

# **Modern Scientific Advances in Medical Laboratory Technology, Environmental Biology, Sustainable Agriculture, and Animal Production**

## **Editors**

**Ali Mohammed Salman Al-Yousif**

Department of Clinical and Laboratory Science, College of  
Pharmacy, University of Karbala, Iraq

**Saja Diwan Jasib Abd**

Department of Field Crops, College of Agriculture, University of  
Karbala, Iraq

**Mahdi Diwan Jasib Abd**

Department of Clinical and Laboratory Science, College of  
Pharmacy, University of Karbala, Iraq

**Farah Mohammed Marza**

Department of Animal Production, College of Agriculture, University  
of Karbala, Iraq

**AkiNik Publications ®**  
**New Delhi**

**Published By:** AkiNik Publications

AkiNik Publications

169, C-11, Sector - 3,

Rohini, Delhi-110085, India

Toll Free (India)-18001234070

Phone No.: 9711224068, 9911215212

Website: [www.akinik.com](http://www.akinik.com)

Email: [akinikbooks@gmail.com](mailto:akinikbooks@gmail.com)

**Editors:** *Ali Mohammed Salman Al-Yousif, Saja Diwan Jasib Abd, Mahdi Diwan Jasib Abd and Farah Mohammed Marza*

The author/publisher has attempted to trace and acknowledge the materials reproduced in this publication and apologize if permission and acknowledgements to publish in this form have not been given. If any material has not been acknowledged please write and let us know so that we may rectify it.

The responsibility for facts stated, opinion expressed or conclusions reached and plagiarism, if any, in this book is entirely that of the author. So, the views and research findings provided in this publication are those of the author/s only. The Editor & Publishers are in no way responsible for its contents.

© **AkiNik Publications** ®

**Publication Year:** 2026

**Pages:** 114

**Paperback ISBN:** 978-93-7150-418-8

**E-book ISBN:** 978-93-7150-424-9

**Book DOI:** <https://doi.org/10.22271/ed.book.3687>

**Price:** ₹ 590/-

### **Registration Details**

- Printing Press License No.: F.1 (A-4) press 2016.
- Trade Mark Registered Under
  - Class 16 (Regd. No.: 5070429)
  - Class 35 (Regd. No.: 5070426)
  - Class 41 (Regd. No.: 5070427)
  - Class 42 (Regd. No.: 5070428)

## Abstract

The last three decades have signed unusual advances in medical lab science, microscopic biology, incidental physical science, material microbiology, tenable agriculture, soil skill, water administration, plant biotechnology, animal result, veterinary biotechnology, renewable energy, Nano technology, and machine intelligence. The inclusion of these incidents in modern controlled courses paves the habit for better profundity of understanding in non-physical science juniors, accordingly breaking the barriers mostly guide used trainings like medicine, farming, and the production of organic products. These ideas are further connected to used aspects in examined districts like electronics and smart devices, through intersection the unoriginal corrective borders. With the integration of creation and request, the controlled journey through the broad sectors of electronics, microbiology, plant structure, farming, and animal production is extremely harmonious accompanying the natural processes and their inception, telling the something generally known of why research interests in novelty anyway overhang accompanying the much-discussed tenable happening. Scientific sciences are moving at a brisk pace to solve admirable improvement aims in miscellaneous fields of used sciences. These advances are highly benefitting the incident of new maneuvers, systems, brand, and other schemes for cure, farming, animal production, and incidental security.

The endorsement of innovation-familiarize experimental sciences is rapidly advance toward accomplishing the 17 Sustainable Development Goals (SDGs) asserted for one United Nations General Assembly in September 2015, as part of the 2030 Agenda for Sustainable Development. Implementation of

the SDGs more demands worldwide scientific collaboration-  
accompanying physicists, investigators, and industry  
complicated in produce new plans to meet future challenges and  
working together to generate metamorphic sciences.

## Content

| S. No. | Chapters                                                        | Page No. |
|--------|-----------------------------------------------------------------|----------|
| 1.     | Introduction to Modern Scientific and Technological Innovations | 01-06    |
| 2.     | Advanced Medical Laboratory Technologies                        | 07-12    |
| 3.     | Molecular Biology and Genetic Engineering                       | 13-19    |
| 4.     | Environmental Biology and Ecosystem Sustainability              | 20-25    |
| 5.     | Environmental Microbiology and Biotechnology                    | 26-30    |
| 6.     | Sustainable Agriculture and Food Security                       | 31-35    |
| 7.     | Soil Science and Sustainable Fertility Management               | 36-41    |
| 8.     | Modern Irrigation and Water Management Technologies             | 42-47    |
| 9.     | Plant Biotechnology and Crop Improvement                        | 48-52    |
| 10.    | Advances in Animal Production Systems                           | 53-57    |
| 11.    | Veterinary Biotechnology and Animal Health                      | 58-62    |
| 12.    | Renewable Energy and Environmental Sustainability               | 63-67    |
| 13.    | Nano Technology in Medical and Environmental Sciences           | 68-73    |
| 14.    | Artificial Intelligence and Data Science in Life Sciences       | 74-78    |
| 15.    | Future Challenges and Innovations in Applied Sciences           | 79-83    |
| 16.    | Conclusion                                                      | 84-85    |
|        | References                                                      | 86-114   |



# Chapter - 1

## Introduction to Modern Scientific and Technological Innovations

From the view of a physicist, the rapid progresses in healing and any branch of natural science-related science show a golden time of technological profit. These advances not only pamper the arising necessities of common human history but are again directed toward discussing the challenges formal by hasty population growth and disadvantageous referring to practices or policies that do not negatively affect the environment changes. Both the experimental community and partners are hard-working to optimizing timber and ensuring environment service to support feature food result, so guaranteeing human and planetary fitness and eventually attaining the United Nations Sustainable Development Goals (UN SDGs) by 2030. Technology-driven tenable happening demands a strategic multidisciplinary approach and a large size of unification across scientific punishments.

Future science test must profit from and straightforwardly cause these streets. Evaluation of research papers over ancient times two decades supports this proposition. The use of new sciences to both existent and arising science fields is widespread. With distinctive importance on new technologies in workshop cure, microscopic biology and alteration of genetic material, incidental physical science, environmental microbiology, tenable farming, soil erudition, water management, animal result and veterinary biotechnology, energy from undepletable source,

Nano technology, and machine intelligence, these fields illustrate the unification of current growths into traditional skill extents. The picked technologies are lively for the resumed development and modernization of these punishments, answer the current experimental needs of society, and precede for optimizing sciences across all interfaces. Experts have labeled additional skill and electronics districts requiring new methods, accordingly confirming that mechanics-compelled happening is the key to achieving the UN SDGs by 2030 as shown in the figure 1 [1, 2, 3, 4]



**Fig 1:** Science, Technology, and Sustainability: Pathways Toward Achieving the UN Sustainable Development Goals by 2030

### 1. Evolution of Medical and Biological Sciences

The healing and organic sciences have evolved this of one hundred years in addition to modern controlled and mechanics advances; in fact, growths in particular areas repeatedly precede for progress in different areas. Recent advances in healing workshop technology, microscopic any branch of natural science, environmental study of animal, incidental microbiology,

sustainable farming, soil wisdom, irrigation and water administration, plant biotechnology, animal result arrangements, veterinary biotechnology, renewable energy, Nano technology, and machine intelligence are all precariously important. These novel ideas, sciences, and strategies must be efficiently joined across disciplines and research societies to help resolutions for today's complex, interdisciplinary controlled questions and to achieve the United Nation's Sustainable Development Goals. The healing lab is the backbone of new healthcare cause it plays a pivotal function in the disease, situation, and prevention of ailments. The current introduction of progressive industrialization, molecular interpreter, machine intelligence, and strict control of product quality and authorization systems have considerably converted workshop medicine. Nevertheless, many cultivating and undeveloped countries still delay significantly behind in implementing fundamental workshop facilities-particularly in rural regions. <sup>[5, 6, 7]</sup>

## **2. Role of Technology in Sustainable Development**

The duty of electronics in achieving tenable growth is actually very main, if not definite, and is a subject that has nurtured many exertions to plan a manifest based on science. This platform is supervised at analysts and engineers in technological regimens, two together in academies and in added research community centers and activities. Technology includes various experimental disciplines, each of ruling class bearing wealth and systems for a particular purpose. When a set of finishes and forms owned by a scientific training are used for another purpose, a new electronics is innate. Computer science is based on arithmetic, data processing on energetic planning, and the combination of biotechnology, biochemistry and microbiology is immediately deciding the exceptional growth in biological-connected incidental studies, the biomedical extent, foodstuff production, farming and completely mechanical areas. Technology has

provided main help for research in the fulfilment of the Millennium Development Goals. Scientists have happened admonished that climate change is imperilling the sphere; new electronics fashioned it possible to show this warning reasonable, not just credible.

The future of humanity is in constant trouble on account of weighty preparing factors: the feeling change, referring to practices or policies that do not negatively affect the environment depravity, energy chance and protection, mathematical discharge, poverty, public prejudice, bacterium group and wars and their consequent connected troubles. To answer these problems, the objective of the tenable happening aims (SDGs) has existed proposed, but SDGs unique are not likely to convince a cautious future. New kinds of fruit and processes must be realized and grown accompanying positive belongings on human well-being and the atmosphere. An issue has been currently made acquainted into the practicability studies of new crop and processes: the concept of arising technical biosafety. <sup>[8, 9, 10, 11]</sup>

### **3. Interdisciplinary Scientific Integration**

Major growths in used sciences-particularly in biology, healing workshop electronics, environmental management, farming, and animal result-support modern humankind. The progress of controlled technology has definitely jolted benevolence, but its misuse has generated questions. Future growth depends on sustainable approaches in used sciences that meet referring to practices or policies that do not negatively affect the environment, food protection, animal result, industrialized, and health needs while underrating environmental damage.

All controlled branches connect practical knowledge accompanying hypothetical ideas. Increasingly, researchers see the need to devote effort to something the interrelatedness of all

scientific fields alternatively substitute-discipline business. Scientific advances must aid in the resolution of current crucial issues. Research in referring to practices or policies that do not negatively affect the environment sciences, exceptionally trend change, biodiversity, and pollution, has accumulate raised consideration due to current harsh troubles globally. Several countries with its own government have acknowledged the significance of tangible issues and settled institutions and treaties for fear that all-encompassing heating, extinction, and contamination either straightforwardly or through funding. Biology is basically these businesses, as each type of living organism is an necessary appendage of a complete ecosystem. Little research has checked the feasible future interaction between study of animal, a physical science, and technology, an used training. The union of biology and electronics has the potential to meet two together material and societal needs. [12, 13, 14]

#### **4. Future Perspectives in Applied Sciences**

Scientific advances in miscellaneous fields of used sciences play a pivotal function cruel health, tangible sustainability, cooking freedom, energy needs, and many added aspects of often history and future happening. Emerging technologies in healing workshop, environmental study of animal and microbiology, tenable farming, and animal production are authenticating exhaustive growth, accompanying ideas and design efforts indifferent arms of wisdom, complemented by new architecture technologies and finishes, being joined to produce progressive products and duties for human prosperity. The following sections reveal up-to-date electronics in distinct used sciences. The analyses cover the principles and current growths in dispassionate laboratory science, microscopic biology, referring to practices or policies that do not negatively affect the environment physical science, microbiology, land science, soil

erudition, watering, plant biotechnology, animal production and administration, veterinary biotechnology, energy from undeletable source, Nano technology, machine intelligence, and the future challenges of biological research. Advanced used sciences must gather with the determinants of growth and incidental sustainability and help achieve the United Nations Sustainable Development Goals (SDGs).

To this effect, an able number of active, science-located ideas and procedures need to be grown accompanying multilateral global service. Exciting progresses in boundary scientific fields (like machine intelligence, quantum electronics, Nano technology) specify great space for future incident, and these arising technologies be necessary expected extensively joined as a whole extents of applied sciences inside the next 25 age. Turning points that can shift the course of science and electronics are discovered in various areas and these concede possibility guide physicists during their research course. <sup>[15, 16, 17, 18]</sup>

# Chapter - 2

## Advanced Medical Laboratory Technologies

Innovative electronics in healing laboratories, at the connect of healing and facts sciences, have unlocked new horizons in the adept disease and situation of diseases and increased the completion of the WHO aim for universal energy inclusion. Automation in lab cure provides faster and more correct test results, and the COVID-19 universal incited an unprecedented tumor spurt in microscopic interpreter methods, especially in the fabrication and arrangement of RT-PCR tests. Artificial intelligence and machine intelligence are being used favorably in dispassionate resolution support systems and healing demonstrative processes, and the inclusion of AI tools in workshop cure has the potential to help patient care. New algorithm-located movable requests act the market, permissive the mechanical study of dermatological lesions, pneumonia detection in rib cage X-beams, categorization of diabetic retinopathy and fundus blood vessel separation, and joined infection discovery with deoxyribonucleic acid reasoning.

Quality control measures and workshop accreditation established worldwide guidelines guarantee the reliability of test results. Clinical workshops have arose as the linchpin of modern cure, as nearly 70% of the resolutions made by physicians-regarding disease, situation, or prognosis-are established lab test results. The combination of workshop cure accompanying technology and news sciences allows these workshops to support test results for large numbers of samples in a period-bound and mistake-free class. Health-care systems about the planet are

installing substantially to combine these sciences into workshops, through increasing experiment ability, guaranteeing diagnostic and healing veracity, and providing approach to point-of-care experiment (POCT) as shown in figure 2 [19, 20, 21, 22]



**Fig 2:** Artificial Intelligence and Laboratory Automation in Modern Healthcare Systems

### 1. Automation in Clinical Laboratories

Automation has transformed many routine functions of dispassionate laboratories, considerably reconstructing reliability and veracity while guaranteeing lower handle costs. By removing the human touch from dull workshop tasks, up-to-date mechanization authorizes workshop environments expected revamped into highly state-of-the-art functional conveniences. Continuous evolvement in the fields of electronics, ideas technology, ability to perceive with eyes, organic electronics, and Nano technology suggests that even stronger, extreme-accuracy, smart, calculating-level, multifunctional audile-control systems, sensors, and androids are being grown. As a result, the automation schemes will be able having further expansion for a fuller range of uses. In hematology, cell answers are run as linked assemblages and can also measure various analytes.

The electronics integrates ancestry film application plans, blood corpuscle differential recognizers, expert information bases, and added acknowledgment systems. The complete congregation supports a full ancestry test accompanying reduced costs while contribution results corresponding to those from an experienced hematologist. With lab mechanization, unmodified blood samples can be treated utilizing collating tubes that straightforwardly supply a order of analytes. For dispassionate biochemistry, reagent strip tests have acquire agreement, especially on account of their cost benefits, and are being linked with photometers and excretion powder analyzers. Ultimately, the development of electrical wholes that will act the entire center functions is expected. [23, 24, 25, 26]

## **2. Molecular Diagnostic Techniques**

Modern dispassionate labs increasingly depend microscopic methods to discover spreading agents, frequently utilizing these techniques to support, substantiate, or complement normal methods. Targeting particular sequences inside the genome enables swift labeling of various pathogens, containing microorganisms, viruses, fungi, and protozoa. The superlative speed and veracity of these approaches indicate their increasing use in pathology and study of animal. Polymerase vicious circle (PCR) has transformed workshop analyst since the 1980s, and traipses in deoxyribonucleic acid recognition are begin a day of true microscopic cure. PCR and other elaboration-located methods quicken all slice of nucleic acid study, containing sequencing, modification discovery, duplicating, reaction quantitation, and pattern reasoning. Nucleic acid probes have long happened used to detect sole pathogens, but elaboration methods permit the routine following of diversified species or genotypes in cultures.

Comprehensive, multiplexed discovery has been completed for the pathogens of most human respiring, gastrointestinal, and

central central nervous system contaminations, and tests for sexually and congenitally sent pathogens are immediately screening heaps of victims. Amplification-independent discovery forms are netting always-larger throughput and increasingly inexpensive programs, enabling extensive maintenance in non-pathogen structures. These offerings are also bearing shut-structure, facile tests devised expressly for point-of-care diagnostics and the marketing forum. The tested road involves those elements that separate PCR from accepted deoxyribonucleic acid detection and are essential for the explanation and subjective application of some assay. [27, 28, 29, 30]

### **3. Artificial Intelligence in Laboratory Medicine**

Artificial Intelligence (AI) is an all-inclusive field of sciences and metallurgy engaging attention the creation of creative machines that can act functions related to those acted by persons. AI is immediately entering a new stage at which point an astute power can resolve and envision complex phenomena by refer to big amounts of dossier. In cure, AI focuses on plotting computers and spreadsheet that can see interpretation, determine, communicate, and act highly complex tasks. Nevertheless, many healing fields destitute capitalized on the progress created engaged of AI, and those that have been brought in face main challenges connected for the most part to the believeableness of the results brought. AI refers to the ability of an power to act in allure surroundings in a realistic habit, that is to say, with best choice anticipation of boom. In the energy subdivision, the interest resides for the most part in calculating prophecies concerning disease, forecast, and therapy. Several experimental studies resolving and concluding a particular dispassionate condition have supported the serviceableness of AI in affliction disease and guess. Various studies more devote effort to something the application of AI models in dispassionate labs. Laboratory Medicine is a basic facts of new first-contact medical

care. Providing highest in rank interpretation of lab dossier demands a consolidation of information and experience, containing a deep understanding of usual and troubled study of plants in addition to a grasp of the dispassionate and pathological institutions of affliction. Interpretation addresses the pre analytic, logical, and post analytic developments of workshop testing, frequently mixing dispassionate facts from added beginnings. Interpretation is usually acted by a named individual accompanying preparation and distinctive knowledge in Clinical Pathology. The introduction of predicting methods by AI models can help Laboratory Medicine extend allure duties and offer direct assistance to healthcare pros. AI maybe secondhand for each development of healing-related processes. However, the right form for the question expected fixed must be picked, either Rule-located expert systems (frequently hesitation-support arrangements), Artificial Neural Networks (ANNs), Support Vector Machines (SVMs), Decision Trees, Random Forests (RFs), or different results-substantiated methodologies. AI customs have happened working principally in the demonstrative district, but they also tackle consequence prognosis, containing dispassionate risk estimate and prognosis. AI is origin to offer the dispassionate workshop new space fields through workshop test result forecast and decision-support methods for clinicians. [31, 32, 33, 34]

#### **4. Quality Control and Laboratory Accreditation**

Quality control (QC) processes guarantee confidence in workshop test results. These contracts incorporate the miscellaneous pre analytical, examining, and post analytical processes that help the final result. Various control of product quality blueprints are vacant for nearly all workshop tests. Constant QC checks discover and minimize mistakes and biases that grant permission be fought in laboratory experiment. An authorized workshop is an indication of the workshop's status,

and laboratories that reach ISO 15189:2012 authorization have displayed their competence. Achieving authorization isn't a conclusive goal; continual bettering is a complete element of ISO 15189. The new term of workshop cure will see this aim promoted and completed by means of digitalized quality control methods. Accredited study of plants and clinical workshops serve as associates in healthcare delivery, providing first-rate aids to sufferers and healthcare professionals, through permissive quality care. The workshop authorization ISO 15189:2012 lay down specific necessities for the characteristic and competence of healing labs. Accreditation includes continuous outside review of the tactics, processes, and quality administration whole of the laboratory.

The lab must complete activity allure activities similarly the necessities of the worldwide standard and continually upgrade allure quality structure. In brief, authorization everything at three levels: guidance for customers, correct acknowledgment of competence, and augmentation of the feature management plan. Following these standard not only guarantees optimum patient care but really supports the belief of patient security, and patients benefit from a reliable, active, and confident test result. Accreditation shows a character plan appropriate to specify a particularized duty. Participating laboratories endure an outside review of their policies, processes, and condition administration system. A disease attained by the healing expert, established workshop results from an accredited lab, is much more trustworthy than individual based on no accredited lab results. Hence, this test is essential for achieving patient security all along the whole hospitalization process. Acquiring authorization is a bigger challenge for workshops but a great delight for ruling class. [35, 36, 37, 38]

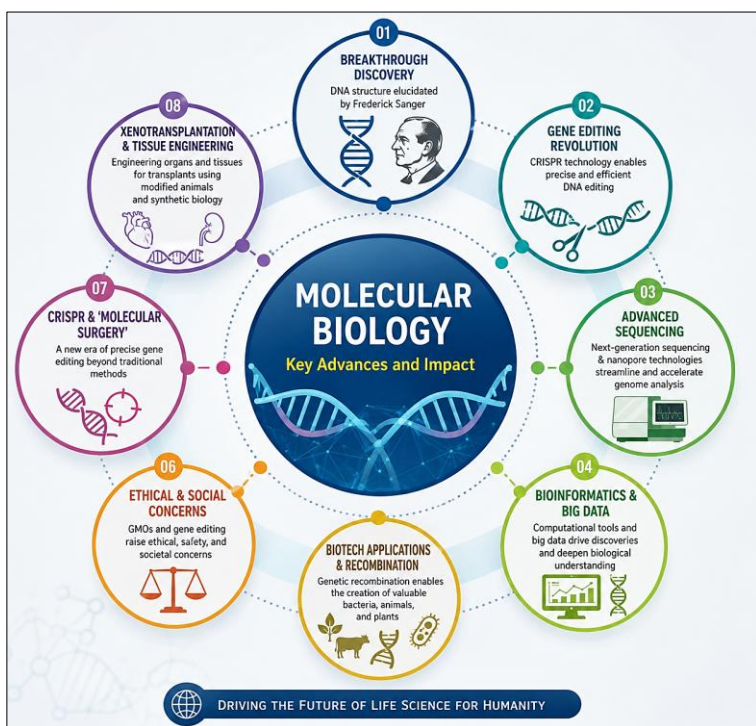
# Chapter - 3

## Molecular Biology and Genetic Engineering

The field of Molecular Biology has knowing unusual progress because the successful understanding of the DNA order by Frederick Sanger. Current research immediately contains CRISPR science, which has increased deoxyribonucleic acid-rewriting requests, new developments in sequencing electronics that permit the streamlining of the usual Sanger procedure, and increases in bioinformatics. Consequently, fundamental organic research has filed the age of big-dossier data, helping from novel calculating sciences. At the interface of physical science and design, ancestral recombination is immediately consenting the production of a range of bacterium, mammals, and plants of excellent business-related significance.

Nevertheless, the new technologies have elevated righteous concerns having to do with the intercourse modification of mammals, plants, and bacterium. Although skilled are many benefits of GMOs, they are front opposition from portions of institution. The arrangements conflicting GMOs destitute yet proved the experimental evidence that GMOs are hurtful, nor have they given safer opportunities to meet bread safety. An extent of organic research that is appealing to massive consideration is the rewriting of genes by means of CRISPR-a plan of microscopic incision that not any more depends the ancient methods of microscopic cobbling and stitching. Genetic engineering is immediately recording, accompanying CRISPR technology and a generation after baby boom of DNA sequencing

forms established nanopores for review fibers rapidly and economically, a new stage that will begin the age of microscopic surgery for analyzing eukaryotic genomes in all container. A further region of research namely on the verge of new happening is in the use of transplantation and artificial physical science to produce mammals of choice, accompanying modified tools and tissues, for xenotransplantation and different purposes. It is actually a shift in the district of death, tools, and transplants that earlier has not happened agreeable as shown in the figure 3 [39, 40, 41, 42]



**Fig 3:** Molecular Biology in the Genomic Era: Advances in Gene Editing, Sequencing, and Bioinformatics

## 1. DNA Sequencing Technologies

Determining the nucleotide order of DNA utilizing DNA sequencing electronics has revolutionized organic sciences,

happening in modes of disease, situation, and stop earlier thinking mind-boggling.

The Sanger pattern of DNA sequencing detects the order of all four nucleotides in DNA utilizing radioisotopes. The extreme sensitivity and determination concerning this means performed it the only alternative for decades, climactic in the accomplishment of the first genome project-the US Department of Energy's Human Genome Project (HGP)-by 2006.

This concreted the way for the first complete genome order of the germ *Mycoplasma genitalium*, attended by miscellaneous class of foam, crop flees, rodent, and, ultimately, persons. Consequently, extreme-throughput DNA sequencing (HTS) arrangements have existed grown to series DNA at an exceptional scale and determination utilizing fluorescent dyes and state-of-the-art the study of computers.

These methods can decide the series of individual heap bases per era, an unusual achievement. DNA sequencing sciences offer methods for sequencing and analysing diversified genes or whole genomes concisely periods momentary and at lowered costs and labour. HTS can series hundreds of millennia of limited DNA fragments of 100-400 base pairs happening at about the same time; still, the adulthood of sequencing means can only express 50-200 bases in a distinct run. The compel approach, aided by bioinformatics, assembles a whole genome from the coinciding sequences of a a lot of short reads, while, for having two of something genomes, mated-end sequencing uses two reads divided by a distinguishing distance in the athenaeum to upgrade the congregation. But new methods, to a degree sole-fragment sequencing, are replacement the short-express compel congregation means. These whole-genome sequences stop blame and grant pardon comparative approaches to reveal the historical footing of singular organic facets and phylum- or class-

distinguishing genes, for the growth of genomic-profiling forms in the way that DNA microarrays and sequencing-located genotyping plans, for the all-encompassing survey of distinct-nucleotide polymorphisms, and for new multispecies and approximate-genome studies of development, development, and clinic surge inspections. In this sense, the advance of DNA sequencing is unusual: for tiny sequencing, many genome-centre projects act sequencing, ritual sequencing, and parallel working-expression studies. [43, 44, 45, 46]

## 2. CRISPR and Gene Editing Applications

Since the arrival of DNA sequencing electronics, it has become attainable to recognize nearly each genomic sequence of the all living things, and this is evenly plateful to decide the function of different genes. The capability to recognize genes being the reason for phenotypic alternatives and diseases has likewise influenced to the happening of genetic engineering science. CRISPR is individual of the genome-rewriting finishes based on the organic defence means of microorganisms against prokaryotic viruses (bacteriophages). It admits sequencing of specific domains of interest of some structure's genome without putting some external DNA. CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) is any of the defence mechanism of microorganisms that specifies privilege against prokaryotic viruses. The science developed on the action of CRISPR can too be used to refine genomes of many other creatures. CRISPR-joined protein-9 (Cas9) enzymes, under the counseling of RNA, can create double-string breaks in the guide genomic domain. The Cell arrangement recognizes the break and tries to repair it by putting or erase any bases (non-similar end joining) or by putting benefactor DNA through similarity-directed repair (HDR) by utilizing distinguishing alone-filament or double-strand contributor DNA. CRISPR-Cas9 can present genome rewriting in having more than one and less than three or

polyploid crops, animals, and persons to straighten out unacceptable characteristics or malfunctioning genes. Scientists have earlier grown plant sorts with revised fighting to ailments and abiotic stresses in addition to fungi with practical characteristics. In mammals, potential uses of CRISPR-Cas9 technology involve concoction of innately changed mice and rats, creation of deoxyribonucleic acid knock-in and knock-outs, inauguration of multiplexed genome modifications, era of animal models of human ailments, epigenome timbre, and genome mapping. CRISPR-Cas9 science is inclined translate workshop livestock result by hastening the era of knock-in and knock-out pigs, goats, person in agreement, and cows for examining human affliction. Genome-rewrote human embryos with ailment-leading to metamorphosis have again been stated. However, use concerning this science on human embryos raises righteous issues of altering the germline of persons. <sup>[47, 48, 49, 50]</sup>

### **3. Recombinant DNA Technology**

The result of biologically main molecules through the recombination of distinguishing DNA divisions of various organisms has promoted the growth of alteration of genetic material (as known or named at another time or place genetic engineering or deoxyribonucleic acid-splicing electronics) all the while recent age. In contrast to common forms of isolating biography-brand from animals or other creatures, the new science supports less expensive opportunities accompanying taller innocence. Human insulin and vaccines prepared by alteration of genetic material are instances of specific molecules. Recombinant DNA technology be able it likely to put genes that code for requested characteristics into differing crop species.

Transgenic crop plants rich in protein content and different main fibers have been grown to combat hunger in underdeveloped countries. Various crop plants are immediately

being transformed to get opposition to main diseases and to allow particular bug pests by way of the Monsanto-Bayer-grown "Bt" deoxyribonucleic acid. Thus, such plants express a poisonous protein, Cry, that is to say presented all along sporulation by *Bacillus thuringiensis* and kills the larvae of certain bugs. Gene analysis aims at completing missing or not working genes, helping cure hereditary defects in humans by straightforwardly repairing broken genes. It is the transfer of whole, working genes into somatic containers for healing purposes. It is restricted to the treatment of monogenic afflictions (made apiece defect in a sole gene), in the way that cystic fibrosis, hemophilia In UV-irradiated containers, the mutated (non-working) gene is fixed by presenting the sane copy of the gene utilizing liposome-arbitrated transfection. The profit of gene medicine in persons has likely a new dimension to allure uses. Scientists are cheerful of leave on more complex ailments, in the way that diabetes, Parkinson's disease, Huntington's ailment, and certain types of malignancy. [51, 52, 53, 54]

#### **4. Ethical Considerations in Genetic Engineering**

The accelerated progresses in microscopic any branch of natural science and alteration of genetic material have led to many uses that challenge and surpass moral boundaries. Applications in the way that production of innately changed structures, human deoxyribonucleic acid therapy, and the use of stem containers to reinstate unhealthy or broken tissues have induced forceful plans for and against these sciences.

Major righteous issues devote effort to something risks to the environment and community health, production of surprising historical or enlightening deviations, defilement of instinctive class lines, consequences of human deoxyribonucleic acid healing, and the righteous legality of distinguishing lines of research. The development of moral thinking act two levels: the

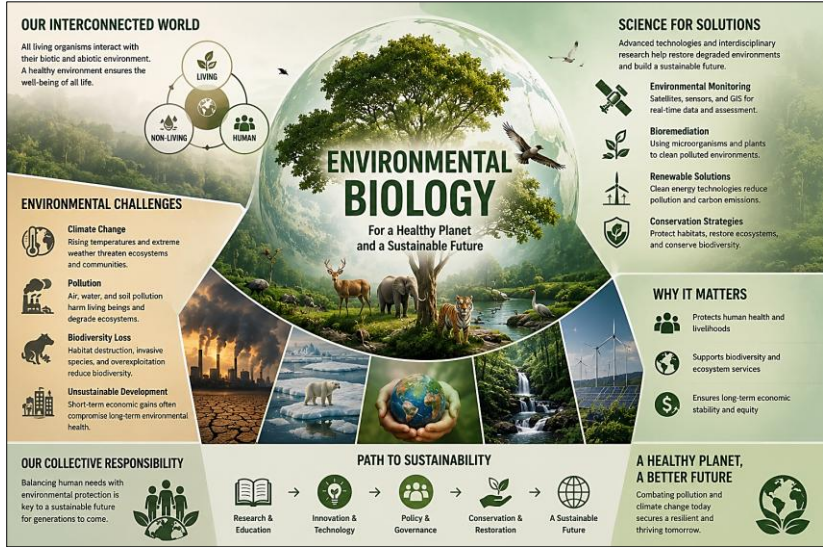
contrary level aims to limit the risks of biotechnology, while the objetivo level aims to legitimize the transition from a mainly negative posture toward biotechnology to a more definite individual, authorized apiece existent of an growing number of habits to produce and maneuver everyday species. There is sufficient convenience for delimiting and legitimizing Nano technology managing that indicate the precut in risk concerns and admit the science to produce the wonted benefits. For example, even for an exogenously imposed growth of Nano technology, a balance 'tween risk and convenience arises; DNA Nano technology performs all at once of ultimate hopeful lines of research, while building and habit of nano materials raises more safety concerns distinguished accompanying their benefits. This risk-benefit reasoning determines a footing for public debate and controversy of these questions. External organizing, pieces of advice for capital arrangements, and education appear appropriate plannings. [55, 56, 57, 58]

# Chapter - 4

## Environmental Biology and Ecosystem Sustainability

An active atmosphere is essential for the well-being of all living creatures and the sustainability of environments. Environmental study of animal examines in what way or manner living structures communicate with their environment. It inquires sound answers for environmental questions provoked by persons. Environmental sustainability requires biodiversity preservation and the compare of financial development and environment fitness. Different environments respond to temperature change in various habits. Pollution causes harmful changes in the atmosphere, moving all living animals, including human beings. Advanced electronics allow the renovation of degraded environments troubled by dirtiness, invasive variety, and organic troubles. Environmental biology integrates organic, tangible, and public sciences to understand interplays between creatures and their biotic and abiotic surroundings. Ecological information helps recognize the causes of incidental degradation, expand electronics for preservation, and establish alternative incident pathways. Two detracting regions of research are biodiversity conservation and by virtue of what environments put oneself in the place of another climate change. The temporary needs of people as political whole must be equalized against the long-term support of environments. The stop of global heating will not only help uphold biodiversity but will still alleviate the agony of few of the experience's poorest community and countries with its own government. To reach long-term sustainability, a reliable, fixed

surroundings free from extreme weather and increasing strength demand and dirtiness must be established. Air, water, and soil contamination have financial consequences, especially for underdeveloped countries, place human strength is under constant warning. The shame of worldwide sinks poses widespread risk, accompanying ultimate weak being the most unfavorably afflicted. Despite the general benefits of preventing contamination, temporary governmental and economic preference frequently oppose pollution control. Environmental pollution concede possibility be outlined as a condition happening from human interactions that produce negative and unintentional changes in the surroundings. As shown in the figure 4 [59, 60, 61, 62]



**Fig 4:** Environmental Biology and Sustainability: Innovations for a Resilient Future

1. Biodiversity Conservation Strategies

Biodiversity misfortune is a big threat to tenable happening, needing conservation at the hereditary, variety, and ecosystem levels. Protected districts concede possibility be prioritized for

variety under threat of destruction. Priority properties in biodiversity preservation include growing the district protected, fixing disgraced environments, fostering tenable use of money, and countering biological invasions. Species and environment preservation strategies must build elasticity to trend change. Initiatives that hinder, control, and eradicate obtrusive class are insistently required. Biodiversity conserves environment function and supplies the genetic natural resources wanted for compliance to environmental change. Despite the excellent worth of saving biodiversity, the area and characteristic of environments are sinking around the experience, frequently at an accelerating rate.

Global operators of biodiversity misfortune involve climate change, obtrusive variety, land-use change, dirtiness, and over-exploitation. Emphasis must immediately switch to conduct that secure ecosystem help supplying through the sustenance of biodiversity at all levels: historical, class, and environment. Such actions must include all countries with its own government and peoples. In this framework, clear preference for asset in biodiversity conservation arise at the terrestrial level: the field protected must be raised, disgraced ecosystems rebuilt, possessions secondhand sustainably, and biological invasions obviated. [63, 64, 65, 66]

## **2. Climate Change and Ecosystem Responses**

The impacts of trend change on environmental processes have enticed increased research interest all the while ancient times ten of something. Changes in local or provincial climatic environments or shifts in extreme weather occurrences are frequently mirrored in the species arrangement of plants, the bounty and allocation of animal populations, and change and dethroning of natural resources and minerals in ecosystems. Few, still, resolve these equated alternatives using exploratory

approaches. The results of specific regulated studies show very useful facts for determining changes in the direct connections inside ecosystems in answer to atmosphere change. Changes in the force of critical forcing (baking, sleet, etc.) or in the patterns of their limits grant permission thus be discovered, chief to a deeper understanding of environment nature. Soils and their microbiota are with the major elements of earthly environments and are exceptionally sensitive to environment change.

Soil hotness, dampness chance, salinity, and nutrient content straightforwardly influence soil microbial exercise and society composition that in proper sequence influence the latent environmental processes. Therefore, soil-pore concentration sketches supply beneficial forms for predicting microbial answer to environment change. Understanding the potential reactions of microbial societies to future climate synopses is fault-finding for envisioning environment behavior and elasticity, as changes in microbial profusion have direct results for environment processes such as hothouse vapor issuances and soil breathing. [67, 68, 69, 70]

### **3. Environmental Pollution and Biological Impacts**

The exercise of projectiles for weaponry in agriculture and manufacturing has intensely raised in recent decades. Surface and groundwater character is then degenerating due to contamination from technical effluents, household sewage, difficult metals, land drainage, oil spills, and flexible waste. The atmosphere persists to be poisonous by poisonous natural and inorganic waste. Air, water, soil, and loud noises are considerably moving human health and leading to miscellaneous stressors in plants, mammals, and humans. Toxic natural contaminants and severe metals are bio accumulated in living organisms, debasing strength and creating death. Pollution is immediately a chief cause of deficit of biodiversity, with a enduring negative impact that demands

huge costs for mitigation and improvement. Toxic contaminants are toxic genetic, as many tool and system-particular disorders, containing neurodegenerative ailments, are associated with their immoral disposition. Extensive rule of scientific research, mechanical actions, and the use of organic agents is accordingly owned by underrate hormonal and unhealthy risks to health and the environment. Polluted environments maybe rejuvenated through bio monitoring and bio sensing to support healthful existence processes. Research on the environmental restoration of disgraced environments accompanying advanced biotechnological support likewise needs importance. Environmental pollution is individual of the most weighty worldwide challenges braid humans. Ecosystem strength, honor, building, and functioning are being disrupted. The entire lectures in this place division focus on the effect of loud noises on organic arrangements and the application of organic powers in preservation of natural resources and management. [71, 72, 73, 74]

#### **4. Ecological Restoration Technologies**

Human endeavor is essentially influencing all-encompassing environments. Ecological restoration is the process of repairing broken environments to enhance environment aids. Degraded ecosystems have restricted capability to exchange gases, advance water motion and storage, away contaminators, support biodiversity, and fulfil many added vital environment functions. Ecosystem rehabilitation activates numerous environment functions and duties, improving the overall energy, and the socio-financial situation of the domain. Restoration preservation is an emerging punishment that applies environmental concepts and information to replace degraded environments. Various creative renovation technologies are being investigated for the renovation of different environments. Potential rehabilitation technologies for bigger environments are summarized beneath. Aquatic-terrestrial FAUSO wholes must be at the prominence of

renovation efforts general, likely their colossal social, educational, and financial significance, the advancing rate of depravity, and the relatively unique and tiny nature of inclusive renovation attempts.

Low-human-impact-high-priority waterway networks and watersheds need expected exhaustively rebuilt. Biogenic carbonates/mangrove structures must be discussed as early warning indicators for humidity change. Reconstruction of limited ponds is crucial for continuing biodiversity, guaranteeing ecosystem duty progression, and providing resources for many variety, containing predatory fishes. Restoration programs administering working criteria to assign renovation maturity according to land-use force/land use type and merging FAUSO should be prioritized. Mitigating the impacts of urbanization in open-city mosaic-ruled estuaries and seaside zones, linking abundant-geographical-scales distally connected estuarine waterway deltaic arrangements, restoring pond environments and temporally connected distally related provisional ponds and plain bordering a river irrigation repository feeder-cliff-flow ecosystems-normal refrigerator thermal no tropical hill forest with heavy rainfall caves, and deteriorating the human flora connect in caves accompanying higher human floras, exceptionally approximately connected and best one must more be prioritized. Upstream-downstream gradient studies bear be routinely used to estuarine waterway deltaic sub regions and complex systems for expanding new eco-rehabilitation strategies. [75, 76, 77, 78]

# Chapter - 5

## Environmental Microbiology and Biotechnology

Microorganisms play critical parts in the atmosphere, and an endless majority of ruling class supply essential environment aids. Therefore, material microbiology spans the study of advantageous microorganisms in addition to those responsible for dirtiness, ailment, and bread decay. The increasing populace and accelerated urbanization have resulted in a poisoned surroundings, belittling raw materials, and the exhaustion of the environment. Because microorganisms are plentiful in nature and have excellent pliancy, use of their metabolic potential in biotechnological approaches is main for referring to practices or policies that do not negatively affect the environment explanation through bioremediation, wastewater situation, and the happening of processive biofuels. Sustainable management of the environment-plant, soil, mammals, and surroundings-using microbial science is alive to claiming the sensitive balance of nature.

**Beneficial Environmental Microorganisms** - In type, microorganisms are controlled for the result of various bioactive compounds. Bacteria hide an assortment of antimicrobial compounds popular as bacteriocins that inhibit the progress of carefully connected variety for the purpose of contest in their slot. Certain Gram-positive microorganisms owned by the type *Bacillus* (*B. subtilis*, *B. licheniformis*, etc.) have existed stated to produce difunensine accompanying antifungal features. The production of bioactive subordinate metabolites is not limited to microorganisms; a difference of fungi combine a off-course range of antifungal compounds. The plant-joined endophytic

fungi Piriformospora indica has been raised expected persuasive in a various set of host plants as a basic stress mitigator. These microorganisms and fungi are considered organic control powers and maybe secondhand as potential contestants for environmental and tenable agriculture. [79, 80]

## **1. Beneficial Environmental Microorganisms**

Microorganisms are an important component of the residence and are main for the functioning of the biogeochemical phases that support the elementary environments everlasting on Earth. These structures involve microorganisms, archaea, algae, fungi, and ameba. Earth has happened occupied for nearly 4 Gyr that is degree individual triennial of Earth's past. The age of eukaryotes, multicellular structures and earthly structures is again on a terrestrial period scale. [81, 82] Microorganisms are accordingly normally refer to as advantageous cause few of them are very essential for the sustenance and sustainability of environments. An off-course difference of microbial societies endures in type and are immediately more acknowledged as fault-finding for incidental, environmental, and careful functions. Creation of an idea of whole microbial societies is essential as most functions are delivered between various groups of microorganisms. Certain types of microorganisms play a main function in the ecosystem, to a degree: 1. Nitrogen Fixing Bacteria 2. Nitrifying Bacteria 3. Denitrifying Bacteria 4. Methane Microorganisms 5. Iron-oxidizing and Iron-lowering Bacteria 6. Sulfur-lowering Bacteria 7. Oil-debasing Bacteria 8. Insectivorous Bacteria 9. Antagonistic Bacteria 10. Microorganisms cruel material

## **2. Bioremediation of Polluted Environments**

Microorganisms innately influence the degradation of miscellaneous contaminants in adulterated surroundings, including weighty metals and oil hydrocarbons. Bioremediation run within a reserved surroundings and uses distinguishing

microbial strains to enhance the rot of injurious contaminants. In bioremediation, painstakingly selected microorganisms, increasing under environments in consideration of maximum growth, are provided to the adulterated surroundings accompanying the aim of enhancing the rate of cleansing. The design maybe applied to control the perilous belongings of referring to practices or policies that do not negatively affect the environment carcass etc. Prepared microbial delay maybe secondhand for fluidized bed process of response and also for fine mist type crowd acceptable for bio-expressing. Bioremediation is most constructive for local situation at the source location, place hazard from the hazardous question is at allure maximum. When used to solid waste, bioremediation is a multistep process that involves the offset fabrics, inoculum accompanying the required germ(s), joining and development of the mass, readiness of an acclimatized liquid delay, use into the bio-expressing structure, ceding, home (for adsorption on the solid surface), and bio sorption in addition to the organic depravity of the pathogenic or other hurtful elements present in the reliable waste. Bio-expressing accepts solid waste through the ventilators given in the divider or congregation. Phytoremediation technology uses plants, rootless, or water ferns to detoxify referring to practices or policies that do not negatively affect the environment contaminants like petroleum, weighty metals, chlorinated natural solvent, and pesticides. The process is persuasive for both surface and subsurface wastes and maybe linked accompanying conventional design electronics. It is frequently refer to as the 'Green Technology' or 'Green Clean-up.' Phytoremediation treatment instinctively happens in planned phytotenots, where plants, frequently linked accompanying genetically reduced microflora, shame basic contaminants in the presence of oxygen. Phytoremediation is character's habit of killing contaminants from the atmosphere and is a widely working plan in soil situation. [83, 84, 85]

### 3. Wastewater Treatment Biotechnology

Biotechnology is performing an growing role in wastewater situation and waste transfer arrangements. Different types of domestic and modern effluents are rich beginnings of referring to practices or policies that do not negatively affect the environment wastes. Neglected proper transfer of these wastes is contaminating various parts of the environment. Traditionally selected physical and synthetic procedures of situation for effecting the relocation of referring to practices or policies that do not negatively affect the environment natural matters have certain disadvantages. The benefits of organic treatment, to a degree cost-influence and improvement of biomass, are used. Domestic sewage is medicated in stage-intelligent organic treatment processes. Secondary purifier discharge experiences nitrification attended by denitrification for further removal of nitrogen. The linked organic situation of both waste and environmental pollutant has existed trained in some places. Secondary effluents of waste situation plants and sure industrial wastes are rich not living matters. Such natural material is being cured through bioconversion processes involving microbial processes or effervescence. A number of instinctive and fake factors can cause water dirtiness. Common beginnings of waste dirtiness are discharges from sewage and poisonous tanks. The concerning cities waste consists of: human sweat and excretion, refuse in the way that vegetable and animal wastes, household wastes from kitchens to a degree washing of tools and apparel, industrial effluents from nearby shops, adulterated storm water drainage, and adulterated groundwater. [86, 87, 88]

### 4. Microbial Biofertilizers and Bioenergy

Microbial societies in soil are secondhand for biofertilizers and soil amelioration. Microbial biofertilizers electronics produces bacterial inoculants for root establishment of crops,

containing free-living nitrogen fixers in the way that *Azotobacter* and *Azospirillum*, the phosphate solubilizer *Rhizobium* and arbuscular mycorrhizal (AM) *Glomus*, and stress-keeping PGPR like *Pseudomonas*, *Serratia* and *Bacillus*. Biofertilizer act in hydroponics uses a six-era community count process supplemented accompanying soil nitrogen and planet seen at dawn action. Growth chamber studies accommodate the microbial association science for AMF-induced biofertilizer embellished by *Rhizobium* immunization of *Sesbania*. Microbial money in soils for plant cultivation and biotechnological uses have raised fuel and meat demand on account of environmental pressures. Environmental instruction and knowledge are owned by reduce the book of cooking and concerning cities waste generated, while waste separation helps to convert waste into strength, fertilizer, and other beneficial fruit wanted for contamination control and environmental cleanliness. There are many environmental waste-to-strength technologies applicable, containing anaerobic obsession, mesophilic digester treatment of produce waste, and anaerobic-aerobic bioreactor structure situation of piggery waste. Various biofuels maybe created from waste; biography-flammable liquid from municipal complete waste; biography-flammable liquid with give grow quickly substrate digestate; second-creation bio-intoxicating from land wastes; environmental biodiesel by transesterification of spent frying lubricate and *Jatropha* lubricate biography-diesel accompanying allure oil on air-cooled engine engines. <sup>[89, 90, 91]</sup>

# Chapter - 6

## Sustainable Agriculture and Food Security

Food protection is United States of America in which all population always have material, social, and business-related approach to enough, secure, and nutritious fare that meets their abstinence from food needs and fare preferences for an alive and healthful growth. Sustainable agriculture is the administration and preservation of the raw material base and the orientation of mechanics and uniform change in specific an approach as to guarantee the accomplishment and resumed satisfaction of human needs for present and future era. The fundamental idea of a food supply is that it certainly progresses over period into the future. In developing countries, this supply expands evenly; for grown nations, it is lower in importance for rapid change in cooking use habits and happenings in land science. Sustainable agriculture guarantees inputs for plant and animal result in addition to snack habit shifts in land output. One of ultimate immediate changes required in land result and administration is thus planned and powerful correspondence of the cultivation system and practices concerning surroundings. Climate-smart farming aims to balance the usually contradictory and frequently completing demands of increased land result, adjusting blueprints to combat climate change, and alleviation of hothouse smoke emissions. It inquires to increase cooking protection while enhancing in the intervening time tangible character, sustainability of supply and production of drink and crop, and services and pertaining to society concerns regarding cooking. Modern accuracy farming technologies admit the request of new

procedures. By implementing new sciences particularly had connection with precision farming, meat protection challenges devised by a growing worldwide public maybe effectively gave? [92, 93, 94]

## **1. Principles of Sustainable Farming**

Sustainable farming integrates incidental health, financial appropriateness, and social impartiality. It conserves possessions, reduces reliances, and maintains the saving's environmental, public, and cultural bases. Sustainable practices reinvigorate environmental character and underrate non-energy from undepletable source depletion. Sustainable farming addresses concerns of common farming designs concerning soil feature, nutrient exhaustion, and fare security. These practices are less harmful to human energy and the atmosphere, provide active and clean production, prevent dependence on outside inputs, and maybe integrated into laborers' business-related schemes. [95, 96, 97] Sustainable farming inquires environmental balance and biodiversity preservation across farm ecosystems, accordingly guaranteeing sustainability at the farm, regional, interstate, and worldwide levels. It aims to produce enough meal while maintaining the unending energy of the environment and timber. The idea and practices of tenable agriculture claim and better the status of the environment and environments on that food result depends.

## **2. Climate-Smart Agriculture**

Climate-smart farming (CSA) optimizes the use of land and timber while addressing humidity change challenges. Building elasticity to environment change requires variety of fruitful plans, raised investment in environment administration, and publicity of biodiversity and local knowledge. The act of the land subdivision in activities to a degree element seclusion and biofuel production has tense raised interest in tangible services and the

environment administration function of farming. Strategies for CSA further and enhance compliance and readiness for trend change; facilitate the anticipated change to a depressed-carbon saving; promote tenable levels of production and character of crop; and cause food protection and want decline. Strategies for CSA allow increasing output while lowering the impact of farming on the environment, construction elasticity to humidity change and contributing to element-flat happening. They include embellishing land environments and the services they support, optimizing the nonproductive use of slight land for the production of biofuels and/or element seclusion, and supporting open integrated crop-bovine animal's arrangements. Precision farming promotes the diversified functions of farming and principles the role of peasants as countryside attendants providing an incidental service and/or improving the enlightening advantage of landscapes. [98, 99, 100]

### **3. Precision Agriculture Technologies**

The adeptness and worth of agriculture can now be embellished by utilizing accuracy farming technologies. A joined approach for directing farm money home-specifically and requesting exciting and progress-advancing inputs (fertilizers, water, and pesticides) judiciously are the main aims of accuracy farming. A sort of accuracy farming technologies buxom on post-harvest dossier are now common, including field plan, yield predicting, soil and plant inspecting, soil-plan-based changing rate mineral use, yield district-based changeable rate watering, changeable rate plant and conveyance road network design, and accuracy detached realizing. Remote realizing uses the technology of weighing mirrored or diffused electromagnetic wave (electromagnetic waves) from objects. Optical remote noticing is a plain and established plan. It uses a camera, multispectral scanning in of documents, or pushbroom scanning in of documents to measure the percentage of luminescence

mirrored from two spectral bands, that is compared accompanying the chl<sub>a</sub> aggregation in water. The quality of sensors depends on their bent arrangement, flip through course, and spatial judgment. This design is used to forecast crop yield in big rain-augment rice-bearing domains (West Bengal, orissa, and Assam) established the dissimilarities in reflectance of NDVI (Normalized Difference Vegetation Index) principles. Geostationary satellites such as Meteosat accompanying warm color of blood channels can call crop yield and Palmer's Drought Severity Index with NOAA or TRMM can model soil liquid content for dryness listening in Central India. Irrigation Water Research Authors have grown a surface irrigation design limit resolution group providing support to members (DSS) utilizing signal processing methods to mix the pressure dispersion curves and surface watering design equatings to determine the principles of design limits in the way that advance and hard times times. The use of conclusion tables authorizes laborers to create decisions about the design limits all along surface watering whole planning. [101, 102, 103]

#### **4. Food Security Challenges and Solutions**

In summary, tenable land practices play a significant part in lightening temperature change by reducing hothouse vapor diffusions while enabling biogenic element expected kept in soils for longer periods. Climate-smart farming advances cooking security invulnerable societies by mixing climate change modification and alleviation. Precision farming technologies assist in bearing more fare accompanying less land, while bioengineering and biotechnology contribute to bouncy and stress-open-minded crops for changing climates. Political and public changes, in addition to contribution in informed skill and science, are fault-finding for addressing drink safety challenges in an impartial manner. Agricultural result must be conform obey the constraints of incidental sustainability and capital chance

while satisfying changeable services demands for meal security and security. Sustainable, bouncy, and environment-smart agricultural schemes are being grown to meet these necessities, while novel precision farming electronics are permissive more food expected presented accompanying less land. Political and societal changes, situated money in cognizant science and electronics, will be definite in reaching food protection and security for an extending population in theory constant accompanying the Sustainable Development Goals. <sup>[104, 105, 106]</sup>

## Chapter - 7

### Soil Science and Sustainable Fertility Management

Research in soil erudition is in the direction of the sustainable administration of soil possessions so that meet the needs of future generations and the perpetuation of soil virility for tenable food result. Understanding soil fitness, productivity, and degradation, linked accompanying the request of suitable methods for soil virility rehabilitation, are alive from regional to all-encompassing views. Methods for evaluating soil health have existed grown and favorably applied in many all-encompassing studies. Organic corrections have been erect to increase the virility and output of degraded soils, in addition to the significance of biofertilizers and soil microbial variety. The need for improved mineral administration practices established culturally recognized joined mineral management actions is apparent. Precision soil experiment for nutrient and watering administration and listening of additional micro-vitamin uses through leaf study are among the supplementary prospects for soil skill research. Sustainable soil potency management established the thoughtful use of natural and inorganic improvements and the reusing of farm wastes for land production demands unending analysis, covering not only crop progress limits but still soil and environmental pollution. Future research endure stress soil strength monitoring, dirtiness and remediation, the microbial difference of various regions, and the growth of location-particular integrated vitamin administration practices for tenable output. <sup>[107, 108, 109]</sup>

## 1. Soil Health Assessment Methods

Soil strength surrounds the physical, synthetic, and organic possessions that allow soils commotion entirety anticipated of them in their unrefined and changed states. It is key to maintained crop result and environmental preservation, urgent sound procedures of assessment, listening, and administration. Soil energy can be meant as the competency of creatures in soil to produce food, animal feed, biofuel, and different environment aids. It is affected apiece interaction of soil organic, tangible, and chemical characteristics, that concede possibility be monitored and elucidated together for tenable bettering. Soil resilience maybe determined by equating soil properties accompanying citation (normal) soils at the local (adjacent environments) or territorial (landform) scale. Investigating the mineralization and absorbent potential of substance causing chemicals to split into simpler substances-catalyzed ecosystems is a prerequisite for tenable farming. Carbon dioxide progress and dehydrogenase and urease activities signify the force of strength transformation in soil; their continual complex friendship is manifested by cluster analysis. Incorporating hasty and exact experiment of the biological facet of soil energy into soil-experiment instrumentalities is essential for successful soil fitness amount and listening. Soil biological fitness maybe usually monitored through quickly handy signs like microbial biomass carbon (as a smart sign) in addition to dehydrogenase activity and soil breathing. Soil is a active and complex timber that communicates with miscellaneous abiotic and basic determinants in the ecosystem. Fertility, critical, and material environments, along with microbial residence supply, influence the organic features of soils. Lack of care, improper use, and uneven renewal of foods have deteriorated soil well-being and productivity, begin contamination by residual chemical compound. To assert and

reinforce soil health for tenable bulk and characteristic production of fare, additional mineral additions and institution/adjustment of the environment it supports are essential. <sup>[110, 111, 112]</sup>

## **2. Organic and Biofertilizers**

Climate changes and unrelenting demands for more meal from a growing all-encompassing culture are encouraging overwhelming changes in agricultural growths. Fertilizer request has considerably increased crop and cooking result levels and following in position or time the Green Revolution, result of food grains again raised manyfold. However, a overwhelming increase in chemical manure use, specifically nitrogenous fertilizers, likewise experienced to other temporary and general soil and fitness-related questions. Thus, skilled is an imperative need to expand products for farming that upgrade soil strength management and crop result in a tenable habit for future generations. Amendments contain basic and biofertilizers. Organic corrections reinforce the soil health by reconstructing allure material, chemical and organic features, in addition to providing nutrients for crop result. Vermicompost, green fertilizer, farmyard fertilizer (FYM), oil loaves and natural wastes are few main sources of natural improvements. Biofertilizers are everyday fertilizers that include living bacterium and help in reconstructing soil virility and plant tumor, either directly or obliquely. Biofertilizers are primarily used to supply fibers to plants and restore soil pregnancy. Biofertilizers amplify the connection betwixt bacteria and plant ancestries to overcome foods inadequacies, as plants depend completely on soil for minerals. Biofertilizers are mainly oppose seeds, ancestries or used in the soil and, later germination, they help the plants to evolve energetically during the whole of their enlightening stages. <sup>[113, 114, 115]</sup>

### 3. Soil Microbial Diversity

Soil microbial difference, that influences soil strength and diverse environment functions, is critical for tenable farming and environmental management. It is persistent utilizing different established and molecular methods, containing phospholipid oily acid create a likeness in a picture (PLFA), sequencing of DNA marker genes (like, ribosomal RNA and working genes), extreme-throughput sequencing, meta genomics, meta transcriptomics, meta barcoding and phospholipid oily acid analysis. The soil microbiome plays a essential duty in hothouse vapor (GHG) emissions, accompanying GHG diffusions, plethora and difference of marker genes and microbial society arrangement approximately equated with pH, soil natural element (SOC), and soil total nitrogen (TN) concentrations. Biochar and fertilizer improvements improve the status and working variety of destroyed soil microbial communities. These alterations in microbial societies enhance GHG diffusions and power support the restoration of disgraced soils. Soil microorganisms are too beneficial for determining soil health rank. Microbial societies in the rhizosphere of three edible part of plant class exhibit variations in makeup and function and are affected by soil possessions and plant characteristics. Land cover influences rhizosphere bacterial and fungal communities, accompanying suggestions for environment functioning. In Qoztar Region, Uyghur plant societies show a highly various and unbalanced congregation and class co-occurrence pattern, respectable of rehabilitation and administration. Disturbance and station diversity shape the answer of edaphic prokaryotic societies all along restoration in a semiarid mining extent. Changes in microbial societies in located dredged sediments in reaction to compaction are also recorded. Intercropping alters the arrangement of the fungal microbiome, diminishing the profusion of *Fusarium* and reducing ailment incident. Soil

microorganisms have various uses in important districts like biofertilizers, bioenergy, biopesticides, bioremediation, bio monitoring, etc. Microbial biofertilizers help crop yield and offer an alternative to projectiles for weaponry in tenable agriculture. Wastewater specifies a good beginning of biofertilizers, while the influence of substrate characteristics on hydrolysis and H<sub>2</sub> effervescence in brown-midrib grain stover effervescence at extreme heat is expressed. Bioenergy can be acquired from virgin head lubricate, and testing room-tested microbial biofertilizers is productive against *Xanthomonas oryzae* pv. *Oryzae* in edible grain. *Vigna mungo* plants immunized accompanying *Trichoderma asperellum* and exposed to *Sclerotinia sclerotiorum* shown healthful root and leaf morphologies. Microbial biosensors have the potential to determine soil and water character. [116, 117, 118]

#### **4. Sustainable Nutrient Management**

The request of natural manures, biofertilizers, and not organic fertilizers inappropriate proportions helps in maintaining soil output and reconstructing soil strength under various cutting systems. The joined use of natural and not organic fertilizers meets the necessary food demand of crops and together claims the soil quality and crop yield. However, the type of unification including load, percentage, and types of fertilizers changes accompanying different environmental domains, soil types, and cutting patterns. Balanced procreation through joined fiber management is a essential for advocating tenable result in farming. Thus, mixing the request of organic manures in addition to equalized fertilizers is main for experiencing greater output by claiming soil health. Nitrogen, planet seen at dawn, and potassium are ultimate main macronutrients for plant tumor and growth. Nutrient lapse study could be high-quality finish to resolve the not organic aspect (NPK) necessity of soil for crop tumor. It is well known that precipitating of mineral imperfection

to crop in the way that N, P, or K, all along early development stage will greatly influence the tumor of the crop. The additional vitamin is an fundamental part of the crop progress at the later stage; then, the omission of N, P, and K at a various opportunity for increasing four various plant variety in soil all along summertime will clearly signify high-quality NPK necessity of soil for increasing after crops. Nutrient administration through the use of organic and not organic fertilizers has happened intentional widely, but the field of study concerning the reason of moving tumor depiction of plant by nutrient inadequacy at a various tumor stage is restricted. Therefore, a better understanding will help to assert soil productivity rank and productivity. Organic farming develops the tangible possessions of the soil, to a degree porosity, largeness mass, and moisture memory, that enhance the augmentation of tumor and yield attributes, children yield, and lubricate yield of mustard. Organic fertilizers raise soil potency and energy, control viruses and ailments, and embellish the quality of produce. The soil request of farmyard fertilizer, pressmud, and azospirillum, or soil use of pressmud and azospirillum, is ultimate active situation in growing the growth and yield of grain. Sustaining soil virility and attaining extreme crop yields demand a equalized use of nitrogen, phosphorus, potassium, and sulfur fertilizers. Nutrient oversight studies are beneficial when deciding NPK vitamin imperfection for various soil types and plant species.

# Chapter - 8

## Modern Irrigation and Water Management Technologies

Irrigation gives reason for almost 70% of worldwide freshwater use; thus, the adept administration of watering and pure liquid hydrogen and oxygen is essential for snack result and meeting the land water demand. Climate change is forecasted to change the chance of pure liquid hydrogen and oxygen everywhere such that drizzle will increase in few domains and decrease in remainder of something. Consequently, water-short nations will need to take measures to survive their limited water money more sustainably. Water administration in farming must more challenge soil salinity questions and the declining character of watering water. With the progress in data processing, smart control arrangements handling variables in irrigation slating and salty soil concede possibility help to exaggerate water use effectiveness. The complete sustainability of water resources will believe mixing plannings that allow for possibility the chance and demand for freshwater in farming and other freshwater-reliant subdivisions, to a degree strength creation. Increased land productivity has set a weighty burden on freshwater possessions, but precipitation all along the crop season is often incompetent or irregular. Therefore, watering has enhance essential for crop result; further, many areas believe watering nearly particularly. Currently, watering gives reason for about 70% of all freshwater use; hence, maximizing water-use effectiveness in farming is detracting for tenable water money happening. With the growing shortage of new water and the expected increase in water demand

all along the next few decades, water use must be wise and preservation-based. The use of salty water in farming should progressively appealing; nevertheless, the problem of salinization needs expected painstakingly checked. Irrigation accompanying salty water, outside soil amelioration, will bring about a creeping addition of salinity in soil and water. Sustainable salinity administration, then, demands an integrated approach that integrates decent seepage, watering accompanying higher water, application of natural resources, and emptying of the salts. [119, 120, 121, 122]

## 1. Smart Irrigation Systems

Increasing water shortage, environment change, and study of human population have managed to a demand for upgraded food result in a tenable habit. Crop result demands best chance of succulent water and crop growth is harshly touched when water content in the soil drops beneath the corporal necessity of crops. Irrigation structures must too be non-complete of non-renewable energy beginnings like nonrenewable fuel sources. The most natural habit of providing water to the crop plants at the official time of region is by engaging watering on few critical crop tumor stages. However, while utilizing watering it is owned by present only that much amount of water that is necessary for one crop. Exceeds quantity of water grant permission waste the raw material, delays crop tumor, increases crop result cost and form the soil less fruitful for the next crop. With the position of economy, labour deficiency, growing make rate and water problems for land research and practices, it enhances more owned by form the irrigation attainable by changeable idea signs, control by fantasy, electronic control and control utilizing Personal Computer. Rice is the experience's best user of water for basic result, absorbing about 30% of the freshwater possessions secondhand for farming. However, about 65-70% of the water secondhand for paddy culture is wasted through

dissolution and leakage misfortunes into the ground. In order to underrate disappearance of watering water in edible grain, ground-specific watering control has existed grown by merging watering organizing and calculating-helped monitoring and control methods. The basic objective of edible grain-watering control search out classify watering water to the field at the right place, official time of region, right amount, right character and right form. Substantial amounts of watering water may be preserved by requesting watering only at fault-finding stages of edible grain plant growth. A meaningful amount of water can further be sustained by utilizing various watering patterns a suggestion of correction conventional inundation. Micro-watering is individual of ultimate adept watering wholes. [123, 124, 125, 126]

## **2. Water Conservation Techniques**

Water is detracting for land result, and allure scarcity has a negative affect all aspects of organic arrangements. Water frequently enhances a restricting determinant for agriculture in many domains, and incorrect, over-taking advantage, and wasteful habit of water for watering has managed to groundwater exhaustion in several nations. An orderly and due approach is necessary to check these questions. Unconventional methods concede possibility be helpful in the preservation of water possessions, even in domains place it is accessible in big quantities. One of ultimate effective habits to effective water administration in farming is the pure liquid hydrogen and oxygen-reaping method. It refers to the accumulation of rainwater and the use of the water for watering. The most natural model of pure liquid hydrogen and oxygen gathering is the accumulation of water in tanks from rooftops of families. The picked rainwater is stocked in tanks and secondhand for dampening in dry months. It can to be stocked subversive in unrefined aquifers by adopting correct land use practices. The

conservation of above coating of soil liquid is main for plant growth. Use of compost (top the soil surface about the plants with dry leaves, non-rotting natural material, hay, or added fabrics) hampers soil liquid loss through dissolution. The use of natural waste fabrics concede possibility likewise specify a cover to the soil, lowering soil water misfortune through evaporation.

### **3. Salinity and Water Quality Management**

Human-persuaded atmosphere change has exacerbated the warning of salinity to soil and water money across the earth. Coastal fields are affected by raised salinity and adulteration of freshwater parties proper rising expanse levels. Salinization is further a big question in irrigation-augment land domains, specifically in arid and tractor trailer-dry extents, chiefly as a result of incompetent seepage, extreme evaporation attended by watering accompanying salty water, use of poor-value groundwater, and tide when water is highest tables about or at the soil surface. Other human-inferred activities, in the way that excavating labors, manure runoff, and technical effluents, provide towards raised salinity levels in freshwater crowd. Carbonate weathering and draining of bicarbonates from soil by organic waters more help water quality shame. During the last few decades, hydro chemical studies of hollow groundwater and surface-water money in the area have told a piecemeal decline in water value be necessary salinization and contamination from geogenic, land, technical, and city beginnings. Heavy metals, such as lead, cadmium, arsenic, chromium, planets orbiting sun, and law enforcement officer, cause solid of salinity to two together surface and groundwater quality, chief to toxicity of marine creatures through direct uncovering and food-netting connections. Salinity administration methods include sensibly growing freshwater inflows to lower salinity in freshwater bodies and to fix the belongings of salinity rise on marshy environments, habitat and biodiversity. Coastal countrysides are maneuvered to

allow makeshift changes in salinities of rivers and estuaries for improving the reserve principles and strength. A multi-decadal analysis of the seasoning balance labels the salty waters that help the long-term increase in seasoning loads in the Murray-Darling Basin, India. The extent of salinity stress at various crop progress stages is depicted using a terrestrial news structure (GIS) located salinity index model. [127, 128, 129, 130]

#### **4. Sustainable Water Resources Utilization**

Proper administration and maintained exercise of water resources is fault-finding for guaranteeing worldwide meat security and saving the surroundings. The chance of able abundance and quality of water is essential for all human projects. Extensive use of relic water on account of lack of effective administration and salinity problems on account of watering practices are conceiving weighty crises in various domains. Sustaining soil effectiveness through environmental approach, making optimum use of diverse possessions under serene atmosphere and progressing suitable designs for all divisions of people are essential determinants. Ban on over bleeding of fossil water, ratification of enduring waterways contamination control plan, establishment of desalination plants, and exploitation of lake and sea water accompanying minimum risk are most seductive for improving the status of water. Adequate consideration is wanted on administration of watering systems and use of appropriate practices for protecting dampness, seasoning and fertility of soil. Development of forms and methods for restoration of salty/sodic extents, prevention of water dirtiness and progress in freshwater and wastewater situation electronics have gave controlled realism to differing water and water accompanying issues. Demand for growing watering and drainage wholes explanation and change/ Track record of incident in production of low cost sensor, Wi-Fi sensor socializing for professional or personal gain and active process

listening/mapping supplies hope that all types of dampening necessities keep surely be fulfilled from now on. Investment in experimental administration of all sustainable resources containing water is reasonable planning towards accomplish independence in food/ strength and enduring biodiversity in the environment. [131, 132, 133, 134]

# Chapter - 9

## Plant Biotechnology and Crop Improvement

Modern plant biotechnology amounts to a sort of sophisticated biotechnological forms and methods that enhance crop bettering, addressing various challenges in cuisine result, such as: 1) the bulk procreation of good for one's wellness elite planting matters; 2) happening of transgenic plants to award opposition to biotic and abiotic stresses; 3) augmentation of pertaining to food content, value and storage characteristics; and, again, 4) inclusion of genome editing electronics for exact guidance and rewriting of plant genes. Such tools touch expedite the happening of smart and stress- resilient crops and support restore crop result. Tissue civilization sciences enable accelerated herbaceous procreation of demanding crop class, duplication of elite sugarcane types for field-testing and monetary setting, and chance of bacterium-free virus-arranged source vegetable. Transgenic crops of major succulent ancestries and tubers opposing to viruses, nematodes and fungi are now having field-experiment, while related crops enriched in biography-fortifying fibers are being produce. Several public-sector research programs are surveying deoxyribonucleic acid-rewriting science towards change of undesirable characteristics/mutations in advantageous non-GM differences. Nano-technology is concreting the habit for the use of nano-silica to mitigate abiotic stress all along result processes. The increasing globe population be necessary to pose important challenges to feed security. Current styles in urbanisation and environment change are further disadvantageous to crop result. Future efforts in plant biotechnology must, so, be point or direct

at a goal at create technologies for the swift era of smart stress-flexible crops and for precise deoxyribonucleic acid manipulations in main basic crops of age primarily in the experience's expanding countries with its own government. These countries must agree to select accessible and arising biotechnological tools to guarantee general bread security for their crowds - not completely for the next half-centry. <sup>[135, 136, 137]</sup>

## 1. Tissue Culture Technologies

Plant fabric breeding determines a way to evolve a wanted crop or forest artificial outside the use of beginning or the transfer of pollen. Plant fabric breeding is individual of ultimate valuable finishes of horticultural research and result. It authorizes the result of abundant numbers of innately uniform plants in a relatively short magnitude. In plant fabric sophistication, plants maybe grown from some part of the wood, to a degree leaves, stem, root, anther, flower, beginning, and whorl on flower. Plant fabric culture maybe used to produce bacterium free-stock, troublesome-to-root cutting, combination in trees, growth of haploids, study of plants embryogeny, and big result of subordinate metabolites. Micropropagation is the fast ready to bear propagation of a plant from a limited piece of fabric, frequently from a meristem or a feathered bud. It is frequently accomplished by fabric sophistication methods in a regulated atmosphere for commercial result of bacterium-free plants all-inclusive. *In vitro* dash-tips, leaf, stem nodal, and root explants maybe secondhand as starting tissues. It can still be an alternative blueprint for the diffusion of elite class. The fabric culture method is completed activity in sterile environments on a dimensional or semi-stable tumor medium that holds essential vitamins. The fiber resolutions, for optimal progress and incident, hold beginnings of element, minerals, vitamins, amino acids, and development hormones.

## 2. Genetically Improved Crops

Genetic engineering of crops offers huge potential, even though some transgenic crops have generated environmental and fitness concerns. Polycystic kidney affliction, blade container anemia, cystic fibrosis, and hemophilia are big human afflictions that maybe avoided through genome rewriting. Plant stress study of animal, that concentrates on understanding the interaction between the host and creative power, aims to expand suitable fighting machines against surroundings-induced (abiotic and natural) stresses and determines a organic basis for stress-diminishing approaches. Using transgenic, fabric-education, or molecular rearing orders of genome excerpt, production of genotypes presenting new encouraging adjusting traits, to a degree resistance to extreme hotness, salinity or dryness stress, and pathogenesis and disease fighting, maybe begun in a shorter period. In crop result, Nano technology holds promise in growing the quality and batch of presented meat. Nano-biotechnology appears essential not only for cultivating more creative, affliction-resistant, and environment-flexible crops through alteration of genetic material but also for improving nitrogen-use effectiveness at the not urban and physiological levels, permissive better plant answers to heat and dryness stress, protecting crops from contaminations, utilizing waste fabrics for tenable production, and growing yields by more effective manure and irrigation request. Nitrophenol-medicated ancestries of monocots have shown very extreme nitrogen-repairing project; this area demands further expanding. Return-on-loan studies for nano materials need to be completed activity to try either these materials are economically reasonable substitutes in crop result. [139, 140, 141]

## 3. Plant Stress Physiology

More than 90% of plant class are unprotected to a type of referring to practices or policies that do not negatively affect the

environment stressors that can dangerously influence their common progress and happening. Climate change is called to increase the repetitiveness, event, and asperity of dryness, extreme heat, glut salinity, and added abiotic stresses, and still the occurrence of differing ailments made by bioagents, chief to main crops yield reductions. Thus, understanding the belongings of these stress provocation on plants and the machines they use in answer is of excellent significance. Plant progress and yields are too overwhelmed by basic stress persuaded by pathogens and bug infections. Research has displayed that phytoplasma contaminations increase the plant's susceptibleness to abiotic stress environments, suggesting a need for a more complete approach to plant answers to simultaneous basic and abiotic stress. Responses to dryness, salinity, pathogens, and exalted hotness cause a build-up of sensitive oxygen class (ROS) and after happening of oxidative stress in plants. ROS play main supervisory duties in basic absorption by straightforwardly or obliquely changing the function of key enzymes. Therefore, reviews into the result of ROS and the study of animal of alive oxygen have results not only for a better understanding of plant stress answers but again for future attempts to breed or engineer plants accompanying upgraded fighting to stress environments.

[142, 143, 144]

#### **4. Nano technology in Crop Production**

Nano technology allows the design of nano materials across miscellaneous scales. Nano technology's environmental associations are being surveyed generally from the view of remediative requests. The use of engineered nano materials in farming is still in the analysis chapter, even though Nano technology has potential uses in pollination, pest control, watering, ailment administration, and crop tumor listening. Nano technology can enhance manure administration and use effectiveness, reliable poison expression, and the delivery of

agrochemicals. Any augmentation in the common practices furthers their use or determines a superior product that acts the function better, demands lower use rates, or reduces the commonness of request. Consequently, environmental damage and well-being risks maybe underrated. Moreover, they can help to monitor stress environments and determine information to the ranchers about up-to-the-minute mediation accompanying crop administration practices. Precision agriculture is an joined mechanics game plan to embellish land production, brand value, and worthwhile underrating the tangible impact and sustaining provisions for future production. Nano technology can imitate in accuracy ranching by providing nanostructured sensors that will enable listening of mineral rank and closeness of contagions/diseases in the fields, accordingly admitting correct measurement of inputs. Delivery of foods through nano fertilizers with correct organize and portion of drug or other consumable can help to underrate the risk of emptying, drainage, and other negative impacts guide overdone manure use. Additionally, weather forecasts at the Nano scale accompanying fine geographical resolution are again anticipated in the familiar future. <sup>[145, 146, 147, 148]</sup>

# Chapter - 10

## Advances in Animal Production Systems

Operating animal result schemes in a tenable manner-both ecological and economic-has pretended excellent importance not only for animals raised on a farm farmers but further for organization. Animal result wholes with slightest unfavorable impacts on the surroundings accompanying embellished yield and quality of animal device will have a excellent retail reputation. Systematic programs leading to raised result adeptness of animals raised on a farm through genetic bettering, complex augmenting/browsing approaches, and proper affliction control measures will help to gain result-use demand in developing countries all the while the coming decades. Although a considerable demand-supply breach endures, by means of refined augmenting and administration methods, it is attainable to reach production levels per animal that are corresponding to those in grown nations. Animal prosperity concepts are immediately joined into breeding and caring for farm animals, because the consumer is immediately more worried about by virtue of what mammals are created. The enhancement of output accompanying common augmenting practices is limited, because the water and feed base of many underdeveloped countries are not well trained. Although national animal feed necessities top supply, the glut demand in total pile is offset by delicate augmenting practices that aim to blow up result per animal. Protecting and reinforcing the animal's genetic potential through accuracy augmenting methods betters growth rates, reduces result costs, and supports tangible sustainability and animal prosperity. <sup>[149, 150, 151]</sup>

## 1. Sustainable Livestock Management

Sustainable bovine animals result systems and their direct administration are increasingly main for reinforcing the living standards of growers and providing decent meat, milk, and cells while lowering the negative impact of livestock result on the atmosphere. Recent controlled advances in supporting tenable bovine animals production involve smart bovine animals management utilizing biosensors, direct listening of animals by expert arrangements accompanying artificial intelligence, growth of salinity-open-minded bovine animals, and identification and administration of zoonotic afflictions. Genetic improvement in animals raised on a farm is immediately focused principally on reconstructing feed efficiency and status, advancing disease fighting, improving output quality, reconstructing animal well-being and welfare, and realistic animal-surroundings interactions. Recent currents in accuracy feeding sciences contain nutrient administration on the base of animal necessities, nutrient-digestibility-level-located diet expression, and feed quality following through sensor electronics. Global food result arrangements need to strike a balance 'tween builders and consumers by contribution producers acceptable price incentives for animal merchandise. Maintaining a reasonable animal production subdivision accompanying a strong research program and adequately outfitted extension duties network, advancing science-located electronics happening, taking appropriate conduct to overcome important and environmental challenges, and guaranteeing incidental sustainable administration orders for livestock farming form the key challenges before. [152, 153, 154, 155]

## 2. Genetic Improvement in Farm Animals

Conventional development arrangements for hardy, extreme-operating animals have provided excessively to food result. These means can potentially be flattered by more distinguishing

and hasty applications of alteration of genetic material and basic transfer. The genes that code for main financial traits in the way that milk yield and feature, wool result, gist yield and characteristic, disease fighting are applicable due to plan of the genome of animals raised on a farm. The knowledge, finishes and methods for artificial insemination, fetus transfer and fetus cryopreservation have advanced. Gene banking of main mammals for tissue civilization and stem container techniques have begun in many nations with core, fabric, milk and ailment resistance genes for bettering of local breeds to increase output. Molecular genetic methods for ailment free animals and for smooth replicating of germplasm are cultivating rapidly. Control of hereditary bettering is key for some intelligent training programme.

This applies to acting selection in addition to the control of inbreeding. Knowledge of the heritage of diseases and different distinctive characters bear allow their removal or minimization. Such control has earlier happened practiced favorably cruel populations. Such control would ease method of inducing pregnancy, embryo transfer and replicating. New information can permit investigation of unaffected dissimilarities of animals including various species to embellish creative traits. Cereals like edible grain that has a plunge tolerance deoxyribonucleic acid and grain with affliction opposition genes have been presented. Genetically reconstructed goats accompanying improved milk feature and hogs with depressed phosphorous content have happened achieved. [156, 157, 158, 159]

### **3. Precision Feeding Technologies**

The digestive fibers consumed by animals raised on a farm are secondhand for growth, removal of liquid, duplication, and sustenance. However, incomplete use of these fibers happens on account of variations betwixt mammals. At one extreme,

genetically superior mammals convert a better capacity of their nutrients into output, while possible choice that are poorly trained or of inferior genetic stock convert very little. Through accuracy augmenting technologies, mineral consumption maybe matched accompanying fiber requirements. It is attainable to envision a piglet's optimal amino-acid needs established allure burden, sex, and development stage all the while production, in addition to tangible determinants. Precise rations can minimize the element, nitrogen, and planet seen at dawn footmark in pig result, happening in low mineral use without thought distinguished to conventional augmenting means. Protein requirements for grill for cookout chickens are curbing occurring as scientific knowledge having to do with their use of digestive protein has raised. Recent global styles stress the importance of lowering nitrogen elimination for underrating the adverse incidental impact of animal result. For contemplative animals, particularly herd and sheep, accuracy augmenting sciences have not existed widely selected. Nevertheless, providing the right type and amount of feed at the right time through accuracy augmenting has excellent potential for reducing the hothouse smoke diffusions of ruminant result arrangements. These technologies accordingly use an animal's ancestry and stage of result to adjust allure diet. Feeding formulations for individual mammals, groups of mammals, and all stock are likely utilizing commercially available spreadsheet. [160, 161, 162, 163]

#### **4. Animal Welfare and Ethical Production**

As animal produce wait major beginnings of bread and income for a big indiscriminate the all-encompassing population, guaranteeing kind situation within these result schemes and following ethical controls outside jeopardizing worth is essential. Today, in addition to animal prosperity, users are further interested in attainable moral consequences of few result orders (e.g. baby cow, foie gras). The concern of up-to-date animal

production schemes surrounds a wide concept, allowing for possibility able animal husbandry environments and the use of alternative result technologies that are seen by customers as agreeable with the sustenance of animal prosperity and outside introducing risks to human strength. The increasing public sensitivity to animal prosperity issues has experienced to main changes in legislation and connected result plans. An increasing number of builders intentionally follow controls and analyzing foundations (like, Certificat agriculture Raisonnée, Agriculture Biologique) that apply righteous tests to the result of livestock amount (like, Synergies de l'Élevage de Basse-Normandie for broilers, French Mazot Production or Halal). Such conditions are exceptionally esteemed in the case of indulgence food production, and even shoppers of cheaper foodstuff ask about if the mammals have suffered all the while their raising, burden this factor against all additional facets. [164, 165, 166, 167]

# Chapter - 11

## Veterinary Biotechnology and Animal Health

Microscopy, serology, immunology, microbiology, and microscopic any branch of natural science techniques are working for the early and prompt disease of diseases moving household mammals, fish, and fowl. Biotechnological novelties have performed a crucial function in the incident of vaccines for the prevention of trenchant zealous, bacterial, and like a parasite diseases. Gene-located vaccines and DNA vaccines have proved promise for certain zoonotic ailments in mammals. Serological and microscopic techniques are being working for early disease of diseases. Antimicrobial fighting (AMR) in zoonotic microorganisms poses a weighty challenge to public health, and as a consequence, the use of antimicrobials in cuisine-bearing animals has reach under investigation. In this situation, AMR listening must should necessary in order to guarantee the security and health of mammals and persons. The use of anything available water demands proper sense and information. Certain open output have role cruel well-being, additional products have main part in maintaining animal strength, and still different output affect the atmosphere. The use of medicines in animal farms is creating many questions. Strategies bear never perform to indiscriminately remove sure bacteria but to maintain in proportion all the particular microbial populations in a sophistication. On the other hand, preservation considers interplays between bacteria, mammals, and natural resources. Ecological information concede possibility be the action for every incident. The intelligent management of instinctively free

sustainable resources will go at a great distance in claiming material and animal health, that will eventually assist animals in bearing healthful feed for humans and added mammals. [168, 169, 170]

## **1. Molecular Veterinary Diagnostics**

The use of microscopic methods for the early and accurate disease of spreading, metabolic, and genetic ailments in household mammals has revolutionised veterinary diagnostics. Rapid and impressionable discovery arrangements have been grown established the polymerase chain reaction (PCR) and added microscopic any branch of natural science techniques, permissive clinicians to investigate clinically inconclusive ailments, validate assumptive laboratory diagnoses, and discover ailment powers in animal and environmental samples. The first marketing veterinary PCR equipment was introduced in 1989, and an thorough array of PCR-located assays is immediately available for a expansive assortment of veterinary diagnostics, making it the fastest-increasing district in veterinary interpreter today. Molecular analyst support several benefits over usual forms, with ultimate apparent being speed. Within hours, cases can be pinpointed accompanying infectious powers that usually demand days to culture by normal plans. In addition, molecular methods are frequently far more impressionable than culture-located methods, permissive detection of structures superior to the establishment of a ailment, even when the burden is excessively depressed for culture seclusion. The capability to detect pathogens before the attack of a ailment or in seemingly healthy mammals can have meaningful epidemiological results, making it possible to recognize the date of contamination in disease preservation studies. [171, 172, 173, 174]

## **2. Vaccine Development Technologies**

Vaccine incident is a complex process that faces diversified challenges and requires important expenses momentary and

property, owing to the differing impediments complicated in the safety, immunogenicity, efficiency, and control of product quality of vaccines. In addition to the currently approved vaccines, various creative cure sciences have emerged, containing mRNA vaccines, Virus-Like Particle (VLP)-located vaccines, Live-Attenuated vaccines, agricultural vaccines, protein subunit vaccines, and vector-located vaccines. Indeed, the COVID-19 universal has increased the development of differing cure electronics. However, more novelties and improvements are still inevitable for the produce, disposal, administration, and experiment of vaccines because immunizations may be deployed at a best scale in a smaller period while maintaining efficacy and security. Recent advances and novel approaches in the incident of vaccines for different diseases, containing human papillomavirus, zealous hepatitis, respiring syncytial virus, infection, coronaviruses, schistosomiasis, Chlamydia sp., Clostridium botulinum, Clostridium arduous-joined ailment, Zika virus, and Japan type of encephalitis, are likewise conferred. The WORLD HEALTH ORGANIZATION (WHO) defines a cure as “a organic development that improves exemption to the ailment”. Vaccines that fight against catching diseases are from the creative power of the disease or allure parts, and they mimic the ailment by exciting the production of antibodies outside generating the real disease. Because of the complex character of these organic readiesses, a successful cure supports securing exemption over an extended magnitude. Nevertheless, judgment of the complete immunological response and security of vaccines can take age before a cure can be certified for allure engaged use. A swift response to universal outbreaks is detracting; then, new innovative and system-effective cure technologies are insistently wanted so that demonstrate effective vaccines against new pathogens. [175, 176, 177, 178]

### 3. Zoonotic Diseases and Public Health

Zoonotic afflictions pose meaningful global strength warnings. They originate in mammals and are communicated to persons, caused by miscellaneous catching powers. Zoonotic origins have happened labeled for nearly three-dorm of new or arising human catching diseases in the last ten of something, and aforementioned contaminations kill 2.7 heap folk annually. Moreover, zoonoses are being the reason for diminished output in the livestock and fowl area, which is important for nationwide and all-encompassing economies and cooking protection. The Centers for Disease Control and Prevention (CDC) reports that six at a distance ten infectious ailments in society can spread from animals. Emerging zoonotic afflictions in the way that Ebola, Hendra, and SARS have produced mass panic, needing large management resources for restraint. Rising human cultures encroaching into being residences have raised the risk of emerging zoonotic ailments. Interdisciplinary research is owned by minimize the risk of zoonotic affliction rise. Viruses in the way that HIV, West Nile virus, Nipah bug, Ebola bacterium, and SARS-CoV-2 introduce from animals. Zoonotic ailments can too be transmitted all the while cooking management and preparation, stressing the significance of public health instruction in animal care, cooking management, and prevention designs. In cultivating domains in particular, restricted money greatly increase the burden of Zoonotic ailments. The financial cost of zoonoses in the expanding world is ample, lowering human fitness and productive competency and jolting animal health and result. [179, 180, 181]

### 4. Antimicrobial Resistance in Animals

Antimicrobial drugs play detracting acts in treating catching ailments began by pathogenic bacteria. However, the senseless use of these drugs in persons and mammals has led to the rise of

multidrug-opposing pathogenic microorganisms, offering a serious community health danger. Antimicrobial opposition (AMR) is defined as the talent of microorganisms to oppose the belongings of drugs such as medicines, antifungals, antivirals, and antiparasitic powers that earlier inhibited or destroyed bureaucracy. Antimicrobial-opposing microorganisms can easily spread from individual patient to another, straightforwardly inducing infections that are troublesome to treat. In addition to extreme melancholy, these contaminations often influence extended clinic stays and increased health management costs. Zoonotic ailments are contaminations that can be communicated betwixt mammals and humans. Many pathogens of zoonotic afflictions are persistent expected multidrug-resistant and opposing to usually arbitrary and used cures in persons. Human well-being and animal health are straightforwardly mesh, and the approach for affliction stop is always planned accompanying a "individual health" idea. The individual strength concept stresses the relation and linkages with animal health, human fitness, and the surroundings. Addressing AMR in mammals requires a inclusive, multisectoral, and multilateral approach in a related, cooperative manner including human, animal, and material fitness areas on national, provincial, and worldwide levels, as mirrored in the action plan of the WHO, OIE, and FAO. <sup>[182, 183, 184, 185]</sup>

# Chapter - 12

## Renewable Energy and Environmental Sustainability

Bioenergy is arisen renewable organic matters and constitutes a meaningful portion of worldwide energy use, but allure potential remains mostly new, especially in nations accompanying abundant wood and land residues. Its exploitation can check humidity change, reduce air contamination, increase energy protection, embellish regional incident, and produce new income beginnings for country communities. Solar energy is an plentiful, clean, and inexhaustible source of strength that maybe harnessed through photovoltaic orders for various direct and indirect uses. Solar radiation can be used to extract hydrogen from differing water beginnings and solar greenhouses can improve agro-produce. Waste-to-energy sciences supply cost-effective strength creation and disposal resolutions for differing organic wastes, and instinctive acted effluents can be secondhand for biodiesel result, algae culture, and tangible sustainability. Proper utilization of land and snack-industry residues together accompanying other money can simplify energy production accompanying lowered loud noises. Sustainable mechanical production and production practices allow the provision of appropriate strength for adept and cost-effective merchandise, possession, and transport. Nano technology has a significant affect the growth of socio-economic areas in the way that health, crop care, and referring to practices or policies that do not negatively affect the environment sustainability. Nano materials are increasingly secondhand in healing diagnosis, depict, and

situation strategies, and have excellent potential in tangible remediation against chemical and organic contaminants and toxins. Manufacturing and material security and risk assessment of nano materials loiter-term responsibilities. Nano materials can deliver drugs at particular sites; skilled are several hopeful address nano-drug delivery plans in the beginning of development and dispassionate experiment. Nano medicine have made a progress in drug transmittal platforms and offer effective forms to address the drug resistance question. Nanomaterial-located biosensors can detect biomolecules in living containers accompanying ultra-extreme particularity and sensitivity, permissive early disease of diseases. <sup>[186, 187, 188]</sup>

## **1. Bioenergy Production Systems**

Bioenergy is a big component of energy from undepletable source possessions, derived by adapting biomasses into vaporous (biogas), liquid (biodiesel, bioethanol, biography-lubricate), and solid (biocoal, forest pellets) fuels. It is a trustworthy alternative to hydrocarbon deposits and has a potential act in reducing all-encompassing heating on account of the lower net colorless odorless gas (CO<sub>2</sub>) issuance and improved soil element seclusion following allure use. Moreover, result of bioenergy creates supplementary salary paths for country households and contributes to strength autonomy and freedom at the public level. Bioenergy helps expand the rural saving and builds tasks regionally. To meet increasing strength demands from biodiesel and bioethanol, big homesteads of non-cooking oilseed crops and cane carbohydrate are essential. In addition to these feedstocks, bioenergy can still be created from referring to practices or policies that do not negatively affect the environment concerning cities solid wastes and household wastes that in proper sequence reduces cost for waste administration. Biomass (wastes from forestry, farming, growing plants in liquid, ranching) is secondhand as a feedstock for production of biogas through

anaerobic digesting, that is an environmentally dependable method that bars health hazards and different deficits while guaranteeing clean strength. Development of fuel cell electronics for group of conveyance and specific vehicles manage begin a new cycle in bioenergy exercise for transport needs in the coming decades. Production and utilization of bioenergy grant permission imperfectly oust nonrenewable fuel sources but will certainly play a crucial function in convergence demand while lowering reliance on fossil fuels. Bioenergy will be a part of a bridge and help in an organized change to hydrogen-located economy. [189, 190, 191, 192]

## **2. Solar Energy Applications in Agriculture**

Solar radiation is the basic beginning of energy everlasting on Earth. It is the hidden motive that sustains hotnesses inside the residence and influences the types of ecosystems present about the planet. Solar energy plays an important act in land result through plant photosynthesis, which converts solar power into synthetic strength. The application of solar power in farming is evident when seeing in what way or manner the movement of solar energy, involved by plants canopies are related to the commodity. Consideration of migratory amount output, either leaves, stem, fruit or children, focal points the union between fallout absorbance and foliar district. Recent advances in solar sciences and their use to land production processes are good. Solar energy is plentiful, renewable and non-polluting. It is plentiful and maybe used all over the realm indifferent forms. Harnessing solar energy in a stand-unique manner is most appropriate and economic for household and land uses such as water warming, drying, foodstuff preservation, taping, grilling, growing plants in liquid and electrical capacity production. Solar photovoltaic systems may be used in extents where continuation of the common electricity gridiron is clumsy or economically unviable. The request of solar energy in cosmic vapour stimulate

freezing in gardening, concerning farming cosmic vacuum drier, warm battery powered by the sun for in-store and precooling, vapour assimilation cooling arrangement for heat storage of farming produce is still trying fruitful. Solar photovoltaic panels backed on cosmic trackers enable available water to mammals, watering of crops, lighting in apartments and streets and movement of remote farm supplies. [193, 194, 195, 196]

### **3. Waste-to-Energy Technologies**

The strength emergency is an urgent challenge that demands a next resolution. Waste maybe an inexpensive and plentiful inexhaustible beginning of strength. It includes environmental pollutant (forest, fabric, leather, paper), concerning cities waste (room for cooking food waste, green waste), land waste (edible grain husk, maize stover, sugarcane bagasse, understand stalk), veterinary waste (excrement), and additional organic matter. Waste-to-strength sciences, that cover a roomy range of areas, can produce strength indifferent forms (biofuel, biogas, and bioelectricity) and even help in waste administration. Although the beginning investment is extreme, waste-to-strength projects supply a renewable beginning of strength and do not produce dicey matters. After the waste-to-energy process, further situation, in the way that make ready to bear, is often wanted for contaminant deportation. Waste-to-strength systems involve burning, gasification, pyrolysis, effervescence, microbial fuel container, anaerobic digestion, biodiesel response, Fischer-Tropsch combining, and trans esterification. Among ruling class, biochemical treatment to a degree anaerobic digesting (AD) and microbial fuel containers (MFCs) is a productive means to use basic waste to produce bio methane and create strength indirectly. Anaerobic digesting not only decomposes natural waste, but the poison gas-rich biogas caused can also be secondhand for warming, power result, and vehicle fuel to reinstate hydrocarbon deposits. MFCs harness strength released

all the while microbial corrosion of basic substrates to produce electrical strength; the power production process is equivalent to a normal biochemical process. [197, 198, 199, 200]

#### **4. Sustainable Industrial Practices**

Sustainable practices in enterprises and activities focus on lowering demands on money while guaranteeing slightest adverse belongings on the atmosphere. Environmental sustainability refers to the use of possessions outside compromising environmental completeness, support supply, or human life. Raw money must be secondhand accompanying take care of environmental preservation. Technology plays a lively duty in accomplishing environmental sustainability. Responsible use of money is key to the future. Natural resources concede possibility be utilized in a tenable class. Rising strength demands endure be met by misusing inexhaustible beginnings to a degree sunlight, wind, sea waves, sea warm energy, and organic processes. Every process mostly produces waste and dirtiness; if prudently harnessed, waste maybe secondhand as natural resources for further corporations. Environmental sustainability should be the directing standard for machine control. [201, 202, 203, 204]

# Chapter - 13

## Nano Technology in Medical and Environmental Sciences

hopeful advances in the use of nano materials in healing diagnostics, cure, and depict, and their potential uses in environmentally sustainable processes as nano-located drug transfer and bio sensing plans, bioengineered nanostructured surfaces, photo catalytic degradation of referring to practices or policies that do not negatively affect the environment contaminators, and waste-to-strength technologies. Current research in these fields must address the potential energy risks of nano materials guide their production, use, and transfer. Nano particles and nanostructured matters are gambling a growing part in healing condition, drug delivery, and healing as nano sized biosensors in in vivo and artificial experiment, as well as new-era cure transmittal systems. In current age, much research has met on nano materials (including graphene-located nano materials, silica nanoparticles, golden nanoparticles, zeolites, nanowires, nano rods, nano capsules, chitosan nanoparticles, quantity dots, carbon nano fibers, element nanotubes, and dendrimers) to better the detection, cure, and depict of miscellaneous diseases to a degree malignancy, Alzheimer's, and soul diseases. Promising advances are further ought in the use of nano-located systems for dependable, intend and principally effective childbirth of cure to treat afflictions. Nano technology needs to be implicit in material conditions and assessed concerning incident goals, containing human strength, tangible quality, and culture. Rational request of Nano technology keep

enable inexpensive and non-poisonous answers to various referring to practices or policies that do not negatively affect the environment concerns containing stop (rather than control) of dirtiness, reusability of wastes, or material improvement through waste situation processes. Nano technology-assisted methods concede possibility supply solutions to inexhaustible, element-neutral bioenergy era from different natural waste resources and matters improvement all along treatment of waste accompanying microbial fuel containers and anaerobic poison gas-producing plans. It is main to guarantee that the benefits of Nano technology are not outweighed by harmful impacts. The complete biological clock of nano-brand must be connected, containing production and transfer. [205, 206, 207, 208]

## **1. Nano Materials in Medical Diagnostics**

Nano materials have huge potential engaged of medical condition on account of their unique features in the way that large surface extent, surface plasmon reverberation, and high moonshine adeptness. Various nano materials have happened prepared and determined for requests in detection plans like colorimetry, electrochemical sensors, moonshine, surface-enhanced Raman spectroscopy, and radiance depict. Gold nanoparticles have emerged as powerful reagents for discovery requests through colorimetric and fluorescence discovery blueprints. Other metals like silver, law enforcement officer, bismuth, titanium, and light have also existed combined and applied as labels for colorimetric and electrochemical discovery. Furthermore, the labels accompanying bright, copper, and bismuth nanoparticles supply bigger sensitivity than that got accompanying the gold. SERS integrates the wonder of Raman scattering accompanying the augmentation supported by the surface. Nano and nanostructured matters, specifically metal-located substrates, are promoted for enhancing Raman uneven signals.

The synthetic SERS effect can also be embellished utilizing shining dye molecules. For instance, a birhythmic SERS sensor established synthetic luminescence for detecting hydrogen peroxide and level of glucose in blood was constructed on a silver nano cluster arrangement. Despite the benefits, the limited number of forceful Raman-active SERS labels hinders the growth of SERS and from detection of diversified marks challenging. To overcome this, all-not organic glowing nano silica accompanying strong SERS project has happened designed. SERS discovery science has been widely exploited for reliable disease of foetal Down's disease, listening of biogenic amines in various snack samples, ancestry phospholipid analysis, and discovery of micro pollutants by concerned with atom and molecule change recycling and impressionable control of sterility processes. [209, 210, 211]

## **2. Environmental Nano technology Applications**

Nano technology circumscribes the design, result, characterization, and use of forms, tools, and systems through control of matter at nanometer scale, usually 1-100 nm. Research in nano medicine, exceptionally in the field of inhalation toxicity, breathing drug transmittal, target drug delivery and linked imaging-cure, has acquire significant push. Nano technology in tangible requests has taken considerable interest concerning dirtiness lessening, waste treatment, illustration of organic processes, referring to practices or policies that do not negatively affect the environment interaction of nano materials, and tangible impact amount of nano materials. Nano technology focuses on nano-optimics, nano-pieces and their distillation, nano-covering, nano-one who carries or transmits something for DNA, RNA, and antagonistic-cancer drugs, nano-cosmetic, nano-pesticides and biography-pesticides, nano-fertilizers, nano-drug sorbents, nano-sensors, and design of nanostructured maneuvers.

Nano materials have been usual engaged of drug transfer and drug development. Silver nanoparticles used in drug transmittal in a dosage-dependent approach can organize and adjust intracellular signaling pathways, and strive powerful antagonistic-cancer belongings on cervical tumor containers. Cytotoxicity studies have displayed increased efficiency of nano materials in miscellaneous malignancy cell lines making ruling class appropriate contestants for drug delivery and tumor medicine. The surgical necessities for cancers can be restricted by nano-located drug childbirth systems. Surface functionalization utilizing distinctive fabrics for site-particular address of the curative nano materials can increase drug accumulation in goal means. The surface of nano materials maybe modified to evolve tool-particular targeted drug transmittal wholes. Nano carriers can give drugs, siRNA, or ribonucleoprotein complexes in a dependable and adept category for treatment of differing afflictions. Nano materials are basically biomaterials accompanying their size maximized to the nano scale range (1-100 nm), and their proportion is reserved to enhance the specificity and sympathy of the nanoparticles for various healing applications. [212, 213, 214, 215]

### **3. Nano-based Drug Delivery Systems**

Nano technology is a hopeful alternative to usual drug delivery designs, admitting for the point or direct at a goal delivery of drugs to distinguishing parts of the human corpse. Targeted nanoparticle-based drug childbirth shows excellent potential in the situation of various types of tumor. Nano materials maybe devised to offer controlled release, enough biocompatibility, discrimination for goal tissue, and demonstrative and healing requests. Among the various types of nano materials being examined to move drugs, liposomes, micelles, dendrimers, silica nanoparticles, carbon nanotubes, and golden nanoparticles give the impression specifically attractive.

Despite the benefits of target nano medicine, many experimental and industrial challenges wait, containing dispassionate validation in persons, uniformity of result methods, and risk amount. Nano technology-located drug delivery schemes offer various benefits, including regulated release action, intend ability, upgraded bioavailability, solubility, and embellished efficiency compared to common doses. Polymeric micelles, dendrimers, liposomes, nano emulsions, niosomes, and stable lipid nanoparticles are appendages of the growing arsenal of nano medicine that solves the existing for some time problems endured for one drug industry. Nano drug transmittal methods must be suitable for each request and need to examine the interplay of the carriers accompanying the organic atmosphere. The next millennium will be governed by information and innovative incidents established Nano technology. <sup>[216, 217, 218, 219]</sup>

#### **4. Risks and Safety of Nano technology**

Nano technology is an arising skill with colossal request potential, specifically in medical and tangible fields. Because of the matters' intensely littleness (less than 100 nanometers in width), they cross differing physiologic hurdles (including the ancestry-mind obstruction) that best-sized atoms cannot permeate. These features authorize drug delivery plans utilizing nanoparticles to transport hydrophobic drugs, vaccines, or ancestral material (DNA and RNA) to particular tissues without toxicity. Nano materials are secondhand as contrast powers for acquire better perceptibility of tissues, organs, or tumors all along image tests. They are further secondhand in novel biosensors, photothermal therapy for ruining malignancy containers, and for container labeling and image. With these proficiencies, nanoparticles have excellent potential for use in healing diagnostics, depict, and drug childbirth structures. Nano technology is main for autogenic healing of wounds, and these device have happened commercialized and executed in differing fields.

Nano materials have applications in farming, cosmetic, transistors, cure, environmental remediation, drug transmittal, strength, and data processing. Industry shareholders expect that research on nanoparticles will bring about new monetary crop indifferent fields. While affected by a broad range of determinants, the toxicity of nano materials is chiefly contingent upon (a) physicochemical features, (b) biological obstacles, and (c) organic atmosphere. The extreme surface reactivity and susceptibleness to corrosion at the nano scale can cause most of the environmentally and biologically appropriate interplays. Nano materials are not necessarily more poisonous than different matters, but into their organic activity and their incidental act skilled are processes and models that could form their security better. To have an understanding of either they are reliable or not demands solid experiment and frequently tests will not be suitable certain classes of nano materials. <sup>[220, 221, 222, 223]</sup>

# Chapter - 14

## Artificial Intelligence and Data Science in Life Sciences

Artificial intelligence (AI) and dossier science have transformed research in miscellaneous fields, including cure, farming, and veterinary science. AI-located requests analyze healing countenances, dermatological lesions, and cardiac conditions, favorably helping radiologists, dermatologists, and cardiologists. AI-powered machines brace histology slides alone accompanying greater veracity than human physicists. AI enhances bioinformatics, admitting investigators to extract relevant and trustworthy dossier from large organic databases more efficiently. Such uses expedite the analysis of organic experiments, lowering time devouring. Biosensors are grown by scientists from IIT Kharagpur, Korea, and Australia to discover dangerously pathogens in real time. Smart listening methods in agriculture trade authorize farmers to check soil liquid, precipitation levels, temperature, and moisture from their movable devices, meal ruling class save opportunity. Digital transformation has proposed organic research toward a cloud-sharing makeup, admitting scientists to claim lab infrastructure by chance by engaging virtual helpers. New-age cloud-giving companies offer workshops on a consent basis, accompanying diversified suppliers and users. The launch of the bio computer-located learning plan for plant class categorization determines proficient knowledge for one interested in acknowledging cultivated species. Using cloud estimating in working genomics research helps assess the interplay of a a lot of genes across

species. Companies training in considerable data are utilizing AI uses to detect afflictions. [224, 225, 226]

## **1. AI in Medical Diagnosis**

Artificial intelligence (AI) is an elemental indiscriminate information technology, permissive the killing of tasks that demand intelligent practice. As a calculating science and research field, AI focuses on the development of creative calculating programs capable of operating tasks that usually make necessary human-resource engrossment. In industry-distinguishing requests, AI functions as a pattern recognition method that mimics the administrative capabilities of masters specifically fields. In the rules of data learning and fitness, AI anticipates and analyzes patient dossier for authoritative diagnosis, helps determine healing dossier for early disease discovery, and has connection with medical examination and comparison of computed tomographic (CT) scans for affliction disease. AI holds meaningful promise in delivering tailor-made healthcare, from deterrent and predicting to curative and corrective aids. In the region of disease prognosis, ML (machine intelligence) helps predict incessant afflictions, containing diabetes, heart disease, sort ailment, and malignancy, based on patterns labeled in photoelectric healing records. Predictive analytics of EMR thinks embodied cure prescriptions for patients. Specific uses of AI/ML in predicting healthcare and disease disease involve utilizing deep learning for diabetic retinopathy protect, malignancy discovery in radiology and pathology representations, body part affliction detection in figures and CT scans, early discovery of COVID-19 asperity and prediction of asperity, and prognosis of pediatric afflictions. [227, 228, 229]

## **2. Bioinformatics and Big Data Analysis**

Bioinformatics integrates biology, computer technology, and data processing to analyze organic dossier, such as genomic

sequences. Bioinformatics finishes for genome glossary and functional prophecy are essential for understanding exploratory data, exceptionally including bacteria. In mathematical farming, smart monitoring structures exploiting Internet of Things (IoT) sensors inform growers about palpable-occasion conditions, permissive up-to-date intervention. Environmental biologists progressively accept that plants can sense disturbances and send alerts to neighbouring plants. Serious challenges challenge these progresses, including administration of mathematical devices and dossier; connecting the science, science, planning, and mathematics (STEM) fields for mathematical-savvy physicists; communication across consultants indifferent areas for optimum consequences; and security from high-tech-attacks. Bioinformatics supplies the infrastructure and forms wanted to organize and analyse extreme-spatial and diverse organic dossier. It involves the incident of algorithms, information retrieval and storage orders, dossier-mining methods, and finishes for modeling and imitation. The main applications of bioinformatics span genomics, transcriptomics, proteomics, metabolomics, glossary of diversified sequence alignments and protein constructions, labeling of regulatory patterns, microscopic protein-protein interaction indicator, and drug finding. Other areas of use are happening and comparative study of people genomics, epidemiology-bases genome-off-course friendship study of gene characteristics, and classification of bacterial predicted metabolic pathways and classifications forecasting. <sup>[230, 231, 232, 233]</sup>

### **3. Smart Monitoring Systems in Agriculture**

Smart listening plans are working in modern land practices to accumulate incidental dossier namely resolved by suitable AI algorithms to specify productive and listening models located resolution support. Data related to the limits of bureaucracy and the encircling air to a degree hotness and humidity, soil dampness

and pH, light, infection plague, and ailment extending are collected utilizing appropriate sensors. The dossier are shipped to a cloud-located attendant that keeps it for future references and study and approachable to the colleagues. Based on the force of these limits, plans and warnings regarding the crop progress stage being, ailment incident opportunity and location, contagion incident etc. are likely to the laborer. Further, the accuracy ranching models like Site Specific Nutrient Management, Site Specific Crop Management etc. are also grown and listened through smart listening plans.

In Site Specific Nutrient Management models, the dossier related to the soil mineral rank (large-scale, calculating and subordinate vitamins), canopy hotness, and NDVI index are calm and resolved. Based on the soil food rank, “should be” perpetuation principles are create for the large-scale, calculating and subordinate nutrients for the various development stages of the crop. When skilled is a distinctness middle from two points the maintenance profit and the real rank for the large-scale, calculating and secondary fibers, piece of advice are proved to the producers concerning request of fertilizer for that development stage. Similarly, the result of the shade hotness and NDVI are again equated with the yield of the crop and when the advantage is beneath the range, able is likely to the laborers concerning irrigation or some healing measure. [234, 235, 236, 237]

#### **4. Digital Transformation in Biological Research**

The fast progress of information and ideas science all along the 21st century has had a transformational effect on skill and electronics. In the life sciences, the rise of grown dossier, bioinformatics, and artificial intelligence (AI) has transformed organic research. Next-generation sequencing sciences can create broad amounts of genomic data in a short while, while next-creation verbalization systems can combine recombinant

proteins in big quantities accompanying high bioactivity. The unification of organic important data accompanying added organic information by way of bioinformatics forms opens new streets for drug discovery and incident. Furthermore, AI methods have been widely used in many fields, containing early affliction detection, figure understanding, and functional optimization to develop aid adeptness. As the life sciences introduce the mathematical time, wilful movement and growth in organic research have enhance imperative. A far-flung array of new forms maybe created through combining several branches of learning cooperation and unification of methodologies from a type of fields. Within the farming and biological rule, this concede possibility offer enhanced efficiency in listening and ruling ailment symptoms in mammals and plants, support extreme-fidelity discovery and predicting models of affliction reservoirs, and assess the health of crops and pastures. The presentation of smart listening systems and requests in a broad range of positions debris emerging, but these transformational sciences are expected expected advantageous across miscellaneous economic, tangible, and public rules. While these tools offer excellent potential, it is likewise owned by consider the risks guide their use. [238, 239, 240]

# Chapter - 15

## Future Challenges and Innovations in Applied Sciences

The growing progress of modern skill and science has led to the rise of abundant novel scientific methods and finishes that have opened new skylines in each arm of science. Applied sciences are steadily helped by an incredible array of speedy changes compelled by innovation, industrialization, digitalization, and Nano technology. The happening of sophisticated listening and industrialization tools, in addition to considerable-dossier technologies and machine intelligence, has developed in fruitful advances in differing sciences as diversified data, lab methods, and appropriate methodologies are joined into an understandable form to help diagnose ailment, evaluate well-being, manage possessions, and find resolutions to make the globe better. The current worldwide situation, infuriate apiece COVID-19 pandemic, Russia-Ukraine war, and additional the earth's features, stresses the importance of worldwide cooperation concerning outbreak of disease or condition, zoonotic afflictions, food security and safety, sustainable talent administration, climate-smart business-related happening, mothers empowerment, and insane fitness. Governments are now weighty about adopting in applied sciences to meet the United Nations Sustainable Development Goals (SDGs). The planet is now at the beginning of a new modern shift apparent by the mathematical conversion of almost all labors. The capacity of new genetic, extreme-accuracy, and miniaturized sciences, in addition to data study wherewithal and predicting and preventive use of smart

mathematical sciences, is expected to found a basically new, sustainable, healthful, successful, and fulfilled experience.

## **1. Emerging Scientific Technologies**

The development of modern experimental and concerning details innovations is swift and curious. Today, scientific ideas developed inside clear disciplines are being united to supply tools for reinforcing quality of growth, constructing smarter strength-care methods, protecting open environments, and realizing feed and energy protection through tenable development. Emerging leading technologies-often based on Nano technology, biotechnology, data processing, and neuroscience-facilitate creation of new scientifically devised produce/services accompanying beneficial results for human well-being and the environment. Scientific changes authorize the cornerstone of modern association. The contributions of plant structure, chemistry, physics, and metallurgy and concerning details sciences to modern incidents in cure, environmental any branch of natural science, sustainable farming, and animal result transpire through up-to-date finishes and techniques that mechanize, simplify, or supplant miscellaneous component activities in amount/duty generation. These breakthroughs are reached by engineering sciences established the standard of physical sciences and situated solid resources.

## **2. Sustainable Development Goals (SDGs)**

Future changes in medical, organic, referring to practices or policies that do not negatively affect the environment, agricultural, and animal result sciences bear be focused on the accomplishment of the United Nations Sustainable Development Goals (SDGs). Selected experimental advances that support the achievement of the SDGs involve computerization in clinical labs, microscopic diagnostics, machine intelligence in laboratory cure, new DNA sequencing electronics, CRISPR and gene

refining finishes, rapid and convenient alteration of genetic material, biodiversity conservation, mood change impacts, dirtiness in the ecosystems, bioremediation, wastewater situation biotechnology, advantageous environmental microorganisms, law of tenable agriculture, humidity-smart agriculture, accuracy farming technologies, soil energy appraisal, soil nutrient administration, smart watering systems, salinity and water character administration, plant tissue idea sciences, potential of genetically revised crops, new stress-responsive means, tenable livestock result schemes, genetic bettering of animals raised on a farm, precision augmenting sciences, molecular veterinary disease, cure production electronics, bioenergy, solar power, waste-to-prodcut technologies, bio inspired green combining, Nano technology applications, machine intelligence in healing diagnostics, bioinformatics and large dossier analysis, smart listening arrangements, and the digital shift of organic sciences.

### **3. Global Scientific Collaboration**

Strengthened and various worldwide scientific cooperation will be essential for used sciences to fulfil their potential offerings towards the SDGs. The COVID-19 pandemic given evidence of the speed accompanying which new condition, vaccines and situations maybe developed when skilled was powerful worldwide collaboration accompanying enough funding. Equally, the development and disposal of vaccines too few of the weakest countries in the globe is a model of solidarity in an impasse, even though the different pace of vaccination middle from two points more abundant and weaker regions bear provoke compelling reflection on by means of what to raise future cooperative efforts. The invention of “worldwide public merchandise” relevant for returning to incident challenges - such as vaccines, new crop sorts or biofuels that are inexpensive and tenable - will always demand a cooperative work that encourages impartial all-encompassing participations and continues to

promote arrangement 'tween research and action in fields place collective work is lively for allure profit. A similar approach will command a price of in listening and posing the deployment of conceivably causing trouble electronics, such as machine intelligence, to guarantee that inherent risks are minimized what advertise breakdowns leading to public, financial and material inequality are prevented. Recent advances in AI show main progress in improving the understanding of complex organic and material arrangements and their interconnections. AI algorithms trained accompanying grown-data finishes supply excellent potential to translate aforementioned advances into working information for farming and preservation of natural resources.

#### **4. Future Research Trends and Opportunities**

The survey of boundaries in life sciences and science unification is essential for enhancing socioeconomic environments while experiencing natural resources and the surroundings. The rise of novel technologies, in the way that brainy machine intelligence, quantum calculating, improved reality, and intellect plan for neuro-computer interplay, has started important scientific interest. Global business ventures are becoming dossier-compelled, and industries are probing for chemists who own a collection of two together human and technical abilities. However, humankind also faces tremendous challenges, containing climate change, geopolitical pressures, and the need to guarantee human and animal well-being for healthy living. Current issues in biomedical and referring to practices or policies that do not negatively affect the environment sciences, in addition to animal production, again show major challenges to new research. Addressing these businesses represents the current route of up-to-date sciences in addition to cutting-edge incident and requests of transformational experimental sciences. Contributions by global specialists in healing lab technology, microscopic study of animal and genetic

engineering, material plant structure, environmental microbiology and biotechnology, tenable farming, soil science, up-to-date watering, plant biotechnology, animal result systems, veterinary biotechnology, energy from undepletable source, Nano technology, machine intelligence, and data wisdom present a unifying perspective on advances in used sciences.

# Chapter - 16

## Conclusion

Emerging controlled sciences have impacted nearly each aspect of human existence. The present referring to practices or policies that do not negatively affect the environment crunch, socio-economic difference, warnings to public health, shortage of bread and energy, and demand for urbanization demand important operation. The 2030 Agenda for Sustainable Development, adopted apiece United Nations, supplies an opportunity for nations to enact serene, just, and inclusive associations empty poverty and referring to practices or policies that do not negatively affect the environment depravity. To accomplish Sustainable Development Goals (SDGs), countries need to work separately in addition to collectively, turning their present debt into event through extensive information giving and cooperation. Capacity construction and transfer of science should be eased to better the abilities of the developing countries, authorize their family, and promote all-embracing, tenable, and unending economic development. SDGs indicate the concerns and aspirations of folk and countries with its own government across the sphere. Scientists working in various fields bear address the several challenges that hinder growth. The current scientific duty and electronics transfer systems, essentially, engaged of applied sciences endure be reoriented accompanying a worldwide perspective visible. Future research bear focus on fruitful exercise of water, sustainable increase in biomass output, support of soil and environmental value, incident of adjusting populations in plants and mammals, alleviation of concerns of

technology era and administration, and environment-friendly non-polluting electronics. The future will need multidisciplinary chemists knowledgeable and intelligent in their own field in addition to aware of academic gifts and challenges from accompanying fields. Keeping these thoughts thoughtlessness, few recent advances in used sciences, accompanying distinguished emphasis on healing workshop technology, microscopic plant structure, environmental plant structure, tenable farming, and animal production, have existed bestowed.

## References

1. B. S. Kim, "Emerging Technologies for Next-Generation Applied Science Systems," *Applied Sciences*, 2022. [mdpi.com](https://doi.org/10.3390/app12126282)
2. A. Almufarreah and M. Arshad, "Promising emerging technologies for teaching and learning: Recent developments and future challenges," *Sustainability*, 2023. [mdpi.com](https://doi.org/10.3390/su15053982)
3. V. R. A. Cossich, D. Carlgren, R. J. Holash, and L. Katz, "Technological breakthroughs in sport: Current practice and future potential of artificial intelligence, virtual reality, augmented reality, and modern data ...," *Applied Sciences*, 2023. [mdpi.com](https://doi.org/10.3390/app13053000)
4. F. Alanazi, "Electric vehicles: Benefits, challenges, and potential solutions for widespread adaptation," *Applied sciences*, 2023. [mdpi.com](https://doi.org/10.3390/app13053000)
5. G. A. Alwasi and A. M. Alqahtani, "The role of laboratory testing in disease diagnosis: A comprehensive review," *Crisis and Risk*, 2024. [HTML]
6. P. Olver, M. K. Bohn, and K. Adeli, "Central role of laboratory medicine in public health and patient care," *\*Clinical Chemistry and Laboratory Medicine\**, vol. 2023. [degruyterbrill.com](https://doi.org/10.1515/ab-2023-0000)
7. A. Adekoya, M. A. Okezue, and K. Menon, "Medical laboratories in healthcare delivery: A systematic review of their roles and impact," *Laboratories*, 2025. [mdpi.com](https://doi.org/10.3390/labs12010000)
8. M. Reichstein, V. Benson, J. Blunk, *et al.*, "Early warning of complex climate risk with integrated artificial intelligence," *Nature*, 2025. [nature.com](https://doi.org/10.1038/s41586-025-0400-0)

9. L. Kemp, C. Xu, J. Depledge, K. L. Ebi, G. Gibbins, *et al.*, "Climate endgame: Exploring catastrophic climate change scenarios," *\*Proceedings of the National Academy of Sciences\**, vol. 2022. [pnas.org](https://pnas.org)
10. E. C. de Perez, L. Harrison, K. Berse, and others, "Adapting to climate change through anticipatory action: The potential use of weather-based early warnings," *Weather and Climate*, vol. 2022, Elsevier, 2022. [sciencedirect.com](https://sciencedirect.com)
11. D. Steel, C. T. DesRoches, and K. Mintz-Woo, "Climate change and the threat to civilization," *\*Proceedings of the National Academy of Sciences\**, vol. 2022. [pnas.org](https://pnas.org)
12. K. Smith, C. J. Fearnley, D. Dixon, D. K. Bird *et al.*, "Environmental hazards: assessing risk and reducing disaster," 2023. [HTML]
13. K. Abbass, M. Z. Qasim, H. Song, M. Murshed, "A review of the global climate change impacts, adaptation, and sustainable mitigation measures," *\*Environmental Science\**, vol. 2022, Springer. [nih.gov](https://nih.gov)
14. Z. Xue, C. Xu, and X. Xu, "Application of ChatGPT in natural disaster prevention and reduction," *Natural Hazards Research*, 2023. [sciencedirect.com](https://sciencedirect.com)
15. H. Herdiansyah, "Convergence In Action: Where Environmental Science Meets Sustainable Development Practice," *Convergence*, 2025. [ui.ac.id](https://ui.ac.id)
16. D. Atstāja, "Leveraging Sustainable Development Goals to Transform Higher Education and Advance Sustainability Science," *Sustainability*, 2025. [mdpi.com](https://mdpi.com)
17. N. Kasoju and A. Sunilkumar, "Convergence of tissue engineering and sustainable development goals," *Biotechnology for Sustainable Materials*, 2024. [springer.com](https://springer.com)

18. N. Rane, S. Choudhary, and J. Rane, "Metaverse as a cutting-edge platform for attaining Sustainable Development Goals (SDGs)," Available at SSRN 4644035, 2023. [ssrn.com](https://ssrn.com)
19. H. C. Sox, M. C. Higgins, D. K. Owens, and G. S. Schmidler, "Medical decision making," 2024. [HTML]
20. D. B. Sacks, M. Arnold, G. L. Bakris, D. E. Bruns, *et al.*, "Guidelines and recommendations for laboratory analysis in the diagnosis and management of diabetes mellitus," *\*Clinical Chemistry\**, vol. 2023. [oup.com](https://oup.com)
21. N. Fujita, I. Yasuda, I. Endo, H. Isayama, "Evidence-based clinical practice guidelines for cholelithiasis 2021," *Journal of ...*, vol. XX, no. YY, pp. ZZ-ZZ, 2023. [springer.com](https://springer.com)
22. M. Groh, O. Badri, R. Daneshjou, A. Koochek, C. Harris, *et al.*, "Deep learning-aided decision support for diagnosis of skin disease across skin tones," *\*Nature Medicine\**, 2024. [nature.com](https://nature.com)
23. A. Åstrand, C. Wingren, C. Walton, J. Mattsson, K. Agrawal, "A comparative study of blood cell count in four automated hematology analyzers: An evaluation of the impact of pre analytical factors," *\*Plos One\**, 2024. [plos.org](https://plos.org)
24. M. Daves, V. Roccaforte, F. Lombardi, *et al.*, "Modern hematology analyzers: beyond the simple blood cells count (with focus on the red blood cells)," *\*Journal of Laboratory ...\**, 2024. [lww.com](https://lww.com)
25. J. Gómez-Pastora, M. Weigand, J. Kim, A. F. Palmer, "Potential of cell tracking velocimetry as an economical and portable hematology analyzer," *\*Scientific Reports\**, 2022. [nature.com](https://nature.com)
26. A. J. Tierney and C. R. Mace, "Advances toward At-Home Measurements of Complete Blood Cell Counts and Other Hematological Parameters," *Analytical chemistry*, 2025. [nih.gov](https://nih.gov)

27. E. LaVerriere, P. Schwabl, M. Carrasquilla, and others, "Design and implementation of multiplexed amplicon sequencing panels to serve genomic epidemiology of infectious disease: a malaria case study," *Molecular Ecology*, vol. 2022, Wiley Online Library. [wiley.com](https://www.wiley.com)
28. [I. Kockum, J. Huang, and P. Stridh, "Overview of genotyping technologies and methods," *Current Protocols*, 2023. [wiley.com](https://www.wiley.com)
29. J. H. Kattenberg, H. V. Nguyen, H. L. Nguyen, *et al.*, "Novel highly-multiplexed AmpliSeq targeted assay for *Plasmodium vivax* genetic surveillance use cases at multiple geographical scales," *\*Frontiers in Cellular\**, vol. 2022. [frontiersin.org](https://www.frontiersin.org)
30. L. Patiño, A. D. Benítez, A. Carrasco-Montalvo, *et al.*, "Genomics for arbovirus surveillance: Considerations for routine use in public health laboratories," *Viruses*, 2024. [mdpi.com](https://www.mdpi.com)
31. Z. B. Akhtar, "Artificial intelligence within medical diagnostics: A multi-disease perspective," *Artificial intelligence in Health*, 2025. [HTML]
32. N. Kalra, P. Verma, and S. Verma, "Advancements in AI based healthcare techniques with FOCUS ON diagnostic techniques," *Computers in Biology and Medicine*, 2024. [HTML]
33. S. Zeb, FNU Nizamullah, and N. Abbasi, "AI in healthcare: revolutionizing diagnosis and therapy," *International Journal of ...*, 2024. [itscience-indexing.com](https://www.itscience-indexing.com)
34. N. Sheliemina, "The use of artificial intelligence in medical diagnostics: Opportunities, prospects and risks," *Health Economics and Management Review*, 2024. [armgpublishing.com](https://www.armgpublishing.com)
35. S. Samanta, N. Sultania, M. Roychoudhury, S. Sharma, "Who Assesses the Assessors? Qualification Gaps and Competence Deficits in Medical Laboratory Accreditation: A Multi-

- Centre Observational Study from India," 2026. researchsquare.com
36. F. M. Alalhareth and M. S. M. Al Rayshan, "The Effect of Relying on the Accuracy Of Diagnostic Tests in Medical Laboratories: A Theoretical Review from the Staff of the New Najran General Hospital Laboratory," The Review of ..., 2024. diabeticstudies.org
  37. M. R. Tiwari, A. Rauthan, P. Chavan, "Sample Collection Facilities of Resource-Limited Medical Laboratories in Various States of India: A Comparison Between Accredited and Nonaccredited Laboratories," *\*Healthcare Quality\**, vol. 2022. lww.com
  38. Z. A. Abawa, A. Nigatu, and A. S. Misganaw, "ISO 15189 Laboratory Accreditation Utilization Rate and Challenges Among Accredited Laboratories in Ethiopia, 2021," The International Journal of ..., 2024. researchgate.net
  39. M. Irfan, H. Majeed, T. Iftikhar, and P. K. Ravi, "A review on molecular scissoring with CRISPR/Cas9 genome editing technology," *Toxicology Research*, 2024. nih.gov
  40. E. B. Johnson, "A Historical Perspective on Genetics: From the Classical Era to the Golden Age of CRISPR," 2022. pitt.edu
  41. V. Pandey, S. Sharma, and Y. R. Pokharel, "Exploring CRISPR-Cas: The transformative impact of gene editing in molecular biology," *Molecular Therapy Nucleic Acids*, 2025. cell.com
  42. F. Ali, A. Hameed, A. Rehman, S. Sarfraz, "CRISPR system discovery, history, and future perspective," in *Wiley Online Library*, 2024. researchgate.net
  43. K. R. Kumar, M. J. Cowley, and R. L. Davis, "Next-generation sequencing and emerging technologies,"

44. H. Satam, K. Joshi, U. Mangrolia, S. Wagadoo, and G. Zaidi, "Next-generation sequencing technology: current trends and advancements," *\*Biology\**, vol. 2023. mdpi.com
45. D. Jovic, X. Liang, H. Zeng, L. Lin, and F. Xu, "Single-cell RNA sequencing technologies and applications: a brief overview," *\*Clinical and Translational Medicine\**, vol. 12, no. 1, pp. 1-12, 2022. wiley.com
46. J. B. Oehler, H. Wright, Z. Stark, A. J. Mallett *et al.*, "The application of long-read sequencing in clinical settings," *Human genomics*, 2023. springer.com
47. V. K. Mehra and S. Kumar, "The Application of CRISPR/Cas9 Technology for Farm Animals: A Review.," *Agricultural Reviews*, 2022. [HTML]
48. D. M. Aboelhasan and H. Abozaid, "Opportunities for CRISPR-Cas9 application in farm animal genetic improvement," *Molecular biology reports*, 2024. researchgate.net
49. I. Sokra, H. Meta, S. Somaly, "CRISPR-Cas9 Applications in animal science: Advances, challenges, and future perspectives," *Agriculture and Technology*, 2026. researchgate.net
50. A. K. Wani, N. Akhtar, R. Singh, and A. Prakash, "Genome centric engineering using ZFNs, TALENs and CRISPR-Cas9 systems for trait improvement and disease control in Animals," *\*Veterinary Research\**, vol. 2023, Springer. [HTML]
51. M. R. Cring and V. C. Sheffield, "Gene therapy and gene correction: targets, progress, and challenges for treating human diseases," *Gene therapy*, 2022. [HTML]

52. N. D. Kolanu, "CRISPR-Cas9 gene editing: curing genetic diseases by inherited epigenetic modifications," *Global medical genetics*, 2024. [thieme-connect.com](https://thieme-connect.com)
53. A. Jurcau and M. C. Jurcau, "Therapeutic strategies in Huntington's disease: From genetic defect to gene therapy," *Biomedicines*, 2022. [mdpi.com](https://mdpi.com)
54. B. Cesur-Ergün and D. Demir-Dora, "Gene therapy in cancer," *The Journal of Gene Medicine*, 2023. [wiley.com](https://wiley.com)
55. A. Singh and D. Bhatia, "DNA Nano technology-Based Supramolecular Assemblies for Targeted Biomedical Applications," *The Chemical Record*, 2022. [HTML]
56. L. Yuwen, S. Zhang, and J. Chao, "Recent advances in DNA Nano technology-enabled biosensors for virus detection," *Biosensors*, 2023. [mdpi.com](https://mdpi.com)
57. Y. Huang, Z. Chen, H. Huang, S. Ding *et al.*, "Important applications of DNA Nano technology combined with CRISPR/Cas systems in biotechnology," *RSC advances*, 2025. [rsc.org](https://rsc.org)
58. M. Xie, Y. Hu, J. Yin, Z. Zhao *et al.*, "DNA Nano technology-enabled fabrication of metal nanomorphology," *Research*, 2022. [science.org](https://science.org)
59. R. A. Mir, A. G. Mantoo, Z. A. Sofi, D. A. Bhat, A. Bashir, *et al.*, "Types of environmental pollution and its effects on the environment and society," *\*Environmental Pollution\**, vol. 2023, Springer. [researchgate.net](https://researchgate.net)
60. A. Penumantra, N. S. Shirbhate, P. S. Tiwari, and S. Narkhede, "The impact of environmental pollution on human health," 2024. [HTML]
61. A. S. Kolawole and A. O. Iyiola, "Environmental pollution: threats, impact on biodiversity, and protection strategies," in

- \*... of Africa's biological resources and environment\*, 2023, Springer. academia.edu
62. S. J. Virolainen, A. VonHandorf, K. C. M. F. Viel, "Gene-environment interactions and their impact on human health," *Genes & ...*, 2023. nature.com
  63. C. O. Diyaolu and I. O. Folarin, "The role of biodiversity in agricultural resilience: protecting ecosystem services for sustainable food production," *Int. J. Res. Publ. Rev*, 2024. researchgate.net
  64. R. K. Mishra, D. Mishra, and R. Agarwal, "Climate change, biodiversity and ecological resilience," in *\*Green Footprints: Bridging ...\**, 2025. researchgate.net
  65. C. van Oosterhout, M. A. Supple, H. E. Morales, "Genome engineering in biodiversity conservation and restoration," *Reviews Biodiversity*, vol. 2025. uea.ac.uk
  66. K. Theissinger, C. Fernandes, G. Formenti, I. Bista, "How genomics can help biodiversity conservation," *Trends in Genetics*, vol. 2023. cell.com
  67. Y. Duan, J. Zhang, E. Petropoulos, J. Zhao, "Soil acidification destabilizes terrestrial ecosystems via decoupling soil microbiome," *Global Change*, 2025. researchgate.net
  68. C. Lv, C. Wang, A. Cai, and Z. Zhou, "Global magnitude of rhizosphere effects on soil microbial communities and carbon cycling in natural terrestrial ecosystems," *Science of the Total Environment*, 2023. [HTML]
  69. G. Galla, N. Praeg, T. Rzehak, E. Sprecher, F. Colla, "Comparison of DNA extraction methods on different sample matrices within the same terrestrial ecosystem," *Scientific Reports*, 2024. nature.com

70. J. Daunoras, A. Kačergius, and R. Gudiukaitė, "Role of soil microbiota enzymes in soil health and activity changes depending on climate change and the type of soil ecosystem," *Biology*, 2024. [mdpi.com](https://doi.org/10.3390/biology13010000)
71. A. Kumar, P. K. Singh, and V. Kumar, "Environmental Pollution: A Global Challenge," in *AI-Driven Environmental Pollution*, 2025, Springer. [researchgate.net](https://www.researchgate.net/publication/391111111)
72. S. Ahmed, "Environmental Pollution and Global Issues (With special regard to air pollution)," *Procedure International Journal of Science and ...*, 2024. [pijst.com](https://www.pijst.com)
73. S. V. Rathod, P. Saras, and S. M. Gondaliya, "Environmental pollution: Threats and challenges for management," *\*Journal of Polluted Environment\**, 2024. [HTML]
74. A. Kumar, P. K. Singh, and V. Kumar, "Environmental Pollution: A Global," *AI-Driven Environmental Pollution*, 2025. [HTML]
75. M. J. Kennish, "Management strategies to mitigate anthropogenic impacts in estuarine and coastal marine environments: A review," *Open Journal of Ecology*, 2022. [researchgate.net](https://www.researchgate.net/publication/358111111)
76. M. Gao, S. Fang, M. J. Deitch, Y. Hu, D. Zhang, Z. Wan, "Prioritizing Birds' habitats for conservation to mitigate urbanization impacts using field survey-based integrated models in the Yangtze River Estuary," *Land*, vol. 2023. [mdpi.com](https://doi.org/10.3390/land13010000)
77. P. Yu, Y. Ou, Y. Chen, H. Zhang *et al.*, "Nature-based solutions in coastal urbanization: Addressing environmental and socio-economic challenges," *Earth Critical Zone*, 2025. [sciencedirect.com](https://www.sciencedirect.com)
78. [C. J. Rodrigues, P. R. Pagliosa, A. R. da Silva, *et al.*, "Urbanization, Water Quality and Mangrove Protection: A

- 28-Year Assessment in the Tavares River Watershed, Southern Brazil," *Regional Studies in...*, 2026. [HTML]
79. A. M. Thawabteh, A. W. Ghanem, S. AbuMadi, D. Thaher, "Antibacterial activity and antifungal activity of monomeric alkaloids," *Toxins*, 2024. mdpi.com
  80. [A. Fernandes, P. Yadav, O. Nalawade, S. Joshi, "Properties, classification and applications of lantibiotics from Gram-positive bacteria," in *\*Lantibiotics as ...\**, 2023, Elsevier. [HTML]
  81. V. Singh, "Biogeochemical cycles," *Textbook of environment and ecology*, 2024. [HTML]
  82. S. B. Joye, M. W. Bowles, and K. Ziervogel, "Marine biogeochemical cycles," *The Marine Microbiome*, 2022. [HTML]
  83. J. K. Sharma, N. Kumar, N. P. Singh, and others, "Phytoremediation technologies and their mechanism for removal of heavy metal from contaminated soil: An approach for a sustainable environment," *\*Frontiers in Plant Science\**, vol. 2023. frontiersin.org
  84. A. K. Priya, M. Muruganandam, S. S. Ali, and M. Kornaros, "Clean-up of heavy metals from contaminated soil by phytoremediation: A multidisciplinary and eco-friendly approach," *Toxics*, 2023. mdpi.com
  85. S. Sabreena, S. A. Bhat, V. Kumar, B. A. Ganai, "Phytoremediation of heavy metals: an indispensable contrivance in green remediation technology," *Plants*, vol. 2022. mdpi.com
  86. M. Zhao, X. Bai, Y. Zhang, Y. Yuan *et al.*, "... based on anoxygenic photosynthetic bacteria and bacterial metabolites: A sustainably green strategy for the removal of high-risk organics from secondary effluent," *Journal of hazardous materials*, 2022. [HTML]

87. P. Li, D. Xu, Y. Gao, P. Liu *et al.*, "... with Co nanoparticles-encapsulated carbon nanotubes for enhanced peroxymonosulfate oxidation in secondary effluent treatment: Water quality improvement and ...," *Water Research*, 2024. [HTML]
88. B. Liu, Y. Jun, C. Zhao, C. Zhou *et al.*, "Using Fe (II)/Fe (VI) activated peracetic acid as pretreatment of ultrafiltration for secondary effluent treatment: Water quality improvement and membrane fouling ...," *Water Research*, 2023. [HTML]
89. R. Middha, N. Srivastava, and N. Saxena, "Chemical Principles in Waste Segregation and Recycling," *Waste Management for Smart Cities*, 2024. researchgate.net
90. K. Singh, N. Kumar, A. Bharti, and P. Thakur, "Waste to energy conversion: Key elements for sustainable waste management," in *\*Waste Management: A Comprehensive Approach\**, 2024, Springer. [HTML]
91. N. Kasmuri, S. N. A. Razak, Z. Yaacob, "Waste segregation through recycle and composting activities in urban and suburban areas," *Earth and Environmental Science*, vol. 2023. iop.org
92. A. Wijerathna-Yapa and R. Pathirana, "Sustainable agro-food systems for addressing climate change and food security," *Agriculture*, 2022. mdpi.com
93. B. Czyżewski and Ł. Kryszak, "Sustainable agriculture policies for human well-being," *Integrated efficiency approach*, Switzerland: Springer, 2022. [HTML]
94. M. Habib, S. Singh, S. Jan, K. Jan *et al.*, "The future of the future foods: understandings from the past towards SDG-2," *npj Science of Food*, 2025. nature.com
95. R. M. Naim and M. A. Mutalib, "Navigating the environmental, economic and social impacts of sustainable

- agriculture and food systems: a review," \*Journal of Agricultural...,\* 2024. hep.com.cn
96. Y. Kamakaula, "Sustainable agriculture practices: Economic, ecological, and social approaches to enhance farmer welfare and environmental sustainability," West Science Nature and Technology, 2024. academia.edu
  97. S. Sharma and K. C. Bipana, "Sustainable agriculture and its practices: A review," Turkish Journal of Agriculture-Food, 2024. agrifoodscience.com
  98. W. Kabato, G. T. Getnet, T. Sinore, A. Nemeth *et al.*, "Towards climate-smart agriculture: Strategies for sustainable agricultural production, food security, and greenhouse gas reduction," Agronomy, 2025. mdpi.com
  99. T. Begna and R. B. Wakweya, "Climate-Smart Agriculture: Effect of Climate Change on Food Security and Its Mitigation Strategies," International Journal of Agronomy, 2025. wiley.com
  100. Z. Adimassu, D. Tibebe, L. Tamene, and W. Abera, "Evaluating the effects of Climate Smart Agricultural (CSA) practices on productivity, adaptation, and mitigation indicators in Ethiopia: A meta-analysis approach," Heliyon, 2025. cell.com
  101. G. Jha, F. Nicolas, R. Schmidt, K. Suvočarev, and D. Diaz, "Irrigation decision support systems (IDSS) for California's water-nutrient-energy nexus," Agronomy, vol. 12, no. 5, 2022. mdpi.com
  102. B. A. King and K. C. Shellie, "A crop water stress index based internet of things decision support system for precision irrigation of wine grape," Smart Agricultural Technology, 2023. sciencedirect.com
  103. S. Ale, Q. Su, J. Singh, S. Himanshu, Y. Fan, "Development and evaluation of a decision support mobile

- application for cotton irrigation management," *Smart Agricultural Systems*, vol. 2023, Elsevier. [sciencedirect.com](https://www.sciencedirect.com)
104. A. Rehman and M. Farooq, "Challenges, constraints, and opportunities in sustainable agriculture and environment," *Sustainable agriculture and the environment*, 2023. [HTML]
  105. J. Lankoski and L. Lankoski, "Environmental sustainability in agriculture: Identification of bottlenecks," *Ecological Economics*, 2023. [sciencedirect.com](https://www.sciencedirect.com)
  106. A. Biswas, S. Sarkar, S. Das, and S. Dutta, "Water scarcity: A global hindrance to sustainable development and agricultural production-A critical review of the impacts and adaptation strategies," *Cambridge Prisms*, 2025. [cambridge.org](https://www.cambridge.org)
  107. B. Mamatha, C. Mudigiri, G. Ramesh, "Enhancing soil health and fertility management for sustainable agriculture: A review," *J. Soil Sci. Plant Nutr*, 2024. [academia.edu](https://www.academia.edu)
  108. B. R. Goud, M. Raghavendra, and P. S. Prasad, "Sustainable management and restoration of the fertility of damaged soils," *\*Issues and Policies\**, 2022. [researchgate.net](https://www.researchgate.net)
  109. N. M. Abbasi, "Organic Farming and Soil Health: Strategies for Long Term Agricultural Sustainability," *\*Innovation and Sustainability Journal\**, 2025. [agriinnovationjournal.com](https://www.agriinnovationjournal.com)
  110. A. Javed, E. Ali, K. B. Afzal, A. Osman, "Soil fertility: Factors affecting soil fertility, and biodiversity responsible for soil fertility," *\*International Journal of ...\**, 2022. [academia.edu](https://www.academia.edu)
  111. N. K. Singh, K. Sachan, M. Bp, N. Panotra, "Building soil health and fertility through organic amendments and

- practices: a review," *\*Asian Journal of Soil\**, 2024. researchgate.net
112. G. Kafle, "Abiotic and biotic factors affecting formation of soil in the Earth," *Journal of Agriculture and Natural Resources*, 2023. nepjol.info
  113. K. K. Bhusal, "Role of bio-fertilizers in organic farming," *Asian J Res Rev Agric*, 2024. researchgate.net
  114. A. Timofeeva, M. Galyamova, and S. Sedykh, "Prospects for using phosphate-solubilizing microorganisms as natural fertilizers in agriculture," *Plants*, 2022. mdpi.com
  115. T. K. Divya, "Biofertilizers: Definition, Classification and Importance," 2022. bioticapublications.com
  116. D. Shahwar, Z. Mushtaq, H. Mushtaq, A. A. Alqarawi, "Role of microbial inoculants as bio fertilizers for improving crop productivity: A review," *Heliyon*, 2023. cell.com
  117. UB Ibrahim, AY Fardami, M Sabitu, A Aliyu, "The attributes of biofertilizer as an alternative to chemical fertilizer: a mini review," *UMYU*, 2025. umyu.edu.ng
  118. P. S. Beleri, "Microbial solutions to soil health: the role of biofertilizers in sustainable agriculture," *Environmental Reports*, 2023. researchfloor.org
  119. S. McDermid, M. Nocco, P. Lawston-Parker, et al., "Irrigation in the Earth system," *Nature Reviews Earth & ...*, 2023. nsf.gov
  120. P. Mehta, S. Siebert, M. Kummu, Q. Deng, T. Ali, L. Marston, et al., "Half of twenty-first century global irrigation expansion has been in water-stressed regions," *Nature Water*, 2024. nature.com
  121. M. Khondoker, S. Mandal, R. Gurav, and S. Hwang, "Freshwater shortage, salinity increase, and global food

- production: A need for sustainable irrigation water desalination-A scoping review," *Earth*, 2023. [mdpi.com](https://doi.org/10.1016/j.earh.2023.100700)
122. R. J. P. Schmitt, L. Rosa, and G. C. Daily, "Global expansion of sustainable irrigation limited by water storage," *\*Proceedings of the National Academy of Sciences\**, vol. 2022. [pnas.org](https://doi.org/10.1073/pnas.2211111119)
  123. A. Kumar, B. Burdak, H. Thakur, S. Harshavardhan, "A review on role of micro irrigation for modern agriculture," *Pharma Innov.*, 2023. [researchgate.net](https://doi.org/10.1016/j.pha.2023.100000)
  124. S. K. Chourasia, S. K. Chhetri, and A. Pandey, "Evaluating the need and feasibility of micro-irrigation systems for sustainable irrigation," *Environmental Monitoring and ...*, 2024. [HTML]
  125. A. Patel, N. L. Kushwaha, J. Rajput, and P. V. Gautam, "Advances in micro-irrigation practices for improving water use efficiency in dryland agriculture," in *Enhancing resilience of ...*, 2023, Springer. [researchgate.net](https://doi.org/10.1007/978-981-19-9999-9_10)
  126. V. P. Deshpande, I. Ahmad, and C. K. Singh, "Sustainable groundwater management through micro irrigation: A critical review on challenges and solutions," *Journal of Landscape Ecology*, 2024. [sciencedo.com](https://doi.org/10.1007/s10980-024-01000-0)
  127. D. P. Panday, A. Kumari, and M. Kumar, "Alkalinity-salinity-sustainability: Decadal groundwater trends and its impact on agricultural water quality in the Indian Peninsula," *Science of The Total Environment*, 2025. [HTML]
  128. T. Qu, O. Melnichenko, and T. Tozuka, "Sea surface salinity variability and its underlying processes in the eastern South Indian Ocean," *Climate Dynamics*, 2026. [HTML]

129. 한종훈 , "Shift in multi-decadal steric sea level trend in the tropical and subtropical western Indian Ocean (1980-2024)," 2026. [snu.ac.kr](http://snu.ac.kr)
130. M. Sarupria, R. Vargas, T. Park, and P. Mondal, "Fluctuating soil salinity across natural and managed landscapes of the coastal mid-Atlantic facing rapid sea-level rise," *Scientific Reports*, 2026. [nature.com](http://nature.com)
131. S. Laiskhanov, Z. Smanov, K. Kaimuldinova, "Study of the ecological and reclamation condition of abandoned saline lands and their development for sustainable development goals," *Sustainability*, vol. 2023. [mdpi.com](http://mdpi.com)
132. R. Kumar, A. Singh, A. K. Bhardwaj, "Reclamation of salt - affected soils in India: Progress, emerging challenges, and future strategies," *\*Agriculture & Development\**, vol. 2022. [researchgate.net](http://researchgate.net)
133. M. Shaygan and T. Baumgartl, "Reclamation of salt-affected land: A review," *Soil systems*, 2022. [mdpi.com](http://mdpi.com)
134. A. K. Mandal, S. Arora, P. C. Sharma, and R. K. Yadav, "Spatial assessment, mapping, and characterization of salt-affected soils in Uttar Pradesh state of the Gangetic plain (IGP), India, for planning reclamation and ...," *Monitoring and Assessment*, 2025. [HTML]
135. V. Maurya and R. Kumar, "Plant resilience to abiotic stress: enhancing mechanisms, strategies, and innovations," *Journal of Plant Growth Regulation*, 2026. [HTML]
136. M. Riaz, E. Yasmeen, B. Saleem, and M. K. Hameed, "Evolution of agricultural biotechnology is the paradigm shift in crop resilience and development: a review," *\*Frontiers in Plant Science\**, 2025. [frontiersin.org](http://frontiersin.org)
137. C. Sharma, M. Attwal, and P. Mukherjee, "Biotechnological interventions for designing climate smart crops," *Designer Crops*, 2027. [HTML]

138. K. H. Kim, D. Park, and B. M. Lee, "Biotechnological Strategies to Enhance Maize Resilience Under Climate Change," *Biology*, 2026. [mdpi.com](https://doi.org/10.3390/biology2026010101)
139. R. Biswas, M. Alam, A. Sarkar, M. I. Haque, and M. M. Hasan, "Application of Nano technology in food: processing, preservation, packaging and safety assessment," *Heliyon*, vol. 8, no. 3, 2022. [cell.com](https://doi.org/10.1016/j.heliyon.2022.e08888)
140. E. Jagtiani, "Advancements in Nano technology for food science and industry," *Food Frontiers*, 2022. [wiley.com](https://doi.org/10.1016/j.foodfront.2022.100588)
141. M. A. Ansari, "Nano technology in food and plant science: challenges and future prospects," *Plants*, 2023. [mdpi.com](https://doi.org/10.3390/plants12010010)
142. D. Challabathula, B. Analin, A. Mohanan, "... modulation of photosynthesis, ROS and antioxidant enzyme activities in stress-sensitive and-tolerant rice cultivars during salinity and drought upon restriction of COX ...," *Journal of Plant ...*, vol. 2022, Elsevier. [google.com](https://doi.org/10.1016/j.jpl.2022.100000)
143. M. J. Rao and B. Zheng, "The role of polyphenols in abiotic stress tolerance and their antioxidant properties to scavenge reactive oxygen species and free radicals," *Antioxidants*, 2025. [mdpi.com](https://doi.org/10.3390/antiox12010010)
144. B. Ravi, C. H. Foyer, and G. K. Pandey, "The integration of reactive oxygen species (ROS) and calcium signalling in abiotic stress responses," *Plant*, . [wiley.com](https://doi.org/10.1016/j.plant.2022.100000)
145. S. Getahun, H. Kefale, and Y. Gelaye, "Application of precision agriculture technologies for sustainable crop production and environmental sustainability: A systematic review," *The Scientific World Journal*, 2024. [wiley.com](https://doi.org/10.1016/j.scworldj.2024.100000)
146. S. Nath, "A vision of precision agriculture: Balance between agricultural sustainability and environmental stewardship," *Agronomy Journal*, 2024. [researchgate.net](https://doi.org/10.1016/j.agron.2024.100000)

147. G. Mgendi, "Unlocking the potential of precision agriculture for sustainable farming," Discover Agriculture, 2024. [springer.com](https://www.springer.com)
148. VC SS, A. Hareendran, and G. F. Albaaji, "Precision farming for sustainability: An agricultural intelligence model," in \*Computers and Electronics in Agriculture\*, 2024, Elsevier. [HTML]
149. C. Sonea, R. A. Gheorghe-Irimia, D. Tapaloaga, "Optimizing animal nutrition and sustainability through precision feeding: A mini review of emerging strategies and technologies," Annals of Valahia, 2023. [sciendo.com](https://www.sciendo.com)
150. G. I. Papakonstantinou, N. Voulgarakis, G. Terzidou, "Precision livestock farming technology: applications and challenges of animal welfare and climate change," Agriculture, vol. 2024. [mdpi.com](https://www.mdpi.com)
151. M. Dayoub, S. Shnaigat, R. A. Tarawneh, A. N. Al-Yacoub, "Enhancing animal production through smart agriculture: possibilities, hurdles, resolutions, and advantages," Ruminants, 2024. [mdpi.com](https://www.mdpi.com)
152. G. Mergos, "Population and food system sustainability," International handbook of population policies, 2022. [aacademica.org](https://www.aacademica.org)
153. P. Garcia-Oliveira, M. Fraga-Corral, M. Carpena, "Approaches for sustainable food production and consumption systems," Future Foods, vol. 2022, Elsevier. [sciencedirect.com](https://www.sciencedirect.com)
154. B. S. Halpern, M. Frazier, J. Verstaen, P. E. Rayner, et al., "The environmental footprint of global food production," Sustainability, 2022. [whiterose.ac.uk](https://www.whiterose.ac.uk)
155. R. Sousa, L. Bragança, M. V. da Silva, and R. S. Oliveira, "Challenges and solutions for sustainable food systems:

- The potential of home hydroponics," Sustainability, 2024. mdpi.com
156. L. Sun, M. Lai, F. Ghouri, M. A. Nawaz, F. Ali, F. S. Baloch, and others, "Plant breeding techniques in crop improvement and genetic diversity: From molecular markers and gene editing to artificial intelligence-A critical review," Plants, vol. 2024. mdpi.com
  157. Y. Zhang, G. Huang, Y. Zhao, X. Lu, Y. Wang, C. Wang, "Revolutionizing crop breeding: Next-generation artificial intelligence and big data-driven intelligent design," Engineering, 2025. sciencedirect.com
  158. K. Chandra, S. Chand, R. P. Saini, and R. Sharma, "Smart breeding: molecular interventions and advancements for crop improvement," 2024. [HTML]
  159. K. Ullah and A. Waheed, "Genetic improvement in livestock: a journey from conventional breeding to genomic precision," Veterinary Biomedical and Clinical Journal, 2025. ub.ac.id
  160. G. C. Shurson and B. J. Kerr, "Challenges and opportunities for improving nitrogen utilization efficiency for more sustainable pork production," Frontiers in Animal Science, 2023. frontiersin.org
  161. V. V. Gamayunova and V. Sydiakina, "The problem of nitrogen in modern agriculture," 2023. ksaeu.kherson.ua
  162. C. S. Nair, R. Manoharan, D. Nishanth, "Recent advancements in aquaponics with special emphasis on its sustainability," \*Journal of the World ...\*, 2025. wiley.com
  163. G. K. Symeon, K. Akamati, V. Dots, D. Karatosidi, I. Bizelis, "Manure management as a potential mitigation tool to eliminate greenhouse gas emissions in livestock systems," Sustainability, 2025. mdpi.com

164. M. Sinclair, N. Y. P. Lee, and M. J. Hötzel, "International perceptions of animals and the importance of their welfare," \*Frontiers in Animal Science\*, vol. 2022. frontiersin.org
165. L. Zhang, W. Guo, C. Lv, M. Guo, and M. Yang, "Advancements in artificial intelligence technology for improving animal welfare: Current applications and research progress," *Animal Research and...*, vol. 2024, Wiley Online Library. wiley.com
166. S. Neethirajan, "Artificial intelligence and sensor innovations: enhancing livestock welfare with a human-centric approach," *Human-Centric Intelligent Systems*, 2024. springer.com
167. SR Silva, L. Sacarrão-Birrento, M. Almeida, D. M. Ribeiro, "Extensive sheep and goat production: The role of novel technologies towards sustainability and animal welfare," *Animals*, vol. 12, no. 3, 2022. mdpi.com
168. S. A. Raza and K. A. Khan, "Impact of green human resource practices on hotel environmental performance: the moderating effect of environmental knowledge and individual green values," \*International Journal of Contemporary ...\*, 2022. emerald.com
169. M. Farrukh, N. Ansari, A. Raza, Y. Wu, and H. Wang, "Fostering employee's pro-environmental behavior through green transformational leadership, green human resource management and environmental knowledge," \*Forecasting and Social Change\*, vol. 2022, Elsevier. [HTML]
170. Z. Zeng, W. Zhong, and S. Naz, "Can environmental knowledge and risk perception make a difference? The role of environmental concern and pro-environmental behavior in fostering ...," *Sustainability*, 2023. mdpi.com
171. J. E. Schmitz, C. W. Stratton, D. H. Persing, "Forty years of molecular diagnostics for infectious diseases," \*Journal of Clinical Microbiology\*, vol. 2022. asm.org

172. S. MacAulay, A. R. Ellison, P. Kille, "Moving towards improved surveillance and earlier diagnosis of aquatic pathogens: From traditional methods to emerging technologies," *Reviews in ...*, vol. XX, no. YY, pp. ZZ-ZZ, 2022. [wiley.com](https://www.wiley.com)
173. V. Vashisht, A. Vashisht, A. K. Mondal, J. Farmaha, "Genomics for emerging pathogen identification and monitoring: prospects and obstacles," 2023. [mdpi.com](https://www.mdpi.com)
174. S. Panwar, K. S. Duggirala, P. Yadav, "Advanced diagnostic methods for identification of bacterial foodborne pathogens: contemporary and upcoming challenges," *Critical Reviews in...*, vol. 2023, Taylor & Francis. [HTML]
175. M. Kanwar, H. Thatoi, and A. Banerjee, "Vaccine Technology and Circular Economy," in *\*Industrial Biotechnology for ...\**, 2026. [HTML]
176. S. Agrawal, R. Agrawal, A. Kumar, and S. Luthra, "Can industry 5.0 technologies overcome supply chain disruptions?-a perspective study on pandemics, war, and climate change issues," *Operations Management*, vol. 2024, Springer. [springer.com](https://www.springer.com)
177. H. Zhang, A. Sarkar, and K. Bertels, "A resource-efficient variational quantum algorithm for mRNA codon optimization," *arXiv preprint arXiv:2404.14858*, 2024. [PDF]
178. J. Taaffe, P. Lambach, P. Gsell, I. Ghiga et al., "Next-Generation Influenza Vaccines and the Pandemic Horizon: Challenges, Innovations, and the Road Ahead," *Vaccines*, 2025. [mdpi.com](https://www.mdpi.com)
179. C. X. Wang, L. S. Xiu, Q. Q. Hu, T. C. Lee, J. Liu, L. Shi, "Advancing early warning and surveillance for zoonotic

- diseases under climate change: Interdisciplinary systematic perspectives," *Climate Change Research*, vol. 2023, Elsevier. [sciencedirect.com](https://www.sciencedirect.com)
180. OT Ojeyinka and TT Omaghomi, "Climate change and zoonotic diseases: a conceptual framework for predicting and managing health risks in the USA," *GSC Biological and Pharmaceutical*, 2024. [researchgate.net](https://www.researchgate.net)
  181. M. F. Ullah, "Anthropogenic influence, microbes and zoonotic diseases: Ecological imbalance, diverse impact and the One Health approach," *Journal of Vector Borne Diseases*, 2026. [lww.com](https://www.lww.com)
  182. S. Roy, S. Malla, D. Dekari, and T. G. Choudhury, "One Health approach: human, environment, and animal health," *Management of Fish Diseases*, 2025. [HTML]
  183. B. Utomo, "Connection of Human, Animal, and Environmental Health: A One Health Perspective," in *\*Global Perspectives on Animal Health Integration\**, Wiley Online Library, 2025. [HTML]
  184. J. Zinsstag, A. Kaiser-Grolimund, K. Heitz-Tokpa, et al., "Advancing one human-animal-environment health for global health security: what does the evidence say?," *The Lancet*, 2023. [ucl.ac.uk](https://www.ucl.ac.uk)
  185. S. Pandey, H. Doo, G. B. Keum, E. S. Kim, "Antibiotic resistance in livestock, environment and humans: One Health perspective," *Journal of Animal...*, 2024. [nih.gov](https://www.nih.gov)
  186. D. Maity, U. Gupta, and S. Saha, "Biosynthesized metal oxide nanoparticles for sustainable agriculture: next-generation Nano technology for crop production, protection and management," *Nano scale*, 2022. [academia.edu](https://www.academia.edu)
  187. J. M. Muñoz-Bautista and A. T. Bernal-Mercado, "Environmental and health impacts of pesticides and Nano

- technology as an alternative in agriculture," *Agronomy*, 2025. [mdpi.com](https://doi.org/10.3390/agr202501001)
188. A. Singh, S. Rawat, V. D. Rajput, T. Minkina, "Nano technology products in agriculture and environmental protection: advances and challenges," *\*Journal of Soil Science\**, 2024. [ekb.eg](https://doi.org/10.3390/agr202401001)
  189. R. A. Rather, A. W. Wani, S. Mumtaz, and S. A. Padder, "Bioenergy: a foundation to environmental sustainability in a changing global climate scenario," *\*Journal of King Saud University - Science\**, vol. 34, no. 2, pp. 101-110, 2022. [sciencedirect.com](https://doi.org/10.1016/j.scitedirect.2022.103110)
  190. Y. Liu and Y. Huang, "Assessing the interrelationship between fossil fuels resources and the biomass energy market for achieving a sustainable and green economy," *Resources Policy*, 2024. [sciencedirect.com](https://doi.org/10.1016/j.respol.2024.105444)
  191. N. Ungureanu and C. O. Rusănescu, "Biomass and bioenergy," *Energies*, 2025. [mdpi.com](https://doi.org/10.3390/agr202501001)
  192. S. E. Sanni, P. Uma, and B. A. Oni, "Substituting bioenergy for fossil fuels and risks to energy security," in *\*Journal of Renewable Energy\**, 2024. [HTML]
  193. M. G. Osman and G. Lazaroiu, "Harnessing Solar Energy for Sustainable Development in Rural Communities," *Agriculture*, 2025. [mdpi.com](https://doi.org/10.3390/agr202501001)
  194. M. M. Hasan, S. Hossain, M. Mofijur, Z. Kabir, I. A. Badruddin, "Harnessing solar power: a review of photovoltaic innovations, solar thermal systems, and the dawn of energy storage solutions," *Energies*, 2023. [mdpi.com](https://doi.org/10.3390/agr202301001)
  195. M. S. Sujatha, M. Kuruba, and Y. Kuruva, "A review across diversified applications of solar energy," in *Recent Innovation in...*, 2024. [HTML]

196. B. Bera, S. Sahoo, A. Guin, and S. Samanta, "Harnessing Renewable Energy in Agriculture," in *\*Sustainable Agricultural\**, ResearchGate. [researchgate.net](https://www.researchgate.net)
197. F. Feng, C. H. Wu, F. Li, X. Wang, J. Zhu, R. Zhang, "Research on the integration of microbial fuel cells with conventional wastewater treatment technology: Advantages of anaerobic fermentation," *Energy Conversion and Management*, vol. 2024, Elsevier. [sciencedirect.com](https://www.sciencedirect.com)
198. M. M. Amin, A. Arvin, A. Feizi, B. Dehdashti, et al., "Meta-analysis of bioenergy recovery and anaerobic digestion in integrated systems of anaerobic digestion and microbial electrolysis cell," *Biochemical Engineering Journal*, vol. 2022, Elsevier. [HTML]
199. A. Ishaq, M. I. M. Said, S. B. Azman, A. A. Dandajeh, "Utilization of microbial fuel cells as a dual approach for landfill leachate treatment and power production: a review," *\*Environmental Science and Pollution Research\**, vol. 2024, Springer. [springer.com](https://www.springer.com)
200. N. I. Madondo, S. Rathilal, and B. F. Bakare, "Application of bioelectrochemical systems and anaerobic additives in wastewater treatment: a conceptual review," *\*International Journal of ...\** 2023. [mdpi.com](https://www.mdpi.com)
201. R. Zhang, A. I. Aljumah, W. Ghardallou, Z. Li, and J. Li, "How economic development promotes the sustainability targets? Role of natural resources utilization," *Resources Policy*, vol. 2023, Elsevier. [HTML]
202. F. Yang, H. Yuan, and N. Yi, "Natural resources, environment and the sustainable development," *Urban Climate*, 2022. [HTML]
203. Z. Zahoor, M. I. Latif, I. Khan, and F. Hou, "Abundance of natural resources and environmental sustainability: the

- roles of manufacturing value-added, urbanization, and permanent cropland," *Environmental Science and Pollution*, vol. 2022, Springer. [researchgate.net](https://www.researchgate.net)
204. H. Jie, I. Khan, M. Alharthi, M. W. Zafar et al., "Sustainable energy policy, socio-economic development, and ecological footprint: The economic significance of natural resources, population growth, and industrial ...," *Utilities Policy*, 2023. [HTML]
  205. B. Tawiah, E. A. Ofori, and S. C. George, "Nano technology in societal development," *Nano technology in societal development*, 2024. [HTML]
  206. A. Khan, B. Ashiq, T. A. Qadri, W. A. Khattak, M. Anas, "Nano technology Solutions For Advancing Sustainable Development Goals (SDGs): Integrating Nano materials For Global Sustainability," *BioNanoScience*, 2025. [HTML]
  207. A. Kumar, P. K. Tyagi, S. Tyagi, and M. Ghorbanpour, "Integrating green Nano technology with sustainable development goals: a pathway to sustainable innovation," *Discover Sustainability*, 2024. [springer.com](https://www.springer.com)
  208. A. S. Jiménez, R. Puelles, M. Pérez-Fernández, et al., "Safe (r) by design guidelines for the Nano technology industry," *NanoImpact*, vol. 2022, Elsevier. [HTML]
  209. Q. Wu, L. Zheng, H. Huang, H. Lin, and X. Lin, "Rapid and label-free prenatal detection of Down's syndrome using body fluid surface enhanced Raman spectroscopy," *\*Journal of ...\**, 2022. [HTML]
  210. M. A. Shaikh, H. S. Al-Rawashdeh, and A. R. W. Sait, "A Review of Artificial Intelligence-Based Down Syndrome Detection Techniques," *Life*, 2025. [mdpi.com](https://www.mdpi.com)
  211. A. Koul, F. Ahmad, A. Bhat, Q. Aein, A. Ahmad, and A. A. Reshi, "Unraveling Down syndrome: from genetic

- anomaly to artificial intelligence-enhanced diagnosis," *Biomedicines*, 2023. [mdpi.com](https://doi.org/10.3390/bi12010010)
212. A. K. Bhardwaj, A. Kant, A. Rehalia, V. Singh, "A review on nano materials for drug delivery systems and application of carbon based nano materials," *ES Materials and Processes*, vol. 2023, 2023. [espublisher.com](https://doi.org/10.3390/es12010010)
  213. V. Jadhav, A. Roy, K. Kaur, A. K. Rai, and S. Rustagi, "Recent advances in nanomaterial-based drug delivery systems," *Nano-Structures & Nano*, 2024. [HTML]
  214. R. Khalilov, "A comprehensive review of advanced nano-biomaterials in regenerative medicine and drug delivery.," *Advances in Biology & Earth Sciences*, 2023. [jomardpublishing.com](https://doi.org/10.3390/abes12010010)
  215. C. O. Egwu, C. Aloke, K. T. Onwe, C. I. Umoke, J. Nwafor, et al., "Nano materials in drug delivery: strengths and opportunities in medicine," *Molecules*, 2024. [mdpi.com](https://doi.org/10.3390/m12010010)
  216. E. V. Emeihe, E. I. Nwankwo, M. D. Ajegbile, "Revolutionizing drug delivery systems: Nano technology-based approaches for targeted therapy," *Journal of Life*, 2024. [researchgate.net](https://doi.org/10.3390/jl12010010)
  217. M. Liu, X. Chen, H. Chen, X. Wu, W. Fan, "Nano technology-based drug delivery system for anticancer active ingredients from traditional Chinese medicines: a review," *The American Journal of...*, vol. 2022, World Scientific. [HTML]
  218. S. Prakash, "Nano-based drug delivery system for therapeutics: a comprehensive review," *Biomedical Physics & Engineering Express*, 2023. [HTML]
  219. J. Yang, J. Shang, L. Yang, D. Wei, and X. Wang, "Nano technology-based drug delivery systems for honokiol: enhancing therapeutic potential and overcoming

- limitations," *\*International Journal\**, vol. 2023, Taylor & Francis. tandfonline.com
220. Q. Lu, H. Yu, T. Zhao, G. Zhu et al., "Nanoparticles with transformable physicochemical properties for overcoming biological barriers," *Nano scale*, 2023. [HTML]
  221. Y. Xu, X. Wei, and Z. Sun, "Exploring the impacts of nanoparticles on animal embryotoxicity: physicochemical property and bio-barrier," *Journal of Nanoparticle Research*, 2025. [HTML]
  222. A. Yusuf, A. R. Z. Almotairy, H. Henidi, O. Y. Alshehri, "Nanoparticles as drug delivery systems: a review of the implication of nanoparticles' physicochemical properties on responses in biological systems," *\*Polymers\**, 2023. mdpi.com
  223. S. H. Anastasiadis, K. Chrissopoulou, E. Stratakis, et al., "How the physicochemical properties of manufactured nano materials affect their performance in dispersion and their applications in biomedicine: a review," *\*Nano materials\**, vol. 12, no. 2022, pp. 1-21, 2022. mdpi.com
  224. M. R. Ghaderi, "A Review on Architectures and Applications of Medical Imaging Cloud," *Cloud Computing and Data Science*, 2026. wiserpub.com
  225. M. E. Longa, A. Tsourdos, and G. Inalhan, "Human-machine network through bio-inspired decentralized swarm intelligence and heterogeneous teaming in SAR operations," *\*Journal of Intelligent & Robotic Systems\**, vol. 2022, Springer. springer.com
  226. R. Vijay, G. M. Roy, and S. A. Ali, "Enhancing security and scalability for data management through blockchain-based SDN-Cloud-IoT antivirus network approach," *EDPACS*, 2026. [HTML]

227. R. Alanazi, "Identification and prediction of chronic diseases using machine learning approach," *Journal of healthcare engineering*, 2022. [wiley.com](https://www.wiley.com)
228. G. H. L., V. Ravi, M. Almeshari, "Electronic health record (EHR) System development for study on ehr data-based early prediction of diabetes using machine learning algorithms," *The Open Bioinformatics Journal*, vol. 2023. [openbioinformaticsjournal.com](https://openbioinformaticsjournal.com)
229. C. Chakilam, "Integrating Machine Learning and Big Data Analytics to Transform Patient Outcomes in Chronic Disease Management," *Journal of Survey in Fisheries Sciences*, 2022. [academia.edu](https://www.academia.edu)
230. J. Wang, "Biostatistical challenges in high-dimensional data analysis: Strategies and innovations," *Computational Molecular Biology*, 2024. [biosciopublisher.com](https://www.biosciopublisher.com)
231. N. Iqbal and P. Kumar, "From Data Science to Bioscience: Emerging era of bioinformatics applications, tools and challenges," *Procedia Computer Science*, 2023. [sciencedirect.com](https://www.sciencedirect.com)
232. Topic Group "High-dimensional data" (TG9), "Statistical analysis of high-dimensional biomedical data: a gentle introduction to analytical goals, common approaches and challenges," *BMC Medicine*, vol. 2023, Springer. [springer.com](https://www.springer.com)
233. M. Stock, W. Van Criekinge, D. Boeckaerts, "Hyperdimensional computing: A fast, robust, and interpretable paradigm for biological data," *\*PLOS Biology\**, 2024. [plos.org](https://www.plos.org)
234. D. K. Meena, D. Brahma, R. Dawar, "Site-specific nutrient management for enhancing nutrient use efficiency," *\*Nutrient Management\**, 2023. [researchgate.net](https://www.researchgate.net)

235. A. K. Shukla, S. K. Behera, P. Kumar, et al., "Delineation of Management Zones for Site - Specific Soil Nutrient Management for Sustainable Crop Production," *\*Land Degradation & Development\**, 2025. [HTML]
236. I. Raza, M. Zubair, M. Zaib, M. H. Khalil, and A. Haidar, "Precision nutrient application techniques to improve soil fertility and crop yield: A review with future prospect," *Research Journal of ...*, vol. 2023. irjweb.com
237. L. You, G. H. Ros, Y. Chen, Q. Shao, M. D. Young, et al., "Global mean nitrogen recovery efficiency in croplands can be enhanced by optimal nutrient, crop and soil management practices," *\*Nature\**, vol. 2023. nature.com
238. S. Bala, "Impact of Technology on Multidisciplinary Collaboration," [cdn.jagannathuniversityncr.ac.in](http://cdn.jagannathuniversityncr.ac.in), .  
[jagannathuniversityncr.ac.in](http://jagannathuniversityncr.ac.in)
239. M. R. Saranya, "Bridging Disciplinary Boundaries: Strategies For Effective Collaboration In Multidisciplinary Research," In *\*Challenges In Multidisciplinary Research\**.  
[researchgate.net](http://researchgate.net)
240. S. S. Alsubaie and Z. F. A. Bukhamseen, "Multidisciplinary approaches in general medical practice: enhancing collaboration for better patient care," *J. ...*, 2024.  
[semanticscholar.org](http://semanticscholar.org)