

THE ROLE OF TRADITIONAL AND INDIGENOUS KNOWLEDGE IN COMBATING MALNUTRITION IN RURAL INDIA

Malnutrition in rural India persists, despite modernization, due to food insecurity and limited healthcare. Traditional knowledge, rooted in local culture and environment, can help address this issue. Combining these practices with modern interventions can create sustainable, culturally relevant strategies to improve rural nutrition.

Nutrient-rich Diets Rooted in Tradition

- **Balanced nutritional intake:** Traditional rural Indian diets, rich in millets, pulses, vegetables, and fruits, provide essential nutrients, addressing both macronutrient and micronutrient deficiencies.
Example: In Karnataka and Maharashtra, the consumption of millets like ragi (finger millet) and jowar (sorghum) is common. These grains are high in calcium, iron, and dietary fibre, making them especially beneficial in combating malnutrition among children and women.
- **Health benefits of indigenous foods:** Many indigenous foods have been recognized for their health benefits. For example, leafy greens and wild edibles are often rich in micronutrients such as iron, vitamin A, and calcium.
Example: In Odisha, tribal communities consume a variety of wild leafy greens, like amaranth and drumstick leaves, which are rich in iron and help in reducing anaemia, a common issue among rural populations.

Food Security Through Sustainable Agricultural Practices

- **Resilient farming techniques:** Traditional agricultural practices like crop rotation and organic farming boost soil fertility, support biodiversity, and enhance food security in changing environments.
Example: In the tribal regions of Madhya Pradesh and Chhattisgarh, mixed cropping and agroforestry systems are common. These practices not only provide a diverse diet but also protect against crop failure, ensuring food availability throughout the year.
- **Promotion of indigenous crops:** Indigenous crops like millets and pulses are drought-resistant and require fewer inputs, making them ideal for cultivation in arid and semi-arid regions. These crops are not only nutritious but also contribute to food security by thriving in challenging environmental conditions.
Example: In Rajasthan, bajra (pearl millet) is a staple crop that is well-suited to the dry climate. It is rich in iron and dietary fibre and plays a vital role in the diet of the rural population, particularly during droughts when other crops may fail.

Cultural Relevance and Acceptance

- **Integration with local traditions:** Traditional food practices are closely linked to local customs, festivals, and religious rituals. This cultural relevance ensures that such practices are widely accepted and easily integrated into daily life, making them effective in improving nutritional outcomes.
Example: In Kerala, the traditional use of medicinal plants like turmeric and ginger in cooking is part of the cultural heritage. These spices are known for their anti-inflammatory and immune-boosting properties, contributing to better health and nutrition.
- **Preservation of traditional knowledge:** The continued practice of traditional diets and food systems helps preserve indigenous knowledge, which is vital for future generations. This knowledge includes not only the use of specific foods but also the methods of preparation and preservation that maximize their nutritional value.
Example: In the northeastern states, traditional methods of fermenting foods, such as bamboo shoots and fish, enhance their nutritional profile by increasing the availability of certain nutrients and promoting gut health.

Adaptability to Local Environments

- **Climate-resilient food systems:** Indigenous knowledge, like selecting drought-resistant crops, conserving water, and using organic fertilizers, helps sustain food production amid climate change in rural areas.

Example: In the arid regions of Gujarat, traditional water management systems like the stepwells and rainwater harvesting techniques are used to support agriculture, ensuring a stable supply of food crops even in dry conditions.

- **Utilization of wild foods:** Many rural communities rely on wild foods that grow naturally in their environment. These foods, which include fruits, nuts, tubers, and leafy greens, are rich in nutrients and provide a crucial safety net during periods of food scarcity.

Example: In Jharkhand, tribal communities gather wild mushrooms, berries, and tubers, which are high in essential nutrients. These foods play a significant role in the diet, particularly during lean seasons when cultivated crops are not available.

Sustainable Food Systems and Environmental Stewardship

- **Conservation of biodiversity:** Traditional farming promotes biodiversity by cultivating diverse crops and using seed-saving methods, ensuring genetic diversity essential for food security and nutrition.

Example: In Tamil Nadu, the practice of saving and exchanging indigenous seed varieties, such as traditional rice strains, helps maintain agricultural biodiversity. These varieties are often more nutritious and better adapted to local conditions than high-yield commercial crops.

- **Low environmental impact:** Indigenous agricultural practices often have a lower environmental impact compared to modern industrial farming. They typically rely on organic inputs, avoid chemical fertilizers and pesticides, and prioritize soil health, leading to more sustainable food production.

Example: In the Sikkim Himalayas, traditional farming practices like shifting cultivation (jhum) are managed in a way that allows the land to regenerate, maintaining soil fertility and ensuring the long-term sustainability of the food system.

Health Benefits and Disease Prevention

- **Medicinal properties of indigenous foods:** Many traditional foods have been used for their medicinal properties, contributing to the overall health of rural populations. These foods are often rich in bioactive compounds that help prevent and manage chronic diseases.

Example: In Andhra Pradesh, the use of tamarind in daily cooking is widespread. Tamarind is rich in antioxidants and has been traditionally used to treat digestive issues and manage blood sugar levels, contributing to better health outcomes in rural areas.

- **Traditional dietary practices and gut health:** The inclusion of fermented foods in traditional diets supports gut health, which is increasingly recognized as vital for overall nutrition and immunity. These foods help in the absorption of nutrients and protect against gastrointestinal infections.

Example: In Nagaland, fermented soybean (axone) is a staple food that is rich in protein and probiotics. It is traditionally prepared and consumed in various forms, contributing to the gut health and nutritional well-being of the local population.

Empowerment and Gender Roles in Nutrition

- **Women as custodians of traditional knowledge:** In many rural communities, women are the primary custodians of traditional and indigenous knowledge, particularly in relation to food production, preparation, and preservation. Empowering women to utilize this knowledge is key to improving household nutrition.

Example: In Rajasthan, women play a central role in maintaining traditional kitchens and managing food resources. Initiatives that support women in growing kitchen gardens have led to improved family nutrition, as they can cultivate a variety of vegetables and herbs for daily consumption.

- **Role in maternal and child health:** Traditional knowledge is particularly important in the context of maternal and child health, where it can be used to address specific nutritional needs during pregnancy, lactation, and early childhood.

Example: In Uttar Pradesh, traditional practices involve the use of special postpartum diets, including foods like sesame seeds, jaggery, and ghee, which are believed to aid in recovery and improve lactation. These practices contribute to better health outcomes for both mothers and infants.

Community-led Initiatives and Knowledge Sharing

• **Revival of traditional foods through community efforts:** Community-led initiatives are playing a vital role in reviving traditional food practices, particularly in areas where they have been neglected or forgotten. These efforts are crucial in combating malnutrition by reintroducing nutrient-rich foods into local diets.

Example: In the tribal areas of Odisha, community-led initiatives have focused on reviving the cultivation and consumption of traditional millets like kodo and kutki. These initiatives, supported by local NGOs and government programs, have led to improved nutritional outcomes, especially among children.

• **Knowledge sharing and capacity building:** Traditional and indigenous knowledge is often shared through community networks, festivals, and social gatherings. This communal approach to knowledge dissemination ensures that valuable practices are passed on to younger generations and adapted to modern contexts.

Example: In the Northeastern states, traditional festivals like Bihu in Assam and Chapcharkut in Mizoram serve as platforms for sharing knowledge about traditional foods and agricultural practices. These events help reinforce the cultural importance of these practices and encourage their continued use.

Integration with Modern Nutritional Interventions

• **Complementary role in government programmes:** Traditional knowledge can complement modern nutritional interventions by providing culturally appropriate and locally sourced solutions to malnutrition. This integration enhances the effectiveness of government programmes and ensures their sustainability.

Example: In Karnataka, the integration of traditional foods like millets into the Mid-Day Meal Scheme (PM-POSHAN) has been successful in improving the nutritional status of school children. This approach not only provides essential nutrients but also promotes the consumption of these traditional foods at home.

• **Incorporation into public health campaigns:** Public health campaigns that promote traditional diets and food practices can effectively address malnutrition while preserving cultural heritage. These campaigns can raise awareness about the nutritional benefits of Indigenous foods and encourage their adoption.

Example: In Maharashtra, public health campaigns have highlighted the benefits of consuming local foods like bhakri (millet flatbread) and varan (lentil stew) as part of a balanced diet. These efforts have led to increased awareness and consumption of these nutritious traditional foods.

• Traditional and indigenous knowledge offers sustainable solutions to malnutrition in rural India. Integrating these practices with modern interventions can improve health, ensure food security, and build resilience against climate change impacts.

• Traditional knowledge can combat rural malnutrition in India, but challenges remain. A multi-pronged approach with education, market development, health campaigns, and cultural rebranding can empower communities and enhance government nutrition programs.

Challenges & Way forward in Incorporating Traditional and Indigenous knowledge in Combating Malnutrition in Rural India

Challenges	Way forward
Erosion of traditional knowledge: Rapid agricultural modernization and urban migration have led to a loss of traditional knowledge in rural India, shifting diets from millets and pulses to processed foods, increasing malnutrition and lifestyle diseases.	Reviving traditional knowledge through education and community initiatives is crucial. Schools and local NGOs can introduce programs to document and teach traditional practices related to nutrition and food preparation. In Karnataka, the reintroduction of millets in school meals has indicated success in reviving interest in these nutrient-rich foods.
Lack of market access for indigenous crops: Farmers who grow indigenous crops like millets, pulses, and local vegetables often face challenges in accessing markets. These crops may not be as	Government interventions are needed to improve market access for indigenous crops. For instance, the government's initiative to include millets PAN India in public distribution systems (PDS) and TPDS can create

profitable as cash crops like rice or wheat, leading to reduced cultivation of indigenous varieties.	demand for these crops. Encouraging local food festivals and direct farmer-to-consumer markets can also help.
Stigma and perception of traditional foods: In rural communities, traditional foods are often stigmatized as 'poor man's food,' especially among youth. This hampers acceptance of nutritious indigenous foods like ragi mudde in favor of fast food.	Public awareness campaigns that promote the health benefits of traditional foods can help shift perceptions. Celebrity endorsements and government initiatives like the Poshan Abhiyaan can promote the benefits of these foods, making them more appealing.
Lack of integration with modern nutrition programs: Many government nutrition programs focus on providing fortified foods or supplements rather than incorporating traditional foods that are locally available and culturally relevant. This disconnect reduces the impact of these programs in rural areas.	Programs like the PM POSHAN in Tamil Nadu, which now incorporates local grains like millets, should be replicated nationwide. A greater emphasis on sourcing locally available traditional foods will not only improve nutrition but also support local economies.
Climate change and environmental degradation: Climate change and environmental degradation pose a significant challenge to the cultivation of traditional crops, which are often more resilient but still affected by erratic weather patterns, soil degradation, and water scarcity.	Promoting climate-resilient traditional crops through government incentives, research, and agricultural extension services can help. Projects like the Millet Mission in Odisha focus on improving traditional agricultural practices while ensuring sustainability and resilience to climate change. Incorporating traditional and indigenous knowledge can provide sustainable solutions to malnutrition in rural India. Overcoming challenges like modernization and stigma requires targeted efforts, including education, promoting market access for indigenous crops, and integrating traditional foods into government nutrition programs.

FUTURE REFORMS FOR INDIA'S HEALTH SYSTEM

- India has improved healthcare access through Ayushman Bharat, benefiting over 500 million citizens, with 173,000 health centers and reduced out-of-pocket health expenses from 63% to 39%.
- India aims for Viksit Bharat by 2047 but faces challenges, with a life expectancy of 71 years and high Infant Mortality Rate (28), alongside high out-of-pocket health expenses (39%).
- India's healthcare reforms face challenges like inconsistent funding and infrastructure gaps, especially in rural areas, where the lack of hospitals and clinics requires significant investment and time for improvement.
- India's healthcare reforms are delayed by complex regulations and low public awareness, leading to underutilization. Technology integration faces challenges with data security, and ensuring equitable access for marginalized groups remains a critical issue.
- India faces a healthcare workforce shortage, with only 10 doctors and 17 nurses per 10,000 people. This lags China, Brazil, and high-income nations like the U.S. and Australia, posing challenges in underserved areas.
- Countries like Singapore, Taiwan, and South Korea harnessed the demographic dividend through progressive policies empowering youth in health decisions. India's National Health Policy 2017 aims to increase healthcare spending to 2.5% of GDP by 2024-25.

- Public healthcare expenditure in India spans health, family welfare, AYUSH, and sanitation. While some states exceed the 8% target set by NHP 2017, others fall short. Investment in nutrition, clean water, and sanitation is crucial to combat undernutrition and anaemia.
- Addressing India's healthcare workforce shortage requires expanding medical education, improving working conditions, deploying community health workers in underserved areas, and incentivizing Indian professionals abroad to return and fill critical gaps.
- Public-private collaborations can expand healthcare access and training. Embracing telemedicine optimizes efficiency, while continuous professional development boosts retention. Regulatory reforms simplify new practice setups, fostering a resilient and equitable healthcare workforce in India.
- Investing in child and adolescent health is vital, especially in early childhood development for ages 0-6. The first 1000 days are crucial for lifelong health, and strengthening 1.4 million Anganwadi Centers with trained staff can significantly enhance outcomes.
- The health of school-aged children is crucial for nutrient storage and growth. Prioritizing their health enables India to harness its youth's potential, shaping a strong future workforce and improving socio-economic conditions.
- A nationwide school health initiative can enhance the well-being of 255 million children and teens (6-18), focusing on physical and mental health, nutrition, and promoting healthy lifestyles through activities like yoga, counselling, and regular health check-ups.
- The primary healthcare system is crucial for optimal health outcomes by 2047, relying on Ayushman Arogya Mandir (AAMs) for effective services. Transforming all AAMs by 2027 is essential, with 173,000 established since 2018, enhancing infrastructure, telemedicine, and free medications.
- Challenges persist in implementing mental health, acute care, geriatric, oral, visual, and ENT services across states. Issues include inconsistent medication supplies at AAMs, inadequate follow-ups, and a need for improved cancer screening and personnel training in critical areas.
- Ayushman Bharat-Pradhan Mantri Jan Arogya Yojana (AB-PMJAY) faces challenges, including low awareness among rural beneficiaries and uneven state participation, requiring better communication strategies and funding to ensure consistent coverage across India.
- There are also considerable deficiencies in healthcare infrastructure, especially in rural and remote areas, which require substantial investment and time to develop and sustain the necessary facilities for the scheme. The quality of care remains a concern, with challenges related to hospital empanelment, accreditation, and monitoring to uphold high standards of service.
- Effective coordination between public and private healthcare providers is crucial for comprehensive coverage and efficient service delivery. Addressing these challenges requires collaboration from Central and State governments, private sector involvement, and civil society engagement.

Social Determinants of Health

- Successful nutrition programs in India require enhancing monitoring systems to track progress and identify improvement areas. Engaging local communities ensures relevance; while building the capacity of frontline workers like Anganwadi and ASHA workers is vital for effective service delivery and education.
- Collaboration across health, education, agriculture, and social welfare is essential to address malnutrition. Extensive public awareness campaigns can inform communities about nutrition's importance and government programs, enhancing participation and adherence to initiatives.
- Technology, including digital tools, enhances service delivery and information dissemination. Strong policy support and advocacy at all government levels are essential for securing funding and maintaining political commitment.
- Developing targeted interventions for vulnerable groups, like pregnant women and young children, is crucial for meeting their nutritional needs. Collaborating with NGOs and the private sector can enhance resources, expertise, and innovative solutions to improve nutrition initiatives in India.

- Future reforms in India's drinking water and sanitation sectors must focus on sustainable access for all citizens. Enhancing efficiency through better management, monitoring, and transparency is essential. Engaging the private sector will introduce innovation and investment, fostering a robust WASH market.
- An integrated approach to planning and management is necessary, incorporating rainwater harvesting, wastewater treatment, and the reuse of treated water to ensure the sustainability of water resources. Community involvement in the planning and execution of water and sanitation projects is essential, as local participation enhances the relevance and acceptance of these initiatives.
- Strengthening policy frameworks is crucial for enforcing water quality and sanitation standards, including stricter pollution penalties. Capacity building for local authorities and service providers is necessary to improve the management and delivery of water and sanitation services.
- Climate resilience entails developing water and sanitation infrastructure strategies that withstand climate change impacts. By focusing on durable systems, India can progress towards universal access to safe drinking water and improved sanitation, supporting the UN's Sustainable Development Goal 6.
- Research shows that improved health outcomes boost economic productivity, making additional healthcare funding essential. Enhancing service quality with existing resources requires strong political will and effective governance to ensure continuity. Collaboration among government, private sector, and civil society is crucial for reform success.

DIETARY GUIDELINES FOR INDIANS: 2024 FOR APPROPRIATE NUTRITION & HEALTH PROMOTION OF THE MASSES

India faces a **triple disease burden**: undernutrition, chronic degenerative diseases, and infectious diseases. Unhealthy diets cause 56.4% of this burden. Balanced diets and physical activity can prevent heart disease, hypertension, Type 2 diabetes, and premature deaths. Just like 17 Sustainable Development Goals (SDGs), in this latest version, there are 17 dietary guidelines (DGs) listed in the box below:

Dietary Guidelines for Indians-2024

- Eat a variety of foods to ensure a balanced diet
- Eat plenty of vegetables (particularly GLVs) /fruits (in moderation) and legumes
- Obtain good quality proteins and essential amino acids (EAAs) through appropriate combination of foods; and avoid protein supplements to build the muscle mass
- Use a variety of oils/fats in moderation; choose a variety of oil seeds, nuts, millets (nutri-cereals/Shree-anna) and pulses/legumes to meet daily needs of fats and especially the essential fatty acids (EFAs).
- Restrict salt intake; and keep sugar intake to the minimum
- Minimize the consumption of high fat, sugar, salt (HFSS) and ultra-processed foods (UPFS)
- Drink adequate quantities of water and other fluids/beverages
- Consume clean & safe food, including water
- Adopt appropriate pre-cooking/cooking methods to minimize the nutrient losses
- Ensure provision of extra food and appropriate healthcare during pregnancy & lactation
- Ensure exclusive breastfeeding for first six months and continued breastfeeding till two years & beyond
- Start feeding home-made semi-solid complementary foods to the infant, soon after six months.
- Ensure adequate quantities of nutritionally appropriate diets for children and adolescents, both in health and disease/sickness
- Include nutrient-rich foods in the diets of the elderly for better health and well-being
- Be physically active and exercise regularly to maintain good health
- Adopt a healthy lifestyle to prevent overweight/obesity (esp. abdominal obesity), type 2 diabetes (12D), hypertension (HTN), coronary artery disease (CAD) etc.
- Read the information on food labels carefully to make informed and healthy food choices

Nutrition is vital from conception to old age. A balanced diet prevents nutritional deficiencies, supports optimal growth, and reduces the risk of diet-related non-communicable diseases in later life. Previously, diets were assessed by comparing intakes with RDAs, based on population nutrient needs. These dietary guidelines emphasize the importance of dietary diversity, advocating for a variety of foods from each group daily. No single food provides all nutrients, but a balanced combination can. Variety also enhances meal appeal and balance. Therefore, by rotation, one should include a variety of:

- Cereals/millet (e.g. wheat, rice, maize, jowar, bajra, barley, Italian millet (foxtail millet), ragi, oats etc.);
- Pulses/legumes (e.g. bengal gram, green gram, black gram, redgram, lentils, moth beans, rajmah, soyabean, cowpea etc.);
- Green leafy vegetables (e.g. spinach, bathua, methi, coriander leaves, mint, cabbage, mustard leaves, amaranth leaves, radish leaves, Bengal gram leaves etc.);
- Starchy roots & tubers (eg. potato, sweetpotato, colocasia, yam, tapioca etc.);
- Other vegetables (e.g. cauliflower, peas, beans, carrot, radish, beetroot, tinda, bottle gourd, brinjal, bitter melon, cucumber, pumpkin, drumsticks, ladies' finger, onion, tomato, ginger etc.);
- Fruits (e.g. apple, orange, sweet lime, guava, papaya, banana, grapes, figs, grapefruit, mango, water melon, musk melon, phalsa, pine apple, sapota, custard apple etc.);
- Nuts & oil seeds (e.g. almond, cashewnut, walnut, coconut, groundnut, sesame seeds, pumpkin seeds, sunflower seeds, watermelon seeds etc.);
- Milk & milk products (cow's/buffalo's/goat's milk, curds, buttermilk, skimmed milk, channa, processed cheese, khoa etc.);
- Non-vegetarian populations can include a variety of meat, poultry/ chicken, fish and various other sea foods in their diets
- In addition, a variety of edible oils and fats (butter/ pure ghee) should be included in moderation not only to improve palatability of the diet but also to meet the daily needs of essential fatty acids, esp. omega-3 and omega-6 series fatty acids.
- Further, moderate amounts of various spices, herbs & condiments should also be included in the diet for improving our immunity, protecting us from various diseases and maintaining our health.

For convenience, food-items with alike nutrient contribution have been grouped together to form a food group; thus, all foods have been categorized into 10 different food groups. This grouping helps in making the food choices much easier so that everyone can achieve better nutrition with far lesser efforts.

- Spices, herbs, and condiments, though not providing energy, are rich in antioxidants and included as a food group.
- The ICMR-NIN 'My Plate for the Day' concept suggests sourcing nutrients from at least eight food groups, including 5-7 daily. Half the plate should consist of vegetables and fruits, while cereals, pulses, and other foods make up the rest, with specified energy contributions from each category.
- A sustainable solution to end malnutrition involves ensuring the availability, accessibility, and affordability of diverse, nutrient-rich foods. Dietary guidelines help in selecting appropriate foods in adequate quantities for optimal nutrition and dietary diversity.
- The guidelines stress limiting salt and sugar intake, avoiding high-fat, sugar, and salt (HFSS) foods, and ultra-processed foods. They also emphasize adequate fluid intake, food safety to prevent infections, and proper cooking methods to preserve nutrients.
- These guidelines emphasize maternal and child nutrition, advocating proper care during pregnancy and lactation, including diet, rest, and healthcare. Nutrition is crucial from the fetal stage to old age, impacting growth and reducing the risk of diet-related non-communicable diseases.
- The guidelines emphasize appropriate infant and young child feeding (IYCF) practices, including exclusive breastfeeding for six months, continued breastfeeding until two years, and complementary feeding. They also stress quality diets for children, adolescents, and the elderly, along with regular physical activity.

- The guidelines emphasize preventing overweight, obesity, and non-communicable diseases (NCDs) like type-2 diabetes, hypertension, cardiovascular diseases, and cancers. Diets should be low in calories, moderate in fats, and high in proteins, vitamins, minerals, and dietary fiber to support overall health.
- For maintaining good health, appropriate dietary practices and lifestyle modifications are necessary; therefore, we need to improve our eating patterns & nutrient intake along with adequate physical activity, cessation of smoking/tobacco, restricting alcohol consumption and appropriately managing the stress.
- These dietary guidelines need to be widely disseminated among the masses for improving their knowledge, attitudes, and practices; and thus, not only improving their health but also for preventing the diet-related diseases/disorders, especially the non-communicable diseases (NCDs).

PRE-PREGNANCY CARE: WHAT EXISTS & WAY FORWARD

Despite progress in maternal and child health, global targets for maternal, under-five, and neonatal mortality remain unmet, especially in low-income countries. A UN report highlights stalled progress due to reduced investments, with most deaths still preventable. India has made significant progress in improving pregnancy related outcomes over the past decade including bringing down maternal and neonatal mortality- an important milestone under Sustainable Development Goal- 3 (SDG-3).

Globally, 1 in 4 pregnancies are unplanned, and in India, 1 in 7 pregnancies occur without prior planning. Unplanned pregnancies increase risks like preterm birth and low birth weight. To improve outcomes, recent focus has shifted to enhancing maternal and child healthcare quality, emphasizing the often-overlooked pre-pregnancy phase in RMNCH+A care.

What is Pre-pregnancy Care?

Pre-pregnancy care involves a spectrum of behavioural, biomedical, and social interventions that can be provided to women and couples before pregnancy. It encompasses health education, medical management, and lifestyle modifications to prevent adverse pregnancy outcomes. The overarching goal is to ensure that women enter pregnancy in optimal health, which not only improves pregnancy outcomes but also enhances the health of future generations.

While considering pre-pregnancy care, two essential criteria must be met: risk prevention and health promotion before pregnancy; and health outcomes for mothers and children.

A. Evidence related to Benefits of Pre-pregnancy care-

- Investing in girls' and women's health and nutrition before pregnancy benefits their well-being and future children's development. Studies like the WINGS trial in Delhi strongly support this preventive approach. The WINGS trial's health, nutrition, psychosocial, and WASH interventions reduced the risk of low birth weight by 24%, with over half of the benefit linked to pre-pregnancy care.
- The PRIYA trial in Pune found that vitamin B12 supplementation before pregnancy improved children's cognitive and language development. This underscores the importance of pre-pregnancy vitamin B12, suggesting fortified foods as a practical solution for women's and children's health.
- Pre-pregnancy care reduces neonatal and birth disorders by addressing modifiable risks early, leading to healthier pregnancies and better child outcomes. Dean SV's review showed pre-pregnancy care increases antenatal care by 39% and reduces neonatal mortality by 17%.
- The Women First trial, conducted across four sites, showed that starting maternal nutrition supplementation before or early in pregnancy increases birth size and reduces stunting, underweight, wasting, and small-for-gestational-age (SGA) births, especially in low-resource settings.
- Zohra et al.'s review on pre-pregnancy care identified five key interventions: completing secondary education, preventing teenage pregnancies, nutritional counselling with family planning, nutritional optimization, and multicomponent youth programs addressing infection prevention, chronic disease management, and mental health.

- A study in Karnataka found that while healthcare officials support pre-pregnancy care, it remains poorly integrated into the maternal-child healthcare system. Challenges include limited awareness, resources, and infrastructure. The study calls for targeted interventions to enhance health outcomes.

Policy Recommendations for Pre-pregnancy Care

To address the needs of women and couples before pregnancy, several existing packages have been developed and are available for adaptation as needed. These include:

India Newborn Action Plan (INAP): INAP is a comprehensive initiative aimed at reducing newborn mortality and improving maternal health. INAP emphasizes the importance of pre-pregnancy care as part of a continuum of care approach that begins before pregnancy and continues through childbirth and the postnatal period.

Pre-pregnancy Guidelines by Indian Academy of Paediatrics (IAP): The Indian Academy of Paediatrics (IAP) has released guidelines on pre-pregnancy care covering ten domains, including metabolic health, nutrition, substance abuse avoidance, genetic screening, reproductive health, and mental well-being. These comprehensive guidelines promote positive community health practices and adolescent well-being.

Specific recommendations in Nutrition by Indian Academy of Paediatrics (IAP) during pre-pregnancy

Nutrient	Target Population	Recommended Dose	Benefit
Folic acid	All women to be continued on folic acid during pregnancy: High risk (previous neural tube defects, anticonvulsant medication, Gestational diabetes mellitus, malabsorption, BMI>30 kg/m ²)	Oral folic acid 400 µg for at least 4 weeks before pregnancy & for the first 12 weeks of gestation for all pregnant women 4 mg daily for at least 4 weeks before pregnancy and for the first 12 weeks of gestation for high-risk pregnancy	Prevention of Neural tube birth defects such as spina bifida and anencephaly
Iodine	All women	150 µg daily while pregnant and breastfeeding	Production of maternal thyroid hormone, fetal brain and central nervous system developments
Vitamin D	Women with vitamin D deficiency identified by blood tests	1000 IU/day (vitamin D3-49 mol/132000 IU/day (vitamin D nmol/l))	Reduces risk of small for gestational-age babies & Impaired fetal skeletal development
Iron	All pregnant women	Oral supplement with at least 60 mg of elemental Iron daily (For 180 day)	Prevention of anaemia
Vitamin B12	Vegans and vegetarians	250-500 µg/day oral	Prevention of neurological sequelae infants
Calcium	Women with Inadequate dietary Intake (<1000mg daily)	At least 1000 mg daily Calcium carbonate	Prevention of pre-eclampsia

Conclusion and Way Forward

- National Consultation for a consensus on pre- pregnancy intervention package and road-map for implementation on ground.

- Numerous studies demonstrate the effectiveness of pre-conception interventions in improving maternal and child health outcomes. Integrating these services into existing health systems necessitates collaboration among stakeholders, including state governments, development partners, research institutions, and scientific communities for effective policy development.
- Engaging and empowering individual and family with informed choices.
- Successful pre-conception care requires not only robust guidelines and policy shifts but also a cultural change toward proactive pregnancy planning. This approach will improve child and maternal health, fostering inter-generational benefits and promoting targeted interventions for individual and family behavior change. Educating women and couples on maintaining a balanced diet, engaging in regular physical activity, managing stress, and avoiding harmful substances is essential.
- Generating community awareness through "Jan Andolan" and "Social Behaviour Change Communication"
- Awareness campaigns and educational initiatives via community structures and social media are vital to inform women and couples about pre-pregnancy health. Outreach programs can enhance access to care services, fostering healthier behaviors for safer pregnancies and healthier children.
- Prioritizing pre-pregnancy care and enhancing nutrition before and during pregnancy can improve fetal growth and obstetric outcomes, ensuring better long-term health for mothers and children, aligning with the vision of a "Viksit Bharat"—a developed India.

THE ROLE OF AGRICULTURE IN PROMOTING HEALTH AND NUTRITION

Agriculture is essential for human survival, providing food, nutrients, and promoting health. It addresses malnutrition, obesity, food safety, and dietary diversity. By fostering sustainable farming, agriculture supports well-being, prevents diseases, and offers a resilient solution to global health and environmental challenges.

Agriculture as a Source of Nutrient-Dense Foods

- Agriculture produces nutrient-rich foods like fruits, vegetables, grains, and animal products, essential for health. These foods provide energy, boost immunity, prevent diseases, and support physical and mental growth.
- Fruits and vegetables are rich in vitamins A, C, and K, antioxidants, and fibre, promoting heart health, cancer prevention, and digestion. Whole grains provide complex carbohydrates, B vitamins, and micronutrients essential for bodily functions.
- Agriculture enables farming of biofortified crops, genetically enhanced to contain more micronutrients like iron, zinc, and vitamin A, helping combat hidden hunger and nutrient deficiencies where diverse diets are scarce.
- The integration of agriculture with nutrition strategies is exemplified by the **Harvest Plus initiative**, which develops biofortified crops like rice, maize, and sweet potatoes to combat nutrient deficiencies in developing nations, showcasing agriculture's role in global nutrition improvement.

Link Between Agricultural Practices and Dietary Diversity

- India's diverse agriculture, supported by its agrarian history and varied agro-climatic zones, promotes dietary diversity and nutrition. Crops like cereals, pulses, fruits, and livestock products help address food security and nutrition challenges, especially in rural areas.
- Diversified agriculture, like mixed farming and crop-livestock integration, improves dietary diversity. Farmers cultivating a variety of crops or raising livestock enjoy more nutritionally diverse diets. NFHS-5 reports show better nutrition, especially for women and children, through these practices.
- Pulses, being one of the basic constituents of diet in India, are a rich source of plant-based protein, iron, and folic acid. The promotion of pulse cultivation in India through interventions like the National Food Security Mission has contributed to sustainable agriculture and improved nutrition.
- Nutrition-sensitive agricultural policies, like the Mission for Integrated Development of Horticulture (MIDH), have strengthened the link between agriculture and dietary diversity. As a top producer of fruits and vegetables, India has great potential to bridge nutritional gaps by increasing access to diverse foods.

- In essence, India's agricultural diversity, when aligned with nutrition-focused policies, has the potential to improve both food security and dietary diversity, ensuring healthier, more nourished populations.

Agricultural Policies and Public Health: A Crucial Intersection

- Agricultural policies significantly impact public health, especially in agriculture-based economies like India. They shape production methods and crop types, influencing food availability, access, and quality, ultimately affecting the nutrition and health of millions.
- In India, several governmental efforts are focused on aligning agricultural production with public health goals.
- The **National Food Security Act** provides subsidized grains to over 800 million people, significantly reducing hunger and undernutrition among vulnerable groups. However, it underscores the need for a nutrition-sensitive approach, as many distributed foods are calorie-rich yet nutrient-poor.
- The **National Nutrition Mission, or POSHAN Abhiyaan**, integrates agriculture with nutrition to combat malnutrition in children and pregnant women. Promoting pulses, fruits, and vegetables enhances diet quality, addressing India's dual challenge of undernutrition and rising obesity rates.
- The **National Food Security Mission**, launched by the Ministry of Agriculture, to promote the production of nutrient-dense crops by facilitating farming for pulses, millets, and biofortified varieties represents a progress toward making this national imperative a reality.
- The **FSSAI's Eat Right India campaign** promotes public health by encouraging sustainable agriculture, organic farming, reduced pesticide use, and consumption of local foods to improve nutrition and minimize contaminants.
- Policies like the **Paramparagat Krishi Vikas Yojana** promote organic farming, reducing chemical inputs and preserving soil health. A 2021 study found organic foods in India have lower pesticide residues, minimizing health risks from chemicals.
- India's agricultural policies, aligned with public health goals, can improve nutritional outcomes, reduce disease prevalence, and foster healthier communities. Promoting nutrient-dense crops, sustainable farming, and food safety measures addresses escalating public health challenges.

Sustainable Agriculture and Food Security: Securing the Future of Global Nutrition

- Agriculture is vital for long-term food security amid growing global concerns about population growth, environmental degradation, and climate change. With food demand expected to rise 60% by 2050, sustainable agricultural practices are essential for future generations.
- Sustainable farming focuses on enhancing land productivity while protecting natural resources. In India, where over 58% of the population relies on agriculture for their livelihoods, initiatives like Zero Budget Natural Farming (ZBNF) promote organic practices, reduce costs, and improve soil health.
- Food security in India, vulnerable to severe weather, relies on the National Action Plan on Climate Change, promoting sustainable agriculture practices like water-conserving drip irrigation and drought-resistant crops, potentially increasing productivity by 50% in rainfed areas.
- Sustainable agriculture enhances food security and environmental protection through practices like crop rotation and agroforestry, improving biodiversity, reducing soil erosion, and boosting long-term productivity, especially vital in India, where over 30% of arable land is degraded.
- Sustainable agriculture addresses current and future food security challenges by integrating ecological preservation, climate resilience, and nutrition-focused practices, ensuring present needs are met without compromising future generations' ability to feed themselves.

Agriculture's Role in Combating Non-Communicable Diseases

- Agriculture is vital in combating non-communicable diseases (NCDs) like diabetes, cardiovascular diseases, cancers, and chronic respiratory diseases, which account for 71% of global deaths, as the foods produced directly impact public health.
- Shifting production towards nutrient-dense foods like fruits, vegetables, whole grains, and legumes can significantly reduce NCD risks. India is addressing the dual burden of NCDs and malnutrition through agricultural guidelines. The National Food Security Mission promotes biofortified crops like iron-rich pearl

millet and zinc-enriched rice to combat micronutrient deficiencies, which can lead to diseases like anaemia and stunted growth. Additionally, the Mission for Integrated Development of Horticulture (MIDH) aims to enhance fruit and vegetable production, essential for a heart-healthy diet.

- Sustainable agricultural practices that reduce harmful inputs help combat NCDs. Excessive chemical fertilizers and pesticides are linked to long-term health issues, including cancer. Initiatives like the Paramparagat Krishi Vikas Yojana promote organic farming, ensuring safer, toxin-free food.
- Agriculture plays a crucial role in combating NCDs by promoting traditional food systems. In India, millets, or Nutri-cereals, are gaining attention for their low glycaemic index and high fibre, aiding diabetes management and reducing cardiovascular disease risk. The Indian government has declared 2023 the International Year of Millets to emphasize their significance in addressing modern health challenges.
- Through the production of nutrient-rich, chemical-free, and health-promoting foods, agriculture serves as a powerful tool in preventing and managing non-communicable diseases, contributing to healthier populations, and reducing the global burden of disease.

Challenges and Opportunities in Agriculture for Health and Nutrition

Agriculture significantly influences health and nutrition, facing complex challenges and opportunities that will shape its future impact. To ensure food security and improved nutrition, it must navigate climate change, population growth, and dietary shifts while leveraging innovative solutions.

Challenges

- One major challenge is natural resource degradation. Soil erosion, water scarcity, and biodiversity loss threaten global farmland productivity. FAO reports that about 33% of soils are degraded, impacting nutrient-dense crop production, particularly for smallholder farmers in India.
- Climate change significantly impacts agriculture, causing rising temperatures, erratic rainfall, and increased severe weather that disrupt crop cycles and reduce yields. By 2030, productivity may decline by 10-25% in some areas, worsening food insecurity and malnutrition.
- Economic and social factors like market access, price fluctuations, and rural poverty hinder farmers. Smallholders often lack resources and infrastructure needed to diversify crops and adopt sustainable practices, limiting their ability to improve nutrition outcomes.

Opportunities

- Despite challenges, agriculture offers opportunities to transform global health. Technological advancements like precision farming, biotechnology, and digital tools enhance agricultural performance and sustainability, allowing farmers to optimize water, fertilizers, and pesticides for better yields and reduced environmental impact.
- Biofortification offers an exciting opportunity by developing nutrient-enriched crops, like those high in vitamin A, iron, and zinc, to combat micronutrient deficiencies. Programs like Harvest Plus have successfully improved nutrition for over 40 million people worldwide.
- Promoting traditional, climate-resilient crops like millets and pulses offers significant potential, as they are nutrient-rich and resource-efficient. India's focus on reviving millet cultivation highlights their role in addressing malnutrition and climate change challenges, especially during the International Year of Millets 2023.
- Public-private partnerships and global collaboration can help overcome agricultural challenges. Increased funding for research and development, along with better farmer support, empowers rural areas to innovate and improve health outcomes through coordinated initiatives like the National Food Security Mission and Eat Right India.

Conclusion

- Agriculture's role in health and nutrition is crucial amid global challenges. With innovative, sustainable practices, it can combat malnutrition and non-communicable diseases while ensuring food security. The Indian government's policies align agriculture with public health goals.

- Programs like the National Food Security Mission, Paramparagat Krishi Vikas Yojana, and biofortified crops reflect a commitment to fostering a healthier, more resilient population by enhancing agricultural productivity and ensuring nutrient-rich food for millions.
- By prioritizing sustainability, nutrition-sensitive farming, and technological innovation, India exemplifies how agriculture can be a key pillar in building a healthier, prosperous future. Continued dedication and collaboration present immense opportunities to uplift public health.

HEALTH MANAGEMENT IN RURAL INDIA: ROLE OF HEALTH TECH STARTUPS

- The healthcare sector in India is expanding, with growing investments and Healthtech startups enhancing rural healthcare through technology integration, improving patient care and health operations.
- India's public health expenditure is set to reach 2.1% of GDP in FY23, but remains below the global average. Despite the Ayushman Bharat Yojana and 2.5 lakh healthcare centers, rural areas still face challenges accessing medicines. To improve India's healthcare infrastructure, a sustainable, cost-efficient model providing 24x7 services in remote areas is needed. Technology-based startups are bridging the gap, ensuring rural areas receive city-like healthcare, fostering an inclusive healthcare system.
- Healthtech startups are transforming rural healthcare by leveraging AI, machine learning, telemedicine, and data analytics, creating innovative, patient-centric solutions that revolutionize accessibility and efficiency in the healthcare system.
- The rapid growth of healthcare technologies and India's vast market attract investors. As smartphone usage and internet access is increasing in rural areas, the potential to reach people in remote areas using technology and digital solutions is also increasing. Healthtech startups are expanding their customer base and developing viable business models by targeting the rural population.
- India's Healthtech startups have grown significantly, driven by telemedicine's reach in rural areas and expanded insurance coverage. During COVID-19, telemedicine overcame geographical barriers, providing remote access to expert medical advice, improving healthcare quality in rural regions.
- In 2023, the healthcare management and life sciences sector saw over 10,000 DPIIT-recognized startups, with 47% from Tier 2 and 3 cities. The sector grew at a 127% CAGR (2016-2023), including 1,002 active Healthtech startups.
- An Ernst & Young report projects India's telemedicine industry to grow at 31% annually and e-pharmacy at 44%, reaching \$4.5 billion by 2025. These trends foster Healthtech startup expansion, with a potential market size of \$50 billion by 2033.
- Government initiatives are bolstering remote healthcare services, fuelling the growth of health technology startups. These digital advancements have reduced healthcare costs, ensured secure data management, and led to improved health outcomes.

Telemedicine platforms: It has transformed rural health management by enabling remote diagnosis and treatment through telecommunications. It facilitates consultations for checkups, prescription renewals, and specialist access, allowing rural patients to receive instant medical advice without traveling long distances.

Digital Health Monitoring: Digital health monitoring platforms are designed to collect, track, and analyse personal health-related data. These platforms monitor various health parameters using digital tools, sensors, and devices. Digital health monitoring aims to enable citizens to actively participate in their own health management. This facility provides real-time data to health providers for informed decisions.

Electronic Health Records: These systems are digital versions of patient charts and diagnostic reports, compiling comprehensive health information. They preserve and manage records securely, ensuring easy access and providing a complete view of patient care.

Health Data Analytics: Health data analytics systems analyze health-related data to extract insights, identify patterns, and enhance decision-making. By processing large volumes of data from various sources, they aim to improve patient care and operational efficiency.

Artificial Intelligence-based Diagnostics: Artificial Intelligence-based diagnostics helps interpret and analyze medical diagnostic data using artificial intelligence or AI technologies, especially machine learning algorithms. The aim of this service is to increase the accuracy, efficiency, and speed of medical diagnoses, ultimately improving patient outcomes and optimizing the healthcare process.

E-pharmacy: E-pharmacy is an online platform for the sale and purchase of medicines and pharmaceutical products. It allows consumers to order medical consultations and medicines online through websites or mobile apps. The popularity of e-pharmacies has grown due to its convenience, wide product range, and ability to reach consumers in remote areas.

Health ID: Under Health ID, citizens are given a unique health ID that makes their health information available to health workers in a secure manner with their consent.

Digi Doctor: Under the Digi Doctor initiative, a detailed database of doctors has been created, including their qualifications, specialization, and affiliations with healthcare facilities. This ensures accurate mapping of available medical resources.

Health Facility Register: The Health Facility Register is a national centralized database of health facilities that facilitates seamless data exchange between public and private Healthcare providers, which is updated regularly.

Personal Health Records: Personal health records are electronic repositories that store an individual's health information, which can be accessed anytime and anywhere. This gives individuals the freedom to manage and update their personal health data.

Electronic Medical Records: Electronic Medical Records is a web-based system containing patients' health records and treatment information, which assists physicians in patient management, health monitoring, and preventive Healthcare recommendations.

- The **National Digital Health Mission** in India aims to create a robust system for managing digital health data and facilitating exchanges among health facilities, providers, and pharmacies. This initiative enhances clinical decisions and telemedicine services, promoting transparency and effectiveness while generating over \$200 billion in economic value for Healthtech startups.
- India's large, rapidly growing population presents an attractive market for Healthtech investors. Startups offering affordable, accessible solutions leverage technology to provide cost-effective healthcare services and reach many consumers, enhancing their investment appeal.
- The Indian healthtech startup ecosystem is experiencing significant growth in funding and investment due to market expansion, government support through initiatives like Ayushman Bharat, and a large talent pool of engineers and scientists. Additionally, deeptech policies and incubators foster innovative health technology solutions, enhancing the startup landscape.
- The rural healthcare industry in India has huge growth potential. With a large rural population and rising health awareness, the need for accessible and affordable healthcare services is increasing. To meet this need, healthtech startups are focusing on rural healthcare and have strong growth prospects. Investors are eager to enter this potentially lucrative sector.
- India's Healthtech startup ecosystem is rapidly expanding, significantly improving healthcare reach, accessibility, and quality in rural areas. Innovations like telemedicine and AI are transforming healthcare delivery, with the market projected to grow to \$50 billion by 2033, enhancing health outcomes nationwide.

Healthtech Startup Success Story-1

Digi Qure Startup Makes Access to Doctors All Year Round in Rural India

To improve primary Healthcare services in rural Tar areas, Akanksh Tandon started a Healthtech startup called 'Digi Qure' in 2020. The startup provides tele-consultation services for just Rs 1. The startup has served more than 20,000 people in rural areas of Madhya Pradesh.

Akanksh Tandon, a resident of Madiyado village in Damoh district of Madhya Pradesh, lost a seven- year-old friend he used to play with as a child. She was the daughter of his house help who died of a stomach disease. He was told that the girl could not get treatment in the village and her mother did not have the money to go to the city for treatment. Until then, Akanksh had only heard of deaths of the elderly, not of children. This incident shook Aakansh's young mind deeply.

A few years later, Akanksh realized that if the right medical infrastructure is established in rural areas, the lives of village children and thousands of others can be saved. Akanksh, who grew up in a rural environment, completed his engineering from NIT Bhopal and worked in a government job for some time. He did not like the job because he had made rural Healthcare his life's goal. Akanksh founded the Digi Qure startup along with his friends Saket Asati and Ankur Chourasia.

The Digi Qure startup connects rural residents to health experts through video consultation, and provides this service through a subscription card worth one rupee. Apart from this, Digi Qure also provides digital prescriptions, lab test services and referrals to partner hospitals. Akanksh took the risk of Improving rural healthcare by leaving his government Job. He launched a subscription-based 'Saksham Card', which costs Rs 365 for a year. That is, at the rate of Rs 1 per day, four members of a family can get video consultation as per their requirement throughout the year. Currently, Digi Qure startup has more than 2,500 members in five telemedicine-based e-clinics in Sagar and Bhopal centers. Apart from this, their services are also available in Fatehpur in Bihar and Aizawl in Mizoram. Digi Qure has established a network of 50 doctors in 10 hospitals and two district level labs.

Recently, in Season 2 of Shark Tank India, Digi Qure startup has received an investment of Rs 40 lakh from Emcure Pharmaceuticals. Emcure Pharmaceuticals has made this investment to support Digi Qure's business. This type of investment helps startups to grow their business and take it to new heights. The managers of Digi Qure startup are investing Rs 2 lakh per month. They are investing their savings of Rs 60-70 lakh in the startup and are providing solutions to the health challenges of rural India. Digi Qure startup is continuously receiving support and encouragement from the country and the world.

Health Startup Success Story-2

Cure Bay Takes Healthcare to Remote Rural Areas

When 63-year-old Basanti Das, a resident of a remote village Alipingal in Puri district, was struggling with a wound on her finger that was not healing, she did not realize that it could be a sign of diabetes. Due to the lack of healthcare services, she was having difficulty getting the right treatment. During this time, Cure Bay startup helped her and got her treated by a doctor. With the right diagnosis and treatment, Basanti's glucose level became normal. Basanti's story is a glimpse of the change brought by Cure Bay startup in rural healthcare.

Healthtech startup Cure Bay was founded in 2021 by Priyadarshi Mohapatra, Shobhan Mohapatra and Sanjay Swain. The Bhubaneswar-based startup aims to make medical services accessible and affordable, especially in remote areas where there is a lack of healthcare services. The startup was born during the COVID-19 pandemic, considering the lack of healthcare services for 65 % of the country's people. Cure Bay's model brings doctors, hospitals, laboratories, pharmacies, and medical equipment on one platform with the help of technology. Additionally, Cure Bay has set up e-clinics in rural areas where there is no adequate health infrastructure.

Cure Bay provides healthcare services at an affordable cost. The initial consultation fee is just Rs 99, which brings doctors to patients living in remote villages without having to travel from village to city for medical treatment. Apart from this, an annual membership program starts at 399 in which patients get free consultations throughout the year, diagnostic tests, discounts on medicines and ambulance services. Cure Bay offers tele-consultation to patients, wherein patients can connect with doctors via video chat, followed by a process of diagnosis, health check-up and hospitalisation if required.

Each Cure Bay e-clinic has two trained healthcare professionals who connect patients to the doctor and help them arrange for their medicines. Apart from this, the company has also arranged trained staff to collect test samples from the doorstep of the patients. Currently, Cure Bay has empanelled 50 hospitals and around 100 medical professionals. The areas selected for e-clinics are those where there is a lack of medical facilities within a radius of 10 km. Currently active in Odisha and Chhattisgarh, Cure Bay aims to set up 150 e-clinics in Jharkhand as well.

A DECADE OF SWACHH BHARAT: HEALTH OUTCOMES THROUGH WASTE MANAGEMENT REFORMS

India generates 55 million tonnes of Municipal Solid Waste (MSW) annually from 377 million urban residents. By 2050, with 814 million urban people, waste could rise to 436 million tonnes. By 2030, MSW-related greenhouse gas emissions may reach 41.09 million tonnes. Circular economy opportunities include INR 11,836 crores from recycling, INR 365 crores from composting, and INR 1,679 crores from Bio-CNG production. This article evaluates SBM's role in improving health outcomes, supporting sustainable development by promoting waste-to-wealth conversion and pollution abatement, crucial for meeting India's NDC targets and environmental goals.

Waste Management at the Core of Swachh Bharat Mission

Swachh Bharat Mission (SBM) focused on solid waste management to address challenges from India's rapid urbanization. Improper waste disposal caused health issues like respiratory problems and diseases. SBM emphasized source segregation, recycling, composting, and scientific disposal, alongside certifications like ODF, ODF+, and ODF++.

Key Certifications and their Impact on Public Health

- **ODF (Open Defecation Free):** The first milestone of SBM was eliminating open defecation by 2019, with 600,000 villages declared ODF. This achievement reduced water contamination and lowered waterborne diseases like diarrhea and cholera.
- **ODF+ and ODF++:** ODF+ ensures public toilet maintenance and prevents open defecation recurrence, while ODF++ covers safe faecal sludge management. As of now, 3,913 cities are ODF+ certified, and 1,423 have achieved ODF++ status.
- **Water and Water+ Status:** Water and Water+ certifications extend ODF goals to manage liquid waste, ensuring no untreated wastewater enters water bodies. By 2022, over 700 cities achieved Water+ certification, protecting water sources and preventing waterborne diseases.

Expanding Sanitation Coverage

One of SBM's major successes has been the large-scale construction of toilets across rural and urban areas:

- **Individual Household Latrines (IHHLs):** By 2024, 63.63 lakh urban IHHLs and 11.66 crore rural household toilets were built, enabling 3,913 cities and 5,54,099 villages to achieve ODF+ status under Swachh Bharat Mission.
- **Aspirational Toilets:** SBM's aspirational toilets initiative built over 1,000 well-designed, hygienic, and inclusive toilets in high-traffic areas like bus stations, hospitals, and schools. These facilities ensure accessible sanitation for people with disabilities and promote cleanliness.
- **Community and Public Toilets:** SBM's aspirational toilets initiative built over 1,000 well-designed, hygienic, and inclusive toilets in high-traffic areas like bus stations, hospitals, and schools. These facilities ensure accessible sanitation for people with disabilities and promote cleanliness.

Turning Waste into Energy: Biogas and Waste-to- Electricity Initiatives

To address organic and municipal waste disposal, SBM embraced bioenergy generation through biogas plants, waste-to-energy projects, and compressed biogas (CBG) plants:

- **Biogas Plants:** By 2023, 4,500+ biogas plants were installed, helping 2 million rural households convert organic waste into methane, reducing firewood use, improving indoor air quality, and lowering respiratory ailments.
- **Waste-to-Electricity Plants:** In urban centers, over 20 waste-to-electricity plants were established, converting 1,500 metric tonnes of waste daily into clean energy, improving air quality and reducing landfill-related fires.
- **Compressed Biogas (CBG) Plants:** As of 2023, 40 CBG plants were operational, converting over 5,000 metric tonnes of biodegradable waste daily into biogas for fuel and electricity generation. This supports India's clean energy goals and mitigates methane emissions from decaying organic waste.

Plastic Waste Management: Addressing the Plastics Challenge

Plastic waste management has been central to SBM's efforts to reduce environmental degradation and public health concerns:

- **Plastic Waste Recycling:** By 2023, over 50,000 metric tonnes of plastic waste were collected and processed annually, with 12,000 plastic waste management units across India. This has reduced plastic pollution in cities and decreased flooding risks from clogged drains.
- **Plastic-to-Fuel Plants:** Over 20 plastic-to-fuel plants now process over 100 metric tonnes of plastic waste daily into alternative fuels like diesel and gasoline, contributing to energy security while reducing landfill waste.

Legacy Waste Remediation: Addressing a Historic Challenge

SBM has also tackled the monumental challenge of legacy waste remediation. Till now, 89.1 million metric tonnes of legacy waste had been treated through bio-mining and bio-remediation, reclaiming 4,543 acres of land. These efforts have not only reclaimed valuable urban land but also significantly reduced the methane emissions and air pollution associated with decaying waste piles.

Data-Driven Health Outcomes

Waste management reforms under SBM have led to significant public health improvements:

- **Reduction in Waterborne Diseases:** The construction of 100 million toilets and India's ODF status led to a significant drop in waterborne diseases, with a 40% reduction in diarrhoea cases in rural areas from 2015 to 2020.
- **Decline in Respiratory Issues:** SBM's focus on waste segregation and reducing open burning has improved air quality in urban areas. ODF++ cities saw fewer respiratory illnesses, with a CPCB study showing a 10-12% drop in particulate matter in 2021.
- **Improvement in Hygiene and Disease Control:** Cleanliness drives under SBM significantly reduced waste accumulation in urban slums. Vector-borne diseases like malaria and dengue declined by 20-25% in cities with ODF++ and Water+ status, improving sanitation and public health.
- **Enhanced Public Health Awareness:** SBM's massive outreach campaigns played a critical role in changing public attitudes towards hygiene and waste management. As of 2023, more than 90% of households in urban areas segregated waste at the source, a critical step toward healthier living environments.

Integration of Informal Sector Rag Pickers

While SBM's success is clear, the informal sector, especially rag pickers, is often overlooked. Integrating them enhances waste management effectiveness, promotes social inclusion, and empowers economically, despite their marginalization and lack of recognition. One of the significant achievements under the Swachh Bharat Mission (SBM) is the successful integration of 1.5 million rag pickers into formal waste management systems.

Challenges and Areas for Improvement

- In urban areas, waste management is more formalized, with ULBs leading initiatives for segregation, collection, and recycling. However, rural areas rely heavily on panchayats, with efforts like open-

defecation free (ODF) programmes and liquid waste management systems being prioritized (Khare & Suresh, 2023).

Areas for Improvement

The next phase of SBM should focus on innovative waste management, scientific disposal systems, and circular economy principles. Empowering local governments, enhancing public health research, and increasing investments in waste-to-energy and recycling are crucial for sustaining progress.

- **Infrastructure Development:** Building and upgrading waste management facilities, including collection systems, composting units, and recycling centers.
- **Community Engagement:** Increasing local community involvement and ownership in waste management initiatives through education and participatory approaches.
- **Tailored Solutions:** Developing waste management solutions that are adaptable to local conditions and cultural practices.
- **Financial Support:** Providing financial assistance and incentives for rural areas to develop waste management infrastructure and services.
- **Capacity Building:** Training local authorities and community members in effective waste management practices and health benefits.

Conclusion

The Swachh Bharat Mission (SBM) transformed waste management in India, emphasizing decentralized practices. Urban local bodies focus on waste infrastructure, while rural panchayats implement local solutions like compost pits and greywater management systems.

Capacity building and Information, Education, and Communication (IEC) activities are vital to SBM's success. Training municipal staff, raising awareness, and promoting behavioural change enhance waste management through an integrated approach of policy, technology, and community engagement.

Case Study 1: Pune's SWaCH Cooperative

In Pune, the SWACH (Solid Waste Collection and Handling) cooperative, run by waste pickers, collects and processes over 1,000 tonnes of waste daily. The integration of rag pickers into SWaCH has greatly improved the city's waste segregation rates while uplifting the livelihoods of over 3,500 waste pickers. Due to the SWaCH Cooperative's initiatives, today, 60 MT of waste is diverted away from landfills per day, with 80-85% of the waste generated in the city being recycled/processed, resulting in annual GHG emission savings of approximately 50,000 tonnes of CO₂. SWACH Model addressed:

- Segregation by citizens
- Better conditions of work for waste pickers
- Cleaner waste for recycling industry
- Reduction in municipal expenses for waste management

Case Study 2: Role of Swachhagrahis in SBM(G)

The success of Phase I of the Swachh Bharat Mission (Grameen) (SBM-G) has been significantly driven by the large army of Swachhagrahis. These dedicated volunteers mobilized communities and played a crucial role in achieving Open Defecation Free (ODF) status in their villages. As the mission moves forward into the ODF Plus phase, Swachhagrahis will continue to be the frontline human resource, essential for advancing the initiatives and fostering sustainable sanitation practices. The role of a Swachhagrahi is versatile and inclusive, drawing from a diverse pool of individuals, including local ASHA workers, ANMS, Anganwadi workers, water line men, pump operators, members of Non-Governmental Organizations (NGOs)/Civil Society Organizations (CSOs), youth organizations, and the public residing in villages.

Case Studies: Waste to Energy Plants	
a. Waste to-charcoal plant, Varanasi, UP	b. Waste-to-Energy Plant, Pimpri-Chinchwad, MH

In Varanasi, a waste-to-charcoal plant has been set up to convert municipal solid waste into biochar (charcoal). This project has processing capacity of 800 TPD waste, converting it into biochar that can be used in agriculture as a soil enhancer. The plant not only reduces the volume of waste headed to landfills but also sequesters carbon, contributing to climate change mitigation.	This plant processes 700 tonnes of waste daily, generating 11.5 MW of energy. This facility has become a model for other cities aiming to address the challenge of growing waste volumes while generating clean energy. The project has also played a role in reducing urban air pollution by minimizing the need for waste burning and landfilling.
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Urban Challenges	Rural Challenges
High Population Density: Urban areas often have high population densities, which leads to large volumes of waste. Managing this volume can strain municipal waste management systems.	Limited Resources: Rural areas frequently face limitations in terms of financial and human resources for implementing waste management systems. This includes a lack of trained personnel and limited budget allocations for waste management.
Inadequate Infrastructure: Many cities lack sufficient infrastructure for waste collection, segregation, and processing. This includes insufficient number of waste collection vehicles, inadequate waste processing facilities, and limited recycling infrastructure.	Infrastructure Gaps: Despite advancements, many rural areas still struggle to maintain ODF and ODF+ status, with some states facing difficulties in ensuring that built toilets are regularly used and maintained.
Informal Sector Involvement: The informal sector, including waste pickers, plays a significant role in urban waste management. While they help in recycling, their lack of formal recognition and support can lead to health risks and inefficiencies in waste management.	Low Awareness and Education: There may be lower levels of awareness and education regarding waste management practices in rural areas. This can lead to improper waste disposal and a lack of community-driven waste management initiatives.
Waste Segregation Issues: Effective waste management relies heavily on proper segregation of waste at the source. In urban areas, there is often a lack of awareness or infrastructure to support proper segregation, leading to increased contamination of recyclable and compostable materials.	Geographic Dispersion: The dispersed nature of rural settlements can make it difficult to implement centralized waste management systems. Transportation of waste from remote areas to processing facilities can be logistically challenging.
Public Engagement: Urban populations may have varying levels of awareness and engagement with waste management practices. There is often a need for more robust public education and participation programs.	Sustainability: Sustaining ODF, ODF+, and ODF++ statuses will require consistent governmental monitoring and community engagement. As urban centers expand, the pressure on existing waste management systems increases, necessitating continuous investment in technology and trained personnel.