{-1}$ including large granular lymphocytic cells of murine in ZnO NPs of *Laurus nobilis* leaves check the spreading of the mutant cancerous cells [174].

In addition to cancer, DDS is also concentrated to cure nerve diseases such as Alzheimer's, etc., primarily Human Immuno-deficiency Virus (HIV) infection [93]. Discrete metallic and its oxides NPs are like iron oxide ($Fe_2O_3$. FeO), ZnO, platinum (Pt), Cu, etc., from plant materials are popular in DDS [112]. The antimicrobial activity of copper oxide NPs is used both as a surface disinfectant and injury bandage [53]. The dopamine-modeled $Fe_2O_3$. FeO NPs from diatoms lead to a far better drug carriage system, including around 22 weight percentage drugs stacking potentiality and safer for drugs more than two weeks [90]. AuNPs from *Lippia citriodora*, *Salvia officinalis*, and *others serve* as equalization and reducing mediums [36] and carry antibiotics [144]. The combined particles of ZnO NPs from *Anabaena* sp. with shinorine work as innocuous sunscreen service [54]. A more significant antioxidant influence than other nutritious phytochemicals like citric acid is found from the Au NPs of freshwater algae – *Phormidium* sp. Furthermore, green Au NPs from *Phormidium* sp. and *Coelastrella* sp. are applied for bio-labeling and detecting deoxyribonucleic acid (DNA) [106]. Establishing the electro-ballistic hydrogen peroxide ($H_2O_2$) biosensors by glassy carbon electrode requires zinc nanoparticles (Zn NPs) as observed from *Corymbia citriodora* [184].

Ag-NPs from the water hyacinth stalk and *Synechococcus* sp. offer antimicrobial activities against a few gram-positive and negative bacteria like *Staphylococcus aureus*, *Pseudomonas fluorescens*, *E. coli*, etc. [167]. Those NPs hinder the membrane penetration, cellular respiration by allocating sulfur protein, dispersing the electrochemical procedure of ATP synthesis, and fracturing the outer cell wall membrane [50, 89, 103].

The antimicrobial activities denote those highly responsive components with a greater surface area, allowing them to bind more with the bacterial surface receptors by their ligands [28].

Au NPs from *Euphorbia hirta* and *Annona muricata* have antibacterial characteristics, while Ag NPs from *Jasminum auriculatum* [13] and *Melia azedarach* leaves [69] behave as antifungal agents. It can also treat dermatological lesions, inflamed injuries, blisters with Ag NPs within a lesser duration, and layering the contact eye lenses. Moreover, Ag NPs have immense power to balance the shear bonds, making them appropriate for use in both dental and orthopedic transplantation [110]. A diabetic sufferer would get a remedy with strong microbicidal effects of Ag NPs of Anabaena sp. It performs against some drug-resistant micro-organisms like *Klebsiella pneumonia*, etc. [154]. The existence of phytochemicals like amino acids, flavonoids, etc., of Zn NPs from the liquid solution of *Barleria gibsoni* leaves offers reducing and defensive methods [147]. It can even treat the unhealed ulcers with *Strychnos nux-vomica's* Zn NPs due to its excessive restorative feature giving decreased immunosuppressive responses [160].

The remedy for DNA and other cellular damages can do customized drug therapy with the help of somewhat lengthy but advanced green NT. Nanorobots are already invented, and these can be used in different surgeries that would be without any scars within the body and 1,000 times more accurate than the present serrated scalpel [6].

Few common plants' leaves like *Rosa Officinalis, Cynodon dactylon, Azadirachta indica*, etc., are used to yield non-contaminating, money, and power-saving, and somewhat pure green CNTs [169]. Those are advantageous for their greater capacity of drug uptake, higher conductivity, and lightweight. It shows lower side effects after chemotherapy and can distinguish between normal and malignant cells. An undeviating mechanism for hitting the target site in the mammalian cells during the treatment gives a well-advised recovery through cytoplasmic transportation of the payload [78, 105]. The blood-brain barriers always block the path by which the drug can reach out to the tumors, but CNTs can go there and heal it [16]. The CNT is a convenient option for applying the drug for cancer treatments (drug delivery) in lymphatic organs.

Hence, it can assume that the empirical approach of green NT will gradually design a revolutionary era in medical history.

## 15.5 CHALLENGES

The classical designs are trying to substitute with the additive processes for green NPs manipulations. Additive manufacturing is restricted to its small range of few polymers and metal powders only. The labyrinthine plan of action of that green biogenesis creates it incurious [68]. Inconsistent Ph, temperature, reducing agents, reagents' concentration, reaction, and incubation time are followed according to the material and architectural configuration of NPs. For example, Ag nano-molecules can be found at room temperature from *Myristica fragans* fruit pericarp while Au NPs demand 90°C, coerced from the same organ of *Terminalia berillica*. In addition, leaves are the only benign source for NPs extraction as it does not affect any plant as much as after removing any other body parts like roots, fruits, etc. [23]. Lack of knowledge is another primary concern. It cannot utilize the end products solely. Many high-priced and harmful products require to obtain the particles, and the target for cost efficiency cannot be achieved [172]. It cannot also be judged the harmful impacts of few NPs still now. The unpleasant consequences are there when the nano-herbicides, pesticides, or fertilizers are applied. Apoptosis, stress sensitivity, and different physiological metabolisms are disrupted in Asian Rice plants by Au NPs and Ag NPs [98]. Much better communication and understanding have to be shared among researchers, administrators, industries, and workers to replete the gap area regarding those disadvantages [173]. It is an emerging area on a global scale, so a lot more investigations are necessitated for transversing and aiming this area expertly. Moreover, there is a lack of proper infrastructure and laboratories for the experiment as it is still mainly in the demonstrative phase. The training purposes demand few expenses too, including some wastage due to uncertainty in its knowledge [65].

## 15.6 FUTURE PROSPECTS

Green NT can be crowned as the significant Industrial Revolution that supports sustainable solutions to varied Global issues [119, 126]. The primary consideration that makes NT a promising future is utilizing the least

energy and most minor use of toxic compounds. Many innovations so far in this field have proved to be of great importance for the future. Besides, these discoveries indeed impose a positive impact on the global economy.

Some well-developed innovations include greener cars where the vehicles can run on non-fossil fuel energy instead of hydrogen fuel. Even there can be prospects of consuming fossil fuels by using nanocomposites (NCs), and also tire innovation can be made using different NMs. Green NT can promise a better future for the paper and packaging industry where cellulose can be involved in paper production. The use of nanotubes for transport and electronic applications has become an essential requirement of today and will be a necessary tool in the future as they bear high strength, low weight, low density, and are cost-effective [185].

Green NT opens another door of a globally important concept called "Green Economic" that is highly dependent on sustainable development. The conceptualization of the Green Economy has been established by the United Nations Environment Program (UNEP). This new concept of the green economy is expected to improve human wellbeing. The Green economy can play a significant role in changing society on a Global platform keeping Environment and Economy as two interfaces. At this juncture, Green NT has an influential role in assembling the precise functioning of NT, plant science, and chemistry and coming up with revolutionized products for mankind.

## 15.7 SUMMARY

The human population is taking a peak globally, and as a consequence, it is impacting our sustainable resources. In this scenario, Green NT has a crucial role to play as it can envisage sustainability. The principles of green chemistry influence the life cycle of nano-products, starting from design to disposal. It can be a novel strategy for humans and the environment that can revolutionize large-scale nano-synthesis procedures. The parameters on which green chemistry stands upon include reduced toxicity, biodegradable, and cost-effectiveness. It mainly aims to exploit the different properties of NMs. These solutions can reduce the renewable Energy source and improve power delivery systems to provide a better ecosystem and livelihood conditions. Green NT, an emerging technology, might meet particular challenges that include technical barriers, proper utilization of NMs, and regulatory policies for synthesis. The amalgamation of NT and green chemistry is gradually taking the right shape with technological advancements and can be considered a sustainable future of nano-synthesis. Undoubtedly, green nano-products

are based on clean energy applications. Moreover, the conjunction of plant sciences and NT has immense potential to evolve an attractive symbiosis between the green revolution and NT with realistic prospects. Thus, green NT should not refrain from providing only green solutions instead of adopting and adapting "green" in terms of overall human safety and healthcare. This tactful deliberation can magnify environmental and social wellbeing, health concerns, and cost savings, thereby maximizing the possibilities of future speculation and sustainability of this promising technological field.

## KEYWORDS

- **carbon nanotubes**
- **energy dispersive x-ray**
- **Fourier transform infrared spectroscopy**
- **gold nanoparticles**
- **nanomaterials**
- **nanoparticles**
- **nanotechnology initiative**
- **selected area electron diffraction**

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# 11

# Role of Local Markets in Tribal Livelihood of Tripura

*Somnath Kar*
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## Introduction

Tripura is India's third smallest state located in the Bio-geographic zone of 9B-North East Hills between 22°56/ and 24°32/N latitude and between 90°09/ and 92°20/E longitude. The total area of the state is 10,497.69 sq. km (Kar and Datta, 2015). The forest covering area of the state isabout 6292.681 sq. km. Temperature ranges from 10-36°c and the annual rainfall about 247.9 cm.The state has eight districts. North East India is very rich in plant diversity (Das *et al.*, 2008). In Tripura, 20 tribal communities are found (TRCI, 2019; Kar *et al.*, 2019), viz. Reang, Noatia, Tripuri, Jamatia, Halam, Kuki, Chaimal and Uchai are known to have migrated to this state from outside in historical period as such they are regarded as the original settlers of Tripura. The list of immigrated tribals includes the rest *i.e.* Chakma, Garo, Lushai, Mog, Bhutia, Bhil, Lepcha, Munda, Oraon and Santhal (Das *et al.*, 2009). Each community has their unique socio-cultural heritage, language, food habits. Although there are different dialect forms among the different communities but Kokborok is the main spoken form among all these dialect (Majumdar *et al.*, 2006).

Tripura is rich in its biological resource and possess an extremely rich plant bio-diversity which is gradually decreasing. Tribal people of Tripura are the eco-system people who live in harmony with nature and maintain a close link between man and environment. Sustainable livelihoods mean that basic needs are met on

a daily basis and in the long term (Wisner *et al.*, 2004). Sustainable livelihood is the one with objectives to improve the capital assets of a household. Home gardens are a natural asset through which other livelihood objectives, such as gender equality, improvement in human capital, increase in finances and sustainable use of resources may be achieved (Ellis, 2000). In addition, land can be a route or opportunity through which a multitude of other assets become accessible to the household.

Access to land sufficient to establish a home garden can enable a household to produce foods for consumption or trade (Galhena, 2013). Sales from surplus produce will improve the financial status of the household. Skills learned in production increase the family's human assets. Consumed foods improve the family's nutritional status and food security. Trade, exchange of information and cooperation with other villagers strengthens the family's relationships with others.

The main features of a home garden according to Brownrigg (1985) are: they are located near homes; contain a wide variety of plants and because of this, nutrients are recycled in a sustainable manner; garden production is a supplementary source of food and income: gardens unlike field agriculture require small area for production to take place and lastly Marsh (1998) added that garden production require little or no economic resources making it a sustainable livelihood as households make use of available resources.

The home gardens may become the principal source of household food and income during periods of stress, e.g. the pre-harvest lean season, harvest failure, prolonged unemployment, health or other disabilities suffered by family members (Marsh, 1998).

Most of the tribal economies have been engaged in subsistence agriculture, jhum, piggery, fishery and hunting. A rich diversity of both population and flora in the state has provided an initial advantage to its inhabitants since times immemorial for observing and scrutinizing the rich flora and fauna for developing for their own traditional knowledge. With the passage of time, they have developed a great deal of knowledge on the use of plant and plants products in curing various diseases. They have a deep belief in their native folklore medicine for remedy (Das *et al.*, 2009).

Market is the place which reflects the production system of sellers and choice of the buyers. In the present study plant materials deals with the cultivated and wild edible plant species sold in the 20 local markets of Tripura.

## Methodology

For authentic identification of the collected plants, various treaties were consulted viz. Prain (1903), Deb (1981) and Kanjilal *et al.*(1938). For updated

nomenclature different information from different internet sources have been regularly consulted.The voucher specimens were processed into mounted Herbarium-sheet following Jain & Rao (1977). Survey with respect to edible plants sold in the markets were carried out during January 2015 to December 2019 by frequently visiting the places to enlist the variability to the products available in the market, local name of the plant, parts used and other information.Market investigation were carried out in 20 number of local markets enlisted in Table 11.1 covering 8 districts of Tripura. Total 422 market vendors of different age group (20-67 years) were interviewed during the market survey.

**Table 11.1. Name of the market studied**

| Sl. No. | Symbol used | Market Name | District |
|---|---|---|---|
| 1 | A | Kanchanpur bazaar | North Tripura |
| 2 | B | Satnala bazaar | North Tripura |
| 3 | C | Dashda bazaar | North Tripura |
| 4 | D | Machli bazaar | Dhalai |
| 5 | E | Dhumachhera bazaar | Dhalai |
| 6 | F | Geolchhera bazaar | Dhalai |
| 7 | G | Mungiakami bazaar | Khowai |
| 8 | H | Ambassa bazaar | Dhalai |
| 9 | I | Lake Chowmuhuni bazaar | West Tripura |
| 10 | J | Arundhutinagar (Drop gate mission) bazar | West Tripura |
| 11 | K | Bijoy Kumar Chowmuhuni bazar | West Tripura |
| 12 | L | Abhoynagar bazaar | West Tripura |
| 13 | M | Hezamara bazaar | West Tripura |
| 14 | N | Auxilium school bazaar | West Tripura |
| 15 | O | Bishramganj bazaar | Sepahijala |
| 16 | P | Matabari bazaar | Gomati |
| 17 | Q | Manu bazaar | South Tripura |
| 18 | R | Gandhari bazaar | Gomati |
| 19 | S | Baikhora bazaar | South Tripura |
| 20 | T | Amarpur bazaar | Gomati |

Source: Author

## Results

The plants reported during the course of study have been enumerated in Table 11.2 with their botanical name along with family, local name, parts used, purpose, market demand, availability, source of collection and the market prices. During our present study different plant parts of 123 plant species belonging to 101 genera and 39 families were recorded during this study. Out of 39 families, Cucurbitaceae with 16 species constituted dominant family which was followed by Leguminosae (11 species), Araceae (10 species), Poaceae, Rutaceae and Solanaceae with 8 species each, Dioscoreaceae (7 species), Apiaceae (5 species), Zingiberaceae (4 species) and rest of the family with three to one species in each (fig. 11.1). The plant parts sold in the market were fruit (54 species), leaves (26 species), stem (40 species), root (3 species), inflorescence (11 species), seed (6 species), whole plant (6 species), petiole (5 species), grains (3 species), flower, juicy stem, young shaft 1 species each (Figure 11.2). Among the 123 studied species, 69 species were used as vegetables, 13 species as fruit, 9 species as spices, 6 as a medicine and vegetable, 4 species as food, 4 species as food adjuncts, 4 species as fruit and vegetable, 2 as pulses, masticator, medicine each, other categories 1 in each (Figure. 11.3).

Amongst the studies species, total 62 plants species have been observed common in all the market. It was also observed that Bishramganj bazar found to be most diversified market having 118 species on the other hand Satnala bazar found to be least diversified market having 63 species (Figure 11.4). The plant species that are sold in local markets were collected from different sources like cultivation, home garden, Jhum, forest and wild (Figure 11.5).

**Table 11.2. Showing results of survey in twenty local tribal markets of Tripura**

| Sl. No. | Scientific name | Family | Local name | Parts used | Uses | Rate (Rs) | Source | Market name |
|---|---|---|---|---|---|---|---|---|
| 1 | *Abelmoschus esculen tus* (L.) Moench | Malvaceae | Dheroso, Muirima | Fruit | Vegetable. | 40-80/kg | h, c, j | D, I, K, M, O, P, Q, S, T |
| 2 | *Acmella oleracea* (L.) R.K.Jansen | Compositae | Osandoi | Leaves | Vegetable. | 20/Bundle | j | E, I, J, K, L, O, Q |
| 3 | *Acmellapaniculata* (Wall. ex DC.) R.K.Jansen | Compositae | Osandoi | Leaves, inflorescence | Vegetable, Medicine | 20/Bundle | j, h | E, G, I, J, K, O |
| 4 | *Aegle marmelos* (L.) Corrêa | Rutaceae | Bel,shilpo | Fruit | Fruit | 10/Piece | h, f | A, D, E, G, H, I, J, K, O, P, Q, T |
| 5 | *Aglaonema hookerianum* Schott | Araceae | Kerangmuithaipek | Caudex | Vegetable | 30-60/Bundle | f | I, H, O |
| 6 | *Alocasia macrorrhizos* (L.) G.Don | Araceae | Thakortama | Rootstock | Vegetable | 30-40/Kg | h | A, C, D, E, F, G, H, I, J, K, L, O, Q |
| 7 | *Alocasia odora* (Lindl.) K.Koch | Araceae | Bishkachumuitu | Rootstock | Vegetable | 20/Piece | h, f | E, G, I, O, Q, S, T |
| 8 | *Alpinia nigra* (Gaertn.) Burtt | Zingiberaceae | Pale, Tharai | Stem | Vegetable, Medicine | 20/Bundle | h, f | All |
| 9 | *Amaranthus tricolor* L. | Amaranthaceae | Denta | Whole plant | Vegetable | 10-20/Bundle | j, h, c | All |
| 10 | *Amorphophallus bulbifer* (Roxb.) Blume | Araceae | Thamaikang, Batema | Corm, young leaves, petiole | Vegetable | Corm - 30/Kg, Young leaves 20/Bundle, Petiole - 10-20/Bundle | h, f, j | A, E, G, I, K, L, O, Q |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11 | *Amorphophallus napalensis* (Wall.) Bogner & Mayo | Araceae | Dagardoma | Corm, young leaves, petiole, inflorescence, cake prepared from boiled corm | Vegetable | Young leaves - 10-20/Bundle, petiole 10-20/Bundle, inflorescence 15-20/Bundle, root tuber 50/Piece, cake prepared from boiled tuber 20-30/Piece | f | A, O |
| 12 | *Ananas comosus* (L.) Merr. | Bromeliaceae | Anaros, Amtoi | Fruit | Fruit | 30-60/Piece | h, c, j | All |
| 13 | *Areca catechu* L. | Arecaceae | Koai | Fruit | Masticator | 300/Kg | h, c | All |
| 14 | *Artocarpusheterophyllus* Lam. | Moraceae | Thaiphung | Fruit, seed | Fruit, Vegetable | Fruit 20-90/Piece, seed 20-30/Kg | h | All |
| 15 | *Baccaurearamiflora*Lour. | Phyllanthaceae | Kok | Fruit | Fruit | 20/Bundle | f | D, E, G, H, I |
| 16 | *Bambusabalcooa* Roxb. | Poaceae | Washur, Woamlang | Shoot | Vegetable | 30-50/Kg | f, h | All |
| 17 | *Bambusatulda* Roxb. | Poaceae | Woarna | Shoot | Vegetable | 30/Bundle | h, f | A, E, I, O, Q |
| 18 | *Basella alba* L. | Basellaceae | Mofrai | Twig, inflorescence | Vegetable | 15-30/Bundle | h, j, c | All |
| 19 | *Benincasahispida* (Thunb.) Cogn. | Cucurbitaceae | Khaklu | Mature stem, young shoot, Fruit | Vegetable | Mature stem 20/Bundle, young shoot 20-30/Bundle, Fruit 20-50/Piece | h, j, c | All |
| 20 | *Borassusflabellifer* L. | Arecaceae | Tal | Fruit | Fruit | 20-30/Piece | h | I, O, G, J, K, Q |
| 21 | *Brassaiopsisgriffithii*C. B.Clarke | Araliaceae | Chapok | Flower | Vegetable | 30-50/Bundle | f | I, L, K, N, Q |
| 22 | *Brassica cretica* Lam. | Brassicaceae | Fulkapi | Inflorescence | Vegetable | 50-80/Kg | c | All |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 23 | *Brassica nigra* (L.) K.Koch | Brassicaceae | Harua | Leaves , seed | Vegetable, Spices | Leaves 20-30/Bundle, Seed 60-80/Kg | h, j, c | A,D, E, G, I, O, Q |
| 24 | *Brassica oleracea* L. | Brassicaceae | Badhakapi | condensed shoot | Vegetable | 30-70/Kg | c | All |
| 25 | *Cajanus cajan* (L.) Millsp. | Leguminosae | Muimaisin, Khakleing | young fruit, leaves, seed | Vegetable, Medicine, Pulses | young fruit 40-50/Kg, leaves 15-20/Bundle, seed 140/Kg | h, j | All |
| 26 | *Canavalia gladiate* (Jacq.) DC | Leguminosae | Baikang | Fruit | Vegetable | 20-30/Bundle | h, j, f | All |
| 27 | *Capsicum annuum* L. | Solanaceae | Mosor, Thamos | Fruit | Spices | 100-200/Kg | h, j, c | All |
| 28 | *Caricapapaya* L. | Caricaceae | Koaiphol | Green and ripen fruit | Fruit, Vegetable | Fruit 40 -80/Piece, Vegetable 30-40/Kg | h | All |
| 29 | *Centella asiatica* (L) Urb. | Apiaceae | Samsata | Whole plant | Medicine | 10-20/Pkt | h, j, f | All |
| 30 | *Chenopodium album* L. | Amaranthaceae | | Leaves | Vegetable | 20-30/Bundle | h, j | All |
| 31 | *Citrullus lanatus* (Thunb.) Matsum. & Nakai | Cucurbitaceae | Buthai | Fruit | Fruit | 50-60/Kg | j, c | A, C, D, E, G, H, I, J, O, Q, S |
| 32 | *Citrus hystrix* Dc. | Rutaceae | Satkora | Fruit | Food adjuncts | 10/Piece | h, f | A, E, G, H, I, J, K, L, M, N, O, Q |
| 33 | *Citrus limon* (L.) Osbeck | Rutaceae | Slung | Fruit | Food adjuncts | 10-20/ 4 Pieces | h, c | All |
| 34 | *Citrus maxima* (Burm.) Merr. | Rutaceae | Jamra | Fruit | Fruit | 15-20/Piece | h | D, E, G, I, J, H, M, N, O, S, T |
| 35 | *Citrus medica* L. | Rutaceae | | Fruit | Food adjuncts | 10-20/2 Pices | h, f | D, I, O, S |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 36 | *Citrus reticulata* Blanco | Rutaceae | Kamla | Fruit | Fruit | 30-70/4 Pieces | h, c | All |
| 37 | *Cocos nucifera* L. | Arecaceae | Narikwra, naningra | Fruit | Fruit | 30-40/Piece | h | A, C, D, G, H, I, M, O, P, Q, T |
| 38 | *Colocasiaantiquorum* Schott | Araceae | Khama | Rootstock | Vegetable | 30-50/Piece | c, j | All |
| 39 | *Colocasia esculenta* (L.) Schott. | Araceae | Mwitu | Corm, cormel, petiole | Vegetable | Corm 40-70/Kg, Cormel 40-70/Kg, Petiole 10-20/Bundle | h, j, c, f | All |
| 40 | *Commelinabenghalen sis* L. | Commelinaceae | Chichirimini | Leaves | Vegetable | 10/Bundle | h, j | I, Q, O |
| 41 | *Corchorus olitorius* L. | Malvaceae | Nailla | Leaves | Vegetable | 15-20/Bundle | h, c, j | All |
| 42 | *Coriandrum sativum* L | Apiaceae | Dhaniabwalai | Leaves | Spices | 10-40/Bundle | h, j, c | All |
| 43 | *Cucumis hystrix* Chakrav. | Cucurbitaceae | Thaichokrom | Fruit | Vegetable | 30-50/Kg | f | E |
| 44 | *Cucumis melo*L. | Cucurbitaceae | Thaisuma | Fruit | Fruit | 20-40/Piece | j, c | All |
| 45 | *Cucumis sativus* L. | Cucurbitaceae | Sasha | Fruit | Fruit, Vegetable | 30-80/Kg | h, j, c | All |
| 46 | *Cucurbita maxima* Duchesne | Cucurbitaceae | Chakumra | Fruit | Vegetable | 60-80/Piece | h, j, c | A, D, I, O, Q, s |
| 47 | *Cucurbita pepo* L. | Cucurbitaceae | Chakumra | Fruit, shoot | Vegetable | 30-60/Piece | h, j, c | All |
| 48 | *Curcuma longa* L. | Zingiberaceae | Siling, Karma, Sithoi | Rhizome, inflorescence | Spices | 60-80/kg | h, j, c | All |
| 49 | *Daucus carota* L. | Apiaceae | Gajor | Modified root | Vegetable | 50-100/Kg | h, c | H, I, J, K, N, O, Q, S |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 50 | *Decalobanthusmammosus* (Lour.) A.R.Simoes& Staples | Convolvulaceae | Thalikbok | Leaves (green & dry) | Medicine, Vegetable | 30-40/Bundle | h | O |
| 51 | *Dilleniaindica* L. | Dilleniaceae | Thaiplok | Fruit | Chatney | 10-20/Piece | h, f | All |
| 52 | *Dioscoreaalata* L. | Dioscoreaceae | Tha,Thamtai | Rhizome | Vegetable | 30-50/Kg | h, f | All |
| 53 | *Dioscorea esculenta* (Lour.) Burkill | Dioscoreaceae | | Rhizome | Vegetable | 20-30/Bundle | w | I,J,K,O |
| 54 | *Dioscoreahamiltonii*Hook.f. | Dioscoreaceae | Thablong | Rhizome | Vegetable | 30-40/Bundle | f | I, J, K, O |
| 55 | *Dioscoreaoppositifolia* L. | Dioscoreaceae | | Rhizome | Vegetable | 40/Kg | w | O |
| 56 | *Dioscoreapubera* Blume. | Dioscoreaceae | | Rhizome | Vegetable | 50- 60/Kg | w | O, I |
| 57 | *Dioscorea esculenta* (Lour.) Burkill | Dioscoreaceae | Thablong | Rhizome | Vegetable | 40/Kg | w | O, I , P |
| 58 | *Dioscoreawallichii* Hook.f. | Dioscoreaceae | Ganga | Rhizome | Vegetable | 60-70/Bundle | w | I,J,K,O |
| 59 | *Diplazium esculentum* (Retz.) Sw. | Athyriaceae | Muikhonchuk | Young leaves | Vegetable | 10-30/Bundle | f | All |
| 60 | *Enhydra fluctuans* Lour. | Compositae | Alencha | Leaves | Vegetable, Medicine | 10-20/Bundle | h, w | All |
| 61 | *Eryngium foetidum* L. | Apiaceae | Kaslingmasla | Leaves | Spices | 10-20/Bundle | h | All |
| 62 | *Euryale ferox* Salisb. | Nymphaeaceae | Thanging | Fruit | Vegetable | 50-70/Kg | w | I, K, O, P |
| 63 | *Glinusoppositifolius* (L.) Aug.DC | Molluginaceae | Bwkhate | Shoot | Vegetable | 10-20/Bundle | h, j | All |
| 64 | *Hibiscus sabdariffa* L. | Malvaceae | Mukhrikaireb | Leaves, fruit | Vegetable, chatney | Leaves 10-20/Bundle, Fruit 60-70/Kg | h, j | A, D, E, H, I |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 65 | *Homalomenaaromatica* (spreng .) Schott | Araceae | Gandhari, Kamaitru | Petiole | Vegetable | 10-20/Bundle | h, j, f | All |
| 66 | *Hygrophilaauriculata* (Schumach.) Heine | Acanthaceae | Kurukhey | Leaves | Medicine | 20-30/Bundle | h, w | E, I, N, O, Q |
| 67 | *Ipomoea batatas* (L.) Lam. | Convolvulaceae | Jinga-thaktwi | Root tuber, shoot | Vegetable | Root tuber 40-60/Kg, shoot 10-20/Bundle | j, c | All |
| 68 | *Kaempferia galangal* L. | Zingiberaceae | Pamla | Leaves | Vegetable | 10-20/Bundle | w | E, I |
| 69 | *Lablab purpureus* (L.) Sweet | Leguminosae | Kasoi | Fruit | Vegetable | 40-100/Kg | h, c | All |
| 70 | *Lagenariasiceraria* (Molina) Standl. | Cucurbitaceae | Muilao | Fruit, shoot | Vegetable | Fruit 30-90/Piece, shoot 20-30/Bundle | h, c | All |
| 71 | *Lasia spinosa* (L.) Thwaites | Araceae | Gantha | Tender leaves, rhizome, inflorescence | Vegetable | Tender leaves 20/Bundle, Rhizome 10-20/Piece, Inflorescence 20-30/Bundle | h, f | G, I, J, K, L, M, N, O |
| 72 | *Leucaena leucocephala* (Lam.) de Wit | Leguminosae | Kelegadam | Fruit | Vegetable | 10-20/Bundle | w | O |
| 73 | *Litchi chinensis* Sonn. | Sapindaceae | Lechu | Fruit | Fruit | 80-100/100 Pieces | h | All |
| 74 | *Luffa acutangula* (L.) Roxb. | Cucurbitaceae | Jhinga | Fruit | Vegetable | 30-80/Kg | h, c | All |
| 75 | *Luffa cylindrica* (L.) M.Roem. | Cucurbitaceae | Fra, Fra- mothai | Fruit | Vegetable | 30-40/3 Pieces | h, w | All |
| 76 | *Luffa hermaphrodita* N.B.Singh & U.C.Bhattach. | Cucurbitaceae | Toroi | Fruit | Vegetable | 90-120/Kg | h | O |
| 77 | *Lycopersicon esculentum* Mill. | Solanaceae | FanthokMukhre | Fruit | Vegetable | 30-80/Kg | h, c | All |

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|---|---|---|---|---|---|---|---|---|
| 78 | *Mangiferaindica* L. | Anacardiaceae | Thaichuk | Fruit | Fruit | 30-50/4 Pieces | h | All |
| 79 | *Manihot esculenta* Crantz | Euphorbiaceae | Thabachu | Root tuber | Vegetable | 30-60/Kg | h, j | All |
| 80 | *Melocannabaccifera* (Roxb.) Kurz. | Poaceae | Woa, Woarthoi | Shoot | Vegetable | 30/Bundle | h, f | All |
| 81 | *Momordica Charantia* L. | Cucurbitaceae | Gangla | Fruit, shoot | Vegetable | 40-70/Kg | h, c | All |
| 82 | *Momordica cochinchinensis* (Lour.) Spreng. | Cucurbitaceae | | Fruit | Vegetable | 40-80/Kg | h, j | Q, S, O, P |
| 83 | *Momordica dioica* Roxb. ex Willd. | Cucurbitaceae | Kangoron | Fruit | Vegetable | 40-80/Kg | h, c | All |
| 84 | *Monochoriahastata* (L.) Solms | Pontederiaceae | Chichiri | Young whole plant | Vegetable | 20-30/Bundle | w | All |
| 85 | *Monochoria vaginalis* (Burm.f.) C.Presl | Pontederiaceae | Chichiri | Young whole plant | Vegetable | 20-30/Bundle | w | All |
| 86 | *Moringa oleifera* Lam. | Moringaceae | Sejna | Fruit, leaves | Vegetable | 60-150/Kg | h | All |
| 87 | *Musa paradisiaca* L. | Musaceae | Thalik | Fruit, scape, young shaft, inflorescence | Fruit, Vegetable | Fruit 30-40/20 Pieces, Scape 10-20/Piece, Young shaft 10-20/Piece, inflorescence 20-30/2 Pieces | h, c | All |
| 88 | *Musa acuminate* Colla | Musaceae | Bolongthalik | Inflorescence | Vegetable | 20-30/Piece | f | All |
| 89 | *Neptunia oleracea* Lour. | Leguminosae | Thamsunduru | Leaves, stem | Vegetable, Medicine | 20-30/Bundle | w | All |
| 90 | *Nymphaea pubescens* Willd. | Nymphaeaceae | Shapla | Inflorescence | Vegetable | 30-40/Bundle | w | I, R, O |

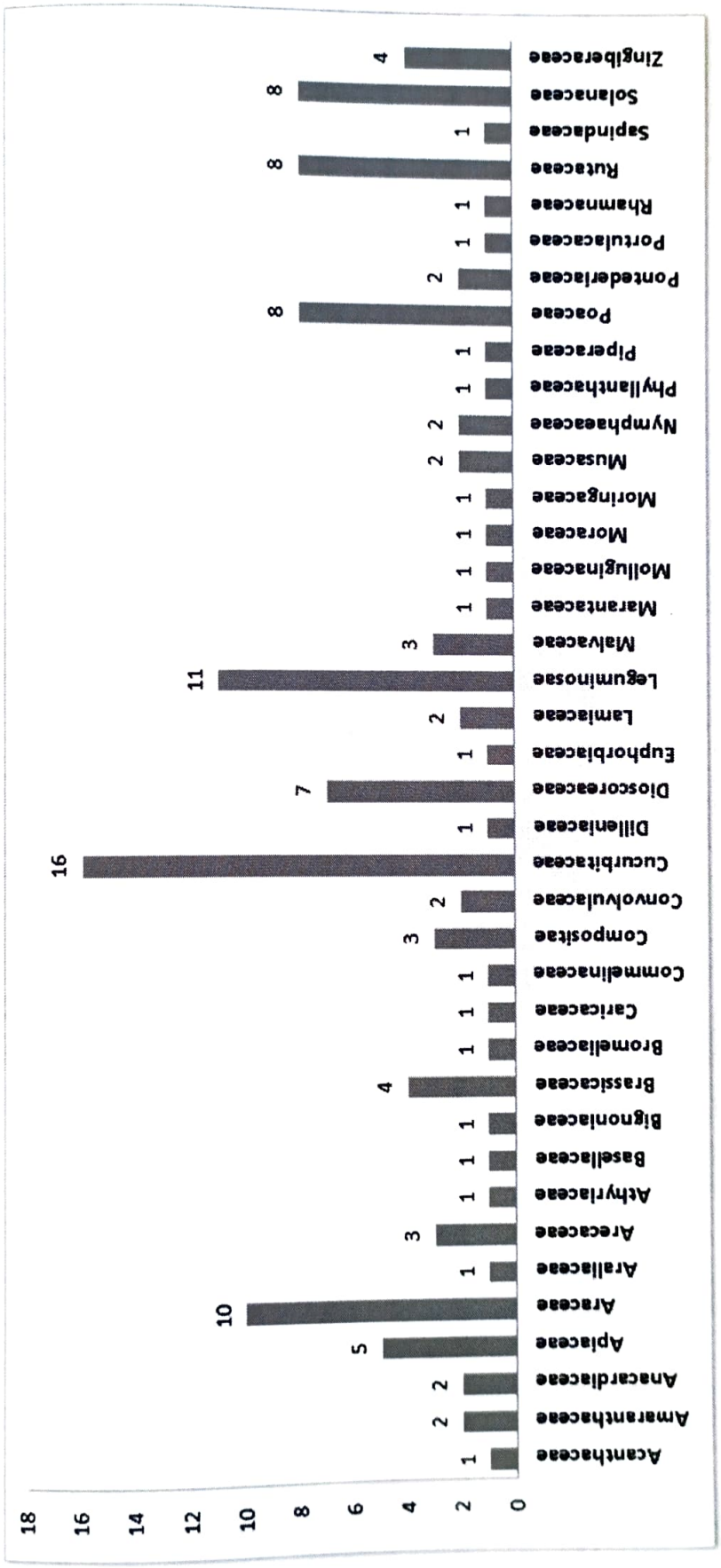
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 91 | *Ocimumamericanum* L. | Lamiacea | Banta | Leaves | spices | 10/Bundle | h, j | E, G, I, J, K, L, N, O, Q |
| 92 | *Oroxylumindicum* (L.) Kurz | Bignoniaceae | Takharung | Fruit | Vegetable, Medicine | 30-50/Piece | h, f | A, D, E, G, I, J, K, L, N, O, P, Q |
| 93 | *Oryza sativa* L. | Poceae | Guriamairung | Grains | Food | 40-60/Kg | j | All |
| 94 | *Parkiajavanica* (Lam.) Merr. | Leguminosae | Waikre | Fruit | Vegetable | 60-70/Kg | h, f | H, I, J, O, Q |
| 95 | *Phaseolus* vulgaris L. | Leguminosae | Farash | Seed | Pulses | 80-90/Kg | j, c | D, E, H, I, O, Q, S, T |
| 96 | *Phryniumpubinerve* Blume | Marantaceae | Lairuk | Leaves | Packing Material | 20-30/Bundle | h, f | I, O |
| 97 | *Piper betle L.* | Piperaceae | Fathoi | Leaves | Masticator | 50-70/100 Pieces | h, c | All |
| 98 | *Pisum sativum* L. | Leguminosae | | Shoots, seed | Vegetable, Pulses | Shoot 20-30/Bundle, Seed 60-90/Kg | c | D, I, O, P, Q, T |
| 99 | *Portulaca oleracea* L. | Portulacaceae | | Shoot | Vegetable | 10-15/Bundle | h, w | E, I, O, Q |
| 100 | *Premna esculenta* Roxb. | Lamiacea | Oraipata | Leaves | Spices | 10-15/Bundle | h, w | I, O |
| 101 | Raphanusraphanistrum subsp. *sativus* (L.) Domin | Brassicaceae | Mula | Whole plant | Vegetable | 20-30/4 Pieces | h, c | All |
| 102 | *Saccharum officinarum* L. | Poaceae | Kuru | Juicy stem | Food | 20-50/Piece | h, c | A, D, E, G, H, I, O, P, Q |
| 103 | *Sechium edule* (Jacq.) Sw. | Cucurbitaceae | Squash | Fruit | Vegetable | 40-70/Kg | h, c | A, B, D, E, G, H, I, K, M, N, O, Q |
| 104 | *Setariaitalica* (L.) P. Beauv. | Poaceae | Maisoi | Grains | Food | 60-80/Kg | j | I, O |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 105 | *Solanumaethiopicum* L. | Solanaceae | Khanta | Fruit | Vegetable | 50-80/Kg | w | D, E, G, I, K, O |
| 106 | *Solanum melongena* | Solanaceae | Phanop, Phantok | Fruit | Vegetable | 30-90/Kg | h, c, j | All |
| 107 | *Solanum ovigerum* Dunal | Solanaceae | Kuphulphantok | Fruit | Vegetable | 60/Kg | h | I, K, O |
| 108 | *Solanum torvum* | Solanaceae | Khanta | Fruit | Vegetable | 30-70/Kg | h, w | All |
| 109 | *Solanum tuberosum* L. | Solanaceae | Alu | Tuberous stem | Vegetable | 20-50/Kg | c | All |
| 110 | *Solanum violaceum* Ortega | Solanaceae | Khamkasikon | Fruit | Vegetable | 80-100/Kg | h, w | A, D, E, G, I, J, K, L, M, N, O, Q |
| 111 | *Spondiasmombin* L. | Anacardiaceae | Amra | Fruit | Fruit | 10/Piece | h | I, R, O |
| 112 | *Tamarindusindica* L. | Leguminosae | Tanthrei | Fruit | Food adjuncts | 40-60/Kg | h, w | I, J, K, L, O, S, T |
| 113 | *Thysanolaenalatifolia* (Roxb. ex Hornem.) Honda | Poaceae | Nouksi | Inflorescence | Broom | 20-30/Bundle | h, f | A, D, E, F, G, H, I, J, M, O, Q, T |
| 114 | *Trachyspermumroxburghianum* (DC.) H. Wolff | Apiaceae | Khumtani | Young whole plant | spices | 20/Bundle | j | All |
| 115 | *Trichosanthes cucumerina* L. | Cucurbitaceae | Poitha | Fruit | Vegetable | 40-70/Kg | h, j | All |
| 116 | *Vigna nepalensis*Tateishi & Maxted | Leguminosae | Sabaibulu | Seed | Pulses | 100-130/Kg | h | E, I, K, O |
| 117 | *Vigna unguiculata* (L.) Walp. | Leguminosae | Sabai,Spai | Fruit | Vegetable | 30-50/Bundle | h, j, c | All |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 118 | *Xanthosomasagittifolium* (L.) Schott | Araceae | Manai | Petiole, stolon | Vegetable | 20/Bundle | h, w | A, C, D, e, G, H, I, J, K, O, P |
| 119 | *Zanthoxylumlimonella* (Dennst.) Alston | Rutaceae | | Leaves | Spices | 10-20/Bundle | j | G, H, I, K, L, N, O |
| 120 | *Zanthoxylumrhetsa* DC. | Rutaceae | | Leaves | Spices | 10-20/Bundle | j | G, O |
| 121 | *Zea mays* L. | Poaceae | Mogodam | Grains | Food | 10-20/Piece | h, j | All |
| 122 | *Zingiber officinale* Roscoe | Zingiberaceae | Thaising, hasing | Rhizome, shoot, inflorescence | Spices, Medicine | 140-200/Kg | h, j | All |
| 123 | *Ziziphus jujube* Mill. | Rhamnaceae | Boroi | Fruit | Fruit | 60-80/Kg | h, w | D, E, G, H, I, J, K, L, M, N, O, Q, S, T |

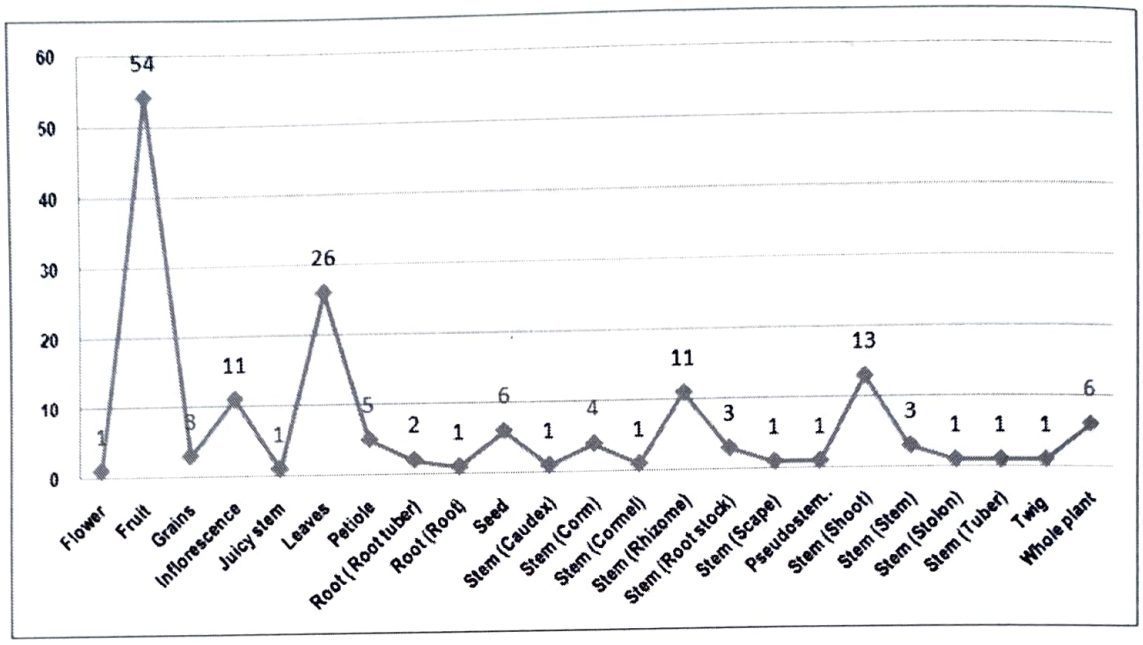
Source: Author

**h**: Home Garden, **c**: Cultivated, **j**: Jhum, **f**: Forest, **w**: Wild



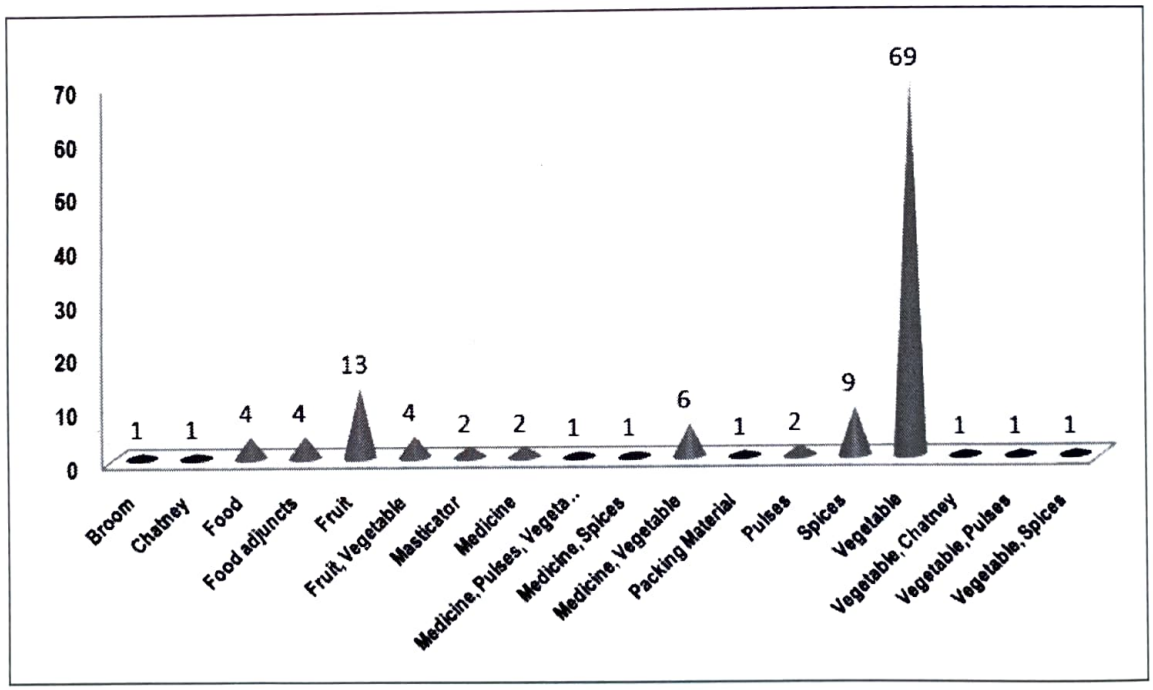

Source: Authors

**Figure 11.1. Showing the number of family and plant species in under each family**



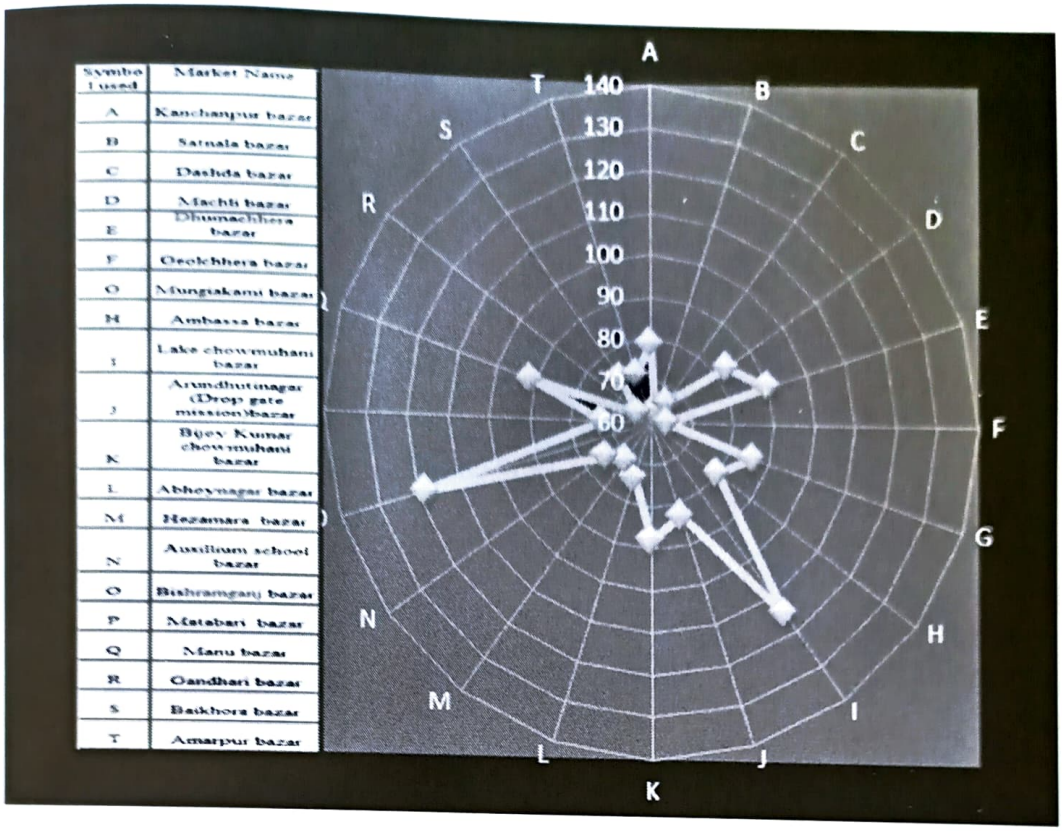

Source: Authors

**Figure 11.2. Showing plant parts used**



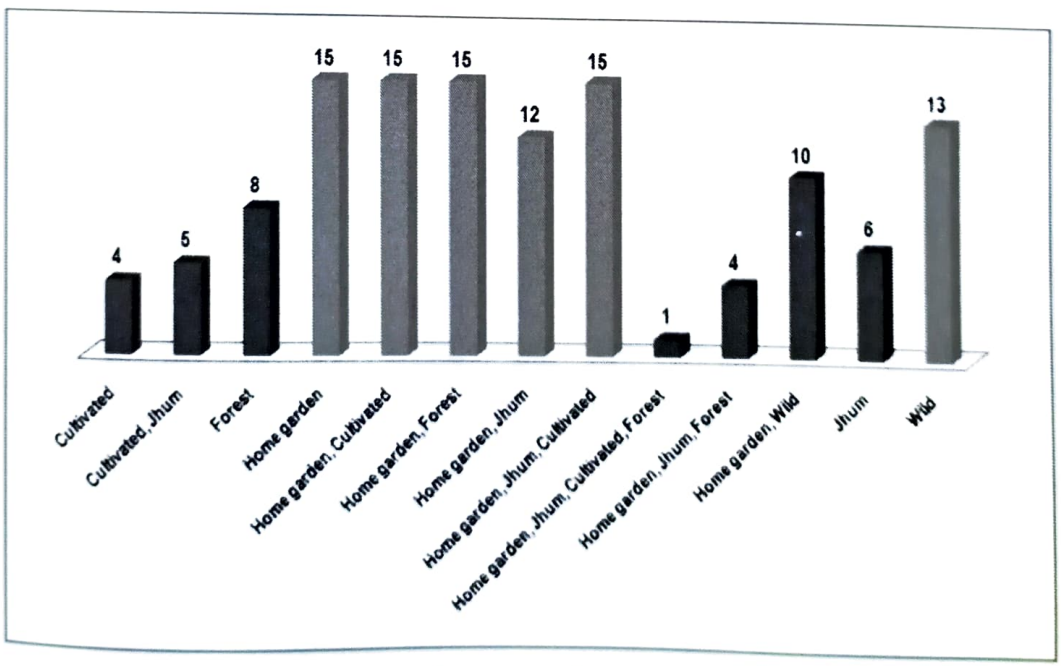

Source: Authors

**Figure 11.3. Showing the plant use categories**



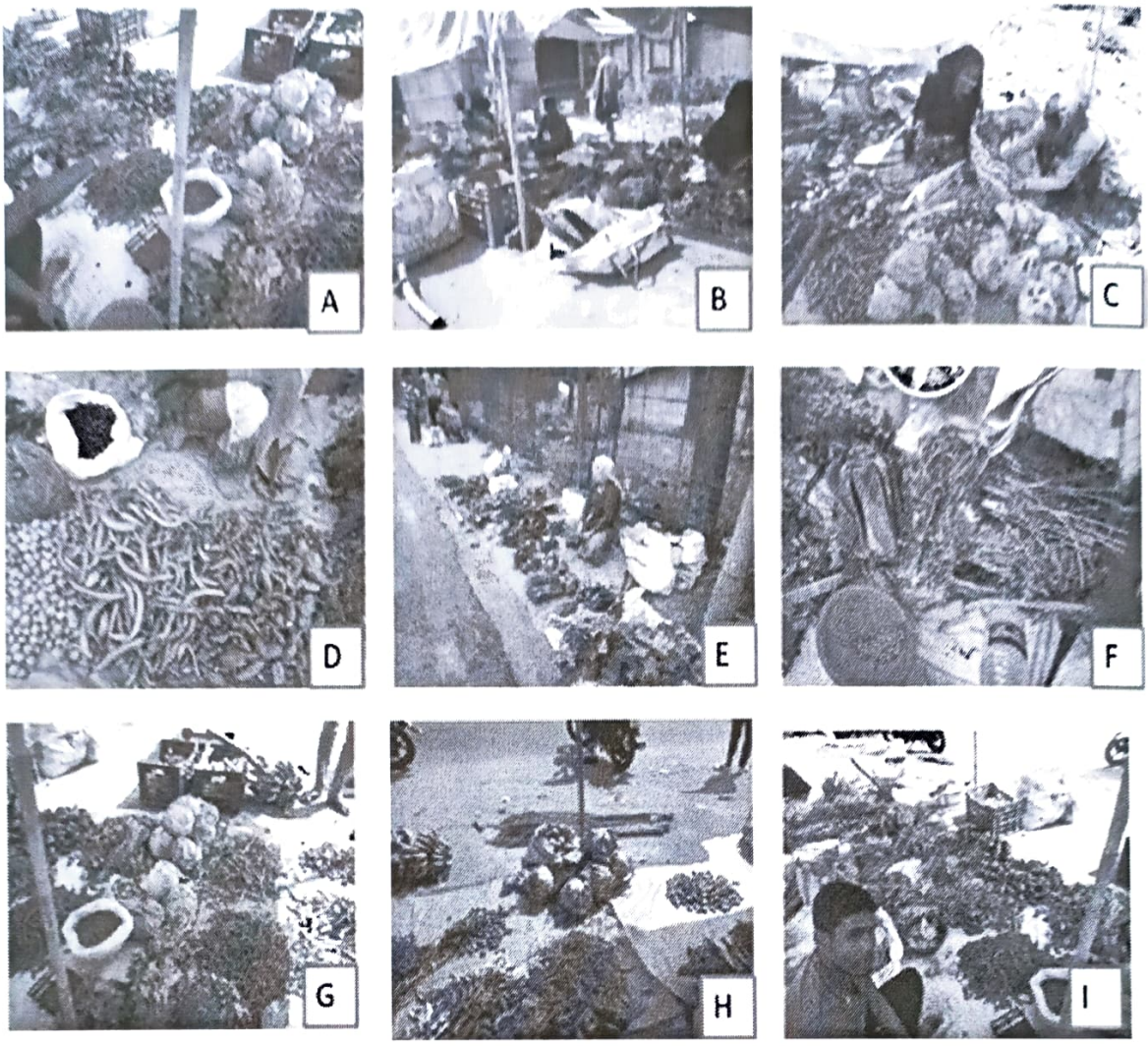

Source: Authors

**Figure 11.4. Showing number of species found in each market**




Source: Authors

**Figure 11.5. Showing source of studied plant**




Source: Authors

**Figure 11.6. Showing market survey at different markets (A- I)**

## Discussion

During the survey, it was observed that ethnic people of Tripura like to use wild plants as different food item. It was noted that only old people know about the use of wild vegetable bearing exception in some cases. Young people mainly rely on the vegetables and fruits like tomato, cow pea, pumpkin, bottle gourd, etc. that are available in the market of plain areas. The use of wild edible plants is generally widespread among elderly people who have been using these from time immemorial, but the unfortunate thing is that the use and conservation of these plants are not seriously thought for.

Among the studied taxa, some were recorded in all the market. Whereas few species were recorded only in one or two markets. The main source of selling plant species was observed to be home garden, where as less from wild, that

means they (seller) are not fully dependent on wild. Main reason being the buyers generally consume food prepared from cultivated plants, such as *Capsicum annuum, Solanum lycopersicon,Carica papaya, Lablab purpureus, Solanum melongena, Cucurbita pepo, Daucus carota*etc.though for particular foods, the demand was more. The use of wild edible plant plays an important role in the diet with reference to supplement of vitamin, protein and fat besides being an important source of income generation. From the investigation, the involvement of indigenous people in the trade of wild edible plants and the existing market chain was observed. Usually villagers used to collect the plants from forest and wild sources and directly sell in the market or sometimes sell it to the middle man. Middleman only does the final marketing either at the local market or sometime outside.

Many types of wild food plant may not be available in near future due to overexploitation, habitat destruction, regular forests fires and invasion of alien exotic species. Therefore, efforts must be taken to know their habitat, their uses, mode of collection of wild edibles, their conservation and cultivation.The minor forest produce is procured and sold by the local tribal people in the weekly markets. Tribal people eke out their livelihood from sale of minor forest produce without any initial input or risk. The Government derives revenue from major forest produce. A major portion of India's forest revenue is contributed by the major forest produce, namely timber and fuel wood. Most of the Tribes' livelihood partly depends on forest produce. Some Tribes dig out several types of roots in the jungle for food.

Local markets play an important role for disposal of forest produce by Tribal people. Local market means a conglomeration of sellers and buyers of different types of goods in certain places during prescribed timings on a particular day of the week. The weekly markets are very popular economic phenomena in tribal areas. These weekly markets start by early hours generally at 6 A.M. and they close before sunset.

Weekly market plays an important role in the tribal economy because these markets serve as the main channels through which local forest produce and the other important forest goods are distributed. They cultivate whatever land is available to them with primitive methods. They reap the forest produce also. On the other hand, local markets study also gives a view on some underutilized and neglected wild edibles plant species with enormous nutritional food value.

## Conclusion

The findings suggest further investigation on nutritional aspects, processing methods, cultivation techniques, conservational studies, direct and indirect source

of income particularly for the poor family and finally the pharmacological properties of the reported wild edible plant species for further exploration that can directly enhance the livelihood of indigenous people of Tripura.

## Acknowledgement

The authors are thankful to Head, Department of Botany, Tripura University for providing the laboratory facilities. First author is grateful to DBT, New Delhi, India for financial assistance.

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Headquarters (India): 88, Patel Street, Navamuvada,

Lunawada, India-389 230

Contact: +91 76988 26988

Registration no. GJ31D0000034

In Association with,

**RED'MAC INTERNATIONAL PRESS & MEDIA. INC**

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ISBN 978-93-95456-48-7

ISBN-10: 93-95456-48-5

DOI: 10.25215/9395456485

DIP: 18.10.9395456485

Price: ₹900

October- 2022 (First Edition)

■



■

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Printed in India | Title ID: 9393239398

# INDEX

ISBN: 978-93-95456-48-7

DIP: 18.10.9395456485.05

# IMPACT OF COVID-19 ON HIGHER EDUCATION IN INDIA: CHALLENGES AND SOLUTIONS

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## ❖ ABSTRACT:

***There is a significant relationship between teaching-learning and the impact of COVID-19 pandemic on students' learning in higher education. As pandemic has cancelled all the physical events and activities, this "sudden" change in strategy necessarily impacts all the components of the higher education sector. This transformative change caused a huge impact on higher education in India as the traditional class room teaching was replaced by virtual e-learning through online web platforms. The institutions were facing the shortcomings in admissions, internships, trainings, apprenticeships, and placements of the students. At last, based on the challenges faced by the students and teachers, some solutions, fruitful suggestions and recommendations are provided in this chapter to minimize and overcome the difficulties.***

***Keywords:*** *Higher Education, e-Learning, impact, pandemic, COVID-19.*

## ❖ INTRODUCTION:

The COVID-19 pandemic outbreak has been a global serious issue that dramatically affected humans' life in various aspects including economy, business, research, education, health, sport, transportation, worship, social interactions, politics, governance and entertainment. Among these the education sector of India has been facing tremendous challenge and terribly affected due to sudden closures, lockdowns and quarantines (Jain and Agarwal, 2020). Education is one of the major pillars of our social system and is the building block of any nation (Pareek and Soni, 2020).
This pandemic era has made greater transformation and has devastatingly affected students' learning in higher education by shifting the face-to-face

ISBN: 978-93-95456-48-7

traditional teaching to online teaching and learning. To avoid the spread of COVID-19, the government has cancelled all the physical events and activities, closed all the educational institutions, locked down the cities and banned people from traveling from a city to another city and this 'sudden' change in strategy necessarily impacts all the components leading to the formation of a 'new normality' in higher education. This paradigm shift has led to re-orientation of the teaching-learning curriculum globally (Hayashi *et al*., 2020; Khan and Naeem, 2021).

To cope up the situation, Ministry of Higher Education responded positively and has taken the immediate steps overnight to transform and evolve the teaching and learning strategies from in-person lectures to e-Learning platforms in spite of limited resources and technological facilities compared to other countries to ensure the continuity of teaching-learning, research and service to the society (Dhoot, 2020).

To protect the students from viral exposures and to keep the academic activities going, educational institutes have shifted to online learning platforms, which is a trigger for educational institutions to pursue creative approaches within a short time (Muthuprasad *et al*., 2021). Sudden closure of COVID-19 pandemic has caused disruptions of the entire world and has not only changed the global architecture, also has tremendously transformed the higher education.

The lockdown drastically disrupted education system worldwide which has threatened their future education rights. This crisis forced Higher Education Institutions (HEIs) to swiftly change the traditional teaching-learning status and at this time of crisis virtual education was the most preferred and widely accepted mode of education. Government instructed temporary closure of all the educational institutions for the safety and security of students, which has drastically impacted their study. To reduce the disruption and adverse impact, educational institutes adopted some emergency alternative new ways of education system to teach students (Jena, 2020).

## ❖ OBJECTIVES OF THE STUDY:

The aim of the study is to point out and analyse the impact of the COVID-19 pandemic on students' learning in higher education sectors in India. The objective of the manuscript is to investigate what is the role of technology in the adoption of an online learning system in higher

education system. The main purpose of the review is to critically observe and understand the relevant issues related to the sudden shift of classroom education to the online mode of teaching-learning and the impact of the Covid-19 pandemic on higher education.

This article highlights on how different higher education systems can be affected by the current global health crisis. The study also attempts to shed light and focuses to understand the problems, challenges, opportunities, positive and negative impacts of COVID-19 on education sector and what strategies can be taken in order to manage the corona crisis and built a resilient education system based on the information collected from various authentic websites, journals, e-contents, reports of government agencies, books, magazines, literature reviews, newspapers, and research of various authors in the relevant field. This chapter gives an overview about what are the alternative measures were taken to move from traditional education to an online digital world by the educators and educational institutes of India.

The finding of the study will help leaders of higher education to review and learn how different policies were adopted for teaching and learning and what are the different ways were taken to mitigate the negative effects and overcome the obstacles in emergency cases of Indian higher education system.

## ❖ DIFFERENT ONLINE PLATFORMS:

To deliver the lectures and to conduct the online classes the higher education institutes used different online platforms like Zoom, Google meet, Google Classroom, Microsoft Teams, Telegram, WhatsApp, WebEx, Skype, Canvas, Black Board, Blue Jeans, Big Blue Button etc.

The Ministry of Higher Education lunched different virtual platforms like e-GyanKosh, Massive Open Online Courses (MOOCs), Learning Management Systems (LMS), Gyandarshan, Gyandhara, Swayam, Swayam prabha, National Digital Library of India (NDLI), e-Yantra, FOSSEE, National Educational Alliance for Technology (NEAT), Virtual Labs, Google suite, Microsoft office 365, Vidya Daan, YUKTI, Bharat podhe, e-vidwan, UMANG, Bharat podhe online, DISHTAVO, e-kalpa, e-shodhsindhu, SMILE (social media interface learning engagement), e-Adhyayan, e-Pathya, Shodhganga, National Educational Alliance for Technology (NEAT), SAKSHAT, PM e-Vidya Programme, e-Pathshala,

ISBN: 978-93-95456-48-7

DIKSHA, National Repository of Open Educational Resources (NROER) (Jena, 2020; Ramakrishna, 2021; Mur Salim, 2021; Jain and Agarwal, 2020; Kantipudia *et al*., 2021; Tari and Amonkar, 2021; Pareek and Soni, 2020; Dhivakar, 2021).

## ❖ IMPACTS OF COVID-19 PANDEMIC ON HIGHER EDUCATION:

As every disaster comes with the light and shadow, it has been observed that, Covid-19 has both negative and positive impacts on the state of online learning in higher education (Dhoot, 2020) and also in research and Professional Development (Ramakrishna, 2021). People involved in the education sector like teachers and students are also facing many challenges and opportunities (Kaur, 2020).

## ❖ POSITIVE IMPACT:

Pandemic is acting as a catalyst in this revolutionary massive transition of the current Higher Educational practices (Khan and Naeem, 2021). This crisis paved the way for a new hybrid education model to deal with the pandemic by introducing e-learning culture and practices which reduced the huge educational gap in the higher education institutions. Virtual education creates many new trends, new perspectives and new models for learning which is only the option to bridge the gap in higher education in the pandemic situation (Kaur, 2020).

It has been observed that, the online classes are also as effective as traditional classes if it is designed appropriately; which suggests e-learning could be a perfect substitute for the traditional classroom learning. Recent studies found students were satisfied and responded positively with online learning because it was effective and most admirable for them during lockdown (Muthuprasad *et al*., 2021).

If we consider the positive side, it encouraged all teachers and students for collaborative and joint teaching-learning and research-work which enriched one another in this difficult time by sharing the knowledge between institutions globally. Webinars and e-conferences became normal option for sharing their knowledge, skills and expertise around the globe. As a result, academicians and students became more technology savvy and got much more time and scope to concentrate on professional development and to improve and enhance their technical skill (Ramakrishna, 2021).

e-learning platform has benefited and created positive impact on learners by conducting online examination, viva through video conferencing, online meeting, attending any lecture or course curriculum without any geographical boundaries, by changing the curriculum, 24×7 -time table with no time restriction, by reducing travel cost, print cost etc. (Mur Salim, 2021).

Many higher education institutions instructed their labs and involved themselves to research on COVID-19 for searching the vaccine and drugs, which could be considered as another positive side as many innovative approaches came out to treat the disease (Marinoni and Land, 2020). Now-a-days it has been observed that, students are using their mobile and computers mostly to learn the new things, to attend their classes, to submit their assignments which make them smart and more conscious for tomorrow and prepare themselves for competitions globally; which also could be considered as advantage and positive side of using e-learning platforms in higher education (Yaseen and Joshi, 2021).

## ❖ NEGATIVE IMPACT:

Students and educators have experienced many negative effects of online learning although online learning has been treated as a remedy for solving different problems of higher education during pandemic situation (Hayashi *et al*., 2020).

COVID-19 has created tremendous changes which negatively affected students' learning in higher education as classes were suspended for long days and impacted badly in students' performance and engagement in education. It also had been noticed that the quality of education reduced where the resources were limited. Due to frequent engagement in online learning students and teachers were facing eye strain causing negative impacts on their health (Yu, 2021). The educational assessment system was severely affected as most of the internal assessments cancelled and external examinations postponed causing negative impact and uncertainty for the future of the students. The researchers also suffered a lot and faced difficulties to travel and work together with others nationally and internationally, and were unable to access labs, libraries, archives, museum collections, etc. and funding opportunities for other areas of research have not increased; which is also a dark side of the lockdown (Ramakrishna, 2021).

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## ❖ PROBLEMS AND CHALLENGES:

The COVID-19 pandemic created many challenges to higher education system in terms of teaching, learning, research collaborations and institutional governance (Hayashi *et al*., 2020).

The crisis impacted various processes like new admissions, classes, examinations, student internships, seminars, fair, exhibitions, placements student mobility etc. in Indian higher education institutions. As many teachers were not computer savvy; the paucity of technically advanced faculty and lack of proper technological support, the paradigm shift and the commencement of online classes was highly challenging (Khan and Naeem, 2021). During the pandemic for coping with the perilous situation, the higher educational institutes have reacted positively and adopted various strategies to face the crisis and to maintain the quality of education (Ramakrishna, 2021).

Some parents lost their jobs during the pandemic and were unable to afford the expenditure of online education. The finding revealed that the teachers and students were facing problems with poor Internet connection and technological facilities as they were locked in remote areas during lockdown. Unstable Internet, technical glitch, unavailability of electronic devices, lack of technological facilities, lack of full-time power supply, inadequate resources, high costly Internet, lack of awareness, lack of linguistic skills, preparation issues have created barriers for students' learning for online teaching in higher education during the pandemic. COVID-19 pandemic devastatingly impacted students' learning as many students did not log into online learning system and were unable to access the materials shared by their teachers. These limitations and lack of enough resources have hindered students' engagement and negatively impacted in learning in higher education (Ramakrishna, 2021).

Moreover, studies showed that the lack of students' engagement and integration in online education compared to face-to-face learning and due to some limitations like insufficient resources, problems in maintaining academic integrity, issues in policy, lack of students' self-discipline, technical issues and lack of confidence, lack of guidelines, policies, and linguistic skills, lack of infrastructure and resources were the key challenges of online teaching which adversely affected students' learning in Indian higher education system during the COVID-19 pandemic. Many students were unable to complete their assignments properly as they don't

ISBN: 978-93-95456-48-7

have their own computers, mobiles or internet connection and were facing difficulties to communicate with their teachers to solve their queries and problems. Despite all such challenges, constraints and problems, the policy makers made every possible endeavour in formulating the new policy to maintain the continuity of education (Khan and Naeem, 2021). Sometimes the educators are finding it is very difficult to judge the involvement of students on a virtual platform (Dhoot, 2020). To keep the weaker students engaged require enough patience and skills, which is another big challenge for online education system (Bhowmick, 2022).

Educators were facing difficulties to design good e-learning contents (Dhivakar, 2021). The biggest challenges were faced in conducting practical courses and training (Indira, 2020). The process of Ph.D. registration including new international research collaborations were also hampered due to the impasse created by COVID-19 (Anonymous, 2020). As the working time and work-load of the teachers has dramatically increased, making it difficult for them to concentrate on their other works. This re-designing classes and transforming education methods in digital formats requires proper training and more funding for higher education institutes to get adequate equipment and to increase the capability and communication skill of the teaching staffs.

Lack of coordination and systemic approach among all academics and staffs was a big challenge to maintain and proper handling of e- learning platform and managing students to attend classes. Based on the opinions and answers collected during various survey, some of the major challenges are highlighted faced by higher education faculties which are as follows-- fear and hesitation of using technology, lack of technical knowledge, problem in student engagement, non-availability of licensing software, work life imbalance, family disturbance in work from home, lack of material benefits by educational institutions, hectic daily online schedules, disturbance after working hours, lots of communication and coordination issues, difficulties to teach practical subjects, unable to measure students' understanding of concept, cheating in daily classroom assessment, challenges in redeveloping content, sometimes students feel boring in online classes (Kaur, 2020) etc.

## ❖ CYBER-CRIME:

Cyber-crime, which is increasing day by day is another big challenge for online teaching and learning which has also exposed many higher

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education institutions in danger (Salmi, 2020). The institutes should take the initiative to train and educate the teachers and students about various tips and tricks to prevent the hackers to hack and manage the cyber-crime.

## ❖ MENTAL IMPACT:

Studies revealed that stakeholders of higher education were psychologically impacted by the COVID-19 pandemic. It has been observed that most of the students were facing anxiety, stress and depression which negatively impacted their learning outcome and academic achievement. Anxiety, feelings of disappointment, worries, sadness, frustration, loneliness, isolation, lack of socialization ultimately leading to physical and mental health degradation of both the students and teachers (Radu *et al*., 2020; Chaturvedi *et al*., 2021). To overcome these serious issues the educational institutions should provide psychological and counselling services to support students' learning in higher education.

## ❖ IMPACT ON JOB AND EMPLOYMENT MARKET:

The young professionals and fresh graduates are facing obstacles and difficulties in placements, trainings, internships, jobs, apprenticeships, on campus and off campus interviews due to the economic losses of employment market and education sectors causing an increase in the unemployment rate. Job withdrawal and sharp decrease in the career prospections of recent graduates has been observed in recent studies in India (Jena, 2020; Hayashi *et al*., 2020; Kaushal and Kaushal, 2021).

Fight against this negative impact is a great challenge in the life of a student of higher education and skill-based education amongst the youth is the only way to beat the dark phase of unemployment during this critical period (Jain and Agarwal, 2020).

## ❖ OPPORTUNITIES:

The pandemic has brought many challenges in terms of teaching, learning, research collaborations and institutional governance, but at the same time offered an excellent and unique opportunity to re-think, re-consider, re-design, to develop and implement effective teaching-learning strategies in the higher education for various stakeholders which ultimately will increase the sustainability and resilience in future (Hayashi *et al*., 2020; Karakose, 2021)

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Flexible schedule as per the convenience is one of the major benefits of the online learnings as it offers the opportunity to the students to study at their own pace and time of their convenience (Muthuprasad *et al*., 2021).

In spite of many negative concerns, virtual learning came as a remedy to improve higher education problems for both students and instructors regarding learning effectiveness and interactions during the pandemic. The new trends, technologies and the new ways of teaching learning and the opportunities created by the pandemic will enhance the skills and self-development which ultimately will lead towards a better tomorrow (Jena, 2020; Aslam *et al*., 2021).

Researchers have noticed that some of the opportunities has created after the pandemic which are as follows-- Students can attend the world class teacher's lecture and any online course at their convenient time and appear the exams from home only by using different online platforms. There is no doubt that this different kind of educational model accelerated the adoption of technologies which will help to strengthen the country's digital learning infrastructure in the long run (Dhoot, 2020).

## ❖ CONCLUSION:

In the field of higher education, a silent revolution was going on during pandemic which opened up new strategies and avenues for transforming the fortune of the society as a whole. Stakeholders in India need to be trained and need to take quick steps for establishing a good infrastructure for online education by the Govt. of India as it will help in the advancement of our country.

Uninterrupted internet facility is the pre-requisite for digital learning. Several initiatives need to take to minimise the adverse impact of COVID-19 in higher education such as -- national and international webinars, online faculty development training for online teaching, leadership talks and online workshops on themes such as assessment and evaluation. With the current technological advancements, higher education institutes should try to provide enough resources for online teaching and learning and for this an effective strategy is necessary to design and introduce a practical online platform by the Ministry of Higher Education which will be free and accessible for all throughout India.

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All the educational institutes need to modify the course structure and curriculum suitably and need to prepare majority of the course content to e-learning platforms. As even after lockdown is revoked, life after the COVID-19 pandemic will not remain same like before and online learning is here to stay as an integral part of the higher education system with regular offline classes in blended mode.

For the conduction of effective and productive classes, some interactive sessions with quizzes and assignments need to be included at the end of each class to optimise the learning experience.

Educational institutes should be very careful for any cyber-crime and they can arrange some licensed software to prevent the hackers. For the smooth conduction and uninterrupted online classes every higher educational institute must provide trainings to all the faculty members so that they can operate the online platforms easily.

To strengthen student-centred learning and quality education, the institutions must emphasise on the importance of teaching and the educators must focus on improving student engagement by providing awareness and training on online teaching-learning sources for both students and faculty. Skill development should be part of the curriculum which will help to create future entrepreneurs and this is the only way to beat unemployment. The educators need to influence and encourage the learners to go forward and utilize all the advantages and facilities available online to improve and enhance their skill to cope up with the 'new normal' and can easily compete with the competitors at global level.

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# BANKING IN INDIA : CONTEMPORARY ISSUES

Edited by :
Chandrasekhar Pillai

Banking in India : Contemporary Issues

Edited by : Chandrasekhar Pillai

Published by : Naya Pustak Mahal



ISBN : 978-93-94123-25-0

Cover Design : Rajib Dutta

First Published in India 2023

Printing

Bangabasi Limited

26, Pataldanga Street, Kolkata - 700 009

Price 895

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# CHAPTER-2

# A Study of Symbiotic Relationship between Banks and Startups

*Dr. Shankha Shubhra Bhadra*

**Abstract :** *The present economic scenario in India shows lot of potential in startups.As such initiatives, not only boost the economy but also addressed to the double-edged problems of unemployment and poverty. Startups are the initiatives of some young dynamic entrepreneurs who create the value for their customers through innovative products or services. The Department of Industrial Policy and Promotion (DIPP) define a startup as an entity, incorporated or registered in India with following parameters: (a) Established not prior to seven years, (for Biotechnology Startups not prior to ten years), (b) With annual turnover not exceeding Rs 25 crore in any preceding financial year, and (c) Working towards innovation, development or improvement of products or processes or services. Hence, startups have high potential to boost Indian economy, but need financial support. On the other hand, Indian Banking System is going through lots of turmoil ranging from Non-Performing Assets to Bankruptcy. Hence a symbiotic relationship between startups and banks would be a win-win situation for both and such relationship can not only revive the banks but also the economic condition of India.Therefore, the present paper attempts to study the symbiotic relationship between the bank and startups.*

**Keywords :** *Startups, Banks, Symbiotic, Non-Performing Assets.*

**Introduction :** Indian Banking system has evolved through various radical changes in the past. The modern-day banking in India started with the establishment of 'Bank of Bengal in 1809, 'Bank of Bombay

CHAPTER-10

# Corporate Social Responsibility Endeavours of State Bank of India

Rajesh Kumar Das

**Introduction :** The term "Corporate Social Responsibility (CSR)" can be referred as corporate initiative to assess and take responsibility for the company's effects on the environment and impact on social welfare. The term generally applies to companies efforts that go beyond what may be required by regulators or environmental protection groups. The concept of Corporate Social Responsibility has witnessed the paradigm shift from Charity, philanthropy and trusteeship to partnership and handholding with an aim to synergize the skills, expertise, strategic thinking, manpower and resources to initiate extensive social change placing the socio-economic development of India on a fast track. Recycling of resources and part of profits enables, empowers and energises the society to contribute towards the sustainable development of resource base.

Banking Sector is one of the important pillar of the Indian economy which plays significant role in the development of the economy. The performance of bank should be judged beyond the financial parameters. The authorities need not only focus on the financial performance but to examine into the CSR performance of the banks. To highlight the role of banks in corporate social responsibility the RBI circulated a notice on December 20, 2007 for all the scheduled commercial banks, with title "Corporate Social Responsibility, Sustainable Development and Non-Financial Reporting - Role of Banks". With the introduction of new Company act 2013, India became the first country in the world to have legislation for compulsory CSR spending. The new legislation of Banks Act 2013 requires certain class of banks to spend at least 2 % of their three years' average annual net profit towards CSR activities.

# CHAPTER-16

# An analysis of perceptions of payment banks in Tripura

Samir Bhowmik

**Abstract :** *Banking sector plays a major role for development of any country. In our nation, we have different types of banks namely public and private bank, cooperative bank, small banks etc. In the year 2014 RBI developed a new concept of banking system namely payment banks. The primary motive of payment banks is digital and cashless banking in our country. The present study is an attempt to understand perception of Payment Banks and why India needs it. The main aim of the research paper to study the popularity of payment banks in India.*

**Key words :** *Digital and Cashless Banking, Payment Banks.*

## 1. Introduction :

The Indian financial system has witnessed some tremendous changes since 1991. Banking sector is one sector, which has been performing really well after liberalization, and success can truly be associated with major banking reforms taken by RBI and also some major technological changes that have take place over years. (Naik, Firdou, & Harika, 2018).

As per the Reserve Bank of India (RBI), India's banking sector is sufficiently capitalised and well- regulated. The financial and economic conditions in the country are far superior to any other country in the world. Credit market and liquidity risk studies suggest that Indian banks are generally resilient and have withstood the global downturn well.