Vision 2047

ICAR-Central Institute for Research on Cotton Technology
(Indian Council of Agricultural Research)
Adenwala Road, Matunga, Mumbai - 400019

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संदेश

कपास भारत के लिए एक बहुत ही उपयोगी नगदी फसल है । यह भारत के औद्योगिक एवं कृषि विकास के लिए एक महत्वपूर्ण अग्रणी भूमिका निभाता है। कपास हमारी सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान करता है। आज के परिवेश में जहाँ ग्रामीण युवाओं का बडे पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, एक बहुत बडी कृषक आबादी कपास की खेतों पर पूर्ण रूप से निर्भर करती है। कपास के प्रसंस्करण से एक बहुत बडे रोजगार का सृजन करता है। कपास की खेतों से कपडे के साथ – साथ एक बडे पैमाने पर खाद्य तेल एवं पशु आहार का भी उत्पादन किया जाता है। इसके डंठलों से विद्युत उर्जा के उत्पादन कर भी जोर दिया जा रहा है। अत: खाद्य, पर्यावरण, आजीविका सुरक्षा एवं समावेशी विकास हासिल करने के लिए कपास के प्रसंस्करण एवं इसके उप उत्पादों में स्थायी विकास बहुत आवश्यक है।

वित्त वर्ष 2021-22 से देश का कपडा निर्यात लगभग 44.4 अरब अमरीकी डालर रहा जो अब तक का सर्वाधिक है। भारत सरकार ने कपडा निर्यात के लक्ष्य को अगले पाँच साल में 100 अरब अमरीकी डालर करने का निर्धारित किया है। इसके अतिरिक्त, भारत सरकार ने 2024-25 तक भारत की अर्थव्यवस्था 5 लाख करोड (5 ट्रिलियन डालर) करने का लक्ष्य निर्धारित किया है । इस लक्ष्य को प्राप्त करने के लिए कपास प्रसंस्करण एवं इसके उपउत्पादों के मूल्य संवर्धन एक महत्वपूर्ण भूमिका निभाएगा।

विगत 20 वर्षों से हमारे कपास के प्रसंस्करण एवं उपउत्पादों के मूल्य संवर्धन की प्रौद्योगिकी से कपास कृषि एवं व्यवसाय में काफी बदलाव आया है। तथापि, हमारे देश में कपास की फसल बुआई एवं कटाई में अभी भी मजदूरों पर निर्भरता ज्यादा है, जिससे कपास की फसल की लागत काफी बढ जाती है। आज के समय में विभिन्न नवीन तकनिकीयों जैसे ड्रोन, नैनो उर्वरक, रोबोट आधारित यंत्र, इत्यादि का विकास हुआ है । नवीन तकनिकीयों का उपयोग करके एक भावी बेहतर कपास प्रसंस्करण की कल्पना करनी होगी, जिसके लिए हमें एक ब्लूप्रिंट तैयार करना होगा ।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के केन्द्रीय कपास प्रौद्योगिकी अनुसंधान संस्थान ने विजन 2047 की रूपरेखा तैयार की गई है । मुझे उम्मीद है कि विजन 2047 में परिकल्पित अभिनव दृष्टीकोण और परिपेक्ष्य शोधकर्ताओं, नीति निर्धारकों और हितधारकों को कपास क्षेत्र में विकास की चुनौतियों का समाधान करने में उपयोगी साबित होगा ।

(नरेन्द्र सिंह तोमर)
केन्द्रीय कृषि एवं किसान
कल्याण मंत्री, भारत सरकार

Foreword

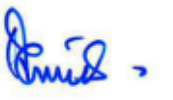
Indian Council of Agricultural Research (ICAR) is the apex umbrella organisation for agricultural research in India and one of the largest NARS with a strong global footprint. The Council has led the agricultural research, education, and extension initiatives through a network of research institutions, All-India coordinated research projects, agricultural universities, and KVK and enabled development and deployment of improved technologies, agricultural machines. Processes and protocols for enhancement of productivity, production, value addition as well as diversification of agriculture. The agricultural research has played a key role in transformation of Indian Agriculture from a food shortage nation to food surplus and net exporter of food grains and other agricultural commodities including farm machineries.

The transformative changes like changing lifestyle, expanding urbanization, and the advent of AI & IoT based data intensive technologies are rapidly redefining the challenges for agricultural research systems across the globe. Multi-disciplinary and multi-institutional research will be of paramount importance, given the reality that technology generation is increasingly getting knowledge and capital intensive. Redesigning the R&D in Agriculture with increased investment can act as a driving force in achieving sustainability along with nutritional security amidst the challenges of climate change and limited availability of natural resources viz., water, land, etc.

The achievement of a sustainable agricultural growth paradigm in long run depends on the adoption of a climate-smart approach, digital agriculture, concerted efforts in genomics, optimal resource use technologies, and high-yielding, and bio-friendly varieties. To make agricultural transformation a reality, building inclusive agricultural value chains and food

systems and implementing systematic production, quality, and safety standards has to be on top priority.

Our institutions should develop the capability to anticipate upcoming challenges and devise a strategy to address emerging needs in the best way possible. I am hopeful that the Vision 2047 document would provide the right direction for the ICAR- Central Institute for Research on Cotton Technology to address the challenges faced in the sector.



Dr. Himanshu Pathak,
Secretary, Department of Agricultural
Research & Education (DARE) and
Director-General

Prologue

Innovation will be the key driver for sustainable productivity growth and meet the challenges that will unveil with time. The next revolution in agriculture should be knowledge-intensive rather than input intensive. The country should achieve improved production of food and fibre crops with best agricultural practices, new crop varieties, and new technologies without associated increases in the utilization of resources. The scientific and the technological gap between our country and the developed nations should be bridged with breakthrough research and creation of strategic partnership and alliances with other public, private and international institutions. There should be institutional consolidation and disciplinary integration to suit the strategic and the basic research, and achieve a balance between the futuristic and the problem-solving research.

Cotton is an important cash crop and Cotton textiles continue to be the predominant component of the Indian textile industry, which is one of the largest and the oldest sectors in the country playing a pivotal role in the economy. Since, it has direct linkages to the rural economy and the agricultural sector, the all-round growth and development of this sector has an immense bearing on the improvement of the economy of the nation.

The human civilization by 2047 would entail a technology that would be energy saving, water conserving and low carbon technologies. There would be need for cutting edge technologies and applications of AI/ML & IoT to meet the future needs of the sector. The research should give priority to users' perspective. It must be demand driven and responsive to ensure delivery to the end users. Social relevance, public image and accountability of the public research need to be ensured.

In this context, I am delighted that Central Institute for Research on Cotton Technology, Mumbai, has envisioned the path ahead and devised a long-term strategy to attain global excellence in cotton technological research. I am sure that the innovative approach and perspectives envisaged in the Vision 2047 document will prove useful for the researchers, policy makers and stakeholders to address the challenges that arise in the growth trajectory of agriculture in general, and the cotton sector in particular.

Dr. S.N. Jha,
Deputy Director General, (AE)
ICAR, New Delhi.

Preface

CIRCOT, established in 1924, is one of the premier constituent Institutes of ICAR and has established itself as the leader in the research and development of technologies and machinery in the domain of post-harvest processing of cotton and value addition to its by-produce. The Institute is acknowledged for its contribution to the field of testing, standardisation and development of test methods for different types of textile materials. The institute is playing an important role in capacity building in the sector by means of organising customised skill development programmes suiting the needs of the stakeholders. The institute has also established Agri-Business Incubation Centre for nurturing innovative ideas and converting them into viable business propositions. The institute is also recognised as the referral laboratory for cotton fibres and provides commercial services to its stakeholders.

The emerging challenges to the post-harvest processing of cotton would include, mechanization in primary processing, limitations in the availability of resources like water & energy, environmental fallouts of processing viz., GHG emission, emission of toxic chemicals, effluents & other occupational hazards. The volatility in the prices is yet another major concern that has an impact on the economic well-being of the stakeholders in the sector including farmers.

The institute has reoriented itself and undertaken a perspective transformation to reiterate its relevance in the emerging context and focus on ensuring technology-led growth along with sustainability. The institute that has been a front runner in adopting cutting edge technologies viz., nanotechnology, and plasma technology in the past has to adopt itself to the new age technologies of application of artificial intelligence / Machine learning, Internet of Things in the post-harvest processing of cotton, value addition, and value creation to further the desirable transformation in the sector.

ICAR-CIRCOT in its journey to 2047 has envisioned the strategies to establish itself as a hub for global excellence in cotton technology and address the issues of traceability, transparency, and sustainability in the cotton value chain.

January 2023 Dr. S.K. Shukla
Mumbai Director

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Context

The Central Institute for Research on Cotton Technology (CIRCOT), one of the premier constituent institutes of the Indian Council of Agricultural Research (ICAR), is the only one of its kind in the world conducting R&D on the utilization of every part of the cotton plant, providing testing and consultancy services and promoting entrepreneurship development through capacity building and incubation programmes. Since its inception in 1924, CIRCOT has been offering continuous technological support to the country's cotton breeding programme which has resulted in quantitative and qualitative improvement of Indian cottons. The Institute is engaged in developing new technologies and machinery for better utilization of cotton, and other textile fibres by carrying out basic, applied, strategic and anticipatory research in postharvest technology of cotton and functioning as a referral laboratory for cotton fibres. Since 2014, it has also been coordinating the Consortium Research Platform (CRP) Project on Natural Fibres as lead centre for promotion of research and development in natural fibres.

In the recent past, the Institute has carried out pioneering work on ginning and mechanical processing of cotton, the development of industrial yarns and fabrics by using natural and synthetic blends, and the production of calibration cotton for the textile industry. It has also forayed into areas of environment-friendly processing of cotton, nanocellulose production and application of nanotechnology in textiles and agriculture, utilization of cotton by-products, crop residues & value addition to cotton processing waste. Over the last 98 years, CIRCOT has proved itself as the main R&D solution provider on cotton technology to its valued stakeholders.

Cotton was grown in India in an area of around 13 million hectares in 2020-21 with a production of 6.3 million metric tons, accounting for about 37 percent of the global area under cotton and 22 percent of the world cotton production. Currently, India is the largest producer of cotton in the world, second largest consumer after China and the third largest exporter of cotton in the world. About six million farm families depend upon cotton and almost 100 million people depend upon cotton value chain. In India, cotton the "White Gold" enjoys pre-eminence as an industrial raw material for the spinning industry with a share of 62%, the rest being chiefly man-made fibres

like polyester, viscose etc. Abolition of the Multi-Fibre Arrangement (MFA) and the advent of quota-free global trade in 2004 has spurred the growth of the cotton textile sector by opening the export market. Besides, India's recent progressive economic growth has resulted in increased spending on clothes dictated by fashion and comfort preferences of consumers and has helped in expanding the domestic market as well. With the technological advances in textile processing and value addition increasingly being adopted by its textile industry, India has emerged as a major player in cotton production, processing, and value addition.

Following is a glimpse of important milestones achieved by CIRCOT:

a. World-acclaimed basic research on the structure of cotton and other natural fibres and in cellulose chemistry.
b. Calibration cotton, a standard reference material, is one of the hallmarks of CIRCOT R&D. It has a countrywide acceptance with about 340 corporate users and is preferred over USDA calibration cotton, the only other supplier in the world.
c. As the technology partner in the prestigious All-India Coordinated Research Project on Cotton (AICRP) since its inception, the Institute has guided and aided cotton breeders of the country in developing varieties and hybrids with improved productivity and fibre quality in tune with the requirements of the textile industries.
d. Ginning Training Centre of the institute at Nagpur with state of art facility for Research and Training in Ginning is the first of its kind in the Asian Continent and among 3 institutes in the entire world.
e. CIRCOT's R & D in cotton ginning and skilling of the workforce for ginning industry is the best in the whole Indian subcontinent. This has made India self- sufficient and exporter of ginning machinery with export earnings of about Rs. 300 crores per annum. Pre cleaning system for ginning industry developed and commercialized under PPP mode has resulted in net improvement in the Bale value of the Indian cotton to the tune of Rs. 438 crores per annum.
f. Active participation in the Govt. of India's Technology Mission on Cotton (TMC) resulted in modernization of over 850 ginneries and along with the clean cotton-picking practices promoted by the institute, led to an acceptable level of trash and contaminants in Indian cotton.

g. The CIRCOT-developed Miniature Spinning System for assessing the spinning potential and quality of cotton is an example of successful indigenous R&D leading to import substitution.
h. CIRCOT's investigation on yarn faults has helped the industry to produce yarns with fewer defects equaling or at times better than the world's 5-25% standard.
i. Research at CIRCOT on Rotor Spinning has proved its aptness in Indian spinning sector for production of quality cotton and blended yarns.
j. Development of novel blended products of cotton with other natural as well as synthetic fibres for improved functionality in apparel.
k. Pioneering work on use of natural dyes wherein uniform shades could be achieved through machine dyeing also.
l. Developed and demonstrated eco-friendly processing of cotton for surgical cotton production and dyeing.
m. Skill up gradation and development of over 10900 farmers and other stakeholders specially from cotton value chain industries in the last 10 years
n. CIRCOT is making a steady impact by methodically foraying into cutting-edge research areas like nanotechnology, plasma processing, green composites and technical textiles.
o. Eco-friendly process to prepare peptone from cottonseed meal.
p. Degossypolisation of cottonseed meal through the microbial process.
q. CIRCOT has carried out pioneering work on utilization of cotton stalks for production of pulp and paper, kraft paper for preparation of corrugated boxes, particle boards, pellets and briquettes.
r. Compost from cotton stalks and textile wastes.
s. Entrepreneurship development in textiles and agri technology through BPD and by Agri Business Incubation (ABI) unit supported by the National Agricultural Innovation Fund (NAIF) and RAFTAAR-ABI scheme of the DA& FW with pre-seed and seed stage funding support to the entrepreneurs.
t. Successful execution of many projects funded by international agencies such as Common Fund for Commodities (CFC), Netherlands through International Cotton Advisory Committee (ICAC), Washington, UNDP, ICEF and World Bank (through NAIP).
u. Provided Technical Assistance to the African countries in Cotton TAP program under Indo African Forum Summit.

v. Forged research collaboration with other R&D institutions within the ICAR system as well as with other national and international research organizations and private manufacturers.
w. Institute as coordinator and lead centre of the Consortium Research Platform (CRP) Project on Natural Fibres, along with co-operating centres is working towards increased availability and utilization of natural fibres for Apparel, Home textile and Technical textile sectors and use their crop-residues and by-products to derive fine chemicals and energy.
x. Has been an active member of the Textile Division of Bureau of Indian Standards (BIS).
y. Recognized by University of Mumbai for providing education in basic sciences.

In the emerging, fast developing, and dynamic technology scenario, CIRCOT ought to have a broad and clear vision for the next twenty-five years when India will complete the centenary of independence. "**Vision 2047**" aims to provide orientation to the Institute to translate its long-term perspectives into reality through innovative science and engineering interventions in the cotton post-harvest sector.

CIRCOT needs to categorically position itself in the changing scenario of cotton processing, utilization, and value addition with a great role to play by being a bridge connecting the textile industry and the cotton farmers. The CIRCOT Vision 2047 document integrates, encompasses and addresses all these issues and will provide the right path to tackle the challenges and uncertainties that may be encountered in its journey towards the year 2047. By the year 2047, CIRCOT would like to attain "Global excellence in Cotton technology", with sustainable cotton processing and value addition technologies in harmony with human health, society and environment.

Challenges

Demographic transition in India during the period up to the year 2047 will be opening greater opportunities as well as innumerable challenges. India's population is expected to reach 1.6 billion by 2047. The necessity to feed the increasing population will create more pressure on land availability with competition between the food and fibre crops for land. Beyond 2030, the competition will become stiffer as the land will be a source of fuel as well. Moreover, climate change will induce a lot of uncertainty and may seriously impact agricultural production. The other limiting factors that will pose a challenge in the time to come are the inadequate availability of water and power and depletion of the fossil fuels. The technologies of the future should be socially relevant with greater concerns towards the environment, human health and safe disposal of wastes and effluents. In cotton value chain, the manufacturing stage contributes to 28 per cent CO_2 emission, consumer usage accounts for 33 per cent of the emission, while the production phase contributes to 12 per cent emission. The development of environmentally benign technology in cotton processing emerges as a major challenge. The depleting petroleum resources will have its impact on the synthetic fibre industry but there is an inherent challenge to build the consumer preference to use the natural fibre products.

India will be a major global economic power by 2047; with majority of population in the working age group, the per capita income is expected to grow manifold. India will emerge as the third largest economy in the world by 2047 with an estimated GDP of $26 trillion, next only to China ($48 trillion) and USA ($37 trillion). The per capita GDP will rise to $ 16,250 (2047) as against the present per capita GDP of $ 1498. Presently the urban population is around 31 per cent which is expected to be around 50 per cent (843 million) in 2047. With an increasing share of urban population, one can envision an upward trend in the per capita consumption of textiles. Under these circumstances, demand for textiles which is governed by factors like disposable income, population and its structure, fashion trend etc. is expected to flourish.

The total world textile demand at present is around 32 billion square metres with the average per capita consumption of textiles pegged at 26 metres. Even

if we assume that the per capita consumption of textiles increases to 40 metres, the total textile demand would be 64 billion square metres. This huge demand foreseen in the textile sector can tilt towards cotton or other natural fibre-based textiles as there is an increasing consciousness towards Green Globe that will restrict the usage of fibres from non-renewable, greenhouse gas producing synthetic fibre sources. It will also lead to cotton and other natural fibres along with their biomass finding increasing application as functional textiles (technical textiles) catering to diverse applications in various sectors such as automobiles, construction, agriculture, healthcare and industrial safety etc. However, the capability to cater to the increasing demand for cotton and other natural fibres for various textile products poses a major challenge.

By any stretch of the imagination, 2047 will certainly present an expanding Indian cotton and textile sector. State-of-the-art processing machines and technologies will dominate the textile production arena to produce quality fibres, yarns and fabrics. Given this situation, many challenges are anticipated in the cotton technology sector that CIRCOT constantly needs to address through innovative R & D efforts. Some of the important challenges are highlighted below as per the priority areas.

In India, cotton is harvested by hand picking which requires about 450-500 man-hours/ha. Targeted cotton yields of around 1500 kg/ha by 2047 from the current level of 470kg/ha (world average 780kg/ha) would demand a change in both production and processing practices that will reduce the cost of picking and mitigate the labour demand. The challenge is to have appropriately designed machines for harvesting cotton from small landholdings. Mechanically harvested cotton may have the trash content of 12-15% (mechanically picked) and 20-25% (mechanically stripped), hence the challenge would be to reduce it to a nominal level. Proper tillage, planting and defoliation practices and adoption of the concept of on-farm cleaning would minimize the trash content in mechanically harvested cotton. Presently, seed cotton is transported in loose form and both unloading and heaping operations are carried out manually. All these practices lead to very high labour, transportation and material handling costs, besides increased contamination. Challenge lies in improving these practices to reduce both contamination and costs.

Various channels exist for cotton marketing viz., farmer–ginner–consumer, farmer–trader –ginner–consumer, farmer–village merchant–commission agent–consumer. There is a need to reduce the players in the market channel which will empower the small farmers to negotiate for a higher price.

Double roller (DR) gins are of low productivity (80 kg lint/h) and consume more energy (4 units/100 kg lint). Here, the challenges are to improve DR gin's productivity and energy efficiency. The use of high productivity rotary knife ginning machine needs to be explored for ginning of Indian cottons by addressing the shortcomings. The existing principles of cotton ginning should be relooked and new principles that require minimum energy for ginning should be invented.

Consumer preference over the coming decades will be oriented towards wear comfort and feel of the fabric. There arises a challenge to assess the tactile and thermal aspects of the fabric. Cotton apparels will obviously be preferred over synthetic ones in such a scenario. However, cotton must compete with synthetics in performance-oriented garments, where the synthetic fibres/fabrics have distinct advantages.

The applications of high-performance fabrics have been expanding rapidly. They are used in areas such as protective and functional textiles, and acoustic applications and for producing smart, responsive and electronic textiles, such as fabric sensors and actuators. Therefore, suitable and new quality assessment methods based on artificial intelligence and sensor technologies need to be developed for their performance characterization.

Development of cellulose-based transparent films and substrates for flexible and biodegradable electronic systems would be another challenging area where fibrillation of cellulose to a size lesser than one tenth of the wavelength of light must be achieved. CIRCOT can direct its research into these challenging domains to produce new generation technology/materials for mass consumption.

Cottonseed, though rich in oil, protein and essential amino acids is not fit for human and non- ruminant consumption due to the presence of the toxic gossypol. Making it fit for human consumption by developing techniques for the removal of gossypol is another challenge. Cotton linters or the very short fibres remaining on cottonseed after ginning are a very pure form of cellulose.

These can be recovered in special machines known as delinters to the extent of 6% of the weight of the cotton seed but most of the processors do not remove these as currently there is hardly any domestic demand. The challenge is to prevent this national loss by developing indigenous technologies for converting it into regenerated cellulose and other valuable products. Scientific processing of cottonseed where first linters and then cottonseed hull is removed with kernels being processed for oil not only gives 7-18% higher oil recovery as compared to direct crushing of cottonseed but also allows proper utilisation of all seed components. But only about 10% of the available cottonseed is being processed in this way; hence its wider adoption for creating national wealth is a challenge.

Cotton plant residues are available in plenty but remain unutilized and are mostly burnt in the field polluting the environment due to the lack of an efficient cotton stalk supply chain and the non-availability of indigenous machinery for their uprooting, cleaning, and chipping. Use of this renewable resource for energy and high-end products is a key to ensure sustainable development. Use of cotton plant biomass for production of bioenergy, bacterial cellulose, polyhydroxy butyrate (PHB), single cell protein (SCP), poly lactic acid (PLA), plant nutrient supplementation (PNS) and as human food is a major challenging area.

Besides these sectoral challenges, there also exists the challenge of making available adequate skilled human resources and getting sufficient budgetary allocations.

New Opportunities

An increase in textile demand by 2047 on account of an increase in population and GDP opens the opportunity for a vibrant domestic demand in addition to the export opportunities and cotton textiles on account of inherent comfort and biodegradability will have an advantage. As energy and water required for textile processing will be scarce in future, opportunities exist for developing technologies and methodologies that can produce quality yarn and fabric while conserving energy and help in establish a low-carbon society.

Indigenous machinery and protocol will be needed for harvesting, cleaning and ginning of cotton from densely populated cotton fields expected to be in vogue in future to meet increased productivity requirements. Mechanization of picking and material handling operations will solve the issue of contamination and with complementary research on improved fibre quality, Indian cotton can have its distinct brand in the world market. Objective fibre quality-based trading will not only ensure good quality cotton to textile mills for producing quality textile goods but will also ensure proper remuneration to cotton farmers. Development of newer and faster AI and sensor-based quality assessment methods will be needed to make it a reality.

Immense opportunities exist in the production of novel blends of cotton with other natural fibres. Properties of natural fibres like jute, ramie, acacia, hemp, and kenaf can be engineered by methods such as degumming, softening etc., to make them pliable and compatible with cotton which can enable the development of 100% natural fibre blended yarns for use in conventional as well as technical textiles, the fastest growing high end textile category for applications like filtration textiles, agro-textiles, sports textiles, geotextiles, protective textiles, medical textiles and smart textiles. These may also be used to prepare bio-composites for making building materials. Newer spinning and textile manufacturing techniques such as friction and air jet spinning, 3D weaving, and 3D direct printing of garments fitting to body shape also offer new research opportunities.

Expectations of circularity in the textile value chain offer yet another opportunity to develop methods to incorporate pre- and post-consumer cotton textile wastes for manufacture of sustainable textiles. Sustainability requirements will also lead to the development of environment friendly

cotton processing and dyeing technologies. Refinement of nascent waterless technologies, such as plasma and supercritical carbon dioxide in textile processing can drastically reduce the water requirement and the pollution load. Biomolecules from agro and agro-processing residues can also be exploited for imparting colouration and functional properties to textiles. CIRCOT can use its expertise in nanotechnology to develop newer applications in textiles and agriculture and can be a National Centre of Excellence in this field.

For every kg of cotton lint produced, two kg of oil and protein-rich cottonseed is also produced which is presently not being utilized fully. If processed scientifically, it can not only yield up to 20% extra edible oil but can also provide linters (6%on weight basis) for making cellulose derivatives, regenerated cellulose fibres, high end paper; hulls for animal feed and making furfural and other fine chemicals; high protein meal which upon making gossypol free can solve protein malnutrition problems. There also exists scope for developing technologies for converting the renewable cellulosic by-products and agro-residues for use as human food.

Immense opportunities also exist for CIRCOT in utilization of the abundant biomass generated by cotton plants for power generation and improving the energy security of the country. Cotton biomass and other bio-based renewable resources in combination with biopolymers hold great potential in the manufacture of completely biodegradable composite materials which have a great scope in future low carbon society.

Another major opportunity for the Institute is in training and consultancy in all the fields of the cotton post-harvest processing for the global community. Besides, capacity building and entrepreneurship development in all spheres of cotton post-harvest sector is an immense opportunity. These activities along with technology transfer and licensing will also provide the institute with additional revenue which can be utilised for strengthening the R&D activities. Linkages and collaborations with other National and International institutions of repute will complement the faculty capabilities in areas of cutting age research.

CIRCOT is poised to have a tremendous impact globally, in the post- harvest processing scenario by 2047. The opportunities envisioned will require the creation of new innovative business sectors and entrepreneurial skills for

realizing their impact on economy. The Institute can provide a one-stop solution in the creation, implementation and marketing of all the state-of-the-art technologies in the global market. The expertise gained can eventually establish an important link between the agricultural and the industrial sectors, which can benefit both and create a prosperous and sustainable economy besides ensuring a better environment and human health.

Goals / Targets

In view of the challenges for the next 25 years and the operating environment of the cotton value chain and related technologies following goals and targets have been set so that the Institute's R&D activities can be planned to ensure fruitful results and benefits to the stakeholders.

The goals and targets for CIRCOT's Vision 2047 document are as follows:

1. Mechanisation of cotton harvesting

- Mechanical cotton picker/stripper suitable for small farm holdings
- Artificial intelligence-based harvesting of cotton
- Raw cotton packaging/ baling machine after harvesting for contaminant free transportation
- Integrated machine for uprooting, chipping and baling of cotton stalk
- Machinery for uniform mixing of traceable material into bales

2. Development of innovative technologies for cotton ginning

- Reworking on innovative ginning principles to develop a highly productive and energy efficient DR ginning machine (150 kg / h)
- Indigenous ginning, pre- and post-cleaning machinery for mechanically picked and stripped cottons
- Modernisation of all ginning factories in India with automated process control ginning machines and handling systems
- Pollution free modernized ginneries

3. Technological up-gradation of Indian Cottons and Textiles

- Design and development of online National Information system for objective data on cotton fibre quality and quantity

- End use-based data gathering system to support production and market system
- Engineered cotton quality through AICRP for different end uses
- Artificial Intelligence-based optical grading system for judging the cotton quality
- Simulation and modelling of Textile structures
- Marker fibres for cotton traceability

4. Innovation in spinning and weaving to manufacture high quality textiles

- Cotton-rich smart textiles for application in communication, protection and health care
- Development of 3-dimensional fabrics and shaped garments by weaving/3D printing
- Recycling of pre and post-consumer cotton waste for value-added products
- Blending with other natural fibres for high quality textiles

5. Advanced application of cotton and other natural fibres in technical textiles

- Development of multifunctional natural fibre-based nonwovens for use in agriculture, automotive, hygiene, packaging, and filtration applications
- Development of cotton-based fabrics and garments for sports, protective automotive and smart textiles applications
- Development of high-performance green composites as an alternative to glass reinforced plastics (GRP)

6. Environment friendly processing of cotton textiles for various functional properties to mitigate climate change

- Development of ultra-low liquor or water-free technologies for colouration and finishing of cotton textiles like supercritical carbon dioxide/ plasma
- Use of Novel biomolecules and biological materials for processing and finishing of cotton and cotton blends

- Nano-scale architecture in cotton textiles to impart dye-free colouration
- Development of energy-efficient eco-friendly effluent treatment methods by chemical and biological techniques

7. Nanotechnology

- Novel material (Nanocellulose) from cotton processing waste and other cellulosic biomass to suit the varied application in Pharmaceuticals, paper & pulp industries, paint industry, composites and in filtration
- Exploring the use of developed nano- materials in Agriculture

8. Effective and remunerative utilisation of cottonseed and plant biomass

- Energy efficient machinery for cottonseed processing and utilization of all seed parts such as linters and hulls for value added products
- Commercial Utilization of cotton stalks for high value compounds, green energy and compost
- Promoting cotton seed oil as health oil and development of de-gossypolisation technologies to utilize cottonseed cake for non-ruminant animals and human consumption
- Off- farm engineered cellulose from microorganisms
- Increase the scientific processing of cottonseed for oil extraction (over 50% of cottonseed)
- Production of cellulosic based fibres (viscose) from linters

9. Development of human resources and entrepreneurship

- Establishment of - International Centre for Ginning Training and Research (ICGTR) at Nagpur and Ginning Training Centres in cotton growing belts in Western, Southern and Northern parts of India
- Establishing a Centre of excellence in nanotechnology, textile finishing, cottonseed byproduct utilization, automation & textile

manufacturing and Advanced centre for textile trade and market intelligence

- Expansion of the Institute in New Campus preferably in cotton growing areas like Nagpur and establishment of infrastructure and facilities for creation of deemed university for post graduate programmes (M. Tech. and Ph. D.) in specialized areas such as cotton and textile technology, textile chemistry, microbiology, nanotechnology and technical textiles
- International exposure to in-house trainers
- Innovations in Entrepreneurship Development Programme (EDP) for commercialization of CIRCOT technologies

Strategic Technology Areas for Future Growth

1. Sustainable utilization of cotton fibres for diversified applications

Existing Status	Gaps vis-à-vis International Standards	05 Year Target Proposed (Targets@2027)	10 Year Target Proposed (Targets@2032)	Goal@2047 (Specific Outcome Envisaged)	Major Impact over the Existing Capability
1. Cotton is mostly used for apparel and home textiles. Its utilization for technical textiles is limited. Most of the technical textiles are made from petroleum derived synthetic fibres which generate non-biodegradable micro-plastics contaminating water bodies.	Natural fibres lack properties for certain technical textile applications	In depth study of fibre properties and developing technology to modify properties of cotton and biodegradable fibres for high performance technical textiles items	Replace 15% of non-biodegradable synthetic fibres with cotton and biodegradable fibres in technical textiles	Replace 50% synthetic fibres with cotton and bio-degradable fibres	Achieving Sustainable development goals GOAL 13: Climate Action, GOAL 14: Life Below Water GOAL 12: Responsible Consumption and Production.
2. Processing of cotton textiles is resource	Non-availability of carbon neutral / zero waste	Technological innovation and machinery	10% reduction in carbon and environmental	50% reduction in carbon and environmental	

intensive and generates pollution.	processing technologies for cotton even at international level	upgradation to reduce carbon and environmental footprints	footprints of cotton processing	footprints of cotton processing	
3. Pre and post consumer cotton textile waste has limited use and their disposal leading to environmental problem	Lack of technology for recycling pre- and post-consumer Cotton goods even at international level	Process protocol for recycling pre- and post-consumer waste cotton goods for diversified applications	Use of up to 15% recycled waste cotton fibres for diversified applications	Use of up to 50% recycled waste cotton fibres for diversified applications	

2. Sustainable utilization of cotton by-product and plant biomass for food, energy and structural materials

Existing Status	Gaps vis-à-vis International Standards	05 Year Target Proposed (Targets@2027)	10 Year Target Proposed (Targets@2032)	Goal@2047 (Specific Outcome Envisaged)	Major Impact over the Existing Capability
1. Cotton stalks and other lignocellulosic crop residues, a potential energy source, not put to any gainful use and burnt in the field causing severe environmental pollution.	Technology needed to collect and convert various types of biomasses into fuel through gasification/ co-firing in thermal power plants	Use of 10% of the surplus biomass for energy generation	Use of 30% of the surplus biomass for energy generation	Utilization of 90% surplus biomass for energy generation	Achieving Sustainable development goal (SDGs) 7: Affordable and Clean Energy
2. Utilization of cotton, its by-products and biomass residues for extraction of valuable chemicals	Technology for economic extraction of such chemicals from biomass and by-products	Development of suitable extraction methods	Development of technologies for use of plant extracted chemicals for industrial purposes	Substantial industrial demand for plant extracted chemicals reducing	Achieving Sustainable development goal GOAL 12: Responsible

	needs to be developed			dependence on petroleum	Consumption and Production
3. Cotton and other agro processing residues for food and industrial applications	Technology to economically convert plant cellulose to glucose/ starch needs to be developed	Development of technology to convert cellulose to glucose/ starch and microbial metabolites for food and industrial applications	Use of agro residues to obtain food products	Meeting 10% food requirement from cellulose derived products	Achieving Sustainable development goals GOAL 1: No Poverty GOAL 2: Zero Hunger
4. Utilization of fibres and cotton biomass for construction materials or reinforcements. Steel usage in construction increases cost	Technology needed to make high strength structural materials using cellulosic and lignocellulosic fibres as reinforcement for constructing buildings and roads	Replace 5% of steel and synthetic fibre based materials in road and building construction with cellulosic fibre reinforced materials	Replace 15% of steel and synthetic fibre based materials in road and building construction with cellulosic fibre reinforced materials	Replace 30% of steel and synthetic fibre based materials in road and building construction with cellulosic fibre reinforced materials	Achieving Sustainable development goal GOAL 11: Sustainable Cities and Communities

Proposal for a Top R&D Institution (Global) in relevant area (Institutes Aiming Global Eminence-NSTAGE)

International Centre for Cotton Technology

Aim	Location Proposed	Timeline	Major Infrastructure requisites	Major HR requisites	Major Impact over the Existing Capability
To utilise cotton and other natural fibres for food, fuel and structural applications and imparting training and education to the stakeholders	Nagpur	2026-2031	1. multi storey building 2. State of the art instruments and machines	Scientists and technologists for undertaking basic and strategic research, technology and human resource development	Global excellence in cotton technology, Atmanirbhar Bharat, Reducing inequality, Human resource development in cotton technology

Way Forward

Central Institute for Research on Cotton Technology (CIRCOT) is an institute which has been carrying out significant research and development on the post-harvest technology of cotton since 1924, making a positive impact on cotton farmers and the textile industry. Basic, applied and strategic research in the post-harvest processing of cotton and other natural fibres carried out at CIRCOT has resulted in the development of machines and generation of technologies which have addressed the concerns of efficiency, economy and the environment in past 97 years. Over the years, India has emerged as the largest producer of cotton and technological inputs of the institute have ensured that it is able to meet most of the fibre needs of its textile mills sector besides surplus quantity for export. Novel technologies researched and established by CIRCOT have also helped to promote the use of Indian cottons, either alone or in blends with polyester and other fibres for various end-uses. However reduced cotton production during last 2 years on account of pest attacks and unfavourable weather has increased prices and reduced availability of cotton to domestic textiles mills. If such trend continues, there is a possibility of cotton losing its share to man-made fibres despite its inherent comfort and sustainability advantages. Efforts must be taken to improve cotton productivity and production to maintain the prime position of cotton in the Indian textile sector. Use of recycled cotton fibre can increase fibre availability and at the same time cater to sustainability obligations as major brands are aiming to increase the usage of recycled fibres in their products.

The programmes initiated in CIRCOT need to address newer, high end and green products made from cotton and other natural fibres. This will ensure that the Indian cotton farmer gets competitive price on a sustainable basis. Additional income to the cotton farmers can also be ensured through effective utilisation of cotton stalks for the manufacture of value-added products. The linkages of the Institute with farmers and the industries need to be strengthened by adopting novel technology transfer, capacity building and business incubation activities with special emphasis on rural employment generation and augmentation of farm income.

In its way forward towards 2047, CIRCOT desires to be a self-sustained institution of international repute with the vision of "Global Excellence in Cotton Technology" by creating sustainable processing technologies for cotton and its value addition in harmony with Human Health, Society and Environment, integrating the interests of all stake-holders in its value chain, right from the farmer to the consumer and in the process establishing itself as a hub for post harvest cotton technologies, machines, processes & products in tune with the concept of "Make in India" and "Atmanirbhar Bharat".

हर कदम, हर डगर
किसानों का हमसफर

भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch